DUBUS
2/2012
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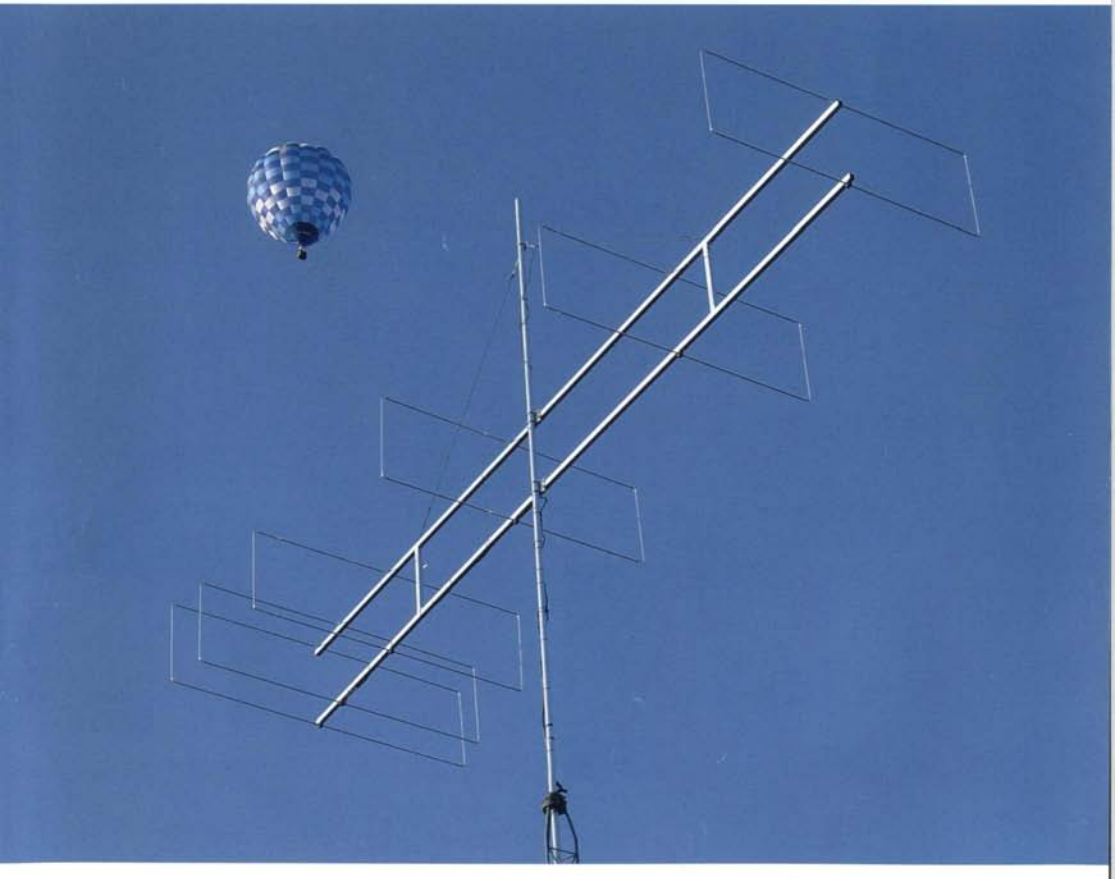
Antenna Design Developments



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Wolfgang Gellerich

Akkumulatoren

Grundlagen und Praxis

Die Welt ist voller Akkumulatoren – zum Betrieb von Geräten unabhängig vom Stromnetz und als geld- und rohstoffschonender Ersatz für Einwegbatterien. Die Kenntnis der Eigenschaften ist Voraussetzung für optimale Leistung, lange Gerätelaufzeit und Lebensdauer des Akkus. Basierend auf wissenschaftlichen Veröffentlichungen, Herstellerunterlagen und Patenten beschreibt dieses Buch den Stand der Technik bei Lithiumionen- und Lithiumpolymerakkus, Nickel-Cadmium- und Nickel-Metallhydrid-Akkus sowie Bleigelakkus.

Nach einer Darstellung der Funktionsweise folgen die für Anwendungen wichtigen Eigenschaften wie das Verhalten beim Entladen, auch mit großen Strömen und bei tiefen Temperaturen, Lagerung und Selbstentladung, Maßnahmen für eine lange Lebensdauer sowie Verfahren zur Ladung und Schnelladung. Eine Zusammenfassung mit Tips zum richtigen Einsatz runden die Kapit
Anwendungsgebie
Digitalkameras, Mo
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funk und Modellbau
sind eigene Kapitel
che farbige Abbildu
Zusammenhänge.
zeichnis mit über 10
einen schnellen Zu
des Buches.

Zum Autor:
Wolfgang Gellerich
sität Erlangen-Nürn
Nebenfach Chemie
Universität Stuttgart
lerich arbeitet bei ei
steller in der Entwic
zahlreicher Beiträge
aus den Bereichen
Elektronik.

August 16 to 18. All infos on www.eme2012.com

The following lectures are proposed:

Al Ward W5LUA: Introduction to EME on 24 GHz and higher

Alex Artieda HB9DRI: The IQ+ dual channel receiver – a practical implementation against Faraday rotation

Allen Katz K2UYH: Simple and low cost solutions for high gain on 70 and 23 cm using offset dishes

Brian Coleman G4NNS:
Some simple hydrogen line astronomy

Charlie Suckling G3WDG:
Application of GaN transistors to SSPAs for EME use

Charlie Suckling G3WDG: A novel 13cm receive converter

Daniella de Paulis: Visual Moonbounce: moonbouncing images as a new practice in moonbounce technology

Dave Powis G4HUP: Stresses on ropes and cables when raising and lowering towers

Dave Robinson WW2R:
Control and monitoring of EME solidstate amplifiers

David Morgan:
Detection of extra-galactic radio source Virgo A

Doug McArthur VK3UM: Inaccuracies that will lead to a deficiency in your EME systems performance or Why the other guy does better than you!

Doug Miller K6JEY: A Comparison of Wattmeter accuracies at 432MHz and 1296MHz

Eddy Jespers ON7UN & Walter Crauwels ON4BCB:
ON0EME 1296MHz Moon beacon

Gaëtan Horlin ON4KHG: Ground gain

Gudmund Wannberg SM2BYA: The 2.3–2.45 GHz spectrum situation and current threats in Sweden, Europe and wordwide

Pictures

EME expedition master DL8YHR as EY8ZF on 2m EME from Tadjikistan in April 2012

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Content / Inhalt 2/12

Title: A 6 Element "LFA-Q" by G0KSC (Photo G3ZSS)

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Greece	R.A.A.G., Manos Darkadakis SV1IW, PO Box 3564, 10210 Athens, raag-hq@raag.org
Italy	Tony Fumagalli, I2FUM, Via Masia 34, 22100 Como Tel: 031571537, email: fumagalli.antonio@gmail.com
Japan	Michaiki Watanabe, JH1KRC, Jingumae 2-2-39-702, Shibuya-ku, Tokyo 150-0001 Phone: +81-3-3404-6064 email: jh1krc@syd.odn.ne.jp
Malta	Joseph Falzon, 9H1VW, « Babs » 104, Sir William Reid Street, Gzira, GZR02 9h1vw@maltanet.net or danielg@maltanet.net
Netherlands	Veron Verkoop Bureau, P.O. Box 1166, 6801 BD Arnhem, veroncb@veron.nl
Norway	Kjell Syverud, LA9CY, Liaveien 8, 1450 Nesoddtangen, dubus@la9cy.com Phone: (+47) 66913546, Mob: (+47) 91841784, Homepage: www.la9cy.com
Portugal	Luis Cupido, CT1DMK, Rua da Vila Verde 39, 3800-810 Eixo / Aveiro. cupido@mail.ua.pt
Poland	Andrzej Walczyk, SP5BTN, ul. Miedzyborska 55 m 1, 04-027 Warsaw. sp5btn@gmail.com Mobile +48 606-493-423, Home +48 22 870 0353, http://sp5btn.republika.pl
Romania	Augustin Preoteasa, YO7AQF, Banat 13, Bl. B2 Sc. D Ap. 15, 110408 Pitesti Phone +40-788-234-273, email: augustin.preoteasa@soliber.net
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R.S.A.	Ivo Chladek, ZS6AXT, P.O. Box 3093,1745, Kenmare email: zs6axt@telkomsa.net
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United Kingdom	Roger Blackwell, GM4PMK, Willowbank, Pennyghael, Isle of Mull, PA70 6HB email: dubus@marsport.org.uk
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Editorial

Dear DUBUS Reader!

Welcome to issue 2/2012. In this issue we have again the summary 2m Es report for Europe and USA for the 2011 season just in time before the new season starts. From the observations of the last VK/ZL 2m Es season together with the increasing solar activity we may conclude that the 2012 2m Es season will be also "weaker" in the northern hemisphere. In two months we will know.

Again interesting experiments are ahead of us: 6W7RT, Francois got the VHF DX virus and is currently setting up beacons for 6m and 2m in his location south of Dakar. He is very interested in possible transatlantic propagation experiments. According to the Hepburn map forcasts his location should be very promising for openings into the Caribbean and South America. His 2m beacon will run > 300 W RF. So this is really a serious project! Thanks to DF7KF, LA0BY and LA8GKA for sponsoring equipment for this beacon.

The new solar cycle is still alive with good flux levels, although the latest charts show that the maximum could be a bit delayed or lower again than predicted. In any case in next autumn also for central EU there should be the break through F2 wise and if you want to join the propagation of the maximum of this solar cycle on 6m it is time to put up a Yagi NOW!

We want to invite all 2m digital EME OPs to take part in the 2012 2m EME Championship on July 21/22. Full rules and details are published in this issue and on www.DUBUS.org in the EME section. Please note that G0KSC from Innov-Antennas has sponsored shopping vouchers of 250€, 125€, and 75€ for the first three places of this event. Thank you for that, Justin!

Thanks to all authors and contributors of this issue! Please keep sending your reports and technical articles.

See you all at the Ham Radio in Friedrichshafen and at the EME conference in Cambridge!

73 from Joe, DL8HCZ / CT1HZE
and the DUBUS team!

Liebe DUBUS Leser!

Willkommen zur Ausgabe 2/2012. In dieser Ausgabe ist wieder der Gesamtbericht über die 2m-Es-Saison 2011 enthalten, gerade noch rechtzeitig, bevor die neue Saison wieder los geht. Aus den Beobachtungen der letzten 2m-Es-Saison in VK/ZL und aufgrund der zunehmenden Sonnenaktivität ist zu erwarten, dass die 2m-Es-Saison 2012 auch auf der Nordhalbkugel „schwächer" ausfallen dürfte. In zwei Monaten werden wir es wissen.

Auch in diesem Sommer wird es wieder interessante Experimente geben: 6W7RT, Francois, wurde vom VHF-DX-Virus infiziert und baut zur Zeit Baken auf 6m und 2m südlich von Dakar auf. Der Standort ist ideal für Tropo in die Karibik, wenn man sich die Hepburn-Vorhersagekarten anschaut. Die 2m-Bake wird mit >300 Watt senden, es ist also ein wirklich ernsthaftes Projekt. Dank geht an DF7KF, LA0BY und LA8GKA für das Spenden von Hardware für die Bake.

Der neue Sonnenfleckenzyklus ist weiter recht aktiv bei guten Fluxpegeln, allerdings scheinen die letzten Trends dafür zu sprechen, dass das Maximum sich etwas verzögern könnte oder etwas niedriger sein könnte, als zuletzt angenommen. Sicher ist, dass F2-mäßig auch für Mittel-EU im kommenden Herbst der „Durchbruch" kommen sollte. Wenn man also im kommenden Maximum auf 6m mitmischen will, muss man JETZT eine Yagi aufbauen!

Wie möchten alle 2m EME OPs einladen, an der 2m Digital EME Championship 2012 am 21./22. Juli teilzunehmen. Details in dieser Ausgabe und auf www.DUBUS.org auf den EME-Seiten. Wir möchten darauf hinweisen, dass G0KSC von InnovAntennas Einkaufsgutscheine für 250€, 125€ und 75€ für die ersten drei Plätze des Wettbewerbs spendiert. Danke, Justin!

Vielen Dank an alle Autoren und Mitarbeiter dieser Ausgabe! Über technische Artikel und Aktivitätsberichte freuen wir uns immer.

Wir sehen uns auf der Ham Radio und auf der EME-Konferenz in Cambridge!

73 von Joachim, DL8HCZ / CT1HZE
und vom ganzen DUBUS-Team!

Rugged 2 m Preamplifier for Tough RF Conditions

by Rastislav Galuscak, OM6AA[1] and Peter Kasparek, OK2ULQ

[1] Dept. of Electromagnetic Field, Czech Technical University, Technická 2, 166 27 Praha 6, Czech Republik, e-mail: om6aa@yahoo.com

1. Introduction

This article builds on the ongoing low noise amplifier (LNA) work of the authors which was published in previous DUBUS editions [1, 2]. The new preamplifier described here was designed as part of a 144/28 MHz transverter for radio clubs OK2C and OM6A and is a lower cost alternative for functionally similar professional products in the 2 m band [3]. The transverter design was carried through separate LNA, Rx mixer, IF amplifier, Tx mixer, PA and OCXO modules (LEGO style) and will be published in a future DUBUS edition. See Fig. 1. The preamplifier, equipped with RF relays, can also be used alone directly at the antenna.

Fig. 1 - 144/28 MHz Transverter

2. LNA RF Operating Parameter Requirements

Operating parameters of a single LNA must accommodate the dynamic range of the system's receiving chain. Receiver dynamic range issues are often described in various publications [4, 5].

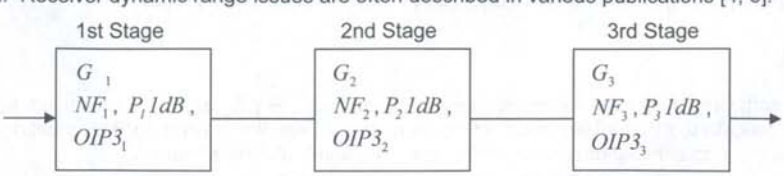

Fig. 2 – A 3-stage cascaded connection. For each stage Gain – G, Noise Figure – NF, Output Power Compression P1dB and Output 3rd-order Intercept Point - OIP3

Let's now review the calculations for a 3-stage cascaded connection. See Fig. 2.

The lower limit of dynamic range is often defined by noise figure. In a 3-stage cascaded system it is given by the well-known Friis formula,

$$NF(\mathrm{dB}) = 10\log\left[NF_1 + \frac{NF_2 - 1}{G_1} + \frac{NF_3 - 1}{G_1 G_2}\right] \quad (1)$$

The upper limit of dynamic range can be defined by the output power compression at 1dB. For three cascaded stages it is given by the formula

$$P1dB(\mathrm{dB}) = 10\log\left[\frac{1}{\frac{1}{P_1 1dBG_2G_3} + \frac{1}{P_2 1dBG_3} + \frac{1}{P_3 1dB}}\right] \quad (2)$$

Another definition for the upper limit of dynamic range may be made by using the 3rd-order intercept point (*IP3*). The relationship between *OIP3* and the output power compression *P1dB* value is given by a rule of thumb and the difference is statistically 10-12 dB in favor of *OIP3* [6]. However, for accurate analysis of these variables, actual measurements must be performed. The 3-stage cascaded *OIP3* calculation is given by

$$OIP3(dB) = 10\log\left[\frac{1}{\frac{1}{OIP3_1 G_2 G_3} + \frac{1}{OIP3_2 G_3} + \frac{1}{OIP3_3}}\right] \quad (3)$$

Note: Linear values of noise figure and gain must be used for all formulas.

The relationship between input (*IIP3*) and output (*OIP3*) 3rd-order intercept point is given by the formula

$$IIP3 = OIP3 - G \quad (dB) \quad (4)$$

During portable operation, many stations are exposed to very high electromagnetic field levels from their 70cm and 23cm antennas and also from professional TV, FM or GSM transmitters. For example, the FM signal power level at OM6A station's portable QTH on the 2 m antenna is +25 dBm. Specifically because of this condition, we need to have a highly linear front end with good selectivity. Also, contest participation requires a very high dynamic range for the entire Rx chain including the LNA.

The noise figure of an LNA on 2 m is not as critical as on higher bands, since the G_a/T_S ratio (where G_a is antenna gain and T_S is system temperature) is influenced by a relatively higher antenna noise temperature of about 400 – 600° K, nevertheless it should be below 2.5 dB for terrestrial operation and the noise figure of the entire Rx chain should be better than 3 dB. This can be achieved by mounting the LNA at the antenna.

Various circuit calculators have been developed to facilitate the signal system analysis. Suitable for our application is the free software APPCAD [7]. In addition to cascaded *IP3*, *NF* calculations, this software also calculates third order intermodulation products (*IM*), Minimum Detectable Signal (*MDS*) and Spurious Free Dynamic Range (*SFDR*). Definitions of these values may be found in the program.

Example 1

Using APPCAD software, determine optimum *Gain*, *IIP3*, and *SFDR* (500Hz) for a cascaded system consisting of the described preamplifier mounted at the antenna, feed line having 3 dB attenuation and an FT 857D transceiver, to achieve maximum *SFDR* and Rx chain 3 dB noise figure.

Parameters of LNA are *NF* = 2 dB, *IIP3* = 11.1 dBm, *SFDR* = 104.06dB related to *BW* 500 Hz.

Parameters of transceiver FT 857D are *NF* = 6.1dB, *IIP3* = -2dBm, *SFDR* = 92.59 dB related to *BW* 500 Hz [8].

File Calculate Application Examples Options Help

NoiseCalc

Set Number of Stages = 3 Calculate [F4]

Stage Data	Units	Stage 1	Stage 2	Stage 3
Stage Name:		LNA	Coax Cable	FT857
Noise Figure	dB	2	3	6,1
Gain	dB	12,4	-3	0
Input IP3	dBm	11,1	100	-2
dNF/dTemp	dB/°C	0	0	0
dG/dTemp	dB/°C	0	0	0
Stage Analysis:				
NF (Temp corr)	dB	2,00	3,00	6,10
Gain (Temp corr)	dB	12,40	-3,00	0,00
Input Power	dBm	-50,00	-37,60	-40,60
Output Power	dBm	-37,60	-40,60	-40,60
d NF/d NF	dB/dB	0,81	0,06	0,26
d NF/d Gain	dB/dB	-0,19	-0,16	0,00
d IP3/d IP3	dBm/dBm	0,00	0,00	0,99

Enter System Parameters:

Input Power	-50	dBm
Analysis Temperature	25	°C
Noise BW	0,0005	MHz
Ref Temperature	25	°C
S/N (for sensitivity)	10	dB
Noise Source (Ref)	290	°K

System Analysis:

Gain =	9,40	dB
Noise Figure =	3,00	dB
Noise Temp =	288,57	°K
SNR =	93,99	dB
MDS =	-143,99	dBm
Sensitivity =	-133,99	dBm
Noise Floor =	-170,98	dBm/Hz

Input IP3 =	-11,42	dBm
Output IP3 =	-2,02	dBm
Input IM level =	-127,15	dBm
Input IM level =	-77,15	dBC
Output IM level =	-117,75	dBm
Output IM level =	-77,15	dBC
SFDR =	88,37	dB

Fig. 4 - APPCAD Software Dialog Window

From Fig. 4 it is apparent that for the cascaded system with resulting *NF* =3 dB, the *IIP3* = -11.42 dBm , *SFDR* = 88.37 dB and optimum LNA gain = 12.4 dB. From the calculation it is also obvious, that while the noise figure was considerably improved, other parameter values such as spurious free dynamic range and especially *IIP3* are significantly inferior. When using an LNA, we must particularly take into account its gain and select it to be as small as possible so as not to significantly reduce the *SFDR* value.

Based on the above calculations, we can refute the ham-radio myth that a high *IP3* preamplifier can improve the dynamic range of the entire receiving system at the working frequency.

3. Circuit Design

Our LNA schematic is shown in Fig. 5. The amplifier employs two RFMD MMIC amplifiers, SPF-5122Z [9]. The MMIC amplifiers are coupled together by a pair of two-way 90 degree power combiners with very low insertion loss. This configuration provides a better input impedance match, since the impedance match of these MMIC amplifiers is not very good at lower frequencies. Input selectivity is achieved using triple helical filters customized for low insertion loss. Filter measurements confirmed factory specifications [10]. See Fig. 6. The output selectivity provides the triple helical filter with narrow frequency bandwidth, since the bandwidth performance of helical filters is a tradeoff against insertion loss, but higher insertion loss on the output is made up by MMIC gain. The LNA gain can be adjusted with fixed attenuators on each MMIC amplifier branch. TOKO 1314 output filters, from "GSM junk," were used. See Fig. 7.

We had similar filters marked with numbers 1313 and 1315. The S_{21} measurements of all these filters can be found on the OK2ULQ web site [11]. Since these filters are no longer in production, our PC board has been designed for variant assembly so that it is possible to use any TT model of Temwell filters as well. The dual sided PC board is made of ROGERS RO4050B material. The component layout is shown in Fig. 8 -10. The parts list is summarized in Tab. 1. Problems may be encountered with hand-soldering the tiny MMIC package. We had the opportunity to test a professional soldering machine for this purpose. See Fig. 11.

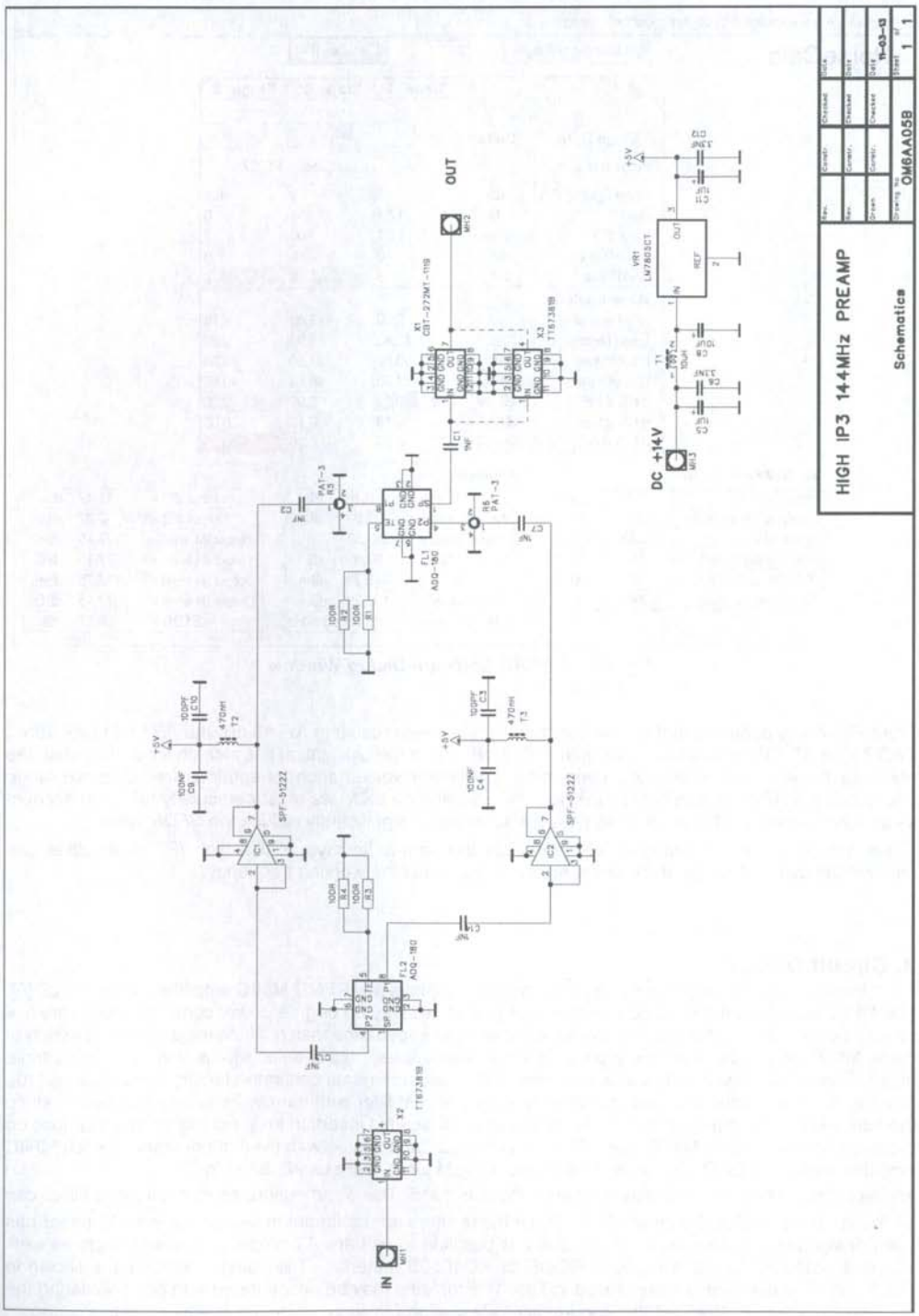

Fig. 5 - LNA Schematic

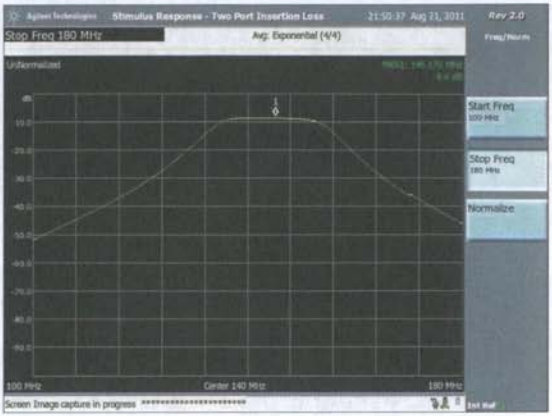

Fig. 6 - Two port insertion loss (S_{21} characteristics) of Temwell TT67381B filter. Insertion loss at 145 MHz is 1 dB.

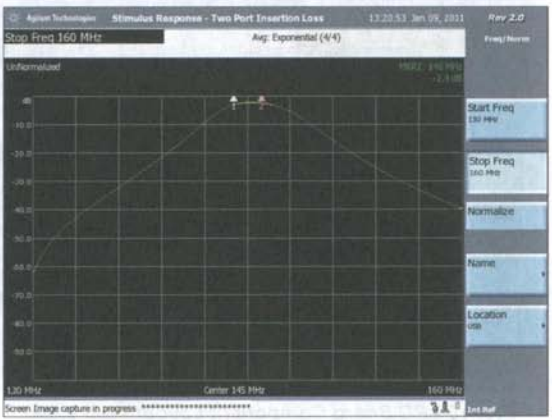

Fig. 7- S_{21} characteristic of TOKO 1314 filter

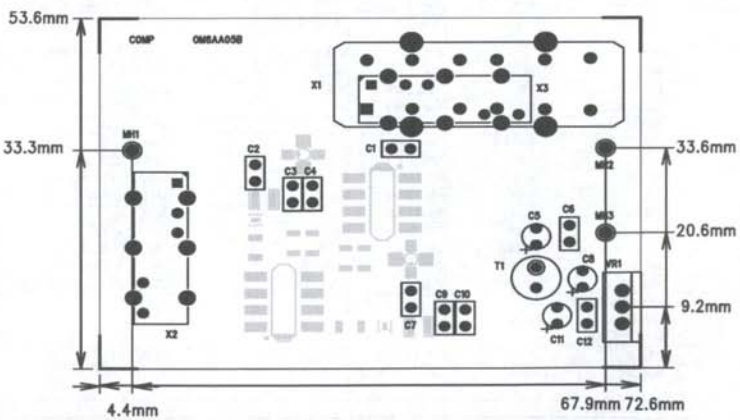

Fig. 8 - PC Board Component Layout Diagram

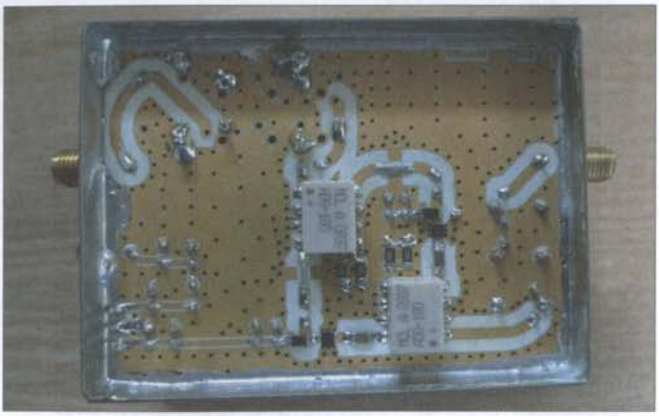

Fig. 9 - PC Board Component Layout – bottom view

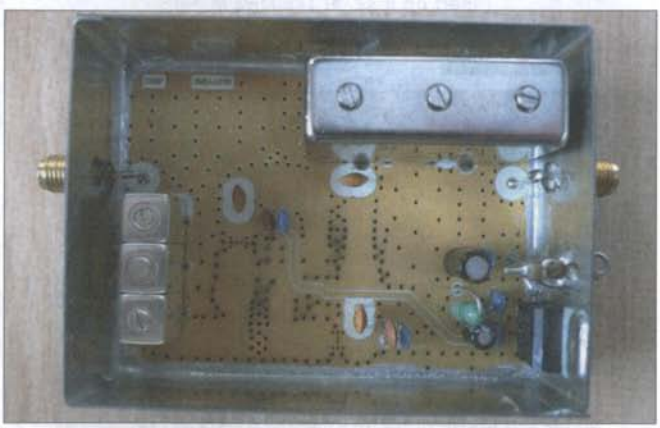

Fig. 10 - PC Board Component Layout - top view

B.O.M OM6AA05B Prepared 5.2.2012 Page 1

Item	Qty	Reference	PART NUMBER	VALUE	PCG	P-S	ARTC	NOTE
1	2	IC1-2	SPF-5122Z	50-4000MHz	2X2 MM	RFMD		LOW NOISE MMIC AMPLIFIER
2	1	VR1	LM7805CT		TO-220	NATIONAL SEMI.		VOLTAGE REG.
3	2	R5-6	PAT-1		AF320	MINI-CIRCUITS		1W MINIATURE CERAMIC FIXED ATTENUATOR
4	4	R1-4	RC-02HP	100R	1206	PHILIPS		RES.SMD
5	3	C1-2 C7	EGRU RM2.54	1NF	RM=2.54MM	PHILIPS		CERAMIC CAP.
6	2	C4 C9	EGRU RM2.54	100NF	RM=2.54MM	PHILIPS		CERAMIC CAP.
7	2	C3 C10	EGRU RM2.54	100PF	RM=2.54MM	PHILIPS		CERAMIC CAP.
8	2	C6 C12	EGRU RM2.54	33NF	RM=2.54MM	PHILIPS		CERAMIC CAP.
9	2	C13-14	KEFQ	1NF	1206	PHILIPS		CERAMIC CAP. SMD
10	2	C5 C11	TANTAL	1UF	RM=2.54MM	PHILIPS		RADIAL ELYT RM=2.54MM
11	1	C8	ELYT	10UF	RM=2.54MM	PHILIPS		RADIAL ELYT RM=2.54MM
12	1	T1	22R103	10uH	RM=3.1MM			INDUCTOR
13	2	T2-3	3650 1008.5%	470nH	36502C	TYCO		SMT INDUCTOR
14	1	X1	CBT-272MT-(1314)	145MHz	CBT	TOKO		TRIPLE TUNED FILTER
15	2	X2-3	TT67381B	144MHz	7H3B	TEMWELL		VHF,UHF HELICAL FILTER
16	2	FL1-2	ADQ-180	120-180MHz	CJ725	MINI CIRCUITS		POWER SPLITTER/COMBINER
17	1	MH3	HIGH-FREQUENCY SEALED LEADTHROUGH					
18	1	BOM2	WBG-35		55X74X30 MM	DONAU		METAL BOX
19	1	BOM1	RO4350B	ER=3.66	WEIGHT=0.762MM	ROGERS		PCB MATERIAL
20	2	MH1, MH2	SMA Connectors					

Tab. 1 - Parts List

Fig. 11 a, b - Soldering the MMICs

4. Measured Parameters

4.1 *S*- Parameters

The *S*-parameters of our LNA were first measured without filters. The results are shown in Fig. 12–15. A Rohde & Schwarz ZVL-6 vector network analyzer was used for these measurements. The *S*-parameters with the output TOKO filter are documented in Fig. 16–19. *S*-parameters of the complete LNA equipped with both filters are plotted in Fig. 20-23. The S_{21} parameter of the complete LNA in the frequency range of 0.05 – 5 GHz is shown in Fig. 24.

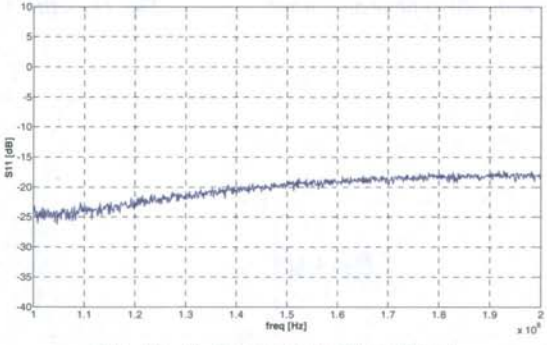

Fig. 12 - S_{11} Parameter without filter

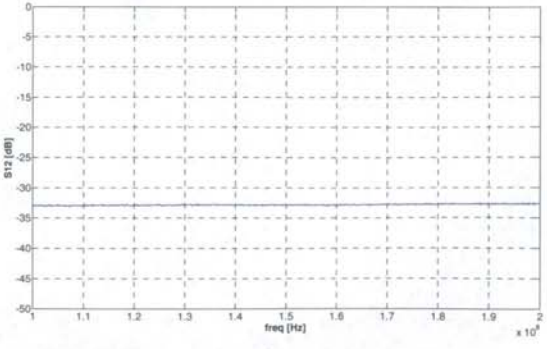

Fig. 13 - S_{12} Parameter without filter

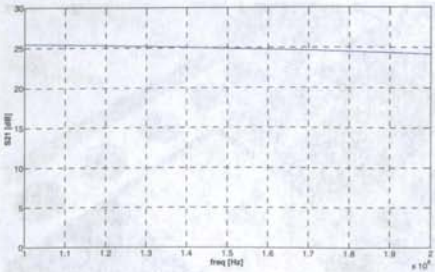

Fig. 14 - S_{21} Parameter without filter

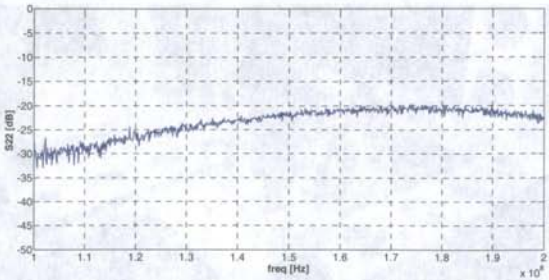

Fig. 15 - S_{22} Parameter without filter

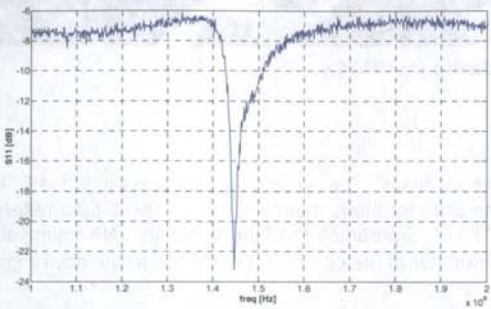

Fig. 16 - S_{11} Parameter with TOKO filter on output

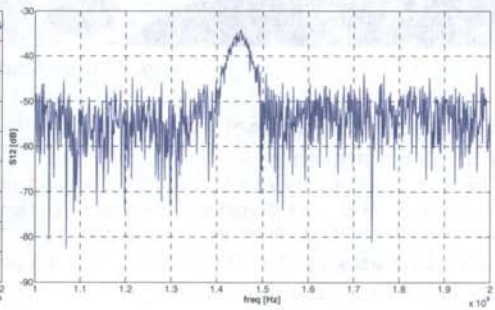

Fig. 17 - Ditto S_{12} Parameter

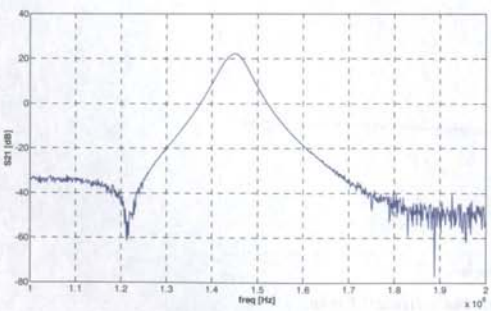

Fig. 18 - S_{21} Parameter with TOKO filter on output

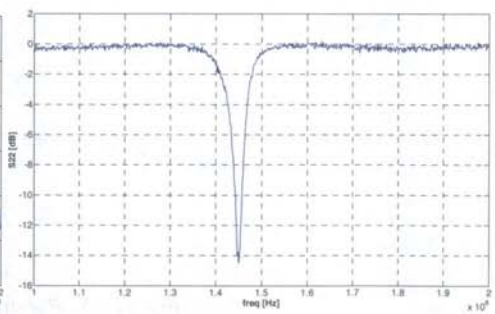

Fig. 19 - Ditto S_{22} Parameter

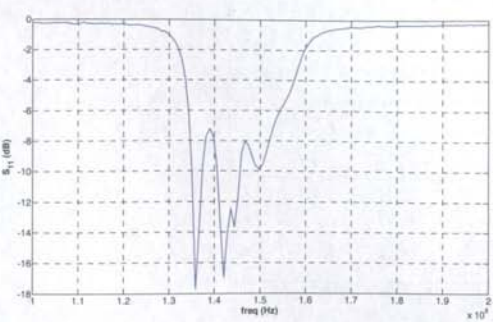

Fig. 20 - S_{11} Parameter with in- and output filters

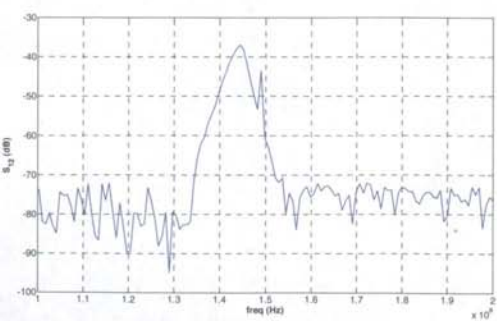

Fig. 21 – Ditto S_{12} Parameter

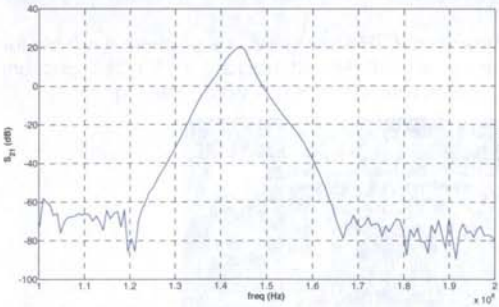

Fig. 22 - S_{21} Parameter with in- and output filters

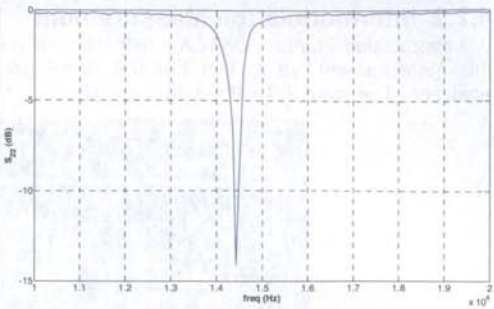

Fig. 23 - Ditto S_{22} Parameter

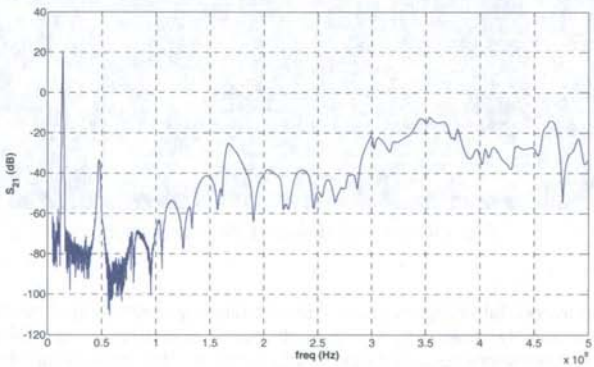

Fig. 24 - S_{21} Parameter with input and output filters for frequency range 0.05 – 5 GHz

4.2 Dynamic Range Measurement

4.2.1 Noise Figure

The noise figure was measured using an R&S spectrum analyzer FSP30 and also with an Agilent N8770B noise figure meter. The average noise figure without front end filter is 0.66 dB. See Fig. 25.

Fig. 25 - Noise figure measurements

The average noise figure with both filters is 2 dB (6 pc were measured). For a less demanding RF environment, the front end filter may be replaced by a simple series resonant circuit, which reduces noise figure values to about 1 dB.

4.2.2 Intermodulation Measurement

We appreciated Franta – OK1CA`s help with this measurement. He has suitable equipment available for this measurement, an Agilent E4432B signal generator and a Hewlett Packard HP8593E spectrum analyzer. The *Input IP3* without front end filter is + 10.1dBm, with filter is +11.1 dBm. See Fig. 26.

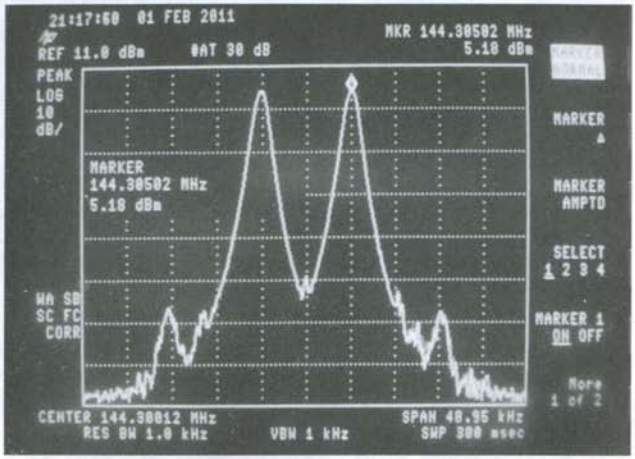

Fig. 26 - Intermodulation Measurements

5. Conclusion

We have designed, analyzed, fabricated and measured a high dynamic range LNA for the 2 m band. The LNA's superior thermal stability, selectivity and linearity permit operation in high RF environments where, until now, it has been necessary to use large cavity filters at the front-ends of even of highly rated professional equipment. The good performance of this device permits applications in high dynamic range systems in conjunction with other elements of the receiving chain. This LNA was used by the OM6A contest team during III. Subregional Contest 2011 and IARU Region 1 VHF Contest 2011 where 267 555 pts/ 725 QSO and 295 118 pts/ 760 QSO were respectively achieved.

Some RF parts, PC boards and pre-assembled LNAs are available from Peter - OK2ULQ, E-mail: ok2ulq@seznam.cz

Acknowledgement

The authors wish to acknowledge the help of Frantisek Strihavka, OK1CA for performing the *IP3* measurements, Vladimir Masek, OK1DAK for technical consultation and Robert Valenta for his technical and language assistance.

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[10] Specification of Temwell filter TT67381B-126M~145M, http://www.temwell.com.tw/

[11] OK2ULQ`s website, http://ok2ulq.blogspot.com/

Robuste 2-m-Vorverstärker für harte HF-Bedingungen

von Rastislav Galuscak, OM6AA[1] und Peter Kasparek, OK2ULQ

[1] Dept. of Electromagnetic Field, Czech Technical University, Technická 2, 166 27 Praha 6, Czech Republik, e-mail: om6aa@yahoo.com

1. Einleitung

Dieser Artikel baut auf der andauernden Arbeit von Autoren mit Vorverstärkern auf, die auch in DUBUS veröffentlicht wurde [1, 2]. Der neue, hier beschriebene Vorverstärker wurde als Bestandteil eines 144/28-MHz-Transverters für die Radio Clubs OK2C und OM6A entwickelt, und stellt eine kostengünstige Alternative zu funktionell gleichartigen Produkten für das 2m-Band dar [3]. Das Transverter-Design umfasst separate Module für LNA, RX-Mischer, ZF-Verstärker, TX-Mischer, PA und OCXO (Baukasten-Prinzip) und wird in einer kommenden DUBUS-Ausgabe präsentiert werden. Siehe Abb. 1. Der mit HF-Relais bestückte Vorverstärker kann auch separat direkt an der Antenne eingesetzt werden.

Abb. 1 - 144/28-MHz-Transverter

2. Anforderungen an die HF-Arbeitsparameter des LNA

Die Arbeitsparameter eines einzelnen LNA müssen an den Dynamikbereich der Empfangskette des Systems angepasst sein. Die Problematik beim RX-Dynamikbereich wurde bereits oft beschrieben [4, 5].

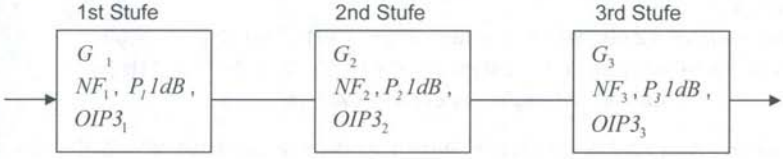


Abb. 2 - Eine 3-stufig kaskadierte Anordnung. Für jede Stufe: Gewinn – G, Noise Figure – NF, Ausgangssignal-Kompression P1dB und Ausgangs-Interzeptpunkt 3. Ordnung - OIP3

Wir betrachten nun nochmal die Berechnungen für eine 3-stufig kaskadierte Schaltung. Siehe Abb. 2. Die untere Grenze des Dynamikbereichs wird oft durch die Rauschzahl festgelegt. Bei einem 3-stufig kaskadierten System wird sie durch die bekannte Friis-Formel beschrieben:

$$NF(\mathrm{dB}) = 10\log\left[NF_1 + \frac{NF_2 - 1}{G_1} + \frac{NF_3 - 1}{G_1 G_2}\right] \tag{1}$$

Die obere Grenze des Dynamikbereichs kann mittels der Ausgangskompression bei 1dB definiert werden. Für 3 kaskadierte Stufen wird sie durch folgende Formel beschrieben:

$$P1dB(\mathrm{dB}) = 10\log\left[\frac{1}{\frac{1}{P_1 1dBG_2G_3} + \frac{1}{P_2 1dBG_3} + \frac{1}{P_3 1dB}}\right] \tag{2}$$

Eine andere Definition für die obere Grenze des Dynamikbereichs kann durch Anwendung des Interzeptpunkts 3. Ordnung (*IP3*) gemacht werden. Die Beziehung zwischen *OIP3* und des Wertes der Ausgangskompression *P1dB* wird mittels einer Faustformel ermittelt, die Differenz beträgt im Mittel 10-12 dB zugunsten des *OIP3* [6]. Für die genaue Analyse dieser Variablen müssen aber echte Messungen vorgenommen werden. Die Berechnung des *OIP3* für 3 kaskadierte Stufen erfolgt so:

$$OIP3(dB) = 10\log\left[\frac{1}{\frac{1}{OIP3_1 G_2 G_3} + \frac{1}{OIP3_2 G_3} + \frac{1}{OIP3_3}}\right] \tag{3}$$

Anmerkung: In allen Formeln müssen lineare Werte für Rauschzahl und Gain verwendet werden.
Die Beziehung zwischen Eingangs- (*IIP3*) und Ausgangs- (*OIP3*) Interzeptpunkten wird so beschrieben:

$$IIP3 = OIP3 - G \quad (dB) \tag{4}$$

Bei Portabelbetrieb sind viele Stationen sehr hohen elektromagnetischen Feldstärken herrührend von ihren 70cm- und 23cm-Antennen, sowie professionellen TV-, FM- oder GSM-Sendern ausgesetzt. Z.B. beträgt der FM-Signalpegel am Portabel-Standort von OM6A an der 2m-Antenne +25dBm. Besonders aus diesem Grund brauchen wir hier ein hochlineares Frontend mit guter Selektivität. Eine Kontestteilnahme erfordert für die ganze RX-Kette, inkl. LNA, einen sehr hohen Dynamikbereich.

Die Rauschzahl eines LNA auf 2m ist nicht so kritisch wie auf höheren Bändern, weil das G_a/T_S -Verhältnis (mit G_a für den Antennengewinn und T_S für die Systemtemperatur) durch eine relativ höhere Antennenrauschtemperatur von ca. 400 – 600 K beeinflusst wird. Dennoch sollte die Rauschzahl für terrestrische Anwendungen kleiner als 2.5 dB sein und die Rauschzahl der gesamten Empfangskette sollte besser als 3 dB sein. Das kann erreicht werden, in dem man den LNA an der Antenne anbringt.
Diverse Programme wurden entwickelt, um eine Signalanalyse von Schaltungen zu erleichtern. Für unseren Fall ist die Freeware APPCAD [7] geeignet. Zusätzlich zum kaskadierten *IP3* und *NF*-Berechnungen berechnet es auch Intermodulationsprodukte 3. Ordnung *(IM)*, das Minimum Detectable Signal (*MDS*) und den Spurious Free Dynamic Range (*SFDR*). Infos dazu finden sich im Programm.

Beispiel 1

Mit der APPCAD-Software wird für ein kaskadiertes System, bestehend aus dem beschriebenen an der Antenne montierten LNA, der Speiseleitung mit 3 dB Verlust und einem FT857-Transceiver, der optimale *Gewinn*, *IIP3* und *SFDR* (500Hz) bestimmt, um maximales *SFDR* und eine Empfangskettenrauschzahl von 3 dB zu erreichen.

Parameter des LNA sind: *NF* = 2 dB, *IIP3* = 11.1 dBm, *SFDR* = 104.06 dB für *BW* = 500 Hz.

Parameter des FT 857D: *NF* = 6.1dB, *IIP3* = -2dBm, *SFDR* = 92.59 dB für *BW* = 500 Hz [8].

Abb. 4 - Dialogfenser der APPCAD-Software

Aus Abb. 4 geht hervor, dass für das kaskadierte System mit der resultierenden *NF* = 3 dB, dem *IIP3* = -11.42 dBm und *SFDR* = 88.37 dB die optimale LNA-Verstärkung = 12.4 dB ist. Aus der Berechnung ist auch ersichtlich, dass, während die NF beträchtlich verbessert wurde, andere Parameter, wie der *SFDR* und speziell der *IIP3* signifikant schlechter geworden sind. Wenn man einen LNA verwendet, muss man besonders dessen Verstärkung berücksichtigen und diese so niedrig wie möglich wählen, um den *SFDR*-Wert nicht signifikant zu reduzieren. Basierend auf obigen Berechnungen, können wir den Amateurfunk-mythos bestreiten, der besagt, dass ein LNA mit hohem *IP3* den Dynamikbereich des ganzen Empfangssystems auf der Arbeitsfrequenz verbessern kann.

3. Design der Schaltung

Das Schaltbild des LNA ist in Abb.5 gezeigt. Der Verstärker verwendet zwei RFMD MMIC-Verstärker SPF-5122Z [9]. Die MMIC-Verstärker werden mittels eines Paares von sehr verlustarmen Zweiweg-90-Grad-Kombinierern zusammengekoppelt. Diese Konfiguration liefert eine bessere Eingangsimpedanz-anpassung, da die Impedanzanpassung dieser MMIC-Verstärker bei niedrigen Frequenzen nicht sehr gut ist. Eingangsselektivität wird mittels eines Dreifach-Helix-Filters, das für niedrige Einfügedämpfung ausgelegt ist, erreicht. Messungen des Filters haben die Spezifikationen des Herstellers bestätigt [10]. Siehe Abb. 6. Die Ausgangsselektivität wird durch das 3-fache Helixfilter mit schmaler Bandbreite geliefert. Die Bandbreite von Helixfiltern stellt immer ein Kompromiß mit deren Einfügedämpfung dar, aber höhere Einfügedämpfung im Ausgang wird durch die Verstärkung der MMIC ausgeglichen. Die LNA-Verstärkung kann mittels fester Abschwächer für jeden MMIC-Verstärkerzweig eingestellt werden. TOKO 1314 Ausgangsfilter aus dem „GSM-Müll" wurden hier verwendet. Siehe Abb. 7. Ähnliche Filter mit den Nummern 1313 und 1315 gehen auch, die S_{21} -Messungen für all diese Filter kann man auf der Webseite von OK2ULQ finden [11]. Da diese Filter nicht mehr produziert werden, wurde die Platine so variabel ausgelegt, dass es möglich ist, auch jedes TT-Filter-Modell von Temwell zu verwenden. Die beidseitig bestückte PCB wurde aus RO4050B-Material von Rogers hergestellt. Das Komponenten-Layout ist in Abb. 8 bis 10 gezeigt. Die Teileliste zeigt Tabelle 1. Probleme könnte es bei der Einlötung der kleinen MMICs von Hand geben. Wir hatten die Gelegenheit, eine professionelle Lötanlage für diesen Zweck zu testen. Siehe Abb. 11.

Abb. 5 - LNA-Schaltbild

Abb. 6 - Zweiport-Einfügedämpfung (S_{21}-Charakteristik) des Temwell TT67381B-Filters. Die Einfügedämpfung bei 145 MHz beträgt 1 dB.

Abb. 7- S_{21}-Charakteristik des TOKO-1314-Filters *Abb. 8 - PCB-Komponenten-Layout - Diagramm*

Abb. 9 - PCB-Komponenten-Layout - Unterseite *Abb. 10 - PCB-Komponenten-Layout - Oberseite*

Tabelle 1 - Teileliste *Abb. 11 a, b - Einlöten der MMICs*

4. Gemessene Parameter

4.1 *S*-Parameter

Die *S*-Parameter unseres LNA wurden zuerst ohne Filter gemessen. Die Ergebnisse werden in den Abb. 12 bis 15 gezeigt. Für diese Messungen wurde ein vektorieller Netzwerkanalysator ZVL-6 von Rohde & Schwarz verwendet. Die *S*-Parameter mit dem TOKO-Filter im Ausgang zeigen die Abb. 16 bis 19. *S*-Parameter des kompletten LNA mit beiden Filtern zeigen die Abb. 20 bis 23. Die S_{21}-Parameter des kompletten LNA für den Frequenzbereich von 0.05 – 5 GHz zeigt die Abb. 24.

Abb. 12 - S_{11}-Parameter ohne Filter *Abb. 13 - S_{12}-Parameter ohne Filter*

Abb. 14 - S_{21}-Parameter ohne Filter *Abb. 15 - S_{22}-Parameter ohne Filter*

Abb. 16 - S_{11}-Parameter mit TOKO-Filter im Ausgang *Abb. 17 - Dito S_{12}-Parameter*

Abb. 18 - S_{21}-Parameter mit TOKO-Filter im Ausgang *Abb. 19 - Dito S_{22}-Parameter*

Abb. 20 - S_{11}-Parameter mit Ein- und Ausgangsfiltern *Abb. 21 - Dito S_{12}-Parameter*

Abb. 22 - S_{21}-Parameter mit Ein- und Ausgangsfiltern *Abb. 23 - Dito S_{22}-Parameter*

Abb. 24 - S_{21}-Parameter mit Ein- und Ausgangsfiltern für den Frequenzbereich 0.05 – 5 GHz

4.2 Messung des Dynamikbereichs

4.2.1 Rauschzahl (NF)

Die Rauschzahl wurde mit einem Spektrumanalysator FSP30 von R&S und auch mit einem Agilent N8770B NF-Meter gemessen. Die durchschnittliche NF ohne Frontend-Filter ist 0.66 dB. Siehe Abb. 25.

Abb. 25 - Rauschzahlmessungen *Abb. 26 - Intermodulationsmessungen*

Die durchschnittliche NF mit beiden Filtern beträgt 2 dB (6 Exemplare wurden gemessen). Für eine weniger anspruchsvolle HF-Umgebung kann das Eingangsfilter durch einen einfachen Serienresonanzkreis ersetzt werden, was die NF-Werte auf cirka 1 dB verbessert.

4.2.2 Messung der Intermodulation

Franta, OK1CA, hat uns dankenswerterweise bei dieser Messung geholfen. Er hat geeigetes Equipment dafür: Einen Agilent E4432B Signalgenerator und einen Hewlett Packard HP8593E Spektrumanalysator. Der *Input IP3* ohne Frontend-Filter beträgt + 10.1dBm, mit Filter liegt er bei +11.1 dBm. Siehe Abb. 26.

5. Schluß

Wir haben einen LNA mit hohem Dynamikbereich für das 2m-Band entwickelt, analysiert, aufgebaut und gemessen. Die ausgezeichnete thermische Stabilität, Selektivität und Linearität erlauben Betrieb in Umbebungen mit hohen HF-Pegeln, in denen es bis jetzt nötig war, große Cavity-Filter im Frontend oder sogar höchst professionelles Equipment einzusetzen. Die guten Leistungsdaten dieses LNA ermöglichen den Einsatz in Systemen mit hohem Dynamikbereich in Verbindung mit anderen Elementen der Empfangskette. Der LNA wurde vom OM6A-Kontestteam im 3. Subregional-Contest 2011 und im IARU-Region-1-VHF-Contest 2011 eingesetzt, bei dem 267.555 Punkte und 725 QSOs bzw. 295.118 Punkte und 760 QSOs erreicht wurden.

Einige Teile, PCB und zusammengebaute LNAs gibt es bei Peter, OK2ULQ, E-mail: ok2ulq@seznam.cz

Danksagung

Die Autoren danken Frantisek Strihavka, OK1CA, für die IP3-Messungen, Vladimir Masek, OK1DAK, für technische Konsultationen und Robert Valenta für technische und sprachliche Hilfe beim Artikel.

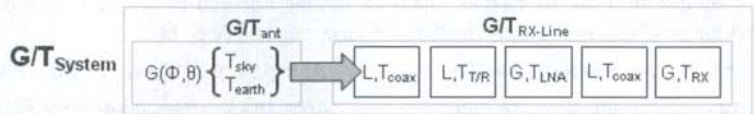
Referenzen: Siehe am Ende des engl. Textes.

Notes on VHF/UHF Antenna G/T
An extended chapter from the TANT Appendix

by Hartmut Klüver, DG7YBN

Introduction

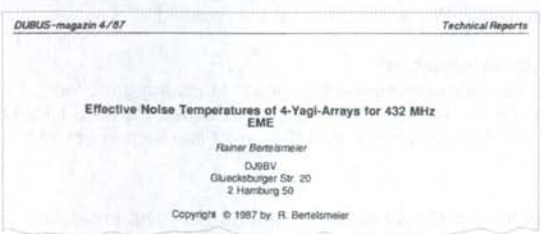
In a classical sense G/T is a signal-to-noise ratio derived from division of the antenna gain by the receiving system noise temperature. Since it includes the noise temperature of the complete system, it is referred to as G/T_{System}. In it, the gains and losses of individual stages are combined with their equivalent noise temperatures.



If we want to see what the signal-to-noise ratio of the antenna can offer us as a function of its directivity and environmental noise pick up, we can define G/T at the antenna feed point, G/T_{ant}. It is practical to use the antenna gain expressed in dB, so antenna G/T is commonly denoted as G_{dB}/T_{ant}.

Computing a G_{dB}/T_{ant} ratio using the TANT software by YT1NT [19] is a widespread and well-acknowledged procedure. TANT is preset to a Sky Temperature of 200 K and an Earth Temperature of 1000 K, which is convenient for the actual numbers used in what has become *the comprehensive standard* - the 144 MHz G/T Table by Lionel Edwards, VE7BQH.

As far as I can see, the determination of G/T Factors by radio amateurs really started with an article by DL6WU entitled "Determining the Sensitivity of Receive Systems with the Aid of Solar Noise" published in VHF Communications, 1980/2 [1]. The topic of this article was refined by DJ9BV and F6HYE in the article "Performance Evaluation for EME-Systems" in Dubus 3/1992 [2]. A paper on how to use cosmic noise sources to measure antenna gain by W5CQ, K3LFO and others [3] might have been written prior to DL6WU's and DJ9BV's articles. However, other bands apart from 144 MHz lack real standard values for Sky and Earth Temperatures. For the 222 MHz band we hardly find any figures at all and for the 432 MHz band there is only a single widely acknowledged source in the literature. The fundamental article on the topic of G/T_{ant} related to antenna pattern, namely DJ9BV's "Effective Noise Temperature of 4-Yagi-Arrays for 432 MHz EME" was published in Dubus 4/1987 [4]:



DUBUS-magazin 4/87 *Technical Reports*

Effective Noise Temperatures of 4-Yagi-Arrays for 432 MHz EME

Rainer Bertelsmeier

DJ9BV
Gluecksburger Str. 20
2 Hamburg 50

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Fig. 1: Fundamental article on Antenna Noise Temperature by DJ9BV

In this article Rainer gave values of 15 K for T_{sky} and 290 K for T_{earth} at 432 MHz. Now we have numbers for 144 MHz and 432 MHz based on more experience. Let us see how they fit into the overall picture and what can be calculated for other UHF bands. To do so on a solid basis we start by looking at how it all began, then wind up the numbers chosen by VE7BQH for 144 MHz and DJ9BV for 432 MHz and finish off with formulas and examples for those who like to calculate G/T and Temperatures themselves.

1. T_{sky} Grass Roots - Jansky's Measurements and beyond

In a scientific sense, T_{sky} can be called Cosmic Noise. It was discovered and first investigated by Karl G. Jansky in 1932 [5]. He used frequencies around 20.5 MHz. His antenna could be turned on a chassis with Ford Model T wheels. It looked like a 'merry-go-round' and thus this was its nickname. Jansky was working at the Bell Telephone Company which offered a transatlantic telephone service on wavelengths

close to 15 m. They had trouble with noise and wanted Jansky to determine its origin. Jansky found that natural sources, mainly tropical thunderstorms, caused it. But he also found a noise peak with a period of 1 sidereal day. He identified the galactic centre as the source. Then he wrote an article on his findings entitled "Electrical Disturbances of Apparently Extraterrestrial Origin" [5]. Though he made an ingenious discovery, the Bell Telephone Company had no commercial interest in what was to become radio astronomy and he had to terminate this study. In "My Brother Karl Jansky and His Discovery of Radio Waves from Beyond the Earth" [6] C. M. Jansky, Jr. writes about his brother's findings:

> *"Karl Jansky's paper, "Electric Disturbances Apparently of Extraterrestrial Origin", is in effect a wedding ceremony. It weds the science of astronomy and the science of radio and electronic engineering, tying them together by inseparable bonds."*

In honour of Jansky, the unit used by radio astronomers for the flux density of radio sources is the 'Jansky' (1 Jy = 10^{-26} W m^{-2} Hz^{-1}). The units that make up the Jansky tell us how it is put together: Captured power per square meter of the antenna collecting area divided by the bandwidth of the power detector. It is understood that what comes in from a star is very small when measured in Watts. Hence the multiplication factor of 10^{-26} was added to lift the number to a useful level.

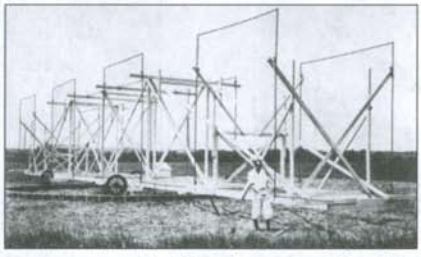

Fig. 2: "Jansky's merry-go-round". Diameter approximately 100 ft., height 20 ft. Source: National Radio Astronomy Observatory (NRAO) [7]

Jansky's measurements were basically confirmed and refined by Grote Reber. He was a radio amateur (W9GFZ) and a radio engineer by profession who read Jansky's article and got hooked on the challenge of working in the field of cosmic noise. He performed experiments on 3.3 GHz in 1937 and 910 MHz later on but had no luck. Finally he used 160 MHz and could detect noise from the Milky Way which confirmed Jansky's findings. That he succeeded on a lower frequency is no surprise today since the radiation intensity of the Milky Way is roughly ten times higher at 160 MHz compared to 3.3 GHz. Additionally we have to take into account the large differences in the noise figures of pre-war 3.3 GHz and VHF equipment. Reber's work was continued by D.C. Hogg and W.W. Mumford [8] and R.H. Brown and C. Hazard [9] three decades later. Their efforts led to the set of three formulas to which Hogg and Mumford contributed the average temperature (1.2), whereas Brown and Hazard contributed the estimations of maximum and minimum temperatures (1.1/1.3). This set of formulas represents the evolution of the scientific approach to cosmic noise in the 1960s.

(1.1) $T_{min} = 58 \cdot \lambda^2$	(1.2) $T_{average} = 100 \cdot \lambda^2$	(1.3) $T_{max} = 1450 \cdot \lambda^2$

Formula Set 1

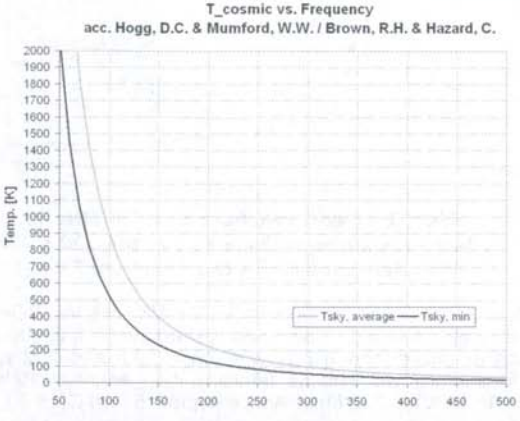

Chart 1

Now T_{sky} is comprised of the cosmic microwave background radiation (CMB) and the sum of all individual sources like Cassiopeia A, Taurus A and all the others. The CMB is a relic of the 'Big Bang' and is uniformly distributed with a blackbody spectrum corresponding to a temperature of about 3 K. It was discovered by A. Penzias and R. Wilson, of Bell Telephone Labs, in 1965. The mean value of the individual sources plus the background radiation represents T_{sky}. The sharp beam of a very large dish will not see this average, hence we need definitions of 'hot' and 'cold' areas.

2. T_{sky} and T_{earth} - Further Research and Development

The pre-war efforts of Jansky and Reber was excellent pioneering work. As the technology improved, Hogg, Mumford, Brown and Hazard were able to refine these initial findings in the 1960s. The importance of both antenna and receiver limitations were crucial to radio astronomy in the past as they are today:

> *"It was obvious to Reber that Jansky had made a fundamental discovery, and realized the limit of Jansky's equipment had been reached"* N1MAA [10]

Fig. 3: Grote Reber's first antenna: a 31 ft. dish built in 1937. Photo: NRAO archives [11]

Fig. 4: Doug McArthur's, VK3UM'S, 28 ft. dish [12]

What Reber recognised so early when reflecting on Janskys findings is what radio amateurs using GaAs FET low noise amplifiers further realized in the 1980s. This built on what Hogg, Mumford, Brown and Hazard found in the 1960s. To illustrate progress up to today, I show radio amateur VK3UM's dish (Fig. 4) which has been carefully calculated and tested with the aid of today's available computer programs. Today amateur Rx equipment uses state of the art low noise preamplifiers mounted at the antenna feed. Using PHEMT FETs, noise figures well below 0.5 dB from 2 m to the higher microwave bands can be achieved.

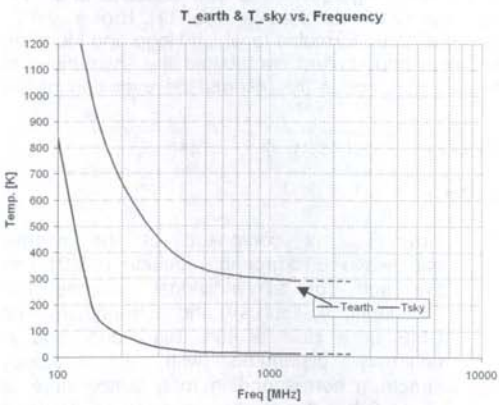

Chart 2: T_{earth} and T_{sky}, as used by radio amateurs today, based on T_{min} in equation (1.1), log frequency scale.

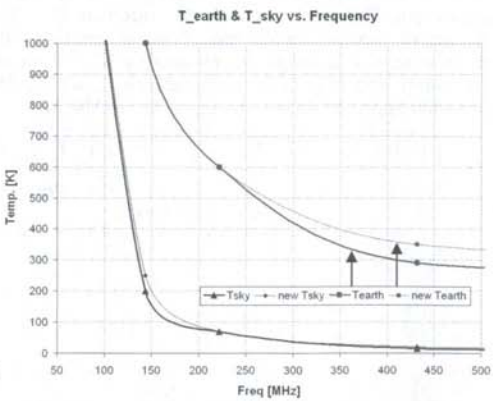

Chart 3: Linear scale from 50 to 500 MHz for better resolution with markers at 144, 220 & 432 MHz. Data used in this chart are from Table 1.

A standard for today (2011) may be the following figures derived by the work of DJ9BV, VK3UM, VE7BQH and others. Looking at Chart 1, derived from what Hogg, Mumford, Brown and Hazard found, it is clear that the graph must be a continuous curve of typical quadratic form. If T_{earth} was only 290 K at 432 MHz there would be no possibility of lowering it further for the microwave bands. Similarly, if T_{sky} was only 15 K at 432 MHz, there would no smooth reduction down to 10 K at 1296 MHz. Above approx. 5…10 GHz, T_{sky}

rises rapidly as we approach the resonance frequencies of water vapour (22 GHz) and atmospheric gases like oxygen (60 GHz) and others. Consequently it is important to quote the humidity when stating a measured G/T for higher microwave bands.

Band	Tearth	Tsky
50 MHz	**3000 K**	**2200 K**
144 MHz	**1000 K**	**200 K** => 250 K
222 MHz	**600 K**	**70 K**
432 MHz	**290 K** => 350 K	**15 K** => 20 K
1296 MHz	**290 K**	**10 K**

Table 1: Values for T_{earth} and T_{sky}, => aligned values

A note on the 144 MHz temperatures:

There is a little kink in the the line between 50 and 222 MHz, which may indicate that the value for T_{earth} is a bit low compared with the values for other bands. It could be changed to be consistent with the other bands in the future. VK3UM in his EME Performance Calculator, V. 7.12, proposes 250 K for T_{earth} [13]. 250 K provides a smoother transition than 200 K and closely matches the curves of Hogg and Mumford.

A note on the 432 MHz temperatures:

Considering the importance of technical progress in measurement equipment, it is understandable that DJ9BV moved from what he initially gave as reasonable temperatures in his well known article "Effective Noise Temperature of 4-Yagi-Arrays for 432 MHz EME" in 1987.

Asking Lionel Edwards, VE7BQH why the T_{earth} on 432 MHz was assumed to be only 290 K in DJ9BV's article he wrote the following:

> *"Yes he did in 1987, but by the 1990s when we were discussing 144 MHz we touched on 432 numbers and he said he thought his Tearth in Hamburg was about 600 K on 432! No doubt Hamburg mid city could be very noisy! In 1987 he was using the theoretical numbers which were the basis for his article. As the Y-factor is large on this band the article results are still very meaningful. By the 1990s he and I realized that the "real" world did not have that low a number hence the numbers you see today."*

The theoretical figure of 273 K + 17 K = 290 K, representing a completely interference-free earth temperature of 17 degrees Celsius, did not allow accurate prediction of the behaviour of a real world receiving system. Consequently the theoretical value for T_{earth} needs to be changed to a practical value of 350 K. It became apparent quite early in the history of cosmic noise measurement that there are adjustments to be made whenever measurement equipment is improved and, as far as T_{earth} is concerned, the noise level keeps on rising in non-rural areas. These figures have been 'on the move' continuously by a few Kelvin since Jansky's pioneering work.

The challenge for the radio amateur is to find a consensus for antenna and receiving system performance comparisons between stations. Clearly, the figures decided on must form a smooth curve as the initial cosmic noise figures do when plotted on a chart. Taking locally differing noise levels into consideration, these should represent an **average mean value** as seen by Hogg and Mumford.

A frequently encountered error is giving a temperature in 'degrees Kelvin'. The fact that 1 K does have the same magnitude as 1 degree Celsius does not justify adding ' degree' or a '°' to the Kelvin. The Kelvin is a unit on its own, just '**K**' is the official unit for temperature in the SI-system.

Actual figures to use for G/T calculations are to be found below in Table 4.

3. Relevance of T_{earth} and T_{sky}

The noise we see in our Rx-system has its origin in T_{earth} and T_{sky} as well as in semiconductors, resistors and so on. The pick up of T_{earth} and T_{sky} accounts for the antenna noise temperature. We cannot expect a better signal-to-noise ratio, even using the best low noise amplifier, than is present at the source of the desired signal. DJ9BV in [4]:

> *"The effective noise temperature of antennas which 'see' different radiation sources with their pattern is a very important property, because it limits the achievable system temperature of the complete receiving system."*

3.1 Y-Factor

The ratio of two noise levels is called Y-Factor. As noise power level 'N' is proportional to noise temperature it can either be defined as noise to noise or a temperature to temperature ratio. Replacing T_{Hot} by T_{earth} and T_{Cold} by T_{sky} we can use the Y-Factor equation for a ratio between the antenna pointed down to the earth and towards a cold patch of sky.

$$(3.1) \quad Y[/] = \frac{N_{On}}{N_{Off}} = \frac{N_{Hot}}{N_{Cold}} = \frac{T_{Hot}}{T_{Cold}} = \frac{T_{earth}}{T_{sky}}$$

Often the noise temperatures are expanded to include that of the receiver:

$$(3.2)\quad Y[/] = \frac{T_{Hot} + T_{RX}}{T_{Cold} + T_{RX}}$$

If a known Y-Factor is available, the noise temperature T_{System} and noise figure (*NF*) of a system or a module (DUT = Device Under Test) can be determined.

$$(3.3)\quad T_{System}\,[K] = \frac{T_{Hot} - Y \cdot T_{Cold}}{Y - 1} \qquad (3.4)\quad NF_{dB} = 10\log\left((T_{Dut}/290K) + 1\right)$$

Applying equation 3.1 to an isotropic radiator using temperatures from Table 4 (below) gives the graph shown in Chart 4:

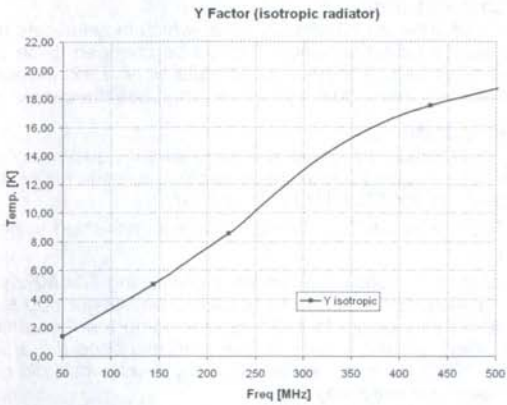

Chart 4: Linear Y-Factor (T_{earth}/T_{sky}) for an isotropic radiation pattern

The chart indicates that paying attention to the G/T ratio is approximately three times more important on 144 MHz than on 50 MHz and nine times more on 432 MHz. Note that the Y factor is not expressed in dB here, but as a ratio. However, it can be converted from the linear ratio into dB and vice versa easily using the equations (3.5) or (3.6).

$$(3.5)\quad Y = 10^{(Y_{dB}/10)} \qquad (3.6)\quad Y_{dB} = 10\log_{10} Y$$

3.2 G/T in radio astronomy terms

A G/T ratio gained from the receiving system noise temperature and the noise power captured from a radio source can be calculated as shown below. Note that this equation has the same form as the DJ9BV formula, and that shown later in an equation that uses the Y factor and solar flux. Equation (3.6) is taken from ITU Recommendation 733-2, "Determination of the G/T ratio for earth stations operating in the fixed-satellite service":

$$(3.6)\quad G/T_{System} = \frac{8\pi k(r-1)}{\lambda^2\,\Phi(f)} \quad with\ 'Noise\ Factor'\quad r = (P_n + P_{st})/P_n \qquad *$$

G = antenna gain [/]
T_{System} = systems noise temperature [K]
$\Phi(f)$ = radiation flux density of a source at frequency f [W m^{-2} Hz^{-1}]
P_n = noise power of the RX system
P_{st} = additional noise power when antenna is pointed at star
λ = wavelength [m] k_B = Boltzmann's constant = $1.381 \cdot 10^{-23}$ J/K

(*) The relation to equation (3.15), which is the common form of the G/T formula in amateur radio publications, is as follows. The 'noise factor' term $r = (P_n + P_{st}) / P_n$ is replaced by the Y factor and radiation flux density $\Phi(f)$ replaced by solar flux density Φ_{sfu}, see 4.2.

The Nyquist equation for noise power in a resistor at a given temperature is the basis for calculating P_n and P_{st}.

$$(3.7)\quad P_{\text{Thermal Noise}} = k_B\,T\,B \quad [W]\ in\ Units\quad \frac{J}{K}\cdot K\cdot Hz = \frac{W\cdot s}{K}\cdot K\cdot\frac{1}{s} = W$$

T = Temperature [K] B = Bandwidth [Hz] or Δ frequency

To convert this to a power level L, in dBm, we normalise to P_0 = 1 mW = 0.001 W and then convert to dB:

$$(3.8)\quad L(dBm) = 10\,\log_{10}\left(\frac{P_{\text{Thermal Noise}}}{P_0}\right) \quad = \quad L(dBm) = 10\,\log_{10}\left(\frac{k_B\,T\,B}{P_0}\right)$$

Or vice versa we can convert from P(dBm) to P[W] using equation (3.9):

$$(3.9)\quad P = \frac{10^{(L_{dBm}/10)}}{1000} \quad [W\ at\ given\ bandwidth]$$

An example for the minimum bandwidth of 1 Hz is given below:

$$L(dBm) = 10\,\log_{10}\left(\frac{1.381\cdot 10^{-23}\,J/K\cdot 290\,K\cdot 1\,Hz}{0.001W}\right) = -174\,\text{dBm}$$

Using this value for 1 Hz we can calculate L(dBm) for other bandwidths:

$$L(dBm) = -174\,[\text{dBm/Hz}] + 10\,\log_{10}\left(B[Hz]\right) \quad for\ T_0 = 290\,K$$

Bandwidth B	1 Hz = min.	100 Hz CW	200 Hz CW	2300 Hz SSB
P[dBm]	-174 dBm	-154 dBm	-151 dBm	-140 dBm
P[W]	4.0*10E-21 W	4.0*10E-19 W	8.0*10E-19 W	9.2*10E-18 W

Table 2: Noise power and levels for 290 K showing the importance of bandwidth on system / receiver sensivity.

However, neither antenna noise nor G/T commonly reflects on receiver bandwidth. The bandwidth can be ignored when measuring sky, earth, radio source or sun noise since it is **spectral noise**. The noise emitted by such sources is wider than any practical receiver bandwidth. Therefore the noise ratio stays the same, no matter if measured at 3 kHz or 200 Hz.

If you use a signal with a bandwidth less than that of the reciever, this would certainly influence the G/T_{System} measurement.

3.3 Rewriting the G/T_{Sytem} equation for Y factor measurements

This was shown by DL6WU in [1] but not explicitly.

(a) What is the Antenna Gain *G*?

$$(3.10)\quad G[/] = \frac{4\pi\,A_{eff}}{\lambda^2} \qquad with\ A_{eff} = \frac{P_O}{w_{inc}} \quad in\ units\ \frac{W}{W/m^2} = m^2$$

The effective antenna area A_{eff}, sometimes termed 'effective capture area' or 'effective aperture' only relates to physical size for ideal aperture radiators (horns and such like). Any losses and other forms of radiators have to be included by adding form and loss factors i.e. efficiency ($A_{eff} = A \cdot \eta_{form} \cdot \eta_{loss}$). It is a measure of the power delivered to the antenna terminals, P_O against the power density w_{inc} across the capture area A. We do not consider A_{eff} further here since it will be removed from the final Y factor equation later on, since the hot and cold sources are received by the same antenna.

(b) How do we arrive at the System Temperature?

Estimating T_{Cold} as being 0 K in the depths of the universe the fraction (3.3) can be simplified

$$(3.11)\quad T_{System} = \frac{T_{Hot} - Y\cdot T_{Cold}\ (=>0K)}{Y-1} \quad = \quad \frac{T_{Hot} - 0}{Y-1} = \frac{T_{Hot}}{Y-1}$$

How to express T_{Hot} using cosmic noise?

The spectral noise power collected by the antenna is flux density Φ multiplied by the effective antenna area. It is equal to the spectral power $P = k_B\,T$. In case of a polarized antenna it is just half the amount (-3 dB), so it must be divided by 2. Any astronomical noise source is so physically large, that it can be considered to have random and constantly varying polarisation. So if two orthogonal field components are measured, they will show varying instantaneous powers, but show equal average powers. So no matter what polarization antenna is used, linear or circular, right or left hand, horizontal or vertical, it will collect 3 dB less of the signal power.

$$(3.12)\quad k_B\,T_{Hot} = \Phi(f)_{Hot}\cdot A_{eff}\cdot\frac{1}{2} \quad solving\ for\ T_{Hot} => \quad T_{Hot} = \left(\Phi(f)_{Hot}\cdot\frac{A_{eff}}{2}\right)\Big/k_B \quad [K],$$

so that T_{System} can be written as follows

$$(3.13)\quad T_{System} = \frac{\left(\Phi(f)_{Hot} \cdot \frac{A_{eff}}{2}\right) \Big/ k}{Y-1}$$

Finally we may put together gain (a) and system temperature (b)

$$(3.14)\quad G/T_{System} = \frac{4\pi A_{eff}}{\lambda^2} \Bigg/ \frac{\left(\Phi(f)_{Hot} \cdot \frac{A_{eff}}{2}\right) \Big/ k_B}{Y-1}$$

Now we can reduce fraction (3.14) because A_{eff} can be eliminated and we derive the usual form that is equal to (3.6), or go on and substitute Φ_{Hot} for solar flux Φ_{sfu} and some constants and finally derive the handsome formula introduced by DJ9BV (see 3.15 and 3.16).

Note that (3.14) is a simplified equation since we made the assumption that our Y factor represents the difference between sun noise and a very cold patch of sky which is at the theoretical value of zero Kelvin (see 3.11). In fact in reality we never have this due to the ever-present cosmic background radiation. So we must 'calibrate' our RX noise level to zero on what we have picked as cold sky before using equation (3.15). This answers why we must the use the change in noise level rather than absolute values.

$$(3.15)\quad G/T_{System} = \frac{2 \cdot 4\pi k_B (Y-1)}{\lambda^2 \Phi(f)_{Hot}} = \frac{Y-1}{I_{sf}(f, sfu)} \quad with\ I_{sf} = 'Solar\ Intensity'$$

Separating the Solar Intensity I_{sf}

Separating the solar intensity I_{sf} (see section 4.1) as a function of frequency and the solar flux density at the required frequency - not that at 2.8 GHz, (see 4.2/3) - we derive equation (3.16). Its unit is the Kelvin as we see below. To follow the dimensional units equation it is helpful to see that 1/Hz = s and a Joule can be expressed as J = Volts · Amperes · seconds which simplifies to W·s

$$(3.16)\quad I_{sf}(f, sfu) = \frac{\lambda^2 \Phi_{sfu}}{2 \cdot 4\pi k_B} \quad [K] \quad in\ units = \frac{m^2 \frac{W}{Hz\, m^2}}{\frac{J}{K}} = \frac{m^2 \frac{Ws}{m^2}}{\frac{V \cdot A \cdot s}{K}} = \frac{Ws}{\frac{Ws}{K}} = K$$

G/T determination without the simplifying assumption

Without the simplification of using T_{Cold} as zero, the equation below looks like 3.15. Here Φ_{Cold} is the flux density received from the cold patch of sky the antenna is pointed at.

We can define a temperature for the cold patch in similar way (see 3.12) as for the hot patch we beam at and work out the G/T equation without T_{Cold} defined as zero for the cold patch:

$$(3.17)\quad T_{Cold} = \left(\Phi(f)_{Cold} \cdot \frac{A_{eff}}{2}\right) \Big/ k_B \quad [K]$$

If we fill in (3.12) and (3.17) as hot and cold temperatures into the T_{System} equation (3.11) we derive a universal equation for calculating the system G/T when measuring against non-zero temperature patches of sky.

$$(3.18)\quad G/T_{System} = \frac{2 \cdot 4\pi k_B (Y-1)}{\lambda^2 \left(\Phi(f)_{Hot} - Y \cdot \Phi(f)_{Cold}\right)} \quad [\frac{1}{K}]$$

An example of an astronomical radio sources flux density:

Cassiopeia A, flux density at *f* GHz [W / (m² · Hz)] that is also taken from the ITU-R 733-2:

$$(3.19)\quad \Phi(f) = 10^{-26} \cdot 10^{[5.745 - 0.770 \log_{10}(1000 \cdot f)]} \quad in\ [\frac{W}{m^2\, Hz}]$$

In [18], YU1AW gives many values and tables of cosmic radiation sources.

Now we can choose between two challenges (1) a measurement carrying an assumption and hence the task to 'null' our RX on some termination or (2) a measurement dependant on a hard to come-by precise temperature for a cold patch of sky. To null the RX level accurately might be more difficult than it seems since even if we switch to a termination at the antenna this might offer a slightly different impedance to the preamp which will influence its amplification, gain and noise figure. If we null the RX with a termination in the shack we degrade the measurement accuracy with cable losses and other errors.

4. From Y-Factor to G/T using Sun Noise

4.1 Basics and elementary equations

As DL6WU already mentioned in the original 1980 article 'Determining the Sensitivity of Receive Systems with the Aid of Solar Noise' [1] it would be a difficult task to derive serious absolute numbers. Also, VK3UM wrote a paper entitled 'Sun Noise, Solar Flux and Measurement methods' [14] which gives a lot of help on the topic of measuring sun noise with amateur radio equipment. This can be very useful for optimising a receiving system even though they are relative measurements.
Lionel Edwards, VE7BQH:

> *"The Y factor on the 144 MHz band is just critical enough to make G/T meaningful. On 50 MHz G/T means nothing as the Y factor is virtually 1:1. All the higher bands have large Y factor making G/T a critical performance indicator."*

G/T and Y factor are proportional, all linked by the antenna pattern and thus the noise pick up from sky and earth. The relation between Y factor and G/T (4.1) is taken from DJ9BV and F6HYE [2] if cold sky vs. sun noise is used to determine the Y factor of the complete RX system:

$$(4.1)\quad \frac{G}{T_{System}} = \frac{Y-1}{I_{sf}(f, sfu)} \quad [\frac{1}{K}] \qquad I_{sf}(f, sfu) = \text{solar intensity at designated freq.[K]}$$

If we wish to apply a noise ratio measured in dB here, we have to convert the Y factor into a dimensionless number first using equation (3.5). The solar flux must be recalculated for the frequency at which the Y factor measurement was made (see below).

4.2 Solar Flux Density Φ_{sfu}, *sfu*, *sfi*, F10.7 Index

Solar flux *sfu*, also known as the 'F10.7 index' correlates with the relative sunspot number and is measured professionally on a daily basis (see: http://www.swpc.noaa.gov/rt_plots). It is called F10.7 because the nominated measurement wavelength is 10.7 cm (2.8 GHz). The unit of the solar flux goes back to the Jansky: 1 sfu = 10^4 Jy = 10^{-22} W m^{-2} Hz^{-1}. Its symbols are Φ, 'F' in DJ9BV's publications and often '*sfu*' is used as well. Typical values for the F10.7 index are in the range 60…200 sfu. F and sfu are to be used as they come along, see the example below. For Φ we have to multiply sfu or sfi values by 10^{-22}. Amateurs often seem to use 'sfi' meaning solar flux index instead of 'sfu'. Judging from its units the solar flux is a flux density since it is measured per square meter. In order to use the conventional term we stick to simply 'solar flux' here.

4.3 Scaling Solar Flux values for amateur bands

If we want to use the F10.7 index for Y factor measurements on amateur bands we have to convert its value at 2.8 GHz to the required frequency or convert it to solar intensity I_{sfu} for the desired band using equations (4.2-1/3) below.

(a) Conversion to Solar Intensity

A helpful set of conversion formulas was released by DJ9BV and F6HYE in [2]. These formulas are completed with the units of the factors. The F10.7 index used corresponds to the general Φ_{sfu} at 2.8 GHz.

$$(4.2-1)\quad I_{sf}(144MHz) = -0.00037689 \cdot F_{10.7}^{\ 2} + 0.162242 \cdot F_{10.7} - 6.02015K \quad [K]$$

$$(4.2-2)\quad I_{sf}(432MHz) = 0.0324167 \cdot F_{10.7} + 0.790833K \quad [K]$$

$$(4.2-3)\quad I_{sf}(1296MHz) = 0.010417 \cdot F_{10.7} - 0.04919K \quad [K]$$

(b) Scaling sfu in frequency using the "EME Calculator"

Obviously better methods for scaling the sfu to amateur bands can be evolved when discrete solar flux levels for a set of observed frequencies are available. For example VK3UM's EME Calc [13] uses the online data table from IPS Learmonth, the Australian Government Radio and Space Services (see: http://www.ips.gov.au/Solar/3/4/2). In [17] Gaëtan Horlin, ON4KHG shows a table comparing the accuracy of the DJ9BV & F6HYE method of polynomial fitting and the data presented by VK3UM which are gained from inter- and extrapolation of the IPS data. He states a maximum difference between the two of about 17% for the 2 m band. The sfu scaled to the amateur bands should be used in equation (3.15). In times of high solar activity like the class 5 and 6 solar flares and CMEs (Coronal Mass Ejections) occurring in March 2012, deviating numbers are reliably detected by the EME Calculator and marked in red. These should not be used.

However, Doug, VK3UM reminds users of the Australian IPS Learmonth daily sfu numbers that they may not be sufficiently accurate for your measurements, given that they are smoothed numbers, they do not represent what you may be measuring at a specific time, and the fact that the time difference between your part of the World and VK6 may be many hours apart. This is especially relevant at times of high solar activity.

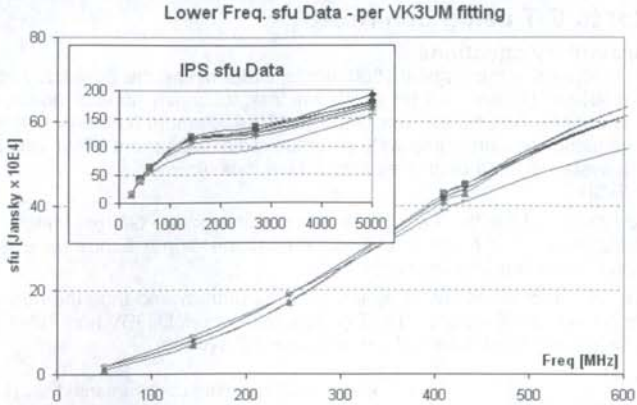

Chart 5: Sfu Data by the IPS (small chart) and numbers computed by the EME Calculator for lower frequencies - excluded numbers marked in red.

4.4 Calculation Example using Solar Intensity

An example with a typical F10.7 solar flux number of 75 sfu and a measured 6.0 dB of sun noise against a noise floor that has been determined as "zero":

$$I_{sf}(144MHz) = -0.00037689 \cdot 75^2\ sfu + 0.162242 \cdot 75\ sfu - 6.02015 = 4.0280\ K$$

An increase in noise by 6.0 dB is equal to a Y factor of 3.981:

$$Y = 10^{(6.0\,dB/10)} = 3.981\,[/]$$

$$\frac{G}{T_{System}} = \frac{3.981-1}{4.080\,K} = 0.731\frac{1}{K} \quad or\ in\ 'dB'\ scale: \quad \frac{G_{dB}}{T_{system}} = 10\log_{10} 0.731\frac{1}{K} = -1.361\frac{dB}{K}$$

Conversion formulas between G/T expressed in [1/K] and G/T in [dB/K]:

$$(4.3) \quad \frac{G_{dB}}{T} = 10\log_{10}\left(\frac{G}{T}\right) in\,[dB/K] \quad and\ (4.4) \quad \frac{G}{T} = 10^{\left(\left(\frac{G_{dB}}{T}\right)/10\right)}\ in[1/K]$$

Using equation (4.3) we can express the G/T in [dB/K] as:

$$\frac{G_{dB}}{T_{system}} = 10\log_{10} 0.731\frac{1}{K} = -1.361\frac{dB}{K}$$

5. Separating T_{Ant} and T_{System}

The system G/T incorporates antenna and system temperatures. Here the system starts where the antenna ends - at the antenna connector. System temperature includes all losses in the coax from RX to antenna, LNA noise temperature, switching relay losses and coax loss between LNA and antenna as well. To compute the system temperature, I recommend the 'Receiver Performance' page of VK3UM's EME Calculator [13] instead of labouring through the Friis formula for noise temperature of cascaded gain stages by hand.

$$(5.5) \quad \frac{G_{System,dB}}{T_{System}} = G_{Ant,dBi} - 10\log_{10}\left(T_{Ant} + T_{RX\_Line}\right)$$

T_{ant} is derived using YT1NT's TANT software. From the TANT manual [15]:

> *"TANT calculates Antenna Temperature and G/T Ratio for antenna elevation angles from 0 to 90 degrees in steps of 5 degrees whilst assuming uniform sky- and earth temperatures for the full sight of sky sphere (π in radian) respectively earth up to horizon (2π in radian for polar coordinates). [...] Common Base for calculating the antenna temperature is the integration of infinite slices of Temperature in observation direction multiplied with equal slice of antenna beam characteristic in that direction over the sight of (noise -) temperature emitting environment."*

Simply put, T_{ant} is the integrated figure of noise picked up from an upper hemisphere of uniform sky temperature and a similar lower hemisphere representing T_{earth} through the antenna pattern. It is understood that the actual pattern determinates the actual T_{ant} figure for a given T_{sky} and T_{earth} for any Yagi antenna. The number and size of rear lobes and any large first sidelobes will increase T_{ant}.

Microwave dishes and very large arrays

Dish and horn antennas are lacking rear lobes as such, but may be quantified by estimating or by calculating the amount of so called 'spill over' and 'feed through noise'. 'Spill over' is caused by dish illumination by the feed beyond the dish border and feed mounts. 'Feed through noise', the equivalent of Yagi noise picked up by the rear lobe, is caused by radiation from the ground passing through the dish reflector to the feed. It is drastically reduced if the mesh apertures are sufficiently small. For any large dish the classical T_{earth} to T_{sky} approach is not really a figure of merit, since the ratio between what still comes in for hot earth and the beam pointing to some point in the sky is very large. Consequently, above a certain size and elevation angle, the ratio of signal-to-noise picked up from nearby astronomical noise sources like the Milky Way or the moon or sun is a better objective. The latter is of significant interest even for small Yagi arrays in real life EME since the amount of sun noise picked up exceeds the strength of the EME signals. But it is not included in the classical T_{ant} concept of using uniform T_{sky} and T_{earth}.

We can calculate or measure a Y factor or G/T for any example without the classical numbers for T_{sky} and T_{earth} as given above. But then we have to specify what assumptions we made or **what hot and cold temperature or noise sources** we have chosen. **Likewise a quantified sun noise level is without any meaning if we do not note the actual solar flux** so that the G/T derived from the Y factor can be seen in the context needed to judge it.

If we want to calculate the antenna temperature from Y factor measurements, we can rewrite (5.5) as below:

$$(5.6)\quad T_{Ant} = 10E\left(\left(G_{Ant,dBi} - \frac{G_{dB}}{T_{System}}\right)\Big/10\right) - T_{RX\_Line}$$

6. Gain [dB] to Antenna Temperature vs. Gain [dB] to System Temperature

$$(6.1)\quad \frac{G_{System,dB}}{T_{System}} = \frac{G_{Ant,dbi}}{T_{Ant}} + 10\log_{10}\left(\frac{T_{Ant}}{T_{Ant}+T_{RX\_Line}}\right) \quad in\,[dB/K]$$

$$(6.2)\quad \frac{G_{Ant,dB}}{T_{Ant}} = \frac{G_{System,dbi}}{T_{System}} - 10\log_{10}\left(\frac{T_{Ant}}{T_{Ant}+T_{RX\_Line}}\right) \quad in\,[dB/K]$$

How to transfer gain to temperature back to dimensionless gain figures:

$$(6.3)\quad G/T_{System} = 10E\left(\frac{G_{System,dB}}{T_{System}}\right) \quad and \quad G/T_{Ant} = 10E\left(\frac{G_{Ant,dBi}}{T_{Ant}}\right) \quad in[1/K]$$

Gain to temperature using dimensionless gain can be converted by following the usual scheme:

$$(6.4)\quad G = 10^{(G_{dB}/10)} \quad and \quad G_{dB} = 10\log_{10} G$$

$$(6.5)\quad G_{dB}/T_{Ant} = G_{dB} - 10\log T_{Ant} \qquad (6.6)\quad G_{dB}/T_{System} = G_{dB} - 10\log T_{System}$$

And additionally the equation for T_{System} using the Friis formula modified for noise temperatures for the explicit $T_{RX\text{-}Line}$ given in the block diagram on the first page of this article.

$$(6.7)\quad T_{System} = T_{ant} + T_{coax1} + \frac{T_{Relay}}{L_{coax1}} + \frac{T_{LNA}}{L_{coax1}\cdot L_{Relay}} + \frac{T_{coax2}}{L_{coax1}\cdot L_{Relay}\cdot G_{LNA}} + \frac{T_{RX}}{L_{coax1}\cdot L_{Relay}\cdot G_{LNA}\cdot T_{coax2}}$$

$$(6.8)\quad T_{System} = T_{ant} + T_{RX\_Line}$$

Gain and loss must be inserted as dimensionless numbers, see equation (6.8) and (6.9). The number for any loss as 'negative gain' is < 1, so that the sign of the loss in equation (6.9) is a negative one. All losses that are expressed in dB, like those of the coax between antenna and LNA can be expressed as loss temperature by conversion through equations (6.9) and (6.10). The noise figure expressed in dB of all gain stages can be transferred into temperature using equations (6.10) and (6.12):

$$(6.9)\ L_{loss\,stage}\,[/] = 10^{\frac{-L_{dB}}{10}} \quad and \quad (6.10)\ G_{gain\,stage}\,[/] = 10^{\frac{NF_{dB}}{10}}$$

$$(6.11)\ T_{loss\ stage} = \left(10^{\frac{L_{dB}}{10}} - 1\right) \cdot T_0 \quad and \quad (6.12)\ T_{gain\ stage} = \left(10^{\frac{NF_{dB}}{10}} - 1\right) \cdot T_0 \quad with\ T_0 = 290\,K$$

An example for calculating a cable loss of 1 dB:

$$L_{coax} = 10^{\frac{-L_{dB}}{10}} = 10^{\frac{-1\,dB}{10}} = 0.794 \quad and \quad T_{coax} = \left(10^{\frac{1\,dB}{10}} - 1\right) \cdot 290\,K = 75.1\,K$$

Any loss expressed in dB such as from coax cables between antenna and LNA can be expressed as an equivalent temperature by conversion using equation 6.8. The noise figure expressed in dB of any gain stage can be converted into temperature by equation 6.9:

$$(6.8)\ T_{loss\ stage} = \left(10^{\frac{-L_{dB}}{10}} - 1\right) \cdot T_0 \quad and \quad (6.9)\ T_{gain\ stage} = \left(10^{\frac{NF_{dB}}{10}} - 1\right) \cdot T_0 \ with\ T_0 = 290\,K$$

Using typical equipment for EME we get the following figures for G/T_{ant} and G/T_{System} when applying equations (6.5/6.6) to demonstrate how the importance of G/T increases with frequency.

Band	G_{ant}	T_{ant}	$T_{RX\ Line}$
50 MHz	16.0 dB	270 K	50 K
144 MHz	21.9 dB	220 K	45 K
222 MHz	22.5 dB	120 K	45 K
432 MHz	24.0 dB	35 K	45 K
1296 MHz	28.0 dB	18 K	40 K

Table 3: Figures used for chart 6. T_{ant} is computed at 30 degrees elevation.

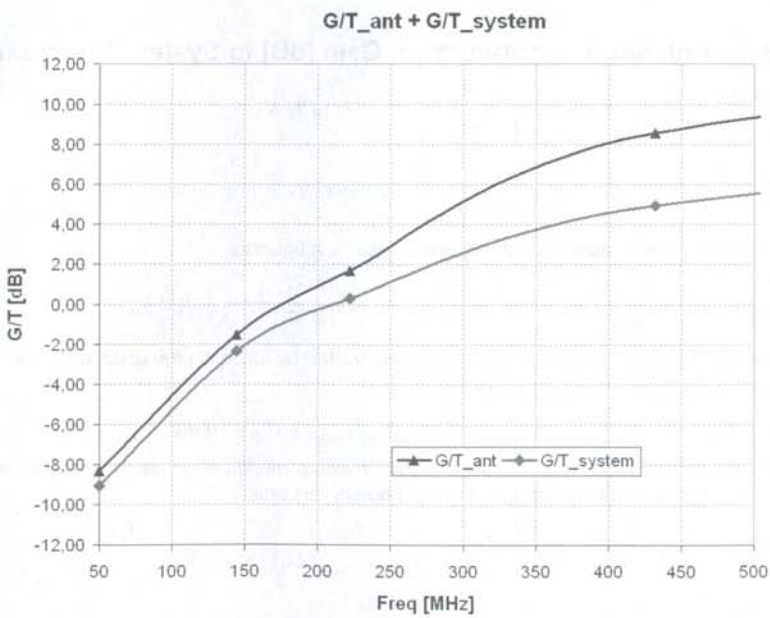

Chart 6: G_{dB}/T_{ant} and G_{dB}/T_{System} for typical EME equipment

7. TANT: Setting T_{earth} and T_{sky} for G/T determination on other bands

TANT's preset of T_{earth} = 1000 K and T_{sky} = 200 K is useful for 144 MHz. However TANT offers a simple facility to enter other values of T_{sky} and T_{earth} from its start-up screen:

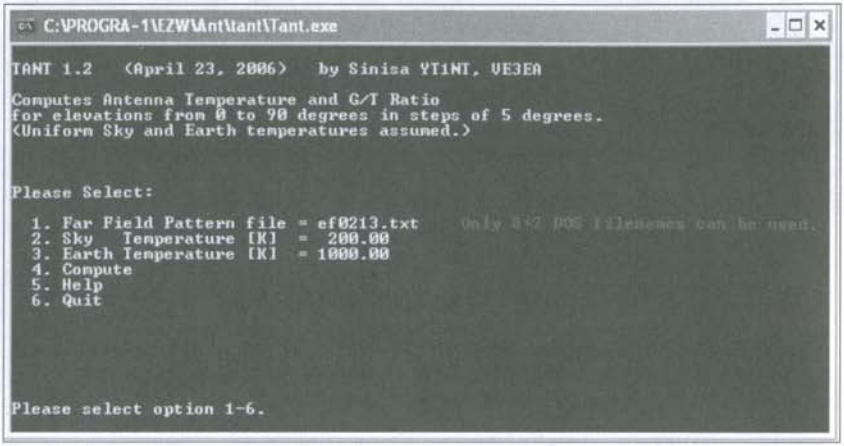

Fig. 5: TANT Start-up screenshot

Enter 2 to edit 'Sky Temperature' (T_{sky}) in Kelvin. Note the cursor blinking in line 2 as shown on the screenshot below. Finish your input by pressing the return key.

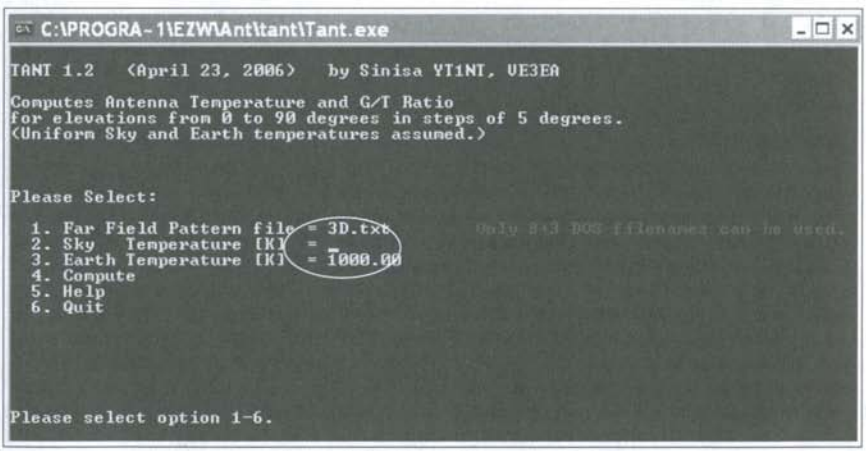

Fig. 6: TANT Pre edit screenshot

Enter 3 to edit T_{earth} in similar way.

Below is a table of temperatures which are based on real world temperatures of today. It would not make much sense to give T_{ant} or G/T figures derived by TANT for general comparison with different T_{earth} or T_{sky} values.

Band	Tearth	Tsky
50 MHz	3000 K	2200 K
144 MHz	1000 K	200 K (250 K)
222 MHz	600 K	70 K
432 MHz	350 K	20 K
1296 MHz	290 K	10 K

Table 4 - holds corrected numbers as shown in section 2

And here is an example using the new suggested temperatures for 432 MHz. Since TANT not only computes the often only given G/T number at 30 degrees, but also values for 0 to 90 degrees, a complete chart (#7) can be derived from these.

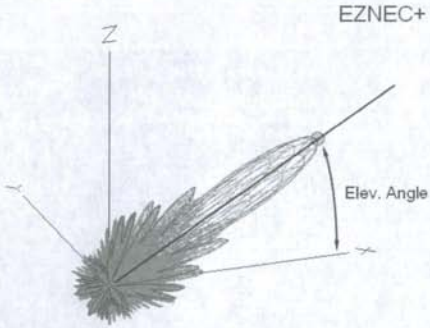

Fig. 7: 3D radiation plot for a 432 MHz bay of 23 ele. BVO by DJ9BV stacked as per DL6WU formula at an elevation angle of 30 degrees

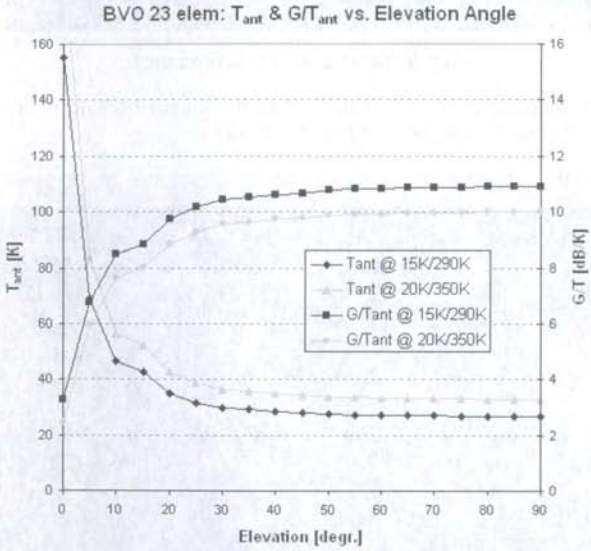

Chart 7: TANT - computed T_{ant} and G/T of a 432 MHz bay of 23 ele. BVO by DJ9BV stacked per DL6WU formula for elevation angles from zero to 90 degrees.

Chart 7 shows the importance of the elevation angle chosen for determination of T_{ant}. I have used a bay of 4 x 23 element BVO Yagis for this simulation. The blue lines show the results for the traditional T_{sky} and T_{earth} as per the DJ9BV article, while the green ones show the results obtained by applying the proposed values of 20 K and 350 K. Note the kink at around 15 degrees. It is caused by the first sidelobe lifting off from the ground. Next we can see that the chosen 30 degree point used by DJ9BV is a critical very carefully chosen number. G/T (30° elevation) is 10.45 dB/K using the old numbers and 9.57 dB/K with new proposal for T_{sky} and T_{earth}. That equals a decrease in S/N ratio of 0.88 dB.

Chart 7 illustrates that it is vital to state at what elevation of the antenna we have determined a claimed T_{ant} or G/T_{ant} or even G/T_{System}. The 30 degree point has become a reference number for good reasons but any other could be specified.

8. Epilogue on Antenna G/T and System G/T

Above 144 MHz there seem to be no universally agreed numbers for T_{sky} and T_{earth}. This is partly due to the lack of a consensus on this topic and partly because on UHF and above very high gain arrays or dishes are used when it comes to serious DX or EME work. This means in practice that not a single uniform sky temperature is of use but temperatures of various hot spots and cold spots in the sky are needed. We find figures ranging from 20 K to 45 K proposed for an average sky temperature on 432 MHz

but note that hot spots like the Milky Way are approx. 60 K, not to mention sun noise or moon noise on the GHz bands.

These are valuable figures no doubt, but the numbers shown here are about a topic that is not far off but a little different in its meaning. We are not concerned with real sun measurements or radio astronomy here. We are only interested in optimising the first part of our system for best S/N ratio. To determine antenna G/T in absolute numbers we need a uniform figure for both T_{earth} and T_{sky} to use in TANT. It should be as close to real values as possible. But we are not talking about segments of sky or earth or singular hot spots but whole hemispheres.

There are voices that remind us not to overestimate antenna temperature or antenna G/T. The dominance of LNA properties when judging T_{RX} in weak signal communication is an established fact, but I would like to emphasize that the antenna is the true first gain stage, if we take its directivity for gain and set it equal to LNA gain. In his Dubus article on his LNA with a PHEMT which was edited by DJ9BV himself, Peter Hoefsloot, PA3BIY [16] formulates this very clearly:

> *"A pre-amplifier will never improve the signal-to-noise (SNR) ratio! The SNR at the antenna plug is the best we are ever able to obtain. Any noise added by the amplifier will deteriorate the SNR, so we want to minimise that amount of noise. The ambient noise [...] sets the limit to the SNR and can be expressed as dB above the thermal noise T0 (T0 = 290 K)."*

The scenario for computing T_{ant} is only a simplified model using uniform noise distribution over two hemispheres. We do not have such a thing in real life. When we have local noise from directions other than main beam, the advantage of the 'Low Temperature Yagi' becomes noticeable. The ability to attenuate the interference of your neighbour's plasma TV or the IM products of nearby contest stations by a measurable amount can be a significant advantage. At the same time gain is gain and is still very important. As a consequence we have a G_{ant}/T_{ant} as a figure of merit.

Let me close with a final word taken from DJ9BV in [4]:

> *"The derived measure of G/T-ratio is a very suitable quality feature to compare different yagi constructions and different stacking schemes for their value for EME applications."*

Antenna developers and weak signal enthusiasts need a benchmark for antenna G/T which we find in Lionel Edwards G/T table. He motivated the use of that figure of merit in his article "G/T for Yagis" in Dubus 1/1996 and for good reasons it is still as effective as ever though now in its 16th year.

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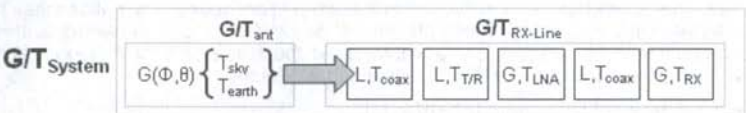
Anmerkungen zum VHF/UHF Antennen-G/T

Ein erweitertes Kapitel aus dem TANT-Appendix

von Hartmut Klüver, DG7YBN

Einführung

Im klassischen Sinne ist G/T ein Signal-Rausch-Verhältnis, welches aus der Division von Antennengewinn und der Rauschtemperatur des Empfangssystems berechnet wird. Da es die Rauschtemperatur des gesamten Systems beinhaltet, wird es G/T_{System} genannt. Dabei werden die Verstärkungen (G = Gain) und Verluste (L = Loss) der einzelnen Stufen mit deren equivalenten Rauschtemperaturen zusammengefasst.



Wenn wir wissen möchten, welches Signal-Rausch-Verhältnis uns die Antenne als Funktion ihrer Direktivität und Rauschaufnahme aus der Umgebung anbieten kann, können wir ein G/T am Fußpunkt der Antenne definieren. Es wird als G/T_{ant} bezeichnet. Weil der Gewinn von Antennen in dB gemessen wird, wird Antennen-G/T meist als G_{dB}/T_{ant} in dB/Kelvin angegeben.

Die Berechnung des G_{dB}/T_{ant} -Verhältnis mit dem Programm TANT von YT1NT [19] ist eine weit verbreitete und anerkannte Methode. TANT ist voreingestellt auf eine Himmelstemperatur [T_{sky}] von 200 K und eine Erdtemperatur [T_{earth}] von 1000 K. Das ist passend ist für die aktuell verwendeten Zahlen in *dem übergreifenden Standard* der 144 MHz G/T-Tabelle von Lionel Edwards, VE7BQH.

Soweit ich es sehe, begann das Bestimmung von G/T-Faktoren erst wirklich mit einem Artikel von DL6WU mit dem Titel "Bestimmung der Empfindlichkeit von Empfangsanlagen mittels Sonnenrauschen", erschienen in UKW Berichte 4/1979 und auf Englisch in VHF Communications, 1980/2 [1]. Das Thema seines Artikels wurde aufgegriffen und weitergeführt von DJ9BV und F6HYE in dem Artikel "Performance Evaluation for EME-Systems" in Dubus 3/1992 [2]. Ein Papier über die Verwendung von kosmischen Strahlungsquellen für die Messung von Antennengewinn von W5CQ, K3LFO und anderen [3] könnte allerdings eventuell noch vor DL6WUs und DJ9BVs Artikeln entstanden sein. Allerdings fehlt es für andere Bänder als 144 MHz noch immer an Standardwerten für Himmels- und Erdtemperaturen. Für das 222-MHz-Band finden wir überhaupt nur schwerlich Angaben und für 432 MHz gibt es lediglich eine weit anerkannte Literaturstelle. Das ist der fundamentale Artikel über das Thema G/T_{ant} in Bezug auf das Strahlungsdiagramm der Antenne, nämlich DJ9BVs "Effective Noise Temperature of 4-Yagi-Arrays for 432 MHz EME", veröffentlicht in Dubus 4/1987 [4].

Bild 1: Fundamentaler Artikel über Antennenrauschtemperatur von DJ9BV

In diesem Artikel gab Rainer Bertelsmeier Werte von 15 K für T_{sky} und 290 K für T_{earth} auf 432 MHz an. Inzwischen haben wir auf größerer Erfahrung beruhende Zahlen für 144 MHz und 432 MHz. Lasst uns sehen, wie diese Werte in das Gesamtbild passen und was für die anderen UHF-Bänder berechnet werden kann. Um das auf einer soliden Basis zu tun, gehen wir zurück zu den Anfängen, um dann die von VE7BQH für 144 MHz und DJ9BV für 432 MHz gewählten Werte aufzurollen und mit Formeln und Beispielen für diejenigen, die selber G/T und Temperaturen berechnen möchten, zu schließen.

1. T_{sky}: die Anfänge - Janskys Messungen und darüber hinaus

In seiner wissenschaftlichen Bedeutung muss T_{sky} als Kosmisches Rauschen bezeichnet werden. Es wurde 1932 entdeckt und zum ersten Mal methodisch erfasst von Karl G. Jansky [5]. Er benutzte dazu Frequenzen um 20,5 MHz. Seine Antenne war mit Hilfe von Ford-Modell-T-Rädern drehbar. Das einem Karussell ähnliche Aussehen prägte deren Spitznamen 'Merry-Go-Round' (was auf Englisch eben Karussell bedeutet). Jansky arbeitete bei der Bell Telephone Company. Diese bot einen transatlantischen Telefonservice auf einer Wellenlänge von etwa 25 m an. Dabei hatten sie Schwierigkeiten mit Störungen und beauftragten Jansky damit, deren Ursprung ausfindig zu machen. Jansky konnte diese auf natürliche Ursachen, zum größten Teil tropische Gewitterstürme, zurückführen. Aber er fand auch einen

Rauschpegel, der mit der Zeitspanne eines astronomischen Tages, sprich einer vollen Erdumdrehung periodisch wiederkehrte. Er identifizierte das Zentrum der Galaxie als dessen Quelle. Daraufhin verfasste er einen Artikel über seine Feststellungen mit Namen "Elektrische Störungen von offensichtlich extraterrestischem Ursprung" [5]. Obwohl er eine geniale Entdeckung machte, hatte die Bell Telephone Company kein kommerzielles Interesse an dem, was die Anfänge der Radioastronomie werden sollten, und so musste er seine Studien abbrechen. In „Mein Bruder Karl und seine Endeckung von Radiowellen von jenseits der Erde" [6] schreibt C. M. Jansky Junior das Folgende über die Entdeckungen seines Bruders:

> *"Karl Janskys Artikel, "Electrical Disturbances of Apparently Extraterrestrial Origin" ist eigentlich eine Hochzeit. Er verheiratet die Wissenschaften von Astronomie und Radio-beziehungsweise Elektrotechnik und verbindet diese mit einem unlösbaren Knoten."*

Zu Ehren Janksys verwendete die Radioastronomie zur Angabe der Flussdichte von Radioquellen das „Jansky" (1 Jy = 10^{-26} W m^{-2} Hz^{-1}). Die im „Jansky" beinhalteten Einheiten zeigen uns dessen Zusammensetzung: Eingefangene Leistung pro Quadratmeter an Antennenfläche geteilt durch die Bandbreite des Leistungsdetektors. Es ist verständlich, dass die von einem Stern empfangene Leistung ausgedrückt in Watt sehr klein ist. Daher wurde ein Faktor von 10^{-26} zugefügt, um die Zahl auf einen handlichen Wert zu bringen.

Bild 2: "Janskys Karussell ". Durchmesser ca. 30 m, Höhe 6,7 m. Quelle: National Radio Astronomy Observatory (NRAO) [7]

Janskys Messungen wurden prinzipiell bestätigt und verfeinert von Grote Reber. Er war Funkamateur (W9GFZ) und Hochfrequenztechniker von Beruf. Nachdem er Janskys Artikel gelesen hatte, konnte er von dem Gedanken nicht mehr loslassen, an weiteren Entdeckungen auf dem Gebiet der kosmischen Strahlung zu arbeiten. Er machte bereits 1937 Experimente auf 3,3 GHz, später auf 910 MHz, hatte aber keinen Erfolg damit. Schließlich ging er auf 160 MHz und konnte Rauschen aus der Milchstraße detektieren und so Janskys Entdeckung bestätigen. Dass er auf einer niedrigeren Frequenz Erfolg damit hatte, ist aus heutiger Sicht keine Überraschung, ist doch die Strahlungsintensität der Milchstraße auf 160 MHz etwa 10 mal höher als auf 3,3 GHz. Zusätzlich müssen wir einen ggf. beträchtlichen Unterschied im Rauschmaß von Vorkriegsgeräten auf VHF oder 3,3 GHz in Betracht ziehen.

Rebers Arbeit wurde drei Jahrzehnte später von D.C. Hogg, W.W. Mumford [8] und R.H. Brown und C. Hazard fortgesetzt [9]. Ihre Leistungen führten zu einem Satz von drei Formeln, zu denen Hogg und Mumford die Durchschnittstemperatur (1.2) und Brown und Hazard die voraussichtlichen Maximal- und Minimaltemperaturen beitrugen (1.1/1.3). Dieser Formelsatz repräsentierte den Stand der Evolution der wissenschaftlichen Betrachtung des kosmischen Rauschens in den 1960er Jahren.

(1.1) $T_{\min} = 58 \cdot \lambda^2$	(1.2) $T_{average} = 100 \cdot \lambda^2$	(1.3) $T_{\max} = 1450 \cdot \lambda^2$

Formelsatz 1: die Originalformeln sind hier im die notwendigen Einheiten K/m² ergänzt

Diagramm 1

Darüber hinaus kann T_{sky} unterteilt werden in die frequenzabhängige kosmische Hintergrund- oder Schwarzkörperstrahlung und die Summe der individuellen Strahlungsquellen wie Cassiopeia A, Taurus A und all die anderen. Die kosmische Hintergrundstrahlung ist ein Nachhall des „Big Bang" des Universums von gleichmäßiger räumlicher Verteilung (entdeckt 1965 von A. Penzias and R. Wilson, auch Bell Telephone Labs). Der Mittelwert der individuellen Quellen plus der Hintergrundstrahlung wird durch T_{sky} repräsentiert. Der strahlförmige Öffnungswinkel eines großen Spiegels wird diesen Durchschnitt nicht sehen. Hier brauchen wir eine andere Definition von „heißen" und „kalten Stellen" wie ausschnittsweiser Temperatur.

2. T_{sky} und T_{earth} - Weitere Forschung und Entwicklung

Die Vorkriegsleistungen von Jansky und Reber waren exzellente Pionierarbeit. Die fortschreitende technische Entwicklung versetzte Hogg, Mumford, Brown und Hazard in die Lage, diese ersten Entdeckungen mit „Up-to-Date" Gerätschaften, wie sie in den 1960ern zur Verfügung standen, zu verfeinern. Der Einfluss von antennen- und empfängerseitigen Limitierungen ist ein kritischer Faktor für die Radioastronomie. So war es in den vergangenen Jahren und so ist es auch heute noch:

> *"Es war Reber klar, dass Jansky eine fundamentale Entdeckung gemacht hatte, und er erkannte, dass die Grenze von Janskys Ausrüstung erreicht worden war"* N1MAA [10]

Bild 3: Grote Rebers erste Antenne: ein Spiegel von 9,5 m Durchmesser, gebaut 1937, Quelle: IL Photo - NRAO archives [11]

Bild 4: 8,5 m Spiegel von Doug McArthur (VK3UM) [12]

Was Reber bei seiner frühen Reflektion über Janskys Ergebnisse bemerkte, ist das, was Funkamateure unter Verwendung von GaAs-Fet-Vorstufen und mehr in den 1980ern realisierten. Es baut wiederum auf

das auf, was Hogg, Mumford, Brown und Hazard in den 1960ern herausgefunden hatten. Um den Fortschritt bis heute zu illustrieren, zeige ich den Spiegel des Radio Amateurs VK3UM (Bild 4), der mit heutigen Computerprogrammen sehr umsichtig getestet ist. Heutiges Radio Amateur Equipment bedient sich „State-of-the-Art" Vorverstärkern mit sehr niedrigem Eigenrauschen, die direkt am Fußpunkt der Antenne verbaut werden. Mit PHEMT FETs können Rauschmaße unter 0,5 dB von 2 m bis zu hohen Mikrowellenbändern hin realisiert werden.

Einen aktuellen Standard (2011) stellen die im Folgenden gezeigten Werte da, welche auf den Arbeiten von DJ9BV, VK3UM, VE7BQH und anderen beruhen. Wenn man sich das auf den Ergebnissen von Hogg, Mumford, Brown und Hazard beruhende Diagramm 1 ansieht, wird klar, dass der Kurvenverlauf wie bei diesen von einer ebenso typischen, quadratischen Funktion und weiterhin auch stetig sein muss. Wenn nun T_{earth} bei 432 MHz nur 290 K betragen würde, gäbe es keine Möglichkeit mehr, diesen Wert von 432 MHz an bis zu den Mikrowellenbändern zu erniedrigen. Die gleiche Argumentation gilt für T_{sky}. Läge T_{sky} auf 432 MHz bei lediglich 15 K, dann würde ein kontinuierlicher Kurvenschwung weiter herunter auf 10 K bei 1296 MHz nicht möglich sein. Über etwa 5…10 GHz steigt T_{sky} dann rapide an, denn wir nähern uns den Resonanzfrequenzen von Wasserdampf (22 GHz) und atmosphärischen Gasen wie Sauerstoff (60 GHz) und anderen. Als Konsequenz ist die Angabe der Luftfeuchtigkeit wichtig bei der Angabe eines gemessenen G/T auf höheren Mikrowellen.

Diagramm 2: T_{earth} und T_{sky}, wie sie Funkamateure heute benutzen, mit Orientierung an T_{min} Gl. (1.1), halblogarithmische Skalierung der Frequenz; Werte s. Tab. 1 (fett).

Diagramm 3: Lineare Skalierung von 50 bis 500 MHz für bessere Auflösung mit Markierungen bei 144, 220 and 432 MHz. Die Zahlenwerte dazu sind in Tabelle 1 zu finden.

Band	Tearth	Tsky
50 MHz	**3000 K**	**2200 K**
144 MHz	**1000 K**	**200 K** => 250 K
222 MHz	**600 K**	**70 K**
432 MHz	**290 K** => 350 K	**15 K** => 20 K
1296 MHz	**290 K**	**10 K**

Tabelle 1: Werte für T_{earth} und T_{sky}, => angepasste Werte

Eine Bemerkung zu den Temperaturen für 144 MHz:
Wir sehen eine kleine Abweichung vom durchgängigen Schwung der Linie zwischen 50 und 222 MHz. Dieser deutet darauf hin, dass der noch aktuelle Wert für T_{earth} im Vergleich zu den anderen Bändern etwas zu niedrig ist. Er sollte zu den Werten der Rauschpegel auf den anderen Bändern eines Tages nachgezogen werden. VK3UM benutzt in seinem EME Performance Calculator, V. 7.12 [13] einen Wert von 250 K für T_{earth}. 250 K ergibt einen glatteren Übergang im Kurvenverlauf als 200 K und passt so besser zu dem Verlauf nach Hogg und Mumford.

Eine Bemerkung zu den Temperaturen für 432 MHz:
Nach Hervorheben der Bedeutung des technischen Fortschritts der Messmittel ist es verständlich, dass DJ9BV später von den 1987 in seinem viel beachteten Artikel "Effective Noise Temperature of 4-Yagi-Arrays for 432 MHz EME" ursprünglich als angemessen angegebenen Temperaturen abging.

Auf die Frage hin, warum T_{earth} für 432 MHz in DJ9BVs Artikel mit nur 290 K angenommen wurde, schreibt mir Lionel, VE7BQH folgendes:

> *"Ja, das tat er 1987. Aber in den 1990ern als wir 144 MHz [Temperaturen] diskutierten, kamen wir auch auf die Werte für 432 MHz zu sprechen und er sagte, dass er annimmt, dass sein T_{earth} in Hamburg etwa bei 600 K liegen würde. Keine Frage, in Hamburgs Innenstadt kann es sehr laut werden!*
> *1987 benutzte er die theoretischen Werte als Basis für seinen Artikel. Weil der Y-Faktor auf diesem Band schon groß ist, sind sie immer noch sehr aussagefähig. Etwa Mitte der 1990er sahen er und ich, dass die „echte" Welt keine so niedrigen Werte bereithält, daher also nun die Werte, die heute zu sehen sind."*

Der theoretische Wert von 273 K + 17 K = 290 K, der eine völlig störungsfreie Erdtemperatur von 17° Celsius repräsentiert, passte nicht für eine wirklich gute Vorhersage der Eigenschaften eines Empfangssystems in der realen Welt. Also muss T_{earth} weg von der reinen Theorie zu einem praktikablen Wert von 350 K angepasst werden.

Wie in der Historie der Messungen von Kosmischem Rauschen recht bald augenfällig wurde, sind Nachbesserungen zu machen, wann immer das Messequipment verbessert wird. Und auf T_{earth} bezogen ist der Rauschpegel mit Ausnahme ländlicher Gegenden beständig am steigen. Diese Zahlen sind seit Janskys Pionierarbeit kontinuierlich um ein paar Kelvin in Bewegung.

Die Herausforderung für den Radioamateur besteht darin, unter wechselnden Antennen und Leistungen des Empfangssystems, die unter verschiedenen Stationen zu vergleichen sind, einen Konsens zu finden. Sicherlich müssen die gefundenen Werte den gleichen kontinuierlichen Kurvenverlauf ergeben wie die ursprünglichen Werte für das kosmische Rauschen, wenn sie in ein Diagramm eingefügt werden. In

Bezug auf die lokal unterschiedlichen Rauschpegel sollten sie wie die Werte von Hogg und Mumford einen **Mittelwert** repräsentieren.

Häufig wird der Fehler gemacht, einen Wert in Kelvin unter Verwendung des Ausdrucks „Grad" anzugeben. Die Tatsache, dass 1 K den gleichen Betrag wie 1 Grad Celsius besitzt, berechtigt nicht dazu, Grad oder „°" an das Kelvin anzuhängen. Kelvin ist eine eigenständige Einheit. Schlicht „**K**" ist die offizielle Einheit der Temperatur im SI (Système international d'unités).

3. Relevanz von T_{earth} und T_{sky}

Das Rauschen, dem wir in unserem RX-System begegnen, hat seinen Ursprung in T_{earth} und T_{sky} wie auch in Halbleitern, Widerständen und anderem. Die Aufnahme von T_{earth} und T_{sky} geht auf das Konto der Antennentemperatur. Und selbst der beste LNA ist nicht in der Lage, ein besseres Signal-Rauschverhältnis zu erzeugen, als es die Quelle hergibt, die das Signal enthält. DJ9BV in [4]:

> *"Die effektive Rauschtemperatur von Antennen, welche verschiedene Strahlungsquellen mit ihrem Strahlungsdiagramm 'sehen' ist eine sehr wichtige Eigenschaft, denn sie begrenzt die erreichbare Systemtemperatur des gesamten Empfangssystems."*

3.1 Y-Faktor

Das Verhältnis zwischen zwei Rauschpegeln wird Y-Faktor genannt. Da der Rauschleistungspegel ‚N' proportional zur Rauschtemperatur ist, kann es einerseits als Rauschen-zu-Rauschen- oder als Temperatur-zu-Temperatur-Verhältnis definiert werden. Wir können den Y-Faktor als Verhältnis von auf die Erde und auf eine kalte Stelle am Himmel gerichteter Antenne benutzen, wenn wir T_{Hot} durch T_{earth} und T_{Cold} durch T_{sky} ersetzen.

$$(3.1)\quad Y[/] = \frac{N_{On}}{N_{Off}} = \frac{N_{Hot}}{N_{Cold}} = \frac{T_{Hot}}{T_{Cold}} = \frac{T_{earth}}{T_{sky}}$$

Oft wird die Rauschtemperatur differenziert in T_{Hot}, T_{Cold} und T_{RX} des Receivers:

$$(3.2)\quad Y[/] = \frac{T_{Hot} + T_{RX}}{T_{Cold} + T_{RX}}$$

Wenn ein bekannter Y-Faktor verfügbar ist, können die Rauschtemperatur T_{System} und so auch das Rauschmaß (*NF*) eines Systems oder einer Baugruppe (hier als DUT = Device Under Test) bestimmt werden:

$$(3.3)\quad T_{System}[K] = \frac{T_{Hot} - Y \cdot T_{Cold}}{Y - 1} \qquad (3.4)\quad NF_{dB} = 10\log\left((T_{Dut}/290K) + 1\right)$$

Wenn wir Gleichung 3.1 mit Temperaturen nach Tabelle 4 auf einen isotropen Strahler anwenden, würden wir das folgende erhalten:

Diagramm 4: Dimensionsloser Y-Faktor (T_{earth}/T_{sky}) für ein sphärisches Strahlungsdiagram

Das Diagramm zeigt, dass die Beachtung des G/T-Verhältnis auf 144 MHz etwa dreimal wichtiger als auf 50 MHz und sogar neunmal wichtiger auf 432 MHz ist. Beachtenswert ist, dass der Y-Faktor hier nicht in dB sondern als ein Verhältnis angegeben wird. Allerdings kann er mit Gl. (3.6) vom dimensionslosen Verhältniswert in dB konvertiert werden und zurück mit (3.5).

$$(3.5)\quad Y = 10^{(Y_{dB}/10)} \qquad (3.6)\quad Y_{dB} = 10\log_{10} Y$$

3.2 G/T als radioastronomische Formel

Ein G/T-Verhältnis, das aus der Rauschtemperatur des Empfangssystems und der Rauschleistung eines Sterns gewonnen wird, kann wie unten gezeigt berechnet werden. Es ist zu beachten, dass diese Formel vom Aufbau her der Formel von DJ9BV und der später gezeigten Gleichung mit eingesetztem Y-Faktor und Solarem Fluss entspricht. Die Gleichung (3.6) ist der ITU Empfehlung 733-2, „Determination of the G/T ratio for earth stations operating in the fixed-satellite service" entnommen:

$$(3.6)\quad G/T_{System} = \frac{8\pi k_B (r-1)}{\lambda^2\,\Phi(f)} \quad mit\ "Rauschfaktor"\quad r = (P_n + P_{st})/P_n \qquad *$$

G = Antennengewinn [/]
T_{System} = Systemrauschtemperatur [K]
$\Phi(f)$ = frequenzabhängige Flussdichte der Strahlung eines Sterns [W m^{-2} Hz^{-1}]
P_n = Rauschleistung des RX-Systems
P_{st} = zusätzliche Rauschleistung wenn die Antenne auf einen Stern gerichtet wird
λ = Wellenlänge [m] k_B = Boltzmann-Konstante = $1.381 \cdot 10^{-23}$ J/K

Die Nyquist-Gleichung für die Rauschleistung eines Widerstands bei gegebener Temperatur ist die Basis um P_n und P_{st} zu berechnen.

$$(3.7)\quad P_{\text{Thermal Noise}} = k_B\, T\, B \quad [W] \;\; in\ Einheiten \;\; \frac{J}{K}\cdot K\cdot Hz \;=\frac{W\cdot s}{K}\cdot K\cdot\frac{1}{s}=W$$

T = Temperatur [K], B = Bandbreite [Hz] oder Δ Frequenz

Um diese in Rauschpegel L in dBm zu überführen, müssen wir auf ein P_0 = 1 mW = 0,001 W normieren dann und in dB konvertieren:

$$(3.8)\quad L(dBm)=10\,\log_{10}\left(\frac{P_{\text{Thermal Noise}}}{P_0}\right) \;=\; L(dBm)=10\,\log_{10}\left(\frac{k_B\,T\,B}{P_0}\right)$$

Umgekehrt können wir von P(dBm) in P in Watt konvertieren mit Gleichung (3.9):

$$(3.9)\quad P=\frac{10^{(L_{dBm}/10)}}{1000} \quad [W\ bei\ gegebener\ Bandbreite]$$

Ein Beispiel, für die minimale Bandbreite von 1 Hz, ist unten angegeben:

$$L(dBm)=10\,\log_{10}\left(\frac{1.381\cdot 10^{-23}\,J/K\cdot 290\,K\cdot 1\,Hz}{0{,}001\,W}\right)=-174\,\text{dBm}$$

Mit diesem Wert bei einer Bandbreite von 1 Hz kann nun auf andere Bandbreiten geschlossen werden:

$$L(dBm)=-174\,[\text{dBm/Hz}]+10\,\log_{10}\left(B[Hz]\right) \quad für\ T_0=290\,K$$

Bandbreite B	1 Hz = min.	100 Hz CW	200 Hz CW	2300 Hz SSB
L(dBm)	-174 dBm	-154 dBm	-151 dBm	-140 dBm
P[W]	4.0*10E-21 W	4.0*10E-19 W	8.0*10E-19 W	9.2*10E-18 W

Tabelle 2: Rauschleistung und -pegel bei 290 K nach Johnson-Nyquist zeigen den großen Einfluss der Bandbreite auf System- bzw. Receiverempfindlichkeit.

(*) Der Bezug zu Gleichung (3.15), welche der G/T-Formel in der üblichen Darstellung in Amateurfunk-Publikationen entspricht, ist wie folgt. Der „Rauschfaktor" $r = (P_n + P_{st}) / P_n$ wird ersetzt durch den Y-Faktor und die Flussdichte der Strahlung $\Phi(f)$ wird ersetzt durch die Dichte des Solaren Flusses Φ_{sfu}, siehe 4.2.

Allerdings beziehen sich im Allgemeinen weder Antennenrauschen noch G/T auf die Bandbreite des Empfängers. Die Bandbreite kann man bei Messungen des Himmels-, Erd- oder eines stellaren oder Sonnenrauschens aus dem Term für den Rauschfaktor streichen, weil es ein **spektrales Rauschen** ist. Das von solchen Quellen emittierte Rauschen ist breiter als jede praktische Empfängerbandbreite. Das Rauschverhältnis bleibt also immer gleich, ob bei 3 kHz oder 200 Hz gemessen.

Würden wir ein Signal von kleinerer als der Empfängerbandbreite quantifizieren, dann würde Bandbreite beim Lesen eines G/T_{System} natürlich von Belang sein.

3.3 Zusammensetzen der Gleichung für G/T_{System} für Y-Faktor Messungen

Das Folgende wurde bereits von DL6WU in [1] gezeigt, aber nicht so ausführlich.

(a) Wie ist der Gewinn der Antenne definiert?

$$(3.10)\quad G[/]=\frac{4\pi\,A_{eff}}{\lambda^2} \qquad mit\ A_{eff}=\frac{P_O}{w_{inc}} \quad in\ Einheiten\ \frac{W}{W/m^2}=m^2$$

Die effektive Antennenfläche A_{eff} repräsentiert nur für ideale Aperturstrahler (Hornstrahler und ähnliche) auch deren echte physikalische Öffnungsfläche. Alle Verluste und andere Strahlerformen müssen durch Verrechnen mit Form- bzw. Verlustfaktoren ($A_{eff} = A \cdot \eta_{Form} \cdot \eta_{Verluste}$) eingebracht werden. Es ist ein Maß, um die von der Antenne an deren Anschlussterminal abgelieferte Leistung P_O gegen die die Absorptionsfläche A durchströmende Leistungsdichte w_{inc} zu vergleichen. Wir gehen hier nicht näher auf A_{eff} ein, denn es wird aus der endgültigen Gleichung für den Y-Faktor sowieso herausgestrichen, da heiße und kalte Quelle ja mit der gleichen Antenne empfangen werden.

(b) Wie errechnen wir die Systemtemperatur?

Unter der Annahme, dass T_{Cold} in der Tiefe des Universums bei 0 K läge, kann der Bruch aus (3.3) vereinfacht werden

$$(3.11)\quad T_{System}=\frac{T_{Hot}-Y\cdot T_{Cold}\ (=>0K)}{Y-1} \;=\; \frac{T_{Hot}-0}{Y-1}=\frac{T_{Hot}}{Y-1}$$

Wie kann T_{Hot} unter Verwendung von kosmischem Rauschens ausgedrückt werden?
Die mit der Antenne von einer kosmischen Quelle eingefangene spektrale Rauschleistung entspricht der frequenzabhängigen Flussdichte Φ multipliziert mit der effektiven Antennenfläche. Diese ist gleich der spektralen Leistung $P = k_B T$. Im Falle einer polarisierten Antenne ist es aber nur der halbe Betrag (-3 dB). Sie muss also durch 2 geteilt werden. Denn jede astronomische Strahlungsquelle ist so groß, dass deren Rauschquellen statistisch unpolarisiert sind. Eine unpolarisierte Quelle wird ggf. schnell zwischen den beiden orthogonal aufeinander stehenden Feldkomponenten variieren, aber im zeitlichen Mittel eine gleichmäßige Leistung liefern. Eine gegebene, feste Polarisation wird nie passend sein. Es spielt keine Rolle, welche Polarisation gewählt ist. Ob zirkular links oder rechts drehend, horizontal oder vertikal, sie liefert ein um -3 dB geschwächtes Signal von solchen Quellen.

$$(3.12)\quad k_B T_{Hot} = \Phi(f)_{Hot} \cdot A_{eff} \cdot \frac{1}{2} \quad \textit{auflösen nach } T_{Hot} \Rightarrow \quad T_{Hot} = \left(\Phi(f)_{Hot} \cdot \frac{A_{eff}}{2}\right) \Big/ k_B \quad [K],$$

so dass T_{System} wie folgt geschrieben werden kann:

$$(3.13)\quad T_{System} = \frac{\left(\Phi(f)_{Hot} \cdot \frac{A_{eff}}{2}\right) \Big/ k_B}{Y-1}$$

Endlich können wir Gewinn (a) und Systemtemperatur (b) zusammenfügen:

$$(3.14)\quad G/T_{System} = \frac{4\pi A_{eff}}{\lambda^2} \Bigg/ \frac{\left(\Phi(f)_{Hot} \cdot \frac{A_{eff}}{2}\right) \Big/ k_B}{Y-1}$$

Nun kann man den Bruch (3.14) zusammenstreichen, denn A_{eff} kann eliminiert werden und wir erhalten die übliche Form der Gleichung, welche (3.6) entspricht oder fortfahren und Φ_{Hot} durch Solaren Flux Φ_{sfu} und noch einige Konstanten substituieren und schließlich auf die handliche, von DJ9BV gezeigte Formel kommen (siehe 3.15 und 3.16).

Es ist zu beachten, dass (3.14) eine genäherte Gleichung darstellt, denn wir haben die vereinfachende Annahme gemacht, dass unser Y-Faktor das Delta zwischen Sonnenrauschen und einer sehr kalten Stelle am Himmel von theoretischen null Kelvin repräsentiert (siehe 3.11). Tatsächlich gibt es so etwas in Wirklichkeit schon aufgrund des ständig präsenten kosmischen Hintergrundrauschens nicht. Also müssen wir unseren RX-Rauschpegel für eine kalte Stelle am Himmel auf Null 'kalibrieren', bevor wir Gleichung (3.15) bemühen. Das beantwortet, warum wir an Stelle von absoluten Werten mit dem Unterschied zwischen den Rauschpegeln arbeiten müssen.

$$(3.15)\quad G/T_{System} = \frac{2 \cdot 4\pi k_B (Y-1)}{\lambda^2\, \Phi(f)_{Hot}} \left[\frac{1}{K}\right] = \frac{Y-1}{I_{sf}(f, sfu)} \quad \textit{mit } I_s = \text{'Intensität der Strahlung'}$$

Die Intensität I_s der Strahlung daraus isolieren

Wenn man die Zusammensetzung Intensität der Strahlung auf Solare Intensität (s. Kap. 4.1) bezieht und diese isoliert betrachten möchte, kommt man zu Gleichung (3.16). Sie ist abhängig von der gewählten Frequenz und der Solaren Flussdichte („Solarer Flux") - nicht generell bei 2,8 GHz, sondern auf der verwendeten Frequenz (s. 4.2/3). Wie unten gezeigt, ist seine Einheit Kelvin. Um die Einheitengleichung nachzuvollziehen, ist es nützlich zu wissen, dass 1/Hz = s ist und ein Joule = Volt · Ampere · Sekunden ist, was letztlich als W·s geschrieben werden kann.

$$(3.16)\quad I_{sf}(f, sfu) = \frac{\lambda^2\, \Phi_{sfu}}{2 \cdot 4\pi k_B} \quad [K] \quad \textit{in Einheiten} = \frac{m^2 \frac{W}{Hz\, m^2}}{\frac{J}{K}} = \frac{m^2 \frac{Ws}{m^2}}{\frac{V \cdot A \cdot s}{K}} = \frac{Ws}{\frac{Ws}{K}} = K$$

G/T - Bestimmung ohne vereinfachende Annahme

Ohne die Vereinfachung, $T_{Cold} = 0$ sieht die Gleichung (3.15) wie unten gezeigt aus. Darin ist Φ_{Cold} die Flussdichte, welche von dem Kontrastpunkt am Himmel, auf den die Antenne gerichtet ist, empfangen wird. Wir können eine Temperatur für die kalte Stelle in gleicher Weise wie für die heiße Stelle, auf die wir zeigen, definieren (siehe 3.12) und so die G/T Gleichung, ohne T_{Cold} definiert als null für die kalte Stelle, ausarbeiten:

$$(3.17)\quad T_{Cold} = \left(\Phi(f)_{Cold} \cdot \frac{A_{eff}}{2}\right) \Big/ k_B \quad [K]$$

Wenn wir nun (3.12) und (3.17) als heiße und kalte Temperaturen in die Gleichung für T_{System} (3.11) einsetzen, gelangen wir zu einer universellen Gleichung zur Bestimmung des G/T des Systems für Messungen gegen nicht zwangsläufig sehr kalte Stellen am Himmel.

$$(3.18)\quad G/T_{System} = \frac{2 \cdot 4\pi k_B (Y-1)}{\lambda^2 \left(\Phi(f)_{Hot} - Y \cdot \Phi(f)_{Cold}\right)} \quad [\frac{1}{K}]$$

Ein Beispiel für die Flussdichte einer astronomischen Strahlungsquelle: Cassiopeia A, Flussdichte bei *f* in GHz [W / (m² · Hz)], ebenfalls der ITU-R 733-2 entnommen:

$$(3.19)\quad \Phi(f) = 10^{-26} \cdot 10^{[5.745 - 0.770 \log_{10}(1000 \cdot f)]} \quad in \quad \frac{W}{m^2\, Hz}$$

In dem Artikel „Determining the Parameters of a Receive System in Conjunction with Cosmic Radio Sources", VHF Communications 1/1984, [18] von YU1AW, Dragoslav Dobričić finden wir ebenfalls viele Angaben und Diagramme zu kosmischen Strahlungsquellen.
Jetzt können wir zwischen zwei Herausforderungen wählen: (1.) einem Messverfahren, dass eine Annahme und damit die Aufgabe unseren RX „auf null" zu stellen beinhaltet, oder (2.) einer Messung mit einer schwierig zu fassenden Referenz, eben dem präzise zu berechnenden T für die kalte Stelle am Himmel. Den RX-Pegel akkurat auf null zu setzen, könnte eine schwierigere Aufgabe sein, als es den Anschein hat. Denn selbst wenn wir oben an der Antenne auf eine terminierende Last schalten, werden wir dem Vorverstärker eine leicht andere Impedanz anbieten, welche dessen Verstärkungskurve und Rauschmaß beeinflusst. Wenn wir den RX im Shack mit einer Terminierung auf null setzen, werden wir durch Kabelverluste und andere Dinge eine Umschärfe in die Messgenauigkeit einbringen.

4. Von Y-Faktor zu G/T mittels Sonnenrauschen

4.1 Grundlagen und elementare Gleichungen

Wie DL6WU bereits 1980 in dem eröffnenden Artikel "Determining the Sensitivity of Receive Systems with the Aid of Solar Noise" [1] anführt, wäre es eine schwierige Aufgabe, zu seriösen absoluten Werten zu gelangen. Auch VK3UM hat ein Papier mit dem Titel „Sun Noise, Solar Flux and Measurement Methods" [14] dazu geschrieben, welches recht viel Hilfestellung zum Thema Sonnenrauschen Messen mit Amateur Radio Equipment gibt. Das zu tun kann sehr nützlich sein bei der Optimierung der Empfangsanlage, auch wenn die Werte nur relative Größen sind.

Lionel Edwards, VE7BQH:

> *"Der Y-Faktor ist auf dem 144 MHz Band gerade eben kritisch genug, um G/T bedeutungsvoll werden zu lassen. Auf 50 MHz bedeutet G/T gar nichts, denn der Y-Faktor ist hier nahezu 1:1. Alle höheren Bänder besitzen große Y-Faktoren, die das G/T zu einem bedeutsamen Indikator der Leistungsfähigkeit werden lassen."*

G/T und Y-Faktor sind zueinander proportional, verknüpft durch das Strahlungsdiagramm der Antenne und so die Rauschaufnahme von Himmel und Erde. Die Relation zwischen Y-Faktor [/] und G/T (4.1) ist entnommen bei DJ9BV und F6HYE [2], wenn kalter Himmel gegen Sonnenrauschen zur Bestimmung des Y-Faktors des kompletten RX-Systems heran gezogen werden:

$$(4.1)\quad \frac{G}{T_{System}} = \frac{Y-1}{I_{sf}(f, sfu)} \quad [\frac{1}{K}] \qquad I_{sf}(f, sfu) = \text{Solare Intensität auf gewählter Freq.[K]}$$

Wenn wir ein in dB gemessenes Rauschverhältnis hier anwenden wollen, müssen wir diesen in dB beobachteten Y-Faktor zuerst mit Gleichung (3.5) in eine dimensionslose Zahl umwandeln. Weiter muss die Solare Flussdichte auf die für die Messung des Y-Faktors gewählte Frequenz umgerechnet werden (siehe unten).

4.2 Solare Flussdichte Φ_{sfu}, *sfu*, *sfi*, F10.7 Index

Solarer Flux, auch als F10,7 Index bekannt, korreliert mit der relativen Sonnenfleckenzahl und wird täglich professionell gemessen (s. http://www.swpc.noaa.gov/rt_plots). Er wird F10,7 genannt, weil die nominelle Messfrequenz bei 10,7 cm oder 2,8 GHz liegt. Die Einheit des Solaren Flux geht auf das Jansky zurück: 1 sfu = 10^4 Jy = 10^{-22} W m^{-2} Hz^{-1}. Die benutzten Formelsymbole sind Φ, 'F' in DJ9BVs Publikationen und oft auch '*sfu*'. Werte für F und sfu können direkt benutzt werden, Für Φ müssen wir die Werte von sfu respektive sfi mit 10^{-22} multiplizieren. Amateure scheinen anstatt ‚sfu' oft ‚sfi' als Solar Flux Index zu benutzen. Den Einheiten nach ist der Solare Flux eine Flussdichte, denn er wird pro Quadratmeter gemessen. Um bei der gebräuchlichen Benennung zu bleiben, belassen wir es hier bei ‚Solarer Flux'.

4.3 Die Solare Flussdichte auf Amateurbänder skalieren

Wenn wir den F10.7 Index für Y-Faktor Messungen auf Amateurbändern benutzen wollen, müssen wir seinen Wert von 2,8 GHz auf die gewünschte Frequenz umrechnen oder mittels der Gleichungen (4.2-1/3) in Solare Intensität I_{sfu} für das gewünschte Band umrechnen.

(a) Konvertierung in Solare Intensität

Ein hilfreicher Satz von angepassten Formeln wurde von DJ9BV und F6HYE in [2] herausgebracht. Diese

Formeln sind hier um die Einheiten der Faktoren ergänzt. Der benutzte F10.7-Index entspricht dem allgemeinen Φ_{sfu} bei f = 2.8 GHz.

$$(4.2-1)\quad I_{sf}(144MHz) = -0.00037689 \cdot F_{10.7}{}^2 + 0.162242 \cdot F_{10.7} - 6.02015 \quad [K]$$

$$(4.2-2)\quad I_{sf}(432MHz) = 0.0324167 \cdot F_{10.7} + 0.790833 \quad [K]$$

$$(4.2-3)\quad I_{sf}(1296MHz) = 0.010417 \cdot F_{10.7} - 0.04919 \quad [K]$$

(b) Sfu in der Frequenz skalieren mit dem „EME Calculator"

Offenkundig können bessere Methoden sfu zu skalieren, entwickelt werden, wenn diskrete Pegel für den Solaren Flux auf einer Reihe von beobachteten Frequenzen zur Verfügung stehen. So wird es in VK3UMs EME Calculator [13] gemacht. Dieser benutzt die Online-Datentabelle von IPS Learmonth, dem Radio- und Weltraumdienst der Australischen Regierung (siehe: http://www.ips.gov.au/Solar/3/4/2). In "Ground Gain in Theorie und Praxis", Dubus 3/2011 [17] zeigt Gaëtan Horlin, ON4KHG eine Vergleichstabelle für die nach der DJ9BV & F6HYE -Methode des polynomischen Fittens und den von VK3UM präsentierten Daten, welche aus Inter- und Extrapolation der IPS-Datentabelle gewonnen werden. Er gibt eine maximale Differenz zwischen den beiden für das 2-m-Band mit 17% an. Der auf Amateurbänder skalierte sfu wird in Gleichung (3.15) benutzt. In Zeiten höherer Sonnenaktivität wie den Klasse 5 und 6 Solar Flares und CMEs (Coronal Mass Ejection) im März 2012 werden stark abweichende Werte im EME Calculator sicher erkannt und rot markiert. Diese sollten nicht verwendet werden.

Doug, VK3UM gibt Anwendern der täglich ausgegebenen sfu-Werte zu bedenken, dass diese möglicherweise für unsere Messungen nicht [immer] ausreichend genau sind. Da es sich um eine geglättete Kurve handelt, repräsentieren diese ggf. nicht das, was man zu einer bestimmten Uhrzeit misst, unter dem Aspekt, dass die Zeitdifferenz zwischen ihrem Teil der Welt und VK6 möglicherweise um Stunden verschieden ist. Das gewinnt an Relevanz zu Zeiten höherer Sonnenaktivität.

Diagramm 5: Sfu-Daten des IPS (kleines Diagramm) und die vom EME Calculator errechneten Werte für niedrigere Frequenzen - unter Ausschluss von „rot markierten" Werten.

4.4 Ein Rechenbeispiel unter Verwendung der Solaren Intensität

Ein Beispiel mit einem typischen F10.7 Solar Flux von 75 sfu und 6,0 dB Sonnenrauschen, gemessen gegen als „null" gesetzten Rauschflur:

$$I_{sf}(144MHz) = -0.00037689 \cdot 75^2\ sfu + 0.162242 \cdot 75\ sfu - 6.02015 = 4.0280\ K$$

Der Anstieg des Rauschens um 6,0 dB entspricht einem Y-Faktor von 3,981:

$$Y = 10^{(6.0\,dB/10)} = 3.981\,[/]$$

$$\frac{G}{T_{System}} = \frac{3.981-1}{4.080\,K} = 0.731\,\frac{1}{K} \quad oder\ in\ 'dB\ Skala': \quad \frac{G_{dB}}{T_{system}} = 10\log_{10} 0.731\,\frac{1}{K} = -1.361\,\frac{dB}{K}$$

Der Konvertierungsmechanismus von G/T in [1/K] zu G/T in [dB/K]:

$$(4.3)\quad \frac{G_{dB}}{T} = 10\log_{10}\left(\frac{G}{T}\right) in\,[dB/K] \quad und\ (4.4)\quad \frac{G}{T} = 10^{\left(\left(\frac{G_{dB}}{T}\right)/10\right)}\ in[1/K]$$

Mit Gleichung (4.3) können wir nun das G/T in [dB/K] ausdrücken:

$$\frac{G_{dB}}{T_{system}} = 10\log_{10} 0.731\,\frac{1}{K} = -1.361\,\frac{dB}{K}$$

5. Auftrennen in T_{Ant} und T_{System}

Das System-G/T umfasst Antennentemperatur und die Temperatur der kompletten RX-Linie. Hier beginnt das System, wo die Antenne endet - am Antennenanschluss. Die Systemtemperatur umfasst auch alle Verluste in Koaxkabel, Umschaltrelais und Koaxkabel zwischen LNA und Antenne. Um die Systemtemperatur zu berechnen, empfehle ich die „Receiver Performance"-Karte von VK3UMs EME Calculator [13], anstatt sich durch die Friis-Formel für kaskadierte Verstärkerstufen zur arbeiten.

$$(5.5)\quad \frac{G_{System,dB}}{T_{System}} = G_{Ant,dBi} - 10\log_{10}\left(T_{Ant} + T_{RX\_Line}\right)$$

T_{ant} wird mit Hilfe von YT1NT's TANT Software berechnet. Aus dem TANT Manual [15]:

"TANT berechnet Antennentemperatur und G/T-Verhältnis für Elevationswinkeln der Antenne von 0 bis 90 Grad in Schritten von 5 Grad, wobei es gleichförmige Himmels- und Erdtem-

peraturen für den vollen Sichtbereich der Himmelssphäre (π in Radiant) respektive von der Erde bis zum Horizont (2π in Radiant für Polarkoordinaten) annimmt. [...] Die allgemeine Basis zur Berechnung der Antennentemperatur ist die Integration von infiniten Anteilen von Temperatur in Beobachtungsrichtung multipliziert mit dem gleichen Anteil an Antennenstrahlcharakteristik in diese Richtung über die gesamte, Rauschen emittierende Umgebung."

Einfacher gesagt ist T_{ant} der integrierte Wert des von der oberen Halbsphäre aus gleichförmiger Himmelstemperatur und genauso der unteren Sphäre, welche T_{earth} repräsentiert, aufgenommenen Rauschens über das Strahlungsdiagramm der Antenne. Es ist klar, dass das tatsächliche Strahlungsdiagramm den Istwert von T_{ant} für einen gegebenen Satz von T_{sky} und T_{earth} für jede Yagi-Antenne bestimmt. Die Quantität der rückwärtigen Zipfel und jeder große Nebenzipfel heben T_{ant} an.

Mikrowellenspiegel und sehr große Arrays

Spiegel und Hornantennen besitzen keine rückwärtigen Zipfel als solche, können aber über so genanntes „spill over" und „feed through noise" quantifiziert werden. „Spill over" ist ein Ausdruck für kleine Zipfel, die durch Imperfektionen wie nicht genau zum F/D passende Erreger, also Spiegelausleuchtung über den Rand, und Erregerhalterungen entstehen. „Feed through noise" ist equivalent zu dem, was die Yagi von der Rückseite aufnimmt. Es ist durch ausreichende Maschenweite drastisch reduzierbar. Für einen großen Spiegel ist nicht so sehr der klassische Ansatz über T_{earth} zu T_{sky} eine Kennzahl. Denn das Verhältnis zwischen dem, was noch von der heißen Erde und dem auf irgendeinen Punkt am Himmel zeigenden Beam aufgenommen wird, ist sehr groß. Deshalb ist ab einer bestimmten Größe und Elevationswinkel das Rauschverhältnis von nahe zueinander stehenden astronomischen Rauschquellen, oder wenn die Sonne dicht neben dem Mond steht, ein besserer Richtwert. Das letzte ist selbst für kleine Gruppen von Yagis von signifikantem Einfluss für den echten EME Betrieb, weil das Sonnenrauschen die EME-Signale überlagert. Aber es ist nicht in das klassische Konzept der T_{ant}, welches lediglich gleichmäßige T_{sky} und T_{earth} benutzt, integriert.

Wir können ein Y-Faktor oder G/T für jede andere Konstellation als die klassischen Werte für T_{sky} und T_{earth} messen oder berechnen. Aber dann müssen wir dazu angeben, welche Annahmen wir gemacht haben oder welche heiße und kalte Temperatur oder Rauschquellen wir dazu herangezogen haben. **Beispielsweise ist ein quantifizierter Sonnenrauschpegel ohne Aussagefähigkeit, wenn wir dazu nicht den aktuellen Solaren Flux notieren.**

Wenn wir die Antennentemperatur aus Y-Faktor-Messungen heraus berechnen wollen, können wir (5.5) umschrieben zu:

$$(5.6)\quad T_{Ant} = 10E\left(\left(G_{Ant,dBi} - \frac{G_{dB}}{T_{System}}\right)\Big/10\right) - T_{RX\_Line}$$

6. Gewinn [dB] zu Antennentemperatur vs. Gewinn [dB] zu Systemtemperatur

$$(6.1)\quad \frac{G_{System,dB}}{T_{System}} = \frac{G_{Ant,dbi}}{T_{Ant}} + 10\log_{10}\left(\frac{T_{Ant}}{T_{Ant}+T_{RX\_Line}}\right) \quad in\,[dB/K]$$

$$(6.2)\quad \frac{G_{Ant,dB}}{T_{Ant}} = \frac{G_{System,dbi}}{T_{System}} - 10\log_{10}\left(\frac{T_{Ant}}{T_{Ant}+T_{RX\_Line}}\right) \quad in\,[dB/K]$$

Wie der Gewinn zu Temperatur wieder in einen Ausdruck mit dimensionslosem Gewinn transferiert wird:

$$(6.3)\quad G/T_{System} = 10E\left(\frac{G_{System,dB}}{T_{System}}\right) \quad und \quad G/T_{Ant} = 10E\left(\frac{G_{Ant,dBi}}{T_{Ant}}\right) \quad in[1/K]$$

Gewinn zu Temperatur ausgedrückt über dimensionslosen Gewinn [/] können nach dem üblichen Schema konvertiert werden:

$$(6.4)\quad G = 10^{(G_{dB}/10)} \quad und \quad G_{dB} = 10\log_{10} G$$

$$(6.5)\quad G_{dB}/T_{Ant} = G_{dB} - 10\log T_{Ant} \qquad (6.6)\quad G_{dB}/T_{System} = G_{dB} - 10\log T_{System}$$

Und noch die Gleichung für T_{System} mit der von Rauschfaktor zu Rauschtemperatur abgewandelten Friis Formel als explizit geschriebene $T_{RX\text{-}Line}$ für das Blockbild am Anfang des Artikels:

$$(6.7)\quad T_{System} = T_{ant} + T_{coax1} + \frac{T_{Relay}}{L_{coax1}} + \frac{T_{LNA}}{L_{coax1}\cdot L_{Relay}} + \frac{T_{coax2}}{L_{coax1}\cdot L_{Relay}\cdot G_{LNA}} + \frac{T_{RX}}{L_{coax1}\cdot L_{Relay}\cdot G_{LNA}\cdot T_{coax2}}$$

$$(6.8)\quad T_{System} = T_{ant} + T_{RX\_Line}$$

Gain „G" und Verlust „L" müssen als dimensionsloser Wert eingesetzt werden, s. Gleichung (6.8 und 6.9).

Der Zahlenwert von Verlusten als „negative Gewinne" ist dabei < 1. Daher das negative Vorzeichen für Loss „L_{dB}" in Gleichung (6.9). Jeder in 'dB' ausgedrückte Verlust, wie von Koaxkabeln zwischen Antenne und LNA kann mittels Umwandlung durch die Gleichungen (6.9) und (6.11) als Verlusttemperatur ausgedrückt werden. Das in ‚dB' ausgedrückte Rauschmaß einer jeden Verstärkerstufe kann mit den Gleichungen (6.10) und (6.12) in Temperatur überführt werden:

$$(6.9)\ L_{loss\ stage}\ [/] = 10^{\frac{-L_{dB}}{10}} \quad und \quad (6.10)\ G_{gain\ stage}\ [/] = 10^{\frac{NF_{dB}}{10}}$$

$$(6.11)\ T_{loss\ stage} = \left(10^{\frac{L_{dB}}{10}} - 1\right) \cdot T_0 \quad und \quad (6.12)\ T_{gain\ stage} = \left(10^{\frac{NF_{dB}}{10}} - 1\right) \cdot T_0 \quad mit\ T_0 = 290\,K$$

Ein Beispiel für die Berechnung eines Kabelverlusts von 1dB:

$$L_{coax}\ [/] = 10^{\frac{-L_{dB}}{10}} = 10^{\frac{-1\,dB}{10}} = 0.794 \quad und \quad T_{coax} = \left(10^{\frac{1\,dB}{10}} - 1\right) \cdot 290\,K = 75.1\,K$$

Mit durchschnittlichem EME-Equipment erhalten wir unter Verwendung von (6.5/6.6) die folgenden Werte für G/T_{ant} und G/T_{System} zur Demonstration der mit Erhöhung der Frequenz größer werdenden Relevanz des G/T-Verhältnisses.

Diagramm 6: G_{dB}/T_{ant} und G_{dB}/T_{System} für eine typische EME Ausrüstung

Band	G_{ant}	T_{ant}	$T_{RX\ Line}$
50 MHz	16.0 dB	270 K	50 K
144 MHz	21.9 dB	220 K	45 K
222 MHz	22.5 dB	120 K	45 K
432 MHz	24.0 dB	35 K	45 K
1296 MHz	28.0 dB	18 K	40 K

Tabelle 3: Die im Diagramm oben benutzen Werte. T_{ant} ist bei 30° Elevation berechnet.

7. TANT: T_{earth} und T_{sky} für die Bestimmung des G/T auf anderen Bändern einrichten

Die Voreinstellung von TANT ist mit T_{earth} = 1000 K und T_{sky} = 200 K geeignet für 144 MHz. Aber TANT bietet auf dem Startbild eine einfache Möglichkeit, andere als die voreingestellten T_{sky} and T_{earth} einzugeben:

Bild 5: TANT Startbild

Eingabe der Ziffer 2 ermöglicht die Eingabe der "Sky Temperature" (T_{sky}) in Kelvin. Man beachte den blinkenden Cursor in Zeile 2 wie auf dem Bild unten. Mit der Return-Taste wird die Eingabe beendet.

Bild 6: TANT Screenshot mit angewählter Zeile 2

Mit der Eingabe der Ziffer 3 kann T_{earth} auf gleiche Weise geändert werden.
Hier eine Tabelle mit Temperaturen, welche auf echten Werten für den heutigen Gebrauch basiert. Es würde wenig Sinn machen, Werte für T_{ant} oder G/T anzugeben, die mit auseinander laufenden T_{earth} oder T_{sky} mit TANT berechnet wurden.

Band	Tearth	Tsky
50 MHz	3000 K	2200 K
144 MHz	1000 K	200 (250) K
222 MHz	600 K	70 K
432 MHz	350 K	20 K
1296 MHz	290 K	10 K

Tabelle 4 - enthält die nach Kapitel 2 korrigierten Werte

Und hier noch ein Beispiel mit den vorgeschlagenen neuen Temperaturen für 432 MHz. Da TANT eben nicht nur den oft einzig beachteten Wert des G/T bei 30° Elevation ausgibt, sondern Werte von 0 bis 90°, lässt sich daraus ein ganzes Diagramm (Nr. 7) herleiten.

Bild 7: 3D-Strahlungsdiagramm einer 432 MHz 4er-Gruppe aus 23 Element BVO-Yagis von DJ9BV, gestockt nach der DL6WU-Formel, bei einem Elevationswinkel von 30°

Diagramm 7: Mit TANT berechnete T_{ant} und G/T der 432 MHz BVO 4er Gruppe für Elevationswinkel von Null bis 90°.

Diagramm 7 zeigt die Bedeutung des zur Bestimmung von T_{ant} gewählten Elevationswinkels. Ich habe

eine Gruppe aus 4 x 23 Element BVO-Yagis für diese Simulation benutzt. Die blauen Linien zeigen die für traditionelle T_{sky} und T_{earth} aus dem Artikel von DJ9BV resultierenden Zahlen, während die grünen die Werte zeigen, die unter Verwendung der vorgeschlagenen Werte von 20 K und 350 K herauskommen. Man beachte den ‚Schlenker' bei etwa 15°. Er ist bedingt durch das Abheben des ersten Nebenzipfels vom Boden. Als nächstes sehen wir, dass der von DJ9BV gewählte Punkt bei 30° ein kritischer und sehr sorgfältig ausgewählter Wert ist. Der Wert für G/T (30° Elevation) beträgt 10,45 dB/K mit den alten Werten und 9,57 dB/K mit dem neuen Vorschlag für T_{sky} und T_{earth}. Das entspricht einem um 0,88 dB erniedrigten S/N-Verhältnis.

Diagramm 7 illustriert, dass es entscheidend ist, anzugeben, bei welcher Elevation der Antenne wir unsere T_{ant} oder G/T_{ant} oder auch G/T_{System} bestimmt haben. Der 30°-Punkt ist aus gutem Grund zu einer Referenzmarke geworden. Alle anderen sollten spezifiziert werden.

8. Epilog auf Antennen- und System-G/T

Oberhalb von 144 MHz scheint es keine koordinierten Werte für T_{sky} und T_{earth} zu geben. Das hat seinen Grund zum Teil im fehlenden Konsens zu diesem Thema und teilweise, weil auf UHF und darüber hinaus Arrays oder Spiegel mit sehr hohem Gewinn in Gebrauch sind, wenn es um seriöses DXen oder EME geht. Dies bedeutet in der Praxis, dass nicht eine einzige gleichmäßige Himmelstemperatur von Bedeutung ist, sondern Temperaturen verschiedener heißer und kalter Stellen am Himmel. So finden wir Zahlen, die von 20 K bis 45 K reichen, als Vorschläge für die Durchschnittstemperatur des Himmels auf 432 MHz, sehen aber auch, dass heiße Stellen wie die Milchstraße mit etwa 60 K beziffert werden, ohne noch Sonnenrauschen oder für die GHz-Bänder das Mondrauschen anzuführen.

Dies sind zweifelsohne wertvolle Zahlen, aber die hier gezeigten Werte gehören zu einem Thema, welches nicht weit weg aber in seiner Bedeutung etwas anders ist. Wir machen hier ja gar keine echten Sonnenmessungen oder Radioastronomie. Wir tun nichts anderes, als das erste Glied unseres Systems auf bestes S/N-Verhältnis zu optimieren. Um das G/T der Antenne in absoluten Werten zu bestimmen, benötigen wir homogene Zahlen für beide, T_{earth} und T_{sky} für das Einsetzen in TANT. Sie sollten so dicht an echten Werten liegen, wie möglich. Aber wir sprechen hier nicht über Segmente oder singuläre Stellen am Himmel oder der Erde, sondern von ganzen Hemisphären.

Es gibt Stimmen, die uns daran erinnern, Antennentemperatur und Antennen-G/T nicht über zu bewerten. Die Dominanz der Eigenschaften des LNA bei der Beurteilung der T_{RX} in „Weak Signal Communication" ist ein etablierter Fakt, aber ich möchte hervorheben, das die Antenne die wahre erste Verstärkerstufe darstellt, wenn wir ihre Direktivität als Verstärkung ansehen und mit der Verstärkung eines LNA gleichsetzen. In seinem Dubus Artikel über seinen LNA mit PHEMT [16], welcher noch von DJ9BV selbst editiert wurde, formuliert Peter Hoefsloot, PA3BIY das sehr klar im englischsprachigen Teil:

> *"Ein Vorverstärker wird niemals das Signal-Rausch-Verhältnis (SNR) verbessern! Das SNR an der Antennenbuchse ist das Beste, das wir jemals bekommen. Jedes vom Verstärker zugefügte Rauschen wird das SNR verschlechtern, so dass wir diesen Rauschanteil minimieren wollen. Das Rauschen aus der Umgebung […] setzt dem SNR ein Limit und kann in dB über dem thermischen Rauschen T0 (T0 = 290 K) angegeben werden."*

Das Szenario zur Berechnung von T_{ant} ist nur ein vereinfachtes Modell mit gleichförmiger Verteilung des Rauschens über Halbsphären. So etwas gibt es im wahren Leben nicht. Wenn wir lokale Störungen aus anderen als der direkten Strahlrichtung haben, wird der Vorteil einer 'Low Temperature Yagi' bemerkbar. Die Fähigkeit, die durch den Plasmafernseher des Nachbarn verursachten Störungen oder die IM-Produkte einer nahen Contestsstation um einen messbaren Betrag zu unterdrücken, kann einen signifikanten Vorteil darstellen. Gleichzeitig ist der alte Grundsatz „Gain is Gain" immer noch sehr bedeutend. Als Konsequenz haben wir ein G_{ant}/T_{ant} als Kennzahl.

Ich möchte mit einem Schlusswort zum Ende kommen, welches von DJ9BV aus [3] stammt:

> *Das ermittelte Maß für Güte (G/T-Verhältnis) erlaubt einen direkten Qualitätsvergleich zwischen verschiedenen Yagi-Konstruktionen und Stockungsabständen"*

Antennenentwickler und "Weak Signal" Enthusiasten brauchen eine Vergleichsmarke für Antennen-G/T, welche wir in der G/T-Tabelle von Lionel Edwards finden. Er motivierte diese Kennzahl in seinem Artikel "G/T for Yagis" in Dubus 1/1996 aus guten Gründen und sie ist so bedeutsam wie seit jeher, obwohl sie in ihr 16tes Jahr geht.

Quellen

Siehe am Ende des englischen Textes.

Und der 'TANT Appendix' selbst:
http://www.vhfdx.info/docs/TANT_Manual_Appendix_1_0.pdf

A Compact 1 kW 432 MHz High Power Solid State Amplifier using 2 x MRF6VP5600H - (Part II)

by Remco den Besten, PA3FYM (with the help of Michel Rousselet, F5FLN)

Introduction

Being an active member of a contest group in The Netherlands, I am always looking for improvements to our contest station. Our 70 cm (432 MHz) station has been up and running flawlessly for more than 20 years. Although there is a well known saying that 'one should never change a winning station', there is one parameter which can't be optimised enough: weight.

While performing some initial calculations, and philosophizing about a simple and light (!) design for a kW-SSPA for 432 MHz, Michel F5FLN published his 50 MHz SSPA [1]. When looking at the 50 MHz PCB from an 'UHF point of view', input and output striplines 'appeared'. The 50 MHz PCB contraption was modelled at 432 MHz, and we built some prototypes. The results were submitted to this magazine [2].

This paper elaborates further on the design, the use of some alternative components, and cheaper combiners to connect the two RF modules. The result is a state of the art lightweight linear kW for 432 MHz. The weight of the modules, heatsink, and temporary casing is 3.5 kg. The power supply I use weighs 6.5 kg, resulting in a total weight of 10 kg, i.e. 10 grams/Watt!

As Michel stated in his original article [2], I too would stress that experience with high power (solid state) amplifiers is required in order to reproduce this design successfully.

Description of the design of one RF module

I always heed the motto 'thou shalt understand what thou builds'. Especially for these kinds of amplifiers and output powers for amateur radio usage. Therefore, I might repeat some of Michel's considerations (which are mine too!), mentioned in his initial article [2].

Input circuit: A ~¼ λ 50 Ω coaxial balun transforms the 50 Ω unbalanced input into two phase shifted ~25 Ω balanced outputs. In practice a small inductance in series with the input balun seems necessary to realise the input matching. Using striplines and capacitors, the balanced ~25 Ω impedances are transformed towards the complex conjugated input impedances of each die (Zin = ~0.5 + j1.2 Ω) of the LDMOS FET in three steps. The balanced setup of the input circuit permits the matching capacitors to 'float'. I.e. they need no grounding, and their capacitances are half their 'single die analogues'. The input matching is optimised with a trimmer. Thus, the balun is part of the matching, a deliberate choice in the design.

Output circuit: The output impedance of one die at 432 MHz was measured to be $Zout$ = ~1.3 + j0.3 Ω, Vdd = 48 V, Idq = 1 A, Pout = 500 W. This output impedance is transformed in three steps towards ~25Ω with a stripline and capacitors. The output circuit is balanced before the output balun, so here the matching capacitances are floating too. The 2 x ~25 Ω balanced outputs are simultaneously 'reverse phase shifted', and combined into one 50Ω unbalanced output, using a ~¼ λ 50 Ω coaxial balun. The length of the balun is actually ~10% shorter than ¼ λ. Final matching of the output circuit is optimised with a high-Q 3-16 pF glass trimmer. Some people consider this not to be the 'most beautiful solution', but for amateur usage, and in practice, it helps tremendously when the balun is 'in the match'.

Assembly hints and tips

PCB: the TC350 PCB material is 'heavy duty' and you will find that you need a **hot** soldering iron (with a small tip) to get the solder to flow. Mount the SMD components, copper foil, and ATC capacitors first.

Note: See later about placing the 4 x 5.1 pF ATCs in the output circuit. When all the components are mounted on the PCB, remove excess flux with acetone or other polar organic solvent.

Output circuit:

Balun: Use 0.141 inch semi rigid coax (e.g. SM.141, KTR 141-50). It bends and remains into shape relatively easily. Although RG142 coax may be used, you will find that it takes quite some effort to bend

11 cm of RG142 in such a shape that it fits nicely on the PCB without residual tension.
Each RF module actually consists of two amplifiers. From an RF perspective people may disagree, but from my perspective, when mounting the in- and output baluns, pay attention towards their respective positions. Ensure that the input and output baluns on each module are mirror images of each other. Thus, the cores and shields of both the input and the output coaxial baluns should to be connected to the same transistor die.

ATC capacitors: Like Michel already stated in his article [2], large RF currents are flowing in the drain area due to the low output impedance of the transistor. Special attention is required for the first impedance transformation step. It seems that the ESR values of commonly available high power capacitors (e.g. ATC100B) are insufficient to allow the use of only one ~20 pF capacitor at these powers and frequencies. Michel used special TEMEX CLX 18 pF capacitors. I used 4 x 5.1 pF ATC100B capacitors in parallel instead. The characteristics of commonly available capacitors seem to be the limiting design factor for a 'single FET approach' e.g. MRFE6VP61K25H at 432 MHz. I received several reports and rumours of professional RF engineers and fellow amateurs, about exploding/melting capacitors in the output circuit of alternative attempts and/or designs for 432 MHz in the 500 W range.
Mount the 4 x 5.1 pF ATCs vertically next to each other so that the total length of the capacitor array is less (~8 mm) than if they were mounted horizontally ('the normal position'). The position of these ATCs is very important in order to reach 500 W output with a reasonable efficiency. If the second matching cell, i.e. the stripline between the 4 x 5.1 pF and 10 pF capacitors is too short it minimises the amount of current you are able to 'pump' into the FETs, as it sees too high an impedance at the drains. I obtained the best results by placing the first 5.1 pF ATC ~9 mm from the FET casing.

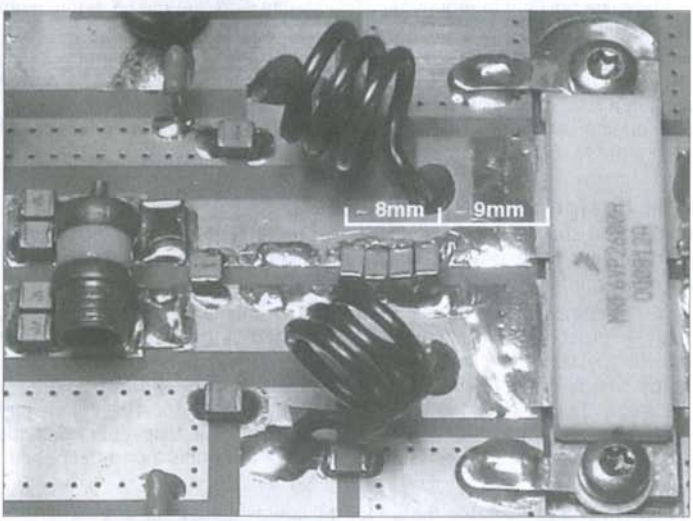


Fig. 1: Close up of the output matching circuit.

Drain inductors: The inductors between the and power supply (V*dd*) were designed to be 50 nH, e.g. 3 turns 1 mm dia. CuAg of 7 mm diameter. Due to the high currents I felt more comfortable using thicker wire, 1.6 mm enamelled copper. To obtain the same inductance, I made these inductors with 3 turns of 8 mm diameter.

Input circuit: There is nothing special here. Either use the same coax as the output balun, or coax of a smaller diameter, like RG178 or SM.186.

Heatsink: Drill 2.5 mm holes. Lubricate and cool the drill with methylated spirit or alcohol to prevent the drill from sticking and/or breaking. When using proper heatsinks for these powers, the depth of the holes is around 8 to 10 mm. Aluminium may easily melt while drilling to these depths. Use a M3 plug tap for the M3 bolt threads. If you use an electric drill for tapping, put it in the 'softest' position to prevent the tap sticking and/or breaking. Also cool and lubricate the tap with methylated spirit or alcohol to minimise the risk of enriching your heatsink with broken off taps (and frustration afterwards).

Don't use the 35.56 mm mounting pitch ('G') for the transistors (NI-1230 casing), as indicated in the Freescale datasheet. Make it ~1 mm wider. The heads of most M3 bolts have diameters such that they the will squeeze the ceramic material of the transistor and/or the bolt will not fit properly.
Do not mount the transistors on anodised (e.g. black) aluminium heatsinks. Use a milling cutter and mill a ~10 mm wide, and 1.0 mm deep strip in the heatsink to lower the transistors so that the leads fit well onto the PCB. Ensure that the resulting surface for the transistor junction is flat and free from dirt.
Although not mandatory, a copper heat spreader is highly recommended. Use heat transfer paste (e.g. Arctic Silver 5) underneath the transistors. Not too much, just enough. Rub the transistors on the heatsink surface and feel that they are 'glued' due to capillary attraction. Then fix the transistors. Don't over-torque the nuts as the mechanical tension on the transistor junction may become too high, resulting in stressing the dies inside when they become hot. I did not measure my torque, but with an electric drill in the 2nd softest position, the transistors were mounted firmly enough.

Transistors: as suggested in the first article, flatten the surface of the transistors with PM1200 abrasive paper on a piece of flat glass, with 'figure-of-8' movements. Michel uses MRFE6VP5600Hs. I use (less rugged, and cheaper) MRF6VP2600Hs, which have ~2 dB less gain. The outputs and efficiencies at 432 MHz of both models are equal. However, the 5600H is better protected against mismatches. This might be a design consideration when building one module. When combining two pmoduless, the output combiner also serves as 'mismatch protector' (see later).
As mentioned earlier in this article, large currents are flowing in, and around, the drain areas. The sources of the FETs are grounded through the heatsink. This requires both flawless RF and electrical conductivity of the PCB to the heatsink. To be on the safe side and to rule 'strange phenomena' out, I advise mounting two solder tags on each transistor M3 mounting nut. The tag is soldered onto a grounded area of the PCB, see figure 1.

Tuning up each RF module

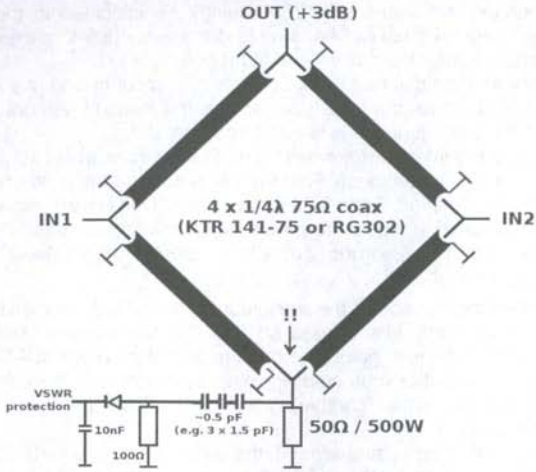
Please consult Michels article [2] when tuning up your RF modules. Adjust the idling current (~1 A) using a power supply with current limiting. The limit between 'no current' and 'too much current' is very narrow.
Check your driving power to ensure that you do not overdrive the modules. These LDMOS FETs are power FETs, i.e. they are designed to 'let current flow'. They will surely do ... to a certain extent. The bandwidth of this extent is narrow when the FETs are properly matched. Initial input matching can be obtained without drain voltage, i.e. with a 'cold' module. Inject ~1 W of drive and tune the input trimmer for minimal reflection. When the module delivers its full output it can be tweaked on the fly.
Connect the module output through a wattmeter to a suitable 50 Ω load. Inject ~1W into the module. If you do not obtain ~150 W output with 1 W of drive with ~10 A drain current, stop immediately. Double check the in- and output circuits. When everything looks good, increase the drive power (slowly). Around 500 W output power should be obtained with ~7 W drive power with an efficiency of ~67% (50 V / 15 A), otherwise there is something wrong. Optimise the efficiency of the module with the glass trimmer in the output circuit. It is possible to gain more output, but with loss of linearity.

Known issues

It may happen that your module saturates (far) below 500 W, i.e. you 'cannot let enough current flow'. Very likely the transistor does not see a low enough impedance at its drains, i.e. matching of the first cell is suboptimal. Repositioning some of the 5.1 pF ATCs may help. Relocate the 'furthest' 5.1 pF ATC towards the drain, and retune the efficiency of the module with the output trimmer to see if there is an improvement. I obtained ~500 W with the first 5.1 pF ATC located ~9 mm away from the FET casing, see figure 1. Your mileage may vary.

Combining two RF-modules

In the original article [2] two RF module are combined using a commercially available (and expensive) 90°-coupler. I made the in- and output hybrid couplers with ¼ λ length (i.e. 120 mm) of 75 Ω PTFE coax. A hybrid coupler may be connected in various ways. I chose the Wilkinson variant. Thus there is no additional 180º-phase shift relative to the the output side. As the 50 Ω load I used a RF resistor which is mounted on the heatsink. The output configuration of the combiner is depicted in figure 2. 180º-phase shifting of one side towards the load is realised by swapping the core and shielding connections of one ¼ λ part. I added a VSWR probe which can drive a protection circuit. When matching of the amplifier is suboptimal, or when you 'forget' to attach a suitable load, the amplifier can be switched off. Sufficient amplifier protection circuits have been published. Figure 4 shows my interpretation of the hybrid output coupler.



For the input splitter the inputs and outputs are reversed, and the 50 Ω load may be less rugged, the VSWR protection circuit is omitted, and the coax cable may be of a smaller diameter. I used RG179.

Fig. 2: Output configuration of the hybrid coupler to combine two modules.

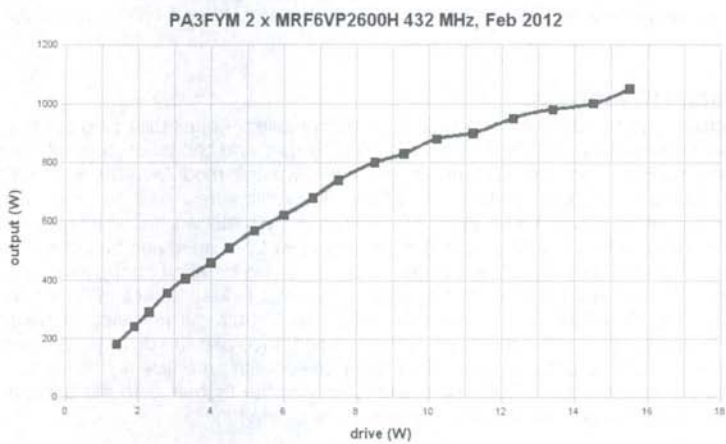


Fig. 3: Closeup of the output hybrid coupler, consisting of two pieces of RG302 (output) and two pieces of KTR-141 75 (RF-resistor)

Firing up the combined modules

When the two modules are tuned for maximum output and efficiency seperately, firing up the combined modules will not be difficult. Use the same approach as for a single module. When reaching full drive (i.e. ~15 W), tweak the input trimmers first for maximum output and maximum current. Last, but not least, tweak the output trimmers for maximum efficiency. The results of my experiments are depicted in figure 3. Measured efficiency is ~68% @1050 W output, and P-1 dB = ~900 W.

Final

Due to reticence of NXP to offer samples, I was not able to study if this design works with NXP equivalents. As fas as I could ascertain at the moment, no working design with e.g. a BLF574 at 432 MHz in the 500 W range has been reported and/or published.

Acknowledgements

Many thanks to: Michel, F5FLN for his generous support, and the good and fruitful discussions we had concerning this design, and the art of RF power design in general. John, PA7JB for milling the slots in my heatsink, and Hans, PE1CKK for bending the aluminium, and loaning the 50 V power supply.

Fig. 4: Closeup of the output hybrid coupler, consisting of two pieces of RG302 (output) and two pieces of KTR-141 75 (RF-resistor)

References

[1] Michel Rousselet, F5FLN, A compact 50 MHz High Power Solid State Amplifier using the MRFE6VP6125KH, DUBUS, 4/2011 pp 9

[2] Michel Rousselet, F5FLN, A Compact 1kW 432 MHz High Power Solid State Amplifier using 2 x MRF6VP5600H, DUBUS 1/2012, pp 9

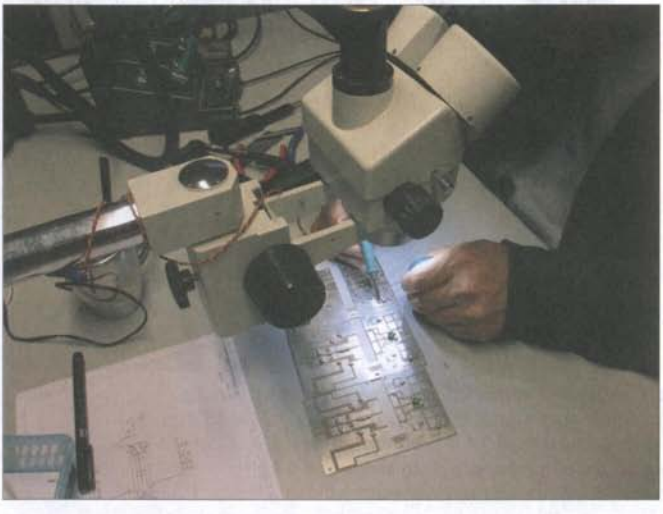


Fig. 5: Building the pallets. Note: the output ATCs were initially already mounted, but practice learned that their positions are very critical. Tuning their positions seems necessary. Photo: PA7FA

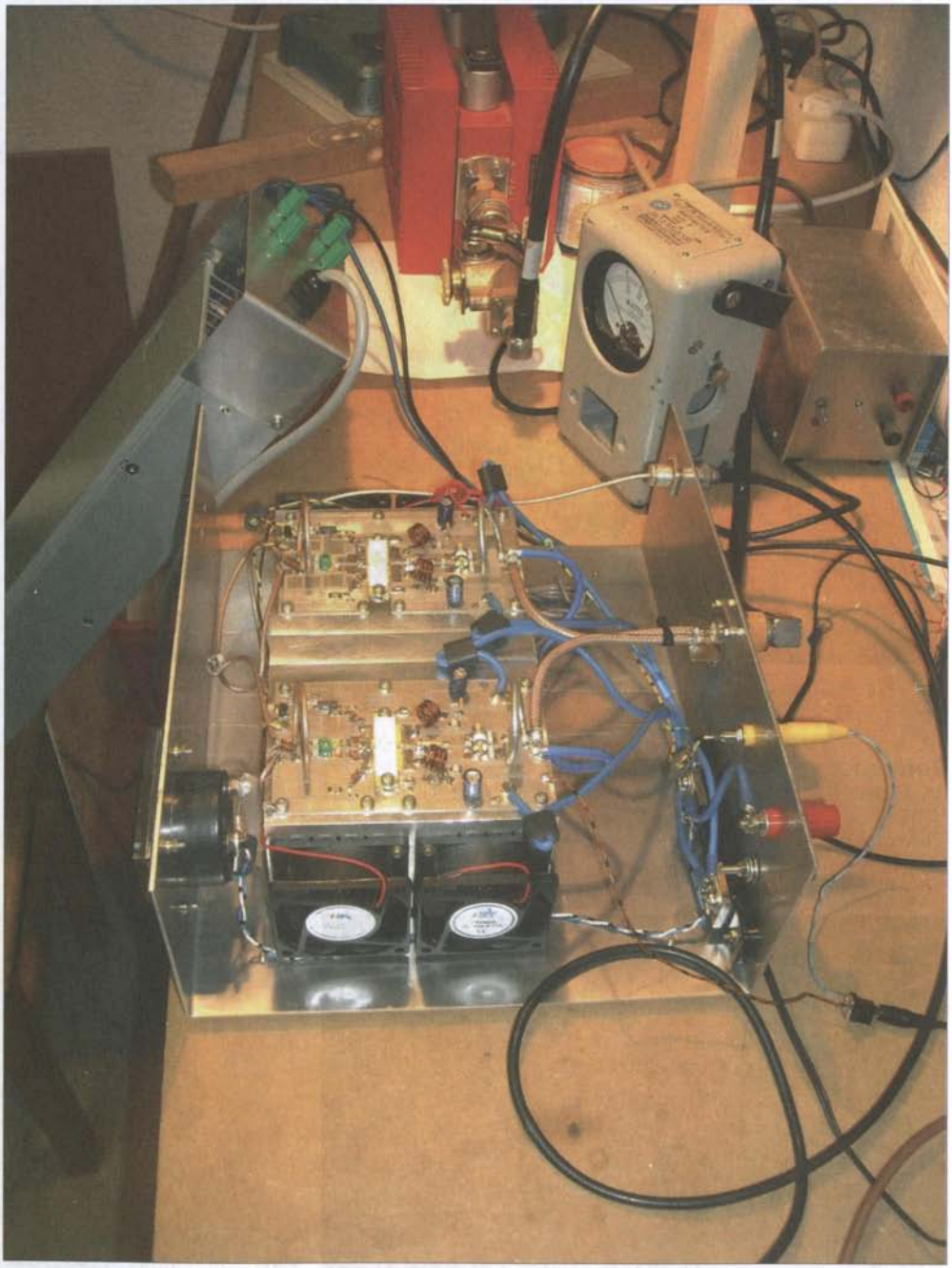


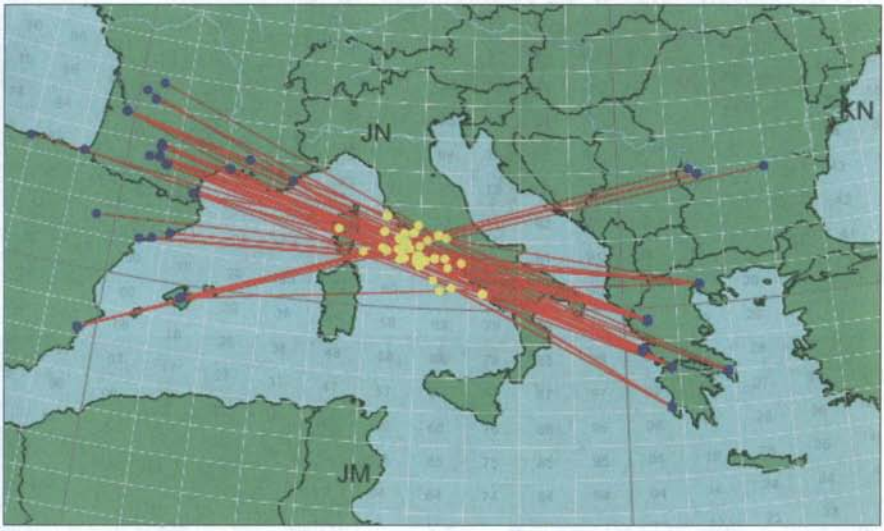
Fig. 6: The kW-amplifier in a temporary housing. Weight: 3.5 kg.
The heatsink is a cooling aggregate, dimensions 200 x 125 x 75 mm.
The fans are four small 12 V blowers in series.
The 50 V / 60 A power supply (left) weighs 6.5 kg,
which results in 10 grams per Watt for the total contraption! Photo: PA3FYM

Sporadic-E Summary 2011 – 144 MHz

by DL8HCZ/CT1HZE

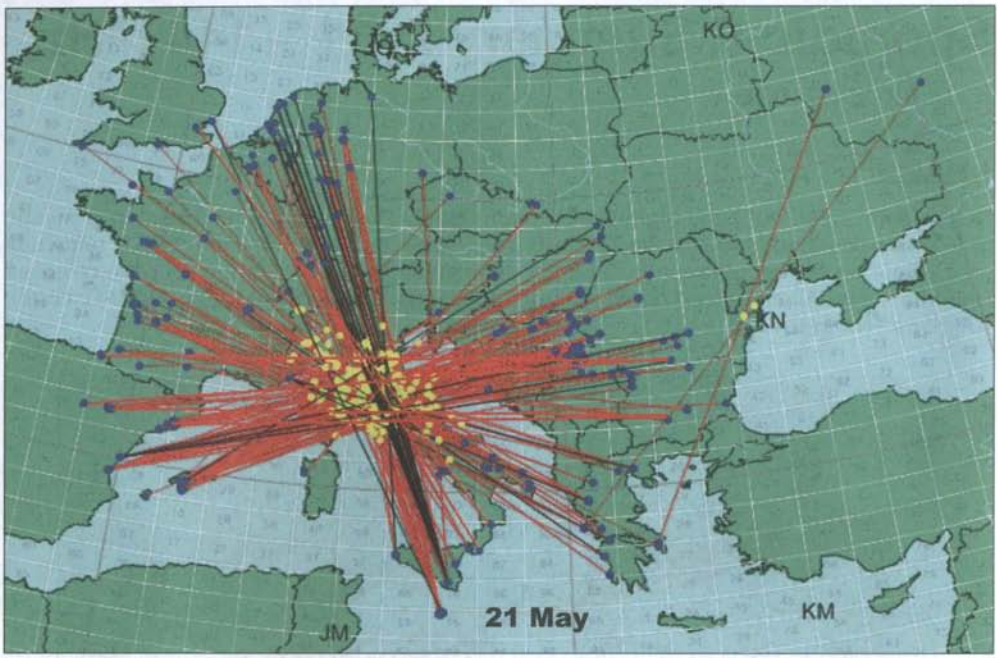
a.) EUROPE

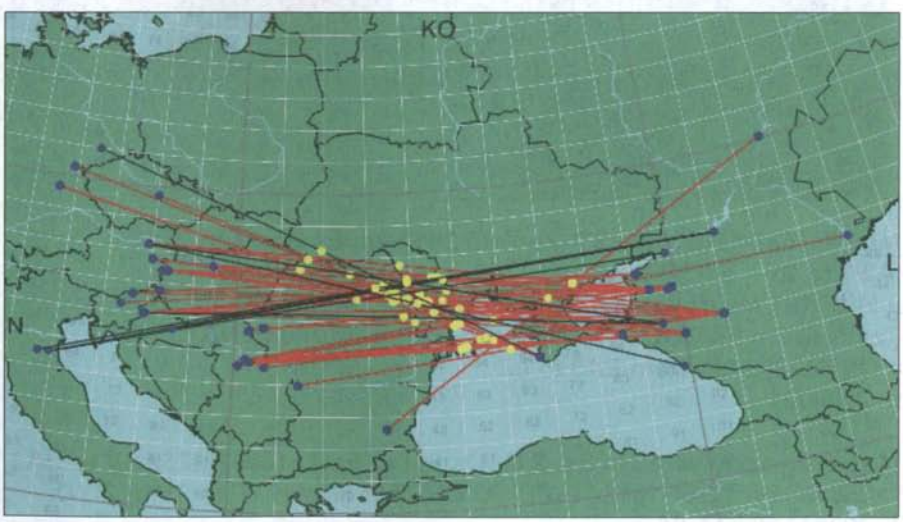
Notes: With "best MUF" the highest Maximum Usable Frequency of the opening is meant. MUF was calculated from real 2m Es spots only. "Spot" means the (main) 2m Es reflection area. Many wrong spots (announcements, 2m instead of 6m QRG spotted) were removed from the maps. All times in UTC. Green and blue maps: TNX to LiveMUF by G7RAU, colour NA maps TNX to EA6VQ.



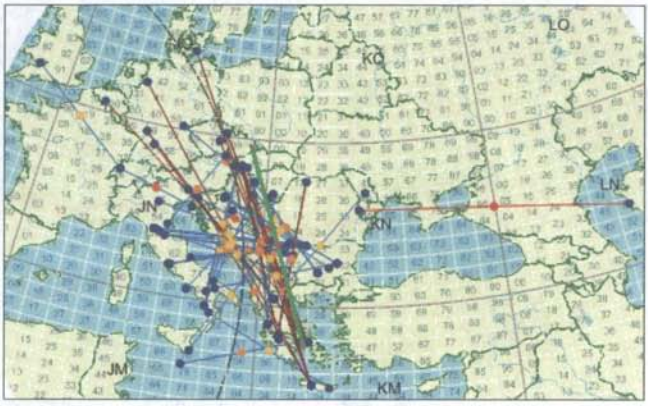
15. May – 1657-1806z: FIRST (known) 2011 2m Es opening
F, EA2/3 to SV EA5/6 to LZ
Best MUF 161 MHz over JN70 (JN33 to KM07, 1440km)
1657z: First 2m Es QSO in 2011 from SV2JL KN10 to F6HTJ JN12.
Best QRB: 2308 km from EA5 to LZ
Spot: JN51/61

21. May – 2nd day with 2m Es, 2 QSOs in the East: 1321-1325z SV to UA3 and >250 QSOs: 1511-1613z PA/DL/ON/HB9 to IT9/9H, F to SV/I/LZ/YO EA to YO/HA/YU/9A/S5
Short from SP to IS0, G to I8, GJ to I.
Best MUF 189 MHz over JN53 (QSO JN25 to JN80 over 1075km)
Also several hours with MUF 90-100 MHz over Baltic and North sea.
First day in 2011 with 2m Es for DL, PA, G etc.
Best DX: EA5 to YO over 2250km.
Spot: KN45 & JN34/44/54/45/43/42/51/52/53/55/62/63/64/72
See map on next page!

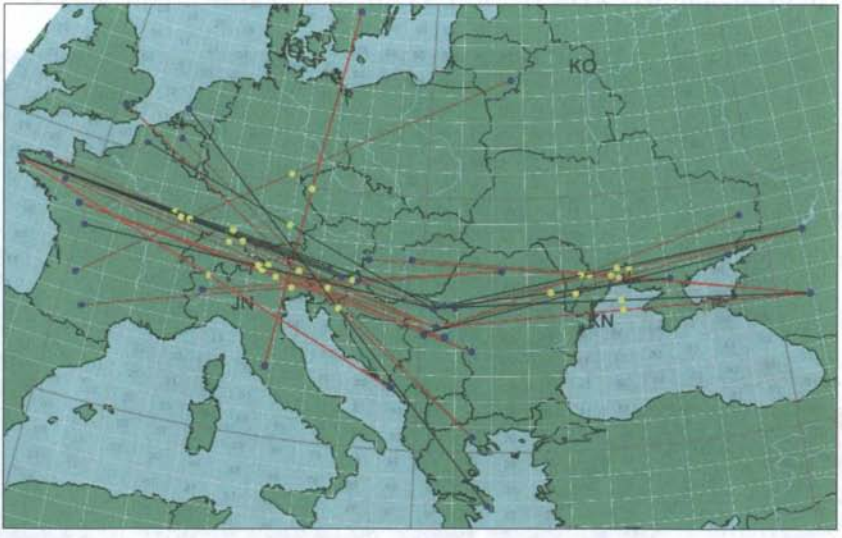




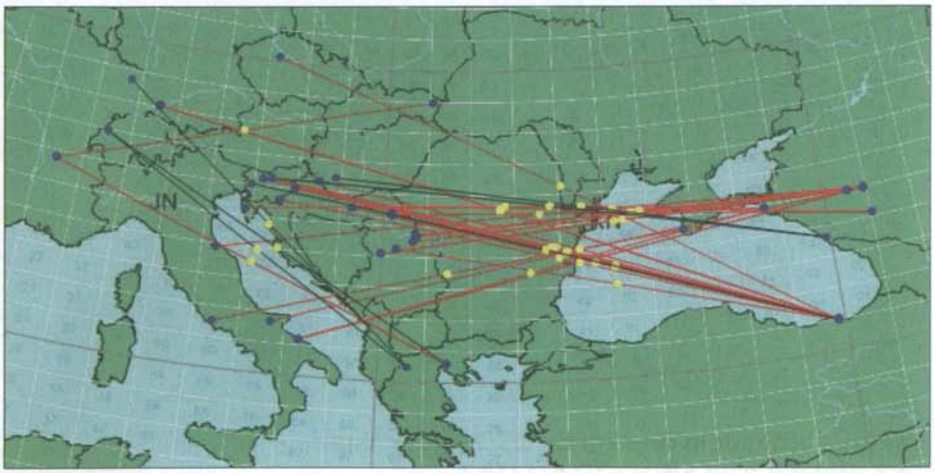
<u>22. May</u> – 0535-0555z & 0607-0715z:
UA6 to YU, S5, 9A, OE UR5 to OK, DL LZ to UA4
Max. MUF 161 MHz over KN27 (JN89 to KN64, 1440km)
Best DX: I4 to RZ6MB LN17 over 2400km
Rare grid: YU to UA4UED LN46 over 2170km Spot: KN17/36/46/47/55
(YO8RHI report on MMM is Tropo!)
(GJ to I report false on MMM on May 22)



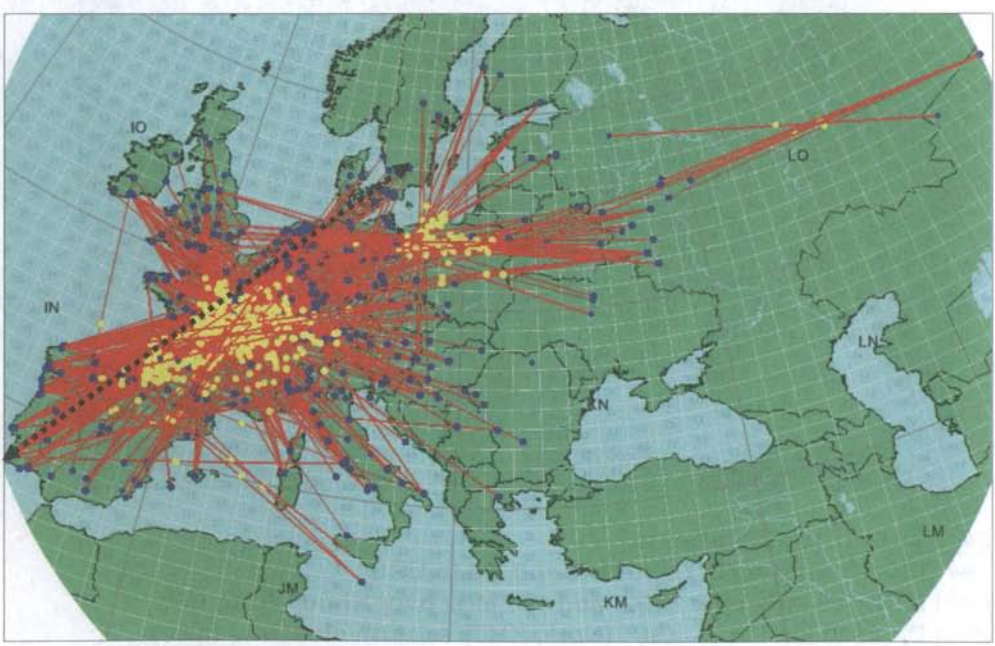
23. May – 1351z: Just one 2m Es QSO (green line):
OK2SS JN99CT wkd SW1MOO KM27AX.
MUF 164 MHz, QRB 1400km, refl. point KN03.
The blue (6m) and dark red (4m) lines are QSOs with MUF >70MHz, indicating MUF > 80MHz close to KN03. Thus it is quite probable that the 2m QSO was Es. – The red line on the right from ER5 to UN7AX was a 2m RX Tropo report!



24. May – 1215-1225z Eeast:
few QSOs from HA/YO/YU to UA6 and YU to UR5
Best MUF 163 MHz over KN46 and 191 MHz over KN36 (YU to UR5)
Best DX 1940 km HA to UA6 (Note: KN55 spot on cluster is false)
1627-1732z West: short and spotty openings from SM to I, F to LY then from F/I to YO/YU, SV to G/ON/PA
MUF 153 MHZ over JN56, best DX 2150km from G to SV2
Spot: KN55/56/46 and JN56/27/47/66/75



25. May – 1531-1645z:
F to OM3/SV2 TA7 to DL, OK, YU, S5, 9A UA6 to YU, HA, I UB5 to I
Best DX DK5EW JN47 to TA7OM JN90 2535km
Best MUF 165 MHz SV2 to HB9 over JN73 Spot: KN34/35/43/44/54/55 JN73/74
Earlier at 0720 and 0740z DK5YA hrd SV2JL and LZ2CM briefly via Es



Map May 26th, 2011 – with over 540 QSOs, black dotted line: 2787km QSO from CT1HZE to SM7GVF.

26. May – 1333-1728z: Widespread 2m Es openings simultaneously over an area of 6000km! Best MUF 258 MHz over central France.

Best DX CT1HZE to SM7GVF over 2787km. CT1HZE hrd the DLs wkg UA3 (Moscow) which wkd UN7 (Asia) at the same time... rumours that UN7 stations hrd DLs turned out to be NOT true!

CT to F, DL, SP, I, HB9, EA3, SM, ON, PA, OZ
DL to EA1, EA2, EA7, F, EW, UA1, UA3, LY, YL, OH
EA1 to OK, SP, DL, HA, OE, F, I, 9H, IT9
EA3, 5, 7 to F, PA, ON, G, DL, F, OZ
EI to I, F, IS0, S5, HB9, 9A
EW to ON, PA, DL, G
F to EA, CT, 9A, OE, YU, HA, S5, DL, OM, OK, YO, ON, EA6
G to I, F, IS0, EA3, UA3, F, TK, EW, 9A, UR5
GJ to TK, I, F, OE, HA, S5, 9A
GW to S5, 9A, I
LY to DL, PA, ON
SM to HA, I, CT, TK, EA (YU7 hrd SM7GVF)
UA3 and UA1 to UN7
9A to F, G, EI, GW

Best DX:
CT1HZE IM57 to SM7GVF JO77 2787km, OZ2M JO65 2595km and DK1CO JO63 2521km.
CT1CAD IM67 to SF7WT JO65 2581km
RA3WDK KO81 to G6HKS IO92 2505km
UA3WM KO72 to G (JO01, JO02, IO92): 2400-2500km
EB7COL IM77 to SF7WT JO65 2508km
EA1BLA IN53 to SP4MPB KO03 2421km
SM7GVF JO77 hrd: EA7AJ IM87 2528km

Spots: LO56/65 JO73/83/84/93/KO03 IN94/JN16 and wide around

The QSOs on the remote eastern edge of the map:
UN7CL MO44 wkd RA3LE KO64, RL3D KO85 and other UA3 stations.
UN9LCW MO13 wkd RA1TT KO68 in FM and another UA3.

Best MUF: 1359z 258 MHz over JN16 (IW1CHX JN36 wkd F1DQJ IN96 over only 681km! In total over 2m 35 QSOs with MUF>190 MHz took place, 20 of them with a MUF >200 MHz. See extra map.

Small map (left): May 26 -
35 (!) 2m Spots with MUF > 190 MHz
1354-1713z: Central France was HOT!

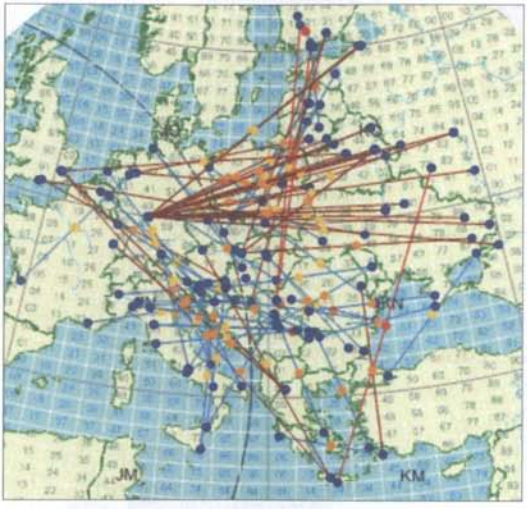
This was already the best 2m opening of the year 2011 in Europe. Although many calendar days with 2m Es in EU followed in June and July really intense openings were rare.

30. May - 1530-1745z:

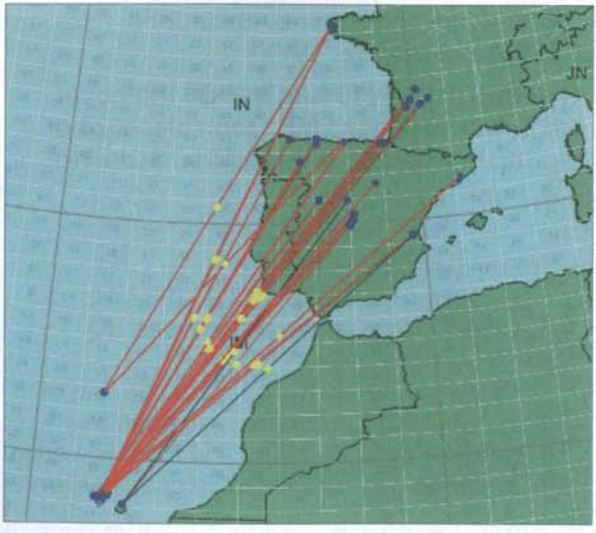
EA8 to EA1, EA3, EA4, F, G
Best MUF 151 MHz over IM44

Best DX: G4LOH IO70 to EB8BRZ IL27 2603km, most probably with Tropo contribution

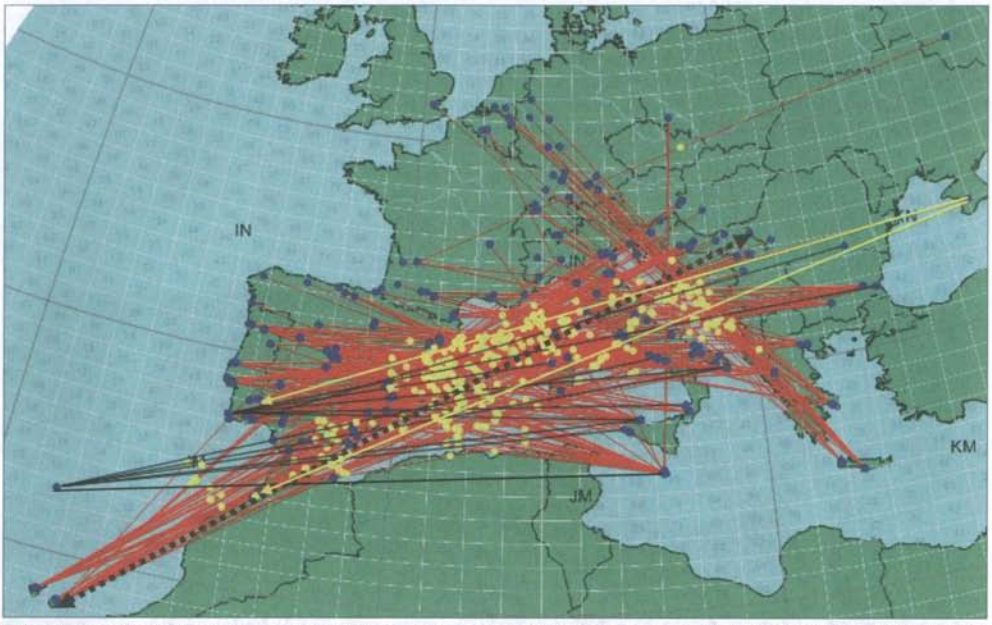
Spot: IM45/57



31. May - 1339-1351z and 1641z:
YU to OH and UA3 to SV9
3 bright red lines: 1340+1351z 2m Es RX reports between YT3I and OH (MUF 153 MHz over KO03). Best MUF from 6m spots is 107 MHz over KO14.
And at 1641z from UA3WM to SV9 (2098km, MUF 145 MHz over KN44). Best MUF from 6m spot is 82 MHz over KN44.
Dark red lines: 70 MHz Es QSOs and 4m FM BC between 1124 and 1700z
Blue lines: 6m Es QSOs with MUF > 70 MHz.



1 June -
1403-1706z with breaks:
EA8 to EA1, EA3, EA5, F
1552 CT3HF to EA1FBF IN73
1839 & 1901z F to CT3
Best MUF 152 MHZ above IM44
Best DX: F to EA8 over 2448km, probably with Tropo contribution
Spot: IM44/54/57



Black dotted line: The best DX of the day 3717km from YT7I KN05 to EB8BRZ IL27. This path was open > 30 mins! - The spot from RA3WDK KO81 to F5VHX JN04 is not from a real RX report. UU2JJ KN75AA confirmed that at 18:08z he hrd CN8LI IM63 3674km and CT1EPC IM68 (3495km) both on 144.320 MHz with 56 reports. See the 2 yellow lines.

2 June - 1637z-2002z 9A to EA5, EA7, CN, CT
CT to I, YO, 9A, 9H, IT9, TK, IS0 HB9/DL/ON/PA to SV1, SV9
EA1,3,5&7 to 9H, IT9, I, SV, EA8, LZ, YU, 9A, E7, HA, S5, YO
F to I, LZ, SV, CN I2,3,4&5 to ZB2ER, CN, EA7, several EA8`s
I8&0 to EA8, CT3HF, CN, CT, EA4 IT9 to CT3HF, EA1,2,4,5, CT, F
LZ to F, I4, CT (chordal hop) YU to EA5, EA8 (double hop)

Max. MUF 175 MHZ at 1709z over JM38 (IT9VDQ JM68 to EA5EH IM98, 1222km) and 167 MHz over JN50. 19z: 171 MHz over JN01, 167 MHz over JN73, 165 MHz over JM09

Spots: IM44/53 IM85/86/87 JN10/11/21/31/32/42 JN51/61 JN73/83/82/91

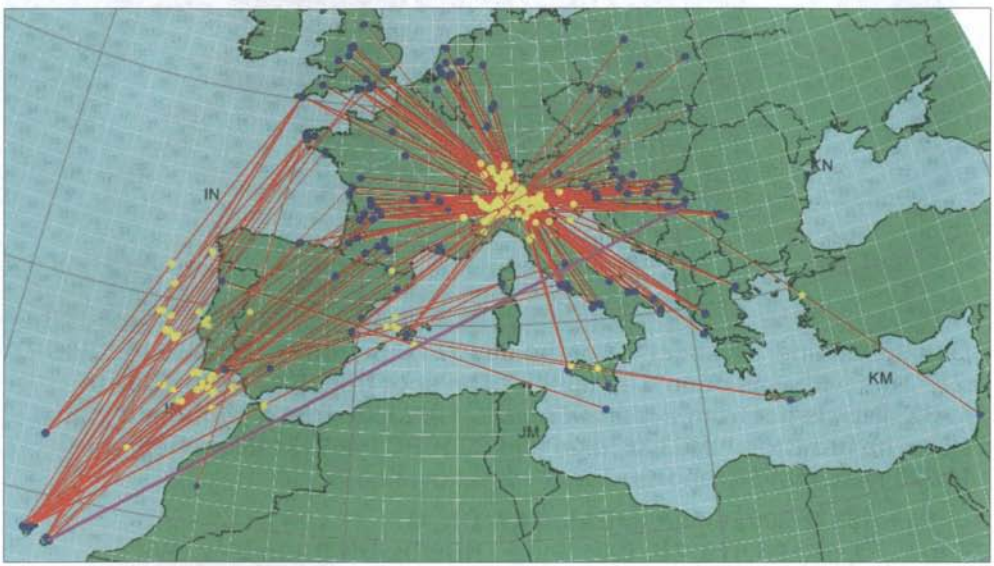
Best DX was YT3I KN05 to EB8BRZ IL27 at 1714z over 3717km for >30mins!

CT3HF, IM12OR, wkd: 1653-1801z: IT9VDQ JM68 2789km, IW9HII JM67 2706km, 9H1GB JM75 2882km, I5TWK/8 JN70 2911km, IK7UXY JN90 3226km.

EA8TX, IL18QI, wkd from 1652 to 1803z >2700km: IW0AIJ JN61 3039km, IZ0RDM 3016km, IK0SMG JN61 3016km, IK8BIZ JN70 3145km, IW0FFK JN61 3016km, IK0RMR JN61 3036km, IK0FTA JN61 3027km, I0DLP JN61 3021km, I5TWK/8 JN70 3140km, I4CIV JN63 3109km, IK5OEA JN53 2991km, IW4EGP JN64 3119km, IZ4BEH JN54 3082km, IK5YJY JN53 2991km, IK8YOQ JN70 3145km, I0FHZ JN62 3019km, IZ5BRW JN53 2984km, IK0RMR JN61 3036km, I0YLI JN61 3032km, IZ0DIB JN61 3032km, IW3HUL JN65 3155km, IW0AIJ JN61 3039km, I4RHP JN54 3055km, IW3FNK JN65 3155km, I0DLP JN61 3021km, 9A9C JN85 3496km, IS0NIR JN41 2761km, IW0FRR JN62 3055km, I0NLK JN62 3040, IZ6RCR JN72 3192km, IK3VZO JN55 3123km, IK5BRW JN53 3002km, and 1902z TK5JJ JN41 2737km.

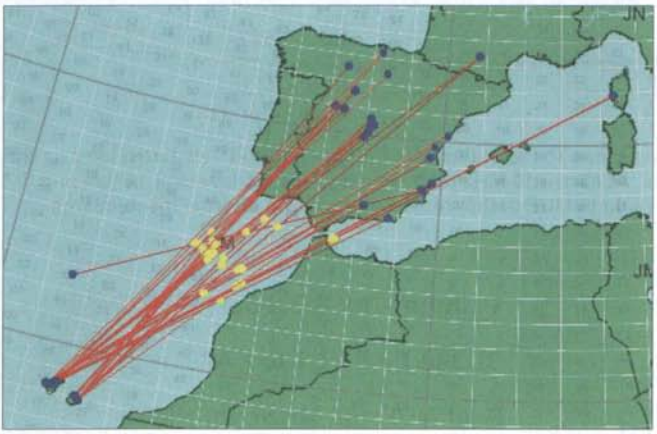
EA8AVI, IL28FC, wkd 1856-1916z: IZ5BRW JN53 2944km, IK4DRY JN54 2912km, IZ4BEH JN54 3026km, IK5DHL JN53 2864km, IZ5EME JN52 2895km, I3MEK JN55 3060km.

Other QSOs on 2 June > 3000km
1900z LZ1ZX (KN32IO) to CT1DIZ (IM58KP) 3032km
1917z LZ1ZX (KN32IO) to CT1HZE (IM57NH) 3064km
1912z LZ3GM (KN32RL) to CT1HZE (IM57NH) 3128km
1802z IK3MLF (JN55WJ) to EA8BRZ (IL27HX) 3146km
1744z IW3HUL (JN65DE) to EA8TJ (IL18RI) 3148km
1927z 9A9SF (JN65UF) to EA8AVI (IL28FC) 3199km
1737z EB8BRZ (IL27HX) to 9A2TE (JN85KK) 3431km
1751z 9A2TE (JN85JO) to EA8TJ (IL18RI) 3488km
1717z EB8BRZ (IL27HX) to YU2KU (KN04ET) 3663km
1732z YU2DX (KN04GS) to EB8BRZ (IL27HX) 3674km

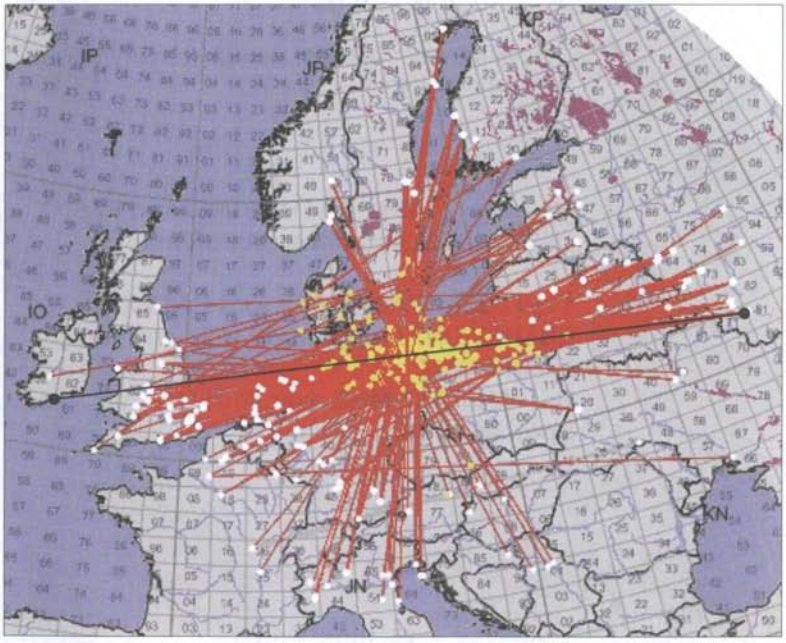


Pink line: Path from YU2DX KN05 who hrd EB8BRZ IL27 over 3711km at 1725z, an interesting repetition from the day before! (Paths to IM62 and IK07 on LiveMUF are wrong!)

3 June - 0756z 4X1GA to HA2MI (confirmed!) 0843-0849 EA5+EA6 to SV9
0956-1107 EA8 to F, G, EA1, EA2 CT3 to F, G
1001-1002 YT3I hrd UA3WM, RA3QTT, UR3EE (may be MS -> not on map)
1518-1635 F to SV, HA, S5, OK, 9A, YU, LZ, 4O ON+PA to I
G to SV, I, 4O GW to I DL to I+IT9 EA3 to OK, OM, SP EA4 to I
EA6 to SP, OK EA1 to S5, 9A, HA, YU, YO CT to I EA7 to TK, I
1538-1547 C37MS JN02UM (Andorra!) wkd to HA, OM
1628-1801 EA8 to F, G, TK, EA1,2,3,5,7 1723z CT to 9H
1725 YU2DX KN05 hrd EB8BRZ IL27 3711km 1830z G to CT3
1737 F8DBF IN78 wkd CN8QR IM51WS (vy rare grid)
Best MUF: 1550z 208 MHz over JN55 from DH2PA JN49 to IK0SMG JN61, 909km, 1544z 184 MHz over JN35 and 175 MHz over JN46
Best DX: 1008z G7RAU IO90 to EA8AVI 2785km,
1637z EA8TX & EA8TJ IL18 to TK5JJ JN41 2736/2730km
Note: EA8 to JN20 (EA6) is just 1 hop 2280km plus the rest to TK is Tropo!
Spot: IM45/56 JM19 JM67 JN45/46/47/55 KM39

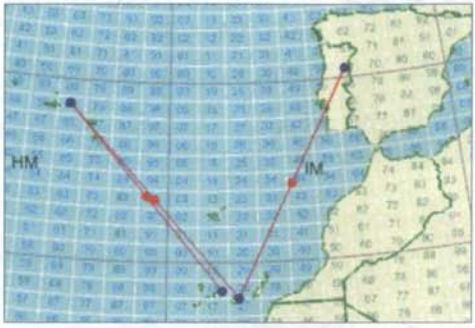


4 June - 1212-1309z:
EA8 to EA1, 2, 3, 4, 5, 7, F, TK CT3 to F
Best MUF 156 MHz over 156 MHz from CT3HF IM12 to EB5FOJ IM98
Best DX: 1256z TK5JJ JN41 to EA8YT IL18 2715km, hrd also EA8TX
Spot: IM44/53/56
EA8 to EA6 is just 1 hop 2280km plus the rest to TK is Tropo! (EA8 to I0 spot on LiveMUF is wrong! June 4 is completely missing on MMMonVHF!)



10 June - 1609-1736z: G/GW/DL/PA/ON to UA3, EW, LY, SP, UR, OH, YL
EI to LY GM to EU F to UA3, EW, UR, LY, ES, OH PA to LY, YL, EW, UA3
DL to UA1
1645-1736z: 9A to SM4 DL to OH, YL, ES, SM2 I to SM2, SM5, OH
LA to HA, 9A, OE, YU
Best MUF 163 MHz over JO73 at 1706z (LA to HA)
Best DX: 1653z RA3WDK KO81 to G4ASR IO81 2583km and
1612z RA3WDK KO81 hrd EI4DQ IO51 briefly over 2996km (black line on map)
Spot: JO43/53/63/73/83/93/72/74/75/76/84/KO02/03/13
(MMM: many OH spots missing, LiveMUF map: KN38 spot wrong)

As the hot spots of this opening are close to the Juliusruh ionosonde (JO64), we had a look on the ionogramm on June 10 from 1643z: At above 10 MHz foEs we can see 2 Es layers at 110km and 135km, which could well explain the high MUF in this region by enabling chordal mechanisms.



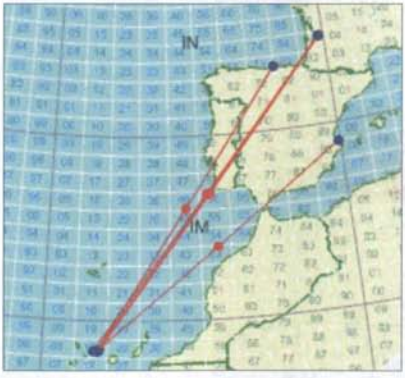
<u>14 June</u> - 1955-2006z

CU3 to EA8 CT to EA8

Best MUF 158 MHz over HM93

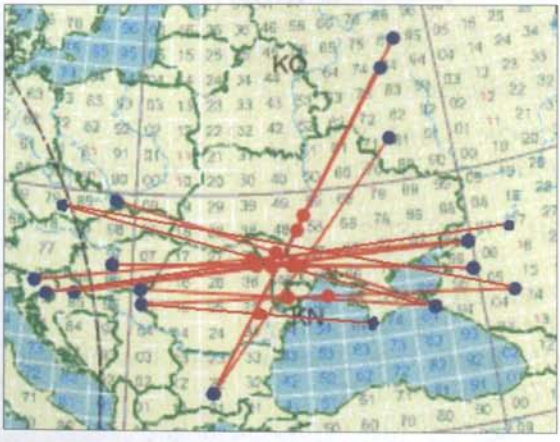
Spot: HM93, IM44

MUF was >100 MHz also calculated from 4m spots over IM35



<u>15 June</u> - 1025z CT1HZE IM57 hrd F6BNX JN33 and EA3 stations (not on map)

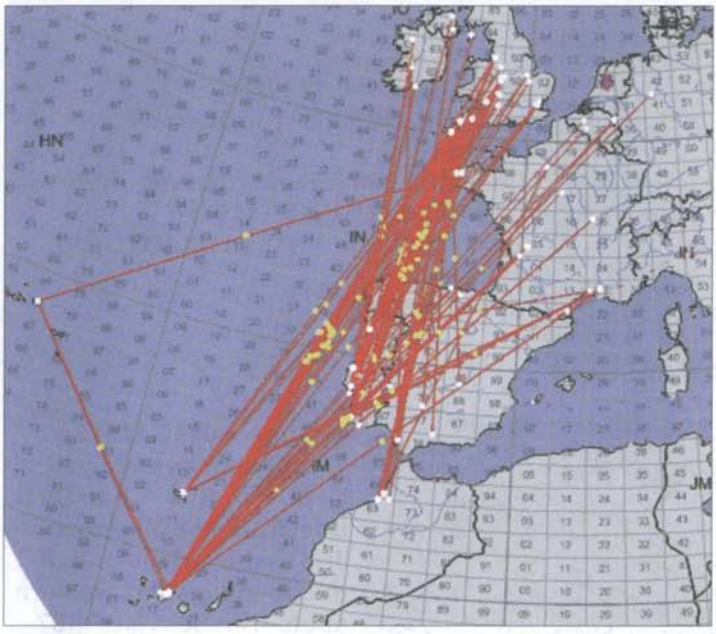
1159-1228z EA8TX IL18 wkd EA1MX & EB1HRW IN73 and F6FHP IN94 and hrd EA5HB IM98
Best MUF 147 MHZ over IM53
Spot: IM46/56



<u>17 June</u> Part 1 -
0838-0842z: UA6 to YU
0948-1015z:
UA6 to OK, S5, 9A, HA
LZ to UA3

Best MUF 168 MHZ over KN45

Spot: KN36/46/47/45



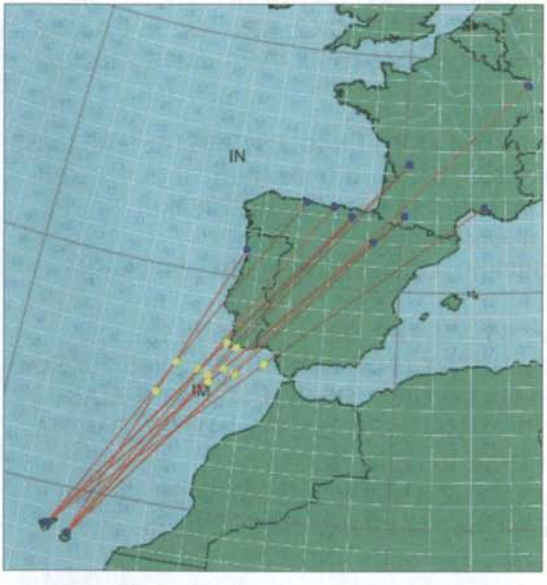
17 June Part 2 - 1017z G4FUF hrd CS3BTM/B any early indication for the following event:

1724-1959z
CT to G, GW, EI, GI, GD, F
EA8 to EA1, F, G, GW, CU3, PA, ON, DL G/F to CT3
CU3 to F GI to EA7
CN to F, G

Spot: IM44/57 IN55/65/76/75/74/73 IN40: (may be not true as Tropo involved)

Best MUF: 1843z 188 MHz over IN82, CT1ANO IN51 to F1USF JN23, 1081km
1935z 178 MHz over IN71, CT1HZE IM57 to F4EZJ JN05, 1182km

Best DX: 1941z DK5QN JO42 hrd EA8TX IL18 3351km for 20 mins
1922z PA4EME JO20 wkd EA8TJ IL18 3136km
1927z ON4KHG JO10 wkd EA8TX IL18 3018km



18 June - 1759-1826z:
EA8 to EA1, EA2, F
Best DX 1815z EG8LP IL27 to F4EBJ JN38 3037km
Best MUF abt. 147 MHz over IM46
Spot: IM45/55/56

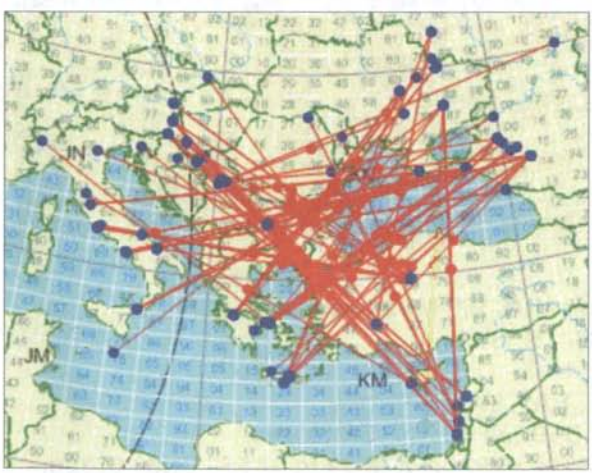
(CT1 to EA8 was most likely Tropo!)

23 June - 1458-1510z:
LZ to DL, HB9, I1, I3 DL to SV
YO to I1, I5
Best MUF 181 MHz 1510z over JN94 from LZ KN22 to I3 JN55 1145km
Best DX SV2JL KN10 to DK9OY JO52 1632km
Spot: JN85/94

27 June - 0950-1101z
1st Hot spot over Italy:
I1, I2, F to SV9 F to SV1
Best MUF 157 MHz over JN81 - Just at the end of the opening short western spots with best MUF 187 MHz 1101z F4EJW IN78 to I1GDH JN44 1115km indicating already the 2nd opening from
1340-1417z 7X to OZ, DL
SP to EA3, EA6
OK to EA1, EA2, EA4, EA5
EA1 to HA, YU, S9, 9A,
OK2, SP DL to EA3/4/6
Best MUF 171 MHz over JN26 - ODX OZ4VV JO46 to 7X2ARA JM16 2282km
Spot: JN70/71 JN24/25/26 JN34/35

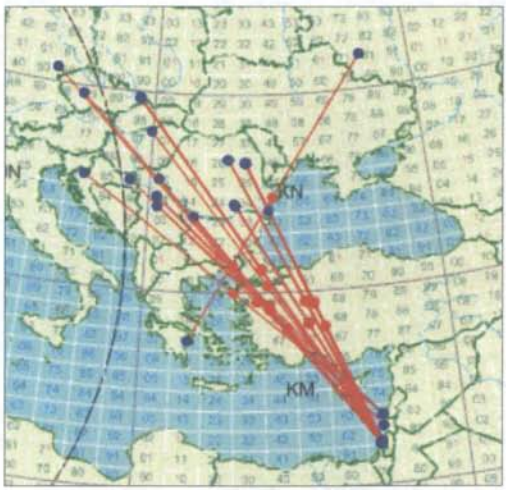
28 June (map next page) - 0726z YT3I KN05 hrd 4K6D LN40, 0813-0814z UA6 to S5
1202-1228z UA6 hrd I1 (beacons) and S5, UR5 hrd I7 beacon
1229-1345z UN3Z MO51 wkd UA6 from LN04/14 over about 2280km
1341-1342z SV2 to EA5 (I7 to EA3 unconfirmed)
1344-1428z R9SL LO71 wkd UA3 (1300km), UR5 (1750km), ER (2070km)
1413+1432z 9H to F, G
1447-1604z UA6/UR to HA, I, OM, SP, S5, YU, OK, OE UA6 to DL
UA4/6 to 9A, E7, YU Best DX: 1528z UN7AX LN53 wkd 9A2SB JN95 2578km
TA7X KN91 to OK2, OM, UR LZ to UA3/6, UR S5 to UA4 YO to UA3
SP to UA3/6, TA7X KN91, TA7Q KN90 UR to SV, LZ, YO, YU, OE, OM, HA
SV5 to UA3, UR 1458-1502z CT1HZE to I1, I2, I3, S5
Best MUF 217 MHz over KN34 1554z UZ2HZ KN69 to LZ3GM KN32 862km
and 214 MHz over KN44 1506z UT1EA KN67 to LZ1KG KN31 885km
Spot: LN78 LO22/23 KN45/46/48/57/38 JN42/50 IN91/JN01

28 June 2011: An interesting day! 2m Es over a range of >6200km at about the same time, with CT1HZE at the westerly edge and UN3Z MO51 at the easterly edge. However no chordal or double hop QSOs were observed just slighly enhanced QRBs at about 2500km from 9A to UN, DL to UA6 and UA3 to SV9, probably caused be Tropo prolongation on one end of the path. Note: This was also a remarkable day on 4m with many QSOs from OH to central EU. On 6m CT1HZE wkd into DU and JA over about 12.000km. With half (!) of the path covered already by 2m (!) Es, still anybody left who believe that this prop o 6m is anything else than Es??

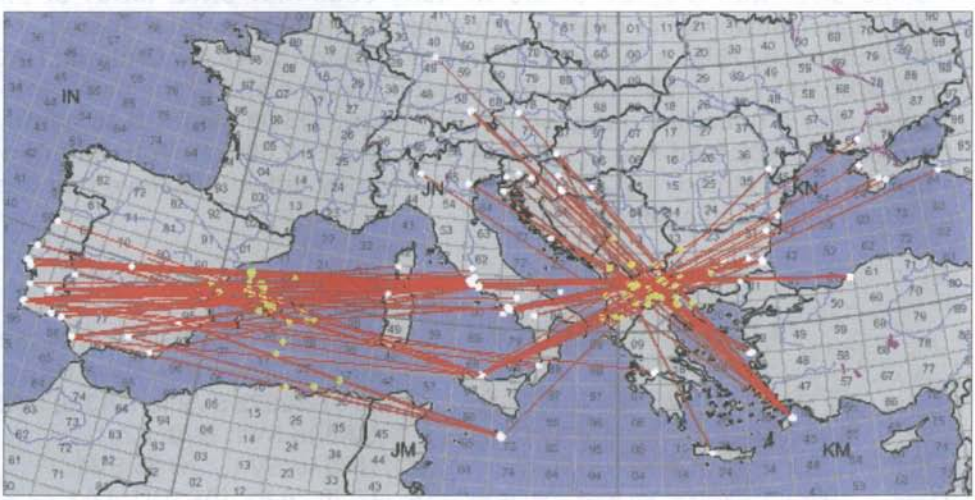


<u>29 June</u> – 0602-0625z:
UA6 to YU, LZ
Best MUF 184 MHz over KN53
0723-0727z YU to UA4, UA6
0757-1007z SV9 to UA3/6, UR5
UA6 to SV1, SV9, LZ, I
UR5 to SV3 I1 to SV1
I7, I8, I0 to UA6, UU, TA2
UA3 to TA4 ER, YO to 4X
9H to UR5
YU, S5, 9A, HA, UR5 to:
TA4AU KM57, 5B4AZ + 5B4AHY KM64, OD5ET KM73, TA2TAF KM69, 4X1ZQ, 4Z6LY, 4X1IF, 4X1GA all KM72

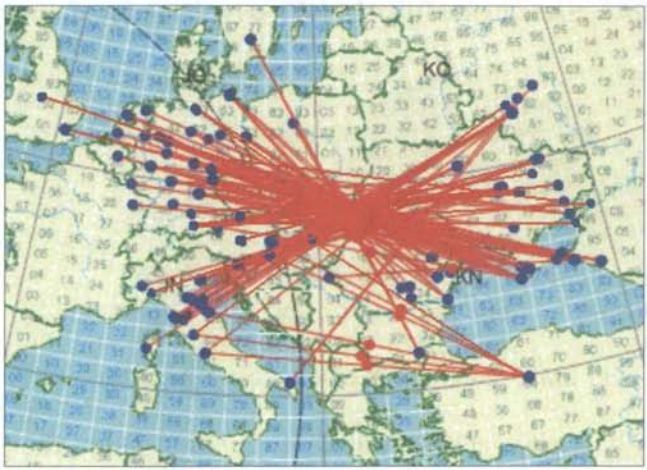
TA to I, HA, OE, E7, 9A, YU, OK2
Best DX OK2 to 4X at 0820z 2360km
Best MUF 181 MHz over KN21 0921z YU7 KN04 to TA4 KM57 1154km
Spot: KN24/34/43 KN21 KN52 KM39



29 June afternoon repetition with 8 hours shift...
1558-1725z 4X to HA, YU, LZ, YO
UA3 to SV1
1607z DL2ARD JO60 hrd 4X1UN for 20 sec, 2709km
YU/S5 to OD5KU/B KM73UW on 144.420 MHz
Best MUF 161 MHz over KM58/68
1645z YO4 KN44 to 4X KM72 1444km
Best DX OK2 to 4X at 1600z 2360km
Spot: KM59/58/48/39/KN40



30 June -
1228-1235z 9H to EA7, EA5 best MUF 162 MHz over JM37
1541-1805 CT to I7, I8, I0, IT9, IS0, TK, SV3
I to EA7, CT, SV, LZ, TA2AD KN51
IT9 to LZ, UU, UA6, UR5, YO, CT, EA7, EA4
SV5 to DL, 9A, HA, I, OE SV9 to HA ER to 9H
Best MUF 200 MHz over KN01 1622z SV8AJN K3M39 to 9A5ST JN83 978km and 155 MHz over IM99
Best DX 1556z CT1HZE IM57 to SV3CYM KM08 2685km
Spot: JM26 JM19/JN00 KN01/11
(JN88 spot on MMM is wrong)



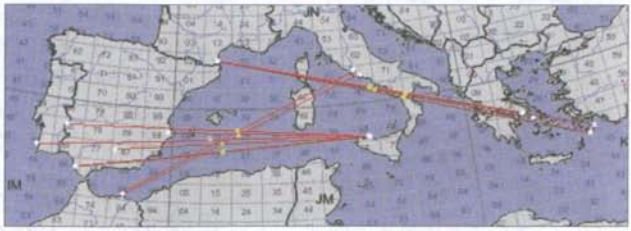
1 July - Part 1:
0725z YU to YU6
0749-0802z TA2ZAF to I0, I5, HA, OE
1354-1438z
UA3 to I4, I5, I0, TK
G to UU, UR, UA6
DL to UU, UR, UA6, YO
LZ to SM7, SP
UA6 to LX, OK, F
UR to OK, S5, I1, I4, PA, ON, HA, OE. Best MUF 171 MHz 1418z over KN18
Best DX UC6A JN84 to G4FUF JO91 2796km

1. July, Part 2 1722-1906z
LZ to F, HB, I, TK G to SV, I7, YU, TA3AX KN30, 4X, 9A, E7, S5, SV9
GW to 9A, E7, YU, S5, SV, I7, SV9, SV5
PA/ON to SV, SV9, I7, I0
F to UR, HA, SP, YO, OE, 9A, YU, SV, I7
UR5 to HA, IS0, EA6
DL to SV1, SV9, LZ, I7
OE to SV SM7 to EA6
YO to TK EA3 to LZ, YO, SP2, UR, LY
SP to 9H, IT9, YU
4X to G, YU, S-DL

Best MUF 252 MHz over JN57 1819z DF1VW to 9A9SV JN65 707km and 190 MHz over JN92 1758z IZ0FWE JN62 to LZ1DP KN22 1060km (black dots) and 165 MHz over JN48.
Black lines on map:
Best DX: 1805z 4X1GA KM72 to G7RAU IO90 3603km
and GW7SMV IO81 hrd 4Z5LY KM72 3707km
1755z 4Z5LY KM72 to ON7EH JO20 3202km
1740z 4X1ZQ KM72 to DF1VW JN39 3023km
1850z SV5BYR/5 KM36 to GM7SMV IO81 2976km
1850z SV9CVY KM25 to G8GXP IO93 2923km
1750z 4Z5LY KM72 to DG2KBC JN58 2647km
plus 4X1GA to YU1EV KN04 and LZ1DP KN22 (4X1GA: 60w + 5 el.)
Spot: KN09/08/07/18/17/28 JN92/83/84/73/74/75/65 JN38/48/47/57

MMMonVHF: SM7 to KM08 line wrong, JN61 to LZ lines: FAI - 30.6. & 1.7. missing on DX Sherlock

2 July - 1047-1148z EA8 to EA4, EA5, best MUF 150 MHz over IM44 (no map)



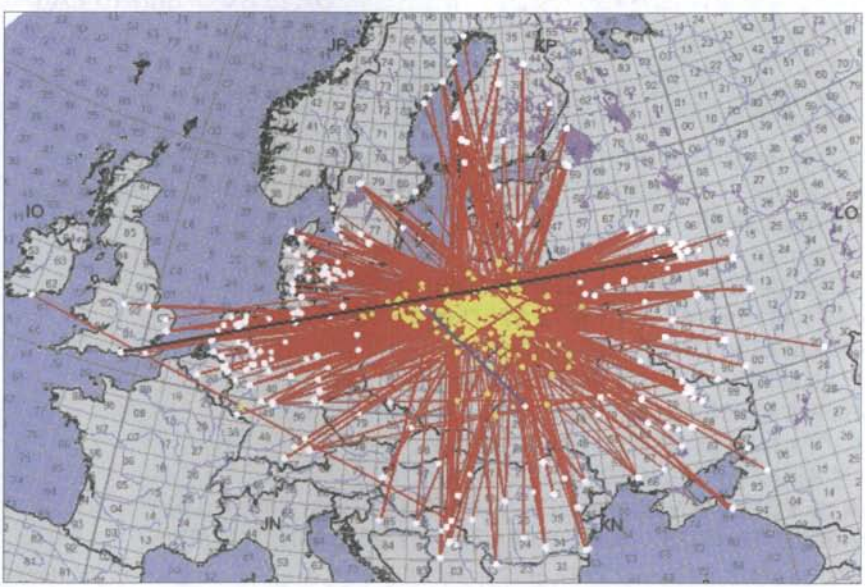
3 July - 1448-1458z: F to SV, SV5 1649-1658 IT9 to EA7, CT
1703-1708z I0 to EA9 Spot: JN70 JM17/28
Best MUF 158 MHz over JM28, best DX 2266km from F to SV5

4 July - 0924-0929z CT to F, ON G to CN

1032-1115z CT to GD, G, GI
EI to EA7 G to CT3

Best MUF 193 MHz over IN65 1054z G4LOH
IO70 to CT1HSN IN61 1024km
Best DX G to CT3/B 2520km
(with Tropo contribution)

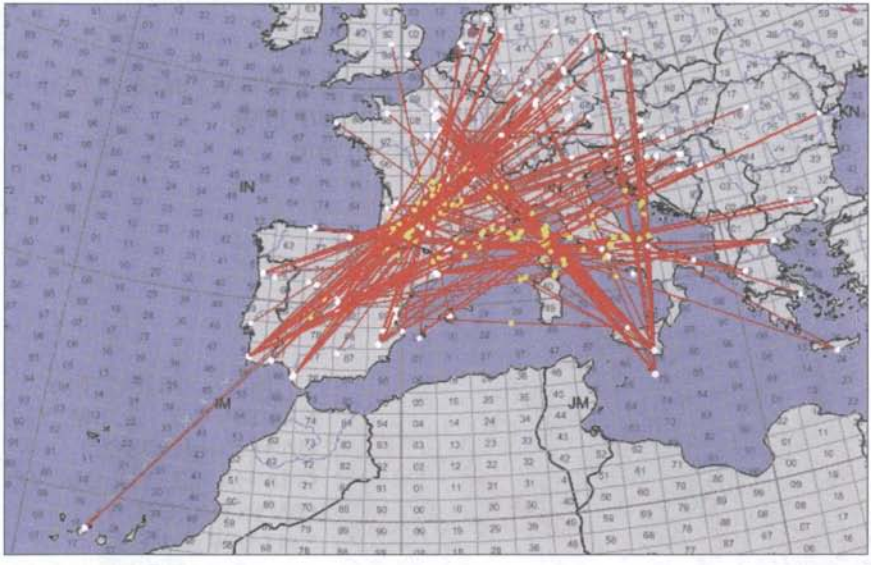
Spot: IN84/74/62/65



6 July - 1455z YT3I KN05 hrd EI4DQ IO51 for 1-2 mins
1644z OH6 KP02 hrd a DL/M station from JN48 for a minute (not on map)
1648-1924 & 1956-2016z OH1/3/6 to HA, YU, YO, ER, 9A, LZ OH8 to YU, YO
UA3 to DL, ON, PA, OZ, G, OK, SP, YU UA6 to SM4/5/6/7 OZ hrd UA4
UR to OZ, SM4/5/6/7/0, SP EW to DL, PA, G UA1 to G, YU, HA
ER to SM4/7 YO to OH2/3/8, SM2, ES

Best MUF 291 MHz over KO02 1744z SP2HPD JO94 to UT4WT KO20 585km (short blue line on map). Other high MUF spots: 1716z 163 MHz over JO84, 1757z 167 MHz over KO04 and 1918z 173 MHz over KO15

Best DX (black line on map): 1719z G7RAU IO90 to UA3ARC 2615km, G7RAU hrd also KO93 2668km (LN04 + LN00 spots on DXSherlock are wrong)
Spot: JO84/94/KO04/14/24/03/13/23

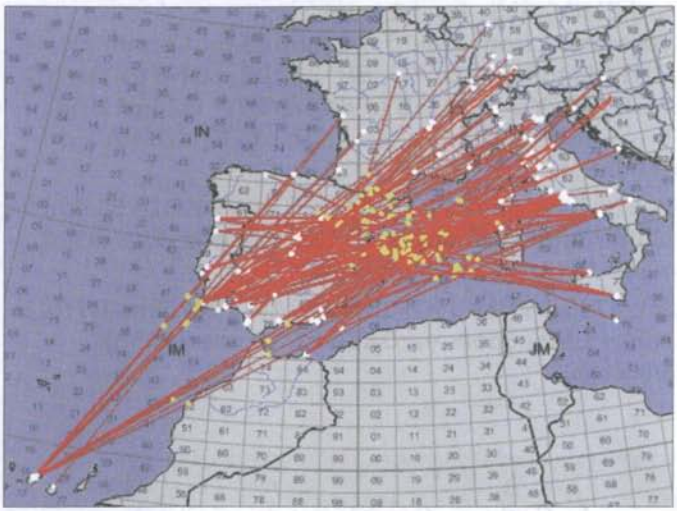


7 July - 1229-1502z
CT to 9A, S5, I0, I3, HA, OE, DL, OK, HB9 EA3 to SV2, I, LZ EA6 to G, YU
9A to CT, EA1/4/6 EA1/4/5 to OE, YU, E7, 9A, SV, I, HA, DL, YO4
F to IT9, 9H, SV1 9H to DL, G (hrd only) DL to CT, EA4/5/7, 9H, EA8 (hrd)
IT9 to HA, F, K, DL, SP PA to EA5 IT9 to EA5 – may be Tropo

Best MUF 186 MHz over JN41 1246z EA3KU JN01 to I7CSB JN71 1097km and 183 MHz over JN33 at 1306z and 179 MHz over JN72 at 1254z and 160 MHZ over JN16 at 1453z

Best DX-QSO 1252z CT1HZE IM57 to 9A2SB JN95 2445km and 1504z DL6SDH JN48 hrd EA8TJ IL18 3183km.
Spot: JN23/33/43 IN93/JN03/04/15 JN61/73

11 July - 2000-2010z G4LOH IO70 hrd CU8DUB/B HM49 2345km (no map)



12 July - 1216-1646z:
CT to HB9, I, 9A, IT9, F, DL, TK
EA8 to TK, I5, EA7, IS0, F, EA1
9H to EA1
EA7 to HB9, DL, F, TK
S5 to EA7, EA9
I to EA7, EA9, CT
IT9 EA4, EA1, CT

Spot: IM45/57
JM09/19/28
IN91/JN01/02

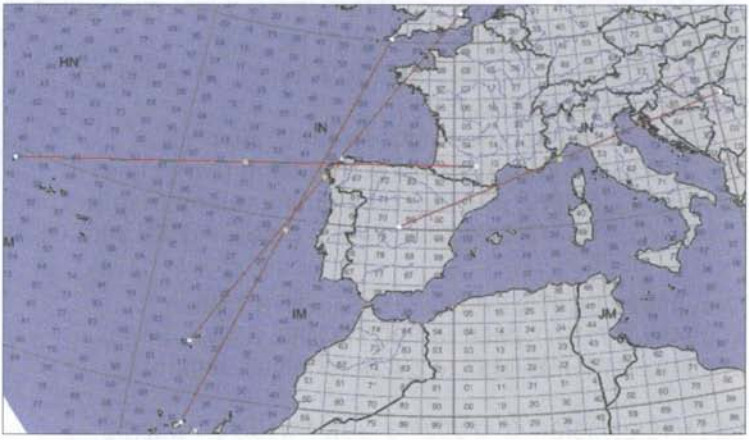
Best MUF 179 MHz over JM19 1320z TK5JJ/p JN42 to EA7GNO IM86 1170km and 170 MHz over JN02 1535z F0FVK JN18 to EA3MS/7 IM96
Best DX 1333z IK5YJY JN53 to EA8TJ IL18 2988km and
1411z IK5YJY JN53 to EA8TX IL18 2991km.
1333z TJ5JJ/p JN42 to EA8TJ IL18 2797km.
(JN52 to IN96 spot is wrong)

13 July - 1620-1708z
F to SP, YO, LZ, SM, YL, UA3 (single QSOs)
G to HA, LZ, YU, OM, YO
GW to HA, OM, YU
SM7 to F, I, HB9
I to OZ, SM S-DL to UA3
PA to YU, SV, E7

Best MUF 195 MHz over JN58 1640z F6BEG JN25 to SP6IQW JO80 1020km and 170 MHz over JO51 at 1642z

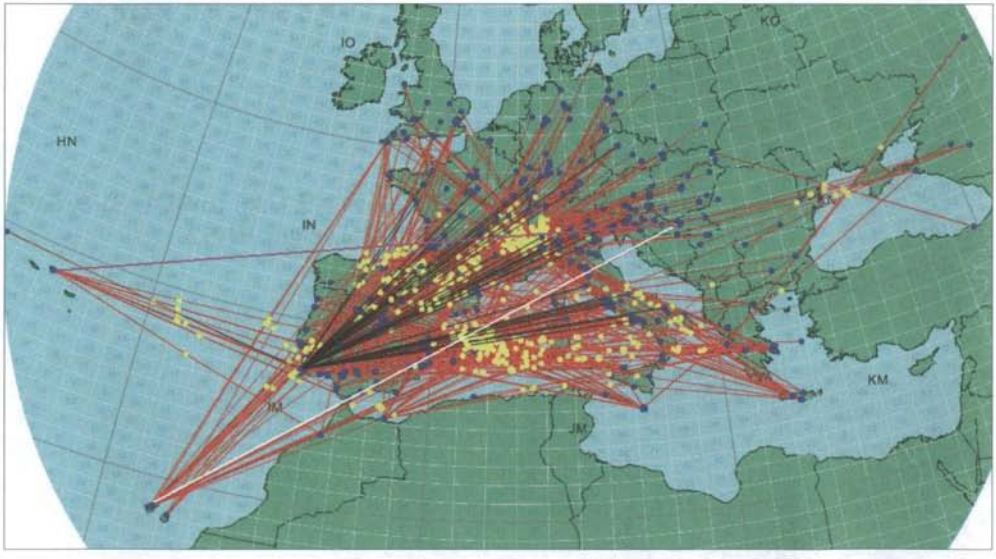
Best DX 1705z G4FUF JO01 to UR7IGF KN88 2619km (Tropo prolonged)
Spot: JO40/50/51/JN59/58 KO01 JN83 JN75/76

14 July - 2100z and again 2204z: CT1HZE IM57 to CU8DUB/B HM49 1950km Es for several minutes (no map), MUF 146.5 MHz, Spot HN52



15 July - 0940z G to CT3, 0952z G to EA8, 1020z F to CU8/B

1548z YT3I KN05 to EA4RN IN80 2084km (several minutes)



16 July - 0820-1252z CT to F, I, IS0, DL, G, HB9, EA2, S5, IT9, OK1
CT1HZE IM57 wkd 103 QSOs, see black lines on map.
DL to EA1, 5, 6, 7, EA9 G to EA5, 7, 9, CN GW to EA6 SV to EA4, 5, 6, 9
EA1 to I, S5, 9H, HA, IT9 9H to EA1, 2, 3, 4, 5 CT TK to EA7, EA8
IT9 to EA1, 3, 4, 5, 7, CT, F (at 10z also briefly to YO4) YO to EA6
SV9 to EA5 I to EA9 F to EA4, 5, 7, CT, 9H 9A to EA4, 5 OK to CT, EA4, 5
I to EA4, 5, 7, 9, CT EA8 to F, TK, EA1, 9A, G, I, OK (hrd) SV3 to 7X (hrd)

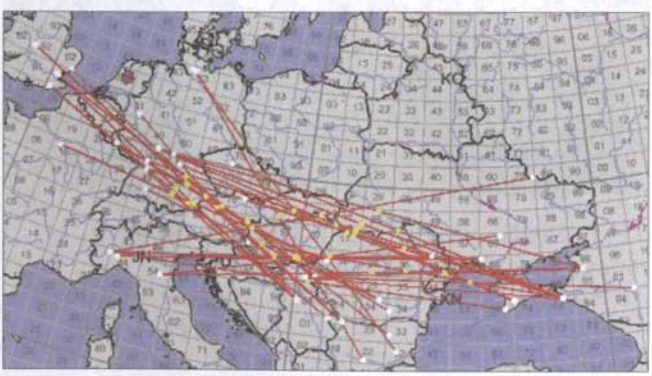
1320-1600z CT to CU3EQ and CU8DUB/B, CU3EQ to ZB2IT, EA7

1543 to 1617z SV8 to UA4 TA7 to OM3 UA6 to LZ, 9H, E7, 9A, YU
1722-1727z & 1750-1830z SV1 to EA5, EA6, F
1734z LZ to IH9
1743-1800 & 1824-1826z F to SV1, 2, 3, SV9

1848-1944z EA1 to HA, OE, S5, YU, 9A, YO, I3 HA to EA1, 2, F OK2 to EA4
SV1, 2, 3 to I, F, EA4, 5, 6 SV9 to I1, 2, 5, 0, F, TK
1912-1950z G/GW to I0, 5, IC8, 9H DL, SM7 to EA6 F to YO, YU, I
SP9 to EA4, 7 SP2 to EA4 OK1 to EA3, 5
(after the Es a strong FAI opening occured until about 2020z)
Best DX: 0926z 9A2SB JN95GM wkd EA8TX IL18QI 3620km (white line)
and hrd at about 19z CU3EQ HM68KP 3801km (see pink lines on map!).
0855z EB8AYA IL18 hrd OK1TEH JO70 3552km (when also CT1HZE wkd OK1)

Best MUF:
249.5 MHz over JN02 at 0909z EC4TR IN80 to F1USF JN23 719km
223 MHz over IN70 at 0948z CT1EAT IM68 to F0CYQ IN93 838km and
211 MHz over IN70 at 0940z CT1HZE IM57 to EA2AWD IN93 900km
189 MHz over JM39
Spot: KN45/55 JN14/24/15/25/35/36/46/02/03/13 JM18/19/28/29/38/39
IN73/83/93/84/82/82/92
IM45/56/57/58 IM18

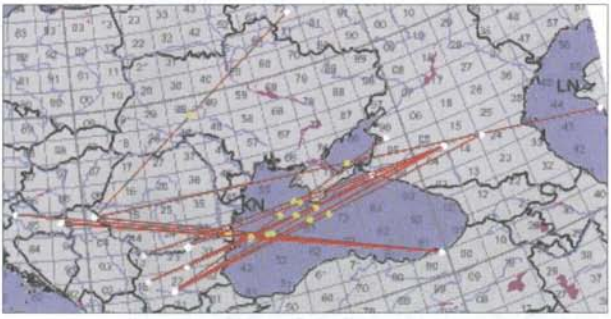
17 July - 1030-1127z UA6 to SV1, SV8, SV5
Best MUF 160 MHz over KN52
Spot: KN52



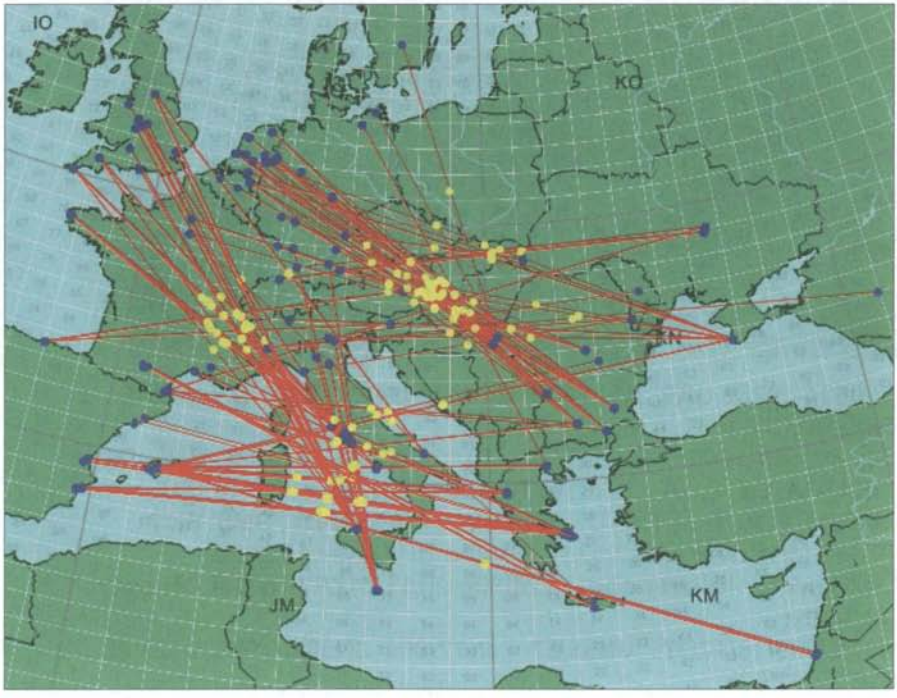
19 July - 0957z I1 to UT5 1110z YU to UA6 1123-1143z G to YU, YO
1318-1417z YO to DL, F, LX LZ to G, DL I1 to UR, ER
1544-1549z LZ to G
1808-1851z UR to I1 UA6 to DL, OE, HA, YU, I4, OK1 DL to UU, LZ, UA6
UR5 to I4
Best MUF 169 MHz over JN86, best DX DL to UA6 2200km
Spot: JN58/68 JN87/95/98 KN17/18 KN35/45/55

21 July - 1001-1009z CT to I1, YU (hrd only)
1601-1646z 9H to EA1, 2, 4, F EA4 to IT9, SV I7 to EA7 EA9 to I7, I8, I0, YU (hrd only)
Best MUF 164 MHz over JM49
1628z F to 9H
Spot: IN91/JN01 JN22 JM28/39

22 July - 1712-1713z: SW1MNE KM27 to DL (JO60 wkd, JO43 hrd) no map



23 July - 0938z YU to UA3
1002-1057z UA6 to LZ
TA7 to YU, 9A
Best DX: YT3I hrd UN7AX KN53 2415km
Best MUF 190 MHz over KN53 1014z UA6 to LZ over 1060km
Spot: KN43/53/63/64

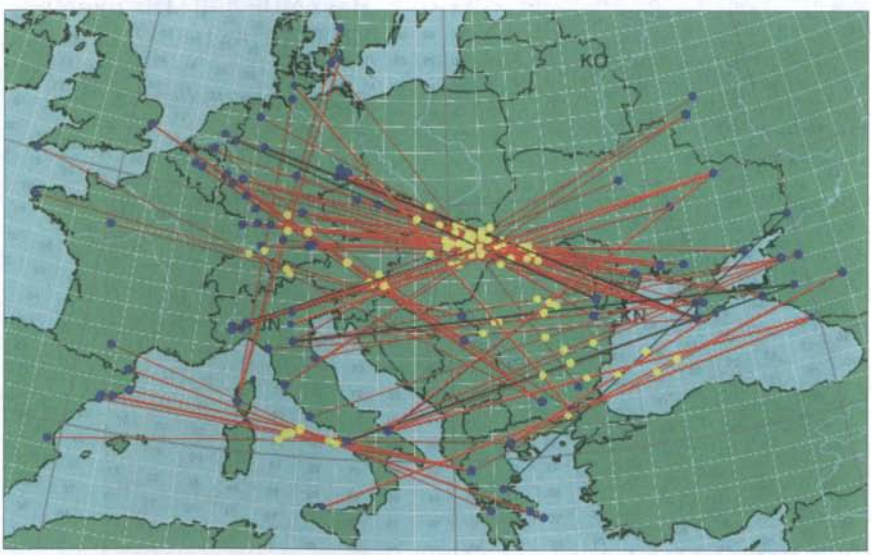


26 July

26 July - 0753z ER to I1, I5 0805z UA6 hrd I1
0808-0937z UR to PA, HB9, DL, F, EA6 N-DL to SV LZ to DL, LA, F, ON
YU to ON DL to YO, UR LZ F to LZ, YO, SV9 YO to F, LX, DL SM7 to YU
Best MUF 235 MHz over JN89 DF3RU JN59 to UT5DV KN18 at 0959z? And
185 MHz over JO80 DL to YU over 1105km
Best DX RT7G LN04 hrd I1DMP JN34 2658km at 0804z and
0916z EA6 to UR5 over 2583km

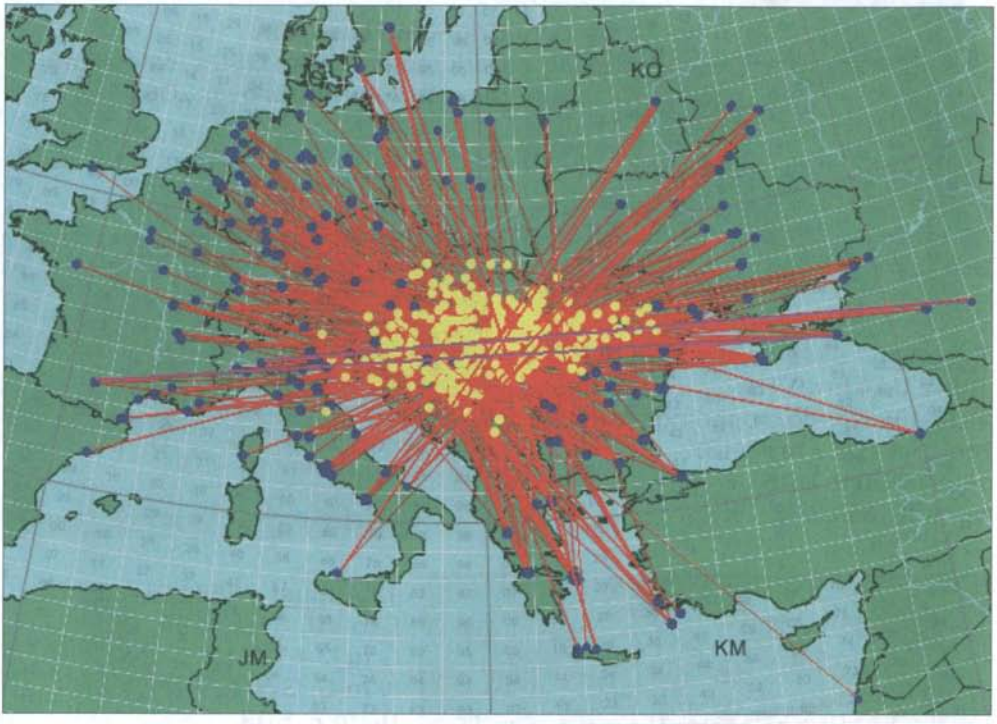
1401-1412 G (IO93) to I7
1555-1645z G to I0, I8, IT9 F to I0 IT9 to G OE to EA1 S5 to EA1 (hrd)
1703-1717z 9H to DL, I3, I4
1719-1843z EA6 to SV1, 2, 3, 6, LZ, 4X EA3/5 to SV1 F to SV6, SV9
Best MUF 198 MHz over JN60 I4 to 9H over 993km at 1705z
Best DX EA6VQ JM19 to 4X1GA KM72 2974km at 1723z
Spot: KN08/09 KN26 JN77/87/96/95 JN15/16/17/25/26
JN72/61/71/61/60 JM58/59/69

4X to F spot wrong on LiveMUF



27 July - 0804-0828z UA6/UU to SV2, 6 I7 to UA6 0900 IT9 to UA6
1240-1258z UA6/UR to I7, 4, 0, 8
1421-1520z & 1548-1646z UA3 to I3, 4 DL to YO, UR, ER, LZ, UA6, TK
UR to I, OK1, PA, S5, F, DL LZ to F, G, OZ, ON, DL YU to G, F
SV1/2/3 to EA3, EA5, F F to UR, YU, SV TK to N-DL, SM6, SM7
Best MUF 193 MHz over KN42 0837z SV2 to UU4 over 1033km
Best DX wkd PA to UR over about 2200km and LZ1ZP hrd G4LOH over
2455km at 1625z
Spot: KN07/08/09/18/17/27 JN58/57 JN77/86 JN50/51/60 KN25/26
KN33/34/52/53 MMMonVHF completely missing the EA to SV part

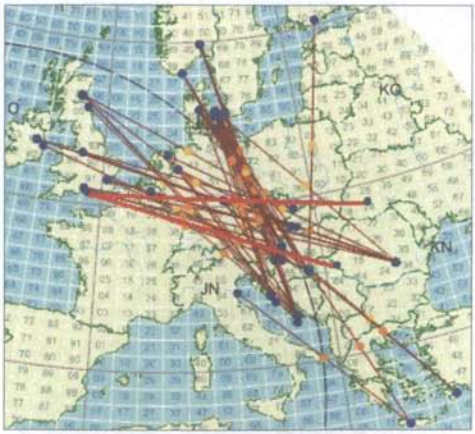
29 July - 1920-1927z & 1953-2002z & 2040-2110z: CT1HZE hrd CU8DUB/B 1950km, MUF 146 MHz, Spot: HN52 (no map)



30 July - 1409-1609z: UA6 to I1,2,3, S5, 9A, OE, HA, DL, F, HB9
LZ to OK1, PE, OE, S5, I, HB9, F, DL, ON F to YO, ER, LZ, UR
DL to LZ, SV5, SV, SV9, TA1, TA7, UR, YO, UA6 OE to UR, UA6, ER
PA/ON to SV2, SV5, YO SP to SV1,2,3, SV5, SV9 TA1D to HB9, SP, DL
I to UA3, UA6, UU, UR, ER, YO, LZ, EU IT9 to UA3, UR IS0 to UR
OK1 to LZ, UA6, TA, SV1,3,6 SV5 SM5 to SV3 SM7 to SV3,6 LZ TK to ER
UR to OE, S5, 9A, HB9, DL, I, E7, IS0 ER to 9A, EA3, F, I, OE, TK
EU to SV1,8, SV9, I5, I7, IT9 HB9 to LZ, UA6, UR, YO, TA7
1600z DL5MAE hrd 4Z5LY

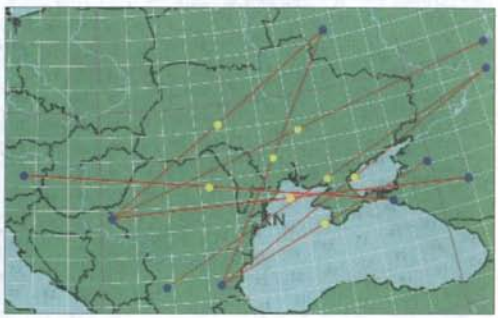
Best MUF 195 MHz over KN04/05 1556z S56ZM JN86 to LZ3GM KN32, 1015km and 191 MHz over KN15 1445z E77 JN84 to UR5 KN56 1056km and 186 MHz over JN95 1440z YO3FOU KN34 to IW3GXW JN65, 1096km. Best DX 1418z UC6A KN84 to F5BUU JN03 over 2845km (>30mins) and 1517z to F1USF JN23 2628km. And 1603z I2FAK JN45 to RW6HP LN24 2741km (see pink lines on map). ON/PA to SV5: 2500km

Spot: JN65/75/85/95/84/94/76/86/96/87/97/98
KN05/06/07/15/16/17/25/26/36/46

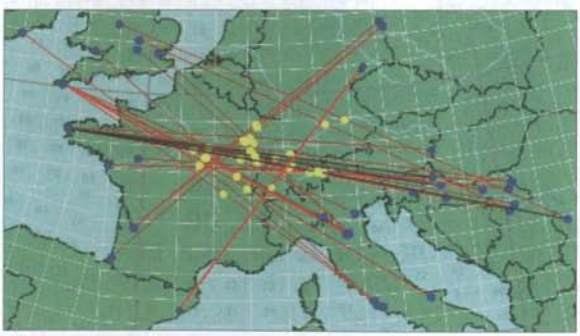


2 August - 1848z: G7RAU IO90 wkd UX2SB KN28IX (MUF 148 MHz)
Spot:
1901z: YT3I KN05 hrd G7RAU

Bright red lines: 2m
Dark red lines: 4m QSOs, calculated max. MUF 107 MHz over JO60



7 August - 0945-0958z: YT3I to RT7G
1004z UA4 hrd YT3I
1018-1054z: short openings only: LZ hrd UA4, UA3 hrd YT3I
1828z OE6 to UA6
Spot: KN55/66/36



19 August - 1650z-1738z:
F to YU, S5, HA, 9A, DL
G to I3,4,7,0, LZ
I0 to G, GW, EI
DL to F, EA3
Max. MUF 182 MHz over JN38
G to I4 at 1650z
Best DX 2100km LZ to G
Spot: JN17/26/27/28/38/47/58

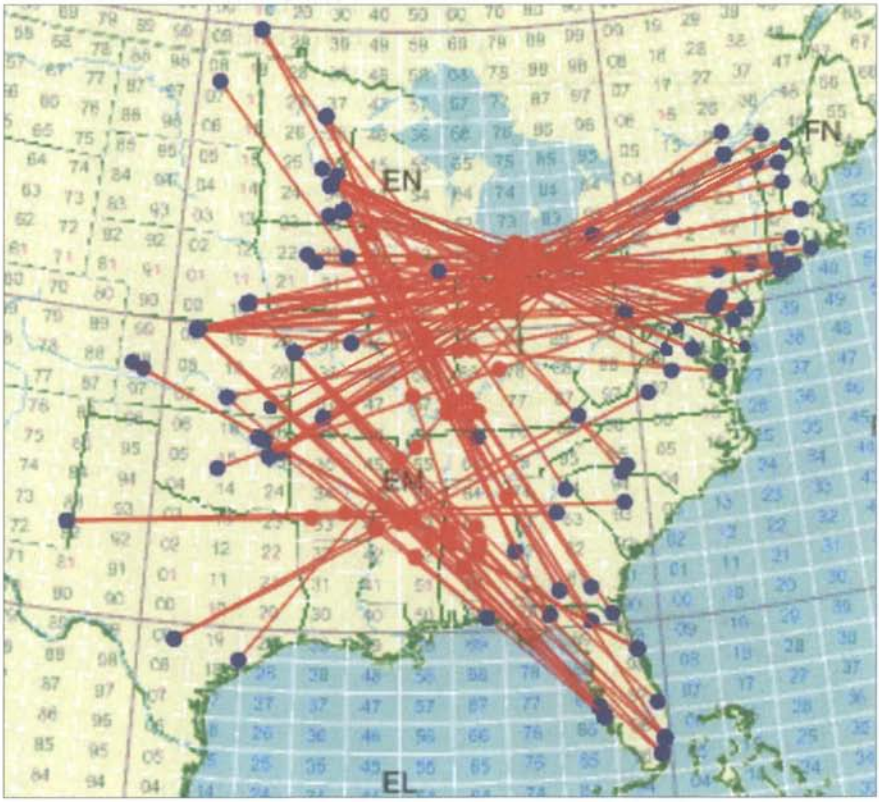
21 August - 1001z-1040z: EA8 to EA1
Best MUF 147 MHz over IM45
Best DX EA8 to EA1 over 2017km
Spot: IM45

(not covered by MMM / LiveMUF)

b.) North America

Note: On May 9th there was a good Tropo opening between Texas and Florida. By mistake all these QSOs were classified as "Es" by DX Sherlock and by GoodDX.

31 May - 2350-0000z: ZF1EJ EK99 to FM05, FM16 over about 1900km at 2310z AC4TO EM70 wkd C6ANX FL15 over 898km what would be equivalent to a MUF of 212 MHz over EL97!
Obviously there was a very high MUF spot over Eastern Florida, that was hardly usable due to missing stations on the Eastern and Southern ends of the possible paths.

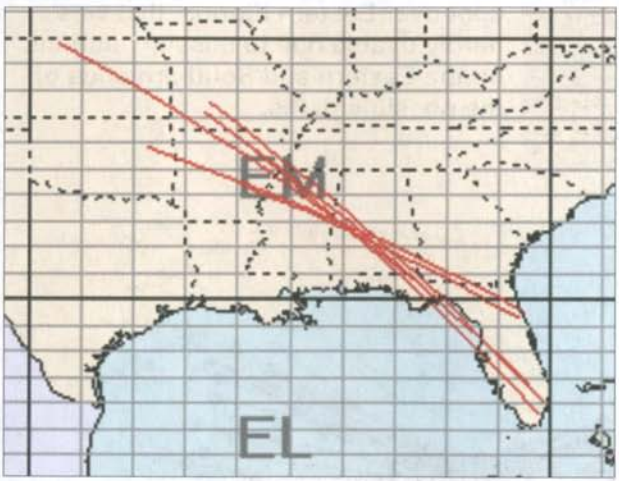


10/11 June

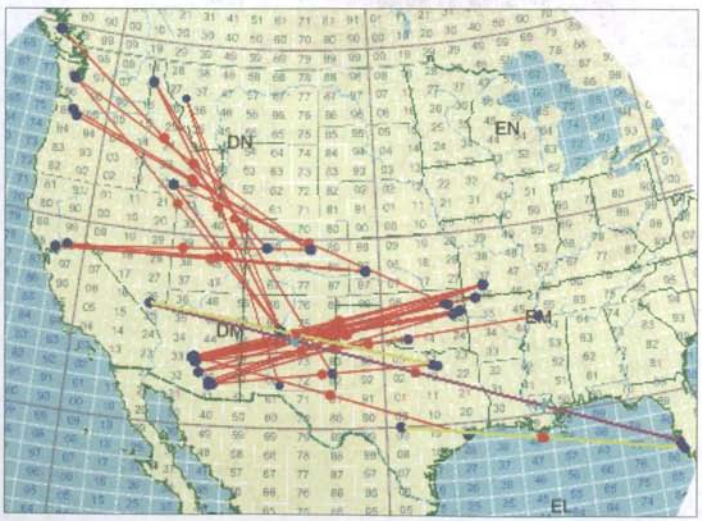
10/11 June - 85 spots: 2204-0155z: 3 hot spot areas: EM67, EM52, EN72

EM60 to EM26 DM82 to EM93/83 EL86 to EM09/36/37/17/29
EL99 to EM26, DM98 EL87/95 to EM09/29 EL09 to EM86, FM07
EL96 to EM29, EN32 EL97 to EM29 EM70 to EN10/33
EN33 to FN20, FM17/29 EN34 to FM08/29, EN90 FN31 to EN52/10, EM09
FN33 to EN10 FN13 to EM09 FN42 to EM09 FN34 to EM39
FN25 to EM26/29/39/25 EN92 to EM09/26/25 EM25 to FN35/44
FN30 to EN10/22, EM09/15 FN21 to EN10/32, EM09 EM66 to EN09/08
FN10 to EM09/17, EN34/32 EM84 to EN19 EN37 to EM72/94
EM09 to FM17/29 EN33 to EM80/81/70/90 EM95 to EN35
FN44 to EM26/27/25/29 EN34 to FM08/09/19/18/28/29, EN90

Best MUF: 190 MHz over EM43 at 2204z and 177 MHz over EN62 at 00:00z
Best DX about 2300km



12 June - 1245-1305z:
EM25 to EL99
EM37 to EL96/95
1750-1800z:
EM70 to EM09

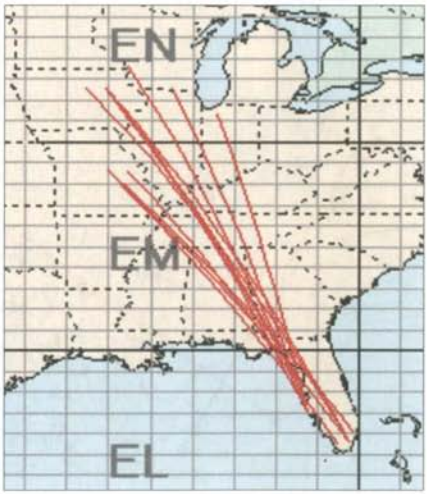


22/23 June

22/23 June – 22 June: 1525z N3LL EL86 to K4MMG EM00
1815z EL29 to DM33 DM26
1937-2006z & 2034z & 2128z DM26 to EM13, EL87
DM43 to EM25/26/04 DM42 to EM55/13/25/37 DM33 to EM26
Best MUF 172 MHz over DM74 at 1950z
Best DX 2003z KD4ESV EL87 to KT6KT DM26 over 3220km (pink line on map)
KT6KT wkd also to EM13 at about the same time (yellow line left), earlier EL86 wkd into EM00 (yellow line right), thus may be this QSO was a real double hop Es QSO. For sure it was the best 2m Es NA DX QSO for the 2011 season. KD4ESV hrd also another W7, but lost him in QRM.

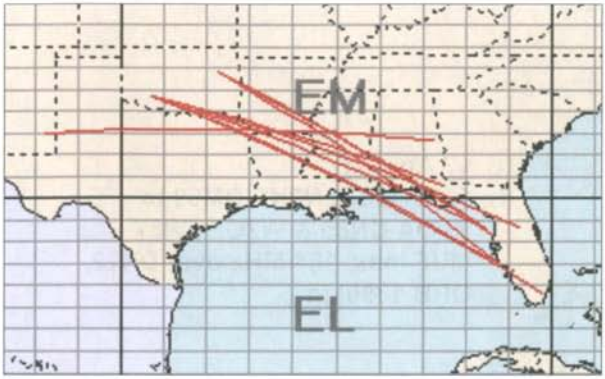
23 June: 0139z & 0157z & 0217-0241z
DM65 to CN87, DN17, DN27 DM69 to CN79 DM79 to CN85/97, CM98
DM98 to CM98 DM82 to DN17 DN22 to DM65, EM26
DM43 to EM36/37 DM33 to EM36 DN27 to DM62/65
Best MUF 188 MHz over DM48 at 0218z, best DX about 2000km

26 June - 0145-0145z: N3LL EL86 to W6ZI EM26 (no map)
1646km, MUF 153 MHz over EM51

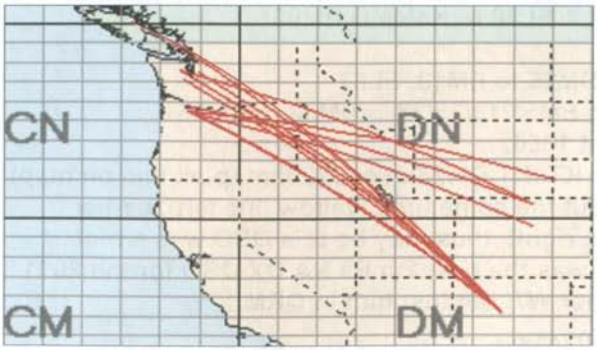


6 July - 0059-0155z: EL86 to EN32/43/52/61
EN32 to EL88/95
EM48 to EL88, 95, 96

At 1936z VE6ZT DO21 hrd K7XC DM09
1336km, MUF 166 MHz (if it was Es),
(not on map)

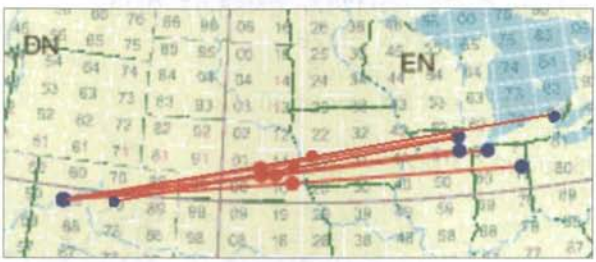


20 July - 0045-0146z:
EM25 to EL88/86
DM82 to EM72
EM04 to EL88/86/95/98, EM70/60
Best MUF 162 MHz over EM42
Best DX about 2000km



21 July - 0232-0255z:
DM65 to CN85/87/88/89, CO70
CN85 to DM65/79
DN70 to CN85/87
0325z CN85 to DN81

Best MUF 156 MHz over DN33
Best DX: 2245 km N5JEH
DM65 to VE7DAY CO70



22 July - 2149-2258z:
DM69 to EN51/52/61/70/82
DM79 to EN52
Best MUF 162 MHz over EN11
Best DX 2087km DM69 to EN82

3 August
2301-2303z N4QWZ EM66 wkd VE1AHM FN76 2122km and was hrd by VE9AA FN66. Max. MUF 146 MHz.

4 August
1045z K4YA EM86 wkd K0AWU EN37 1510km, MUF 157 MHz,
1235z K0KP EN36 wkd K4LX EM85 1568km MUF 155 MHz,
1334z K4YA EM86 wkd K0KP EN36 1427km MUF 161 MHz
(Map for Aug. 3 & Aug. 4)

17 August
1605-1614z N0KE DM69 to KI7JA CN85 & W7CE CN87
MUF max. 164 MHz over DN22, QRB 1390km

Comments: Thanks to G7RAU and his LiveMUF software for 95% of the maps and also to EA6VQ DX Sherlock for another few maps for NA. Again about 100 hours were spent for careful checking and redrawing where necessary to produce this 2011 Es summary. There are far too many mistakes in the reports and maps on the web which often cause false ODX and false max. MUF results for an opening. On many of the web maps there are also false lines, caused by 6m QSOs which were spotted by mistake on 2m or by other "smart" spots. During major openings it is normal that only up to about 50% of the QSOs are spotted on the cluster. Thus many lines are missing on maps that are published real time. Maps that are drawn automatically from unchecked logs often contain nonsense lines (e.g. into water or wrong areas) due to typos in the locators or because home locators are used although someone is operating portable. Thus it still makes sense to spend time and reedit and recalculate everything in case one has serious interest in Es propagation analysis.

Results: NA total 2011: 14 calendar days (UTC days) with 2m Es openings. Would be 2 days less if local time days would be taken. This is about the same as in 2010. EU total 2012: 47 calendar days with 2m Es vs. 42 in 2010, so about 10% more.

NA	May	June	July	August	TOTAL
2009	0 (0)	12 (0)	15 (1)	1 (0)	28 days
2010	1 (0)	9 (1)	4 (1)	0 (0)	14 days
2011	1 (1)	6 (0)	4 (0)	3 (0)	14 days

EU	May	June	July	August	TOTAL	2m Es hours
2009	3 (1)	23 (7)	14 (2)	8 (1)	48 days	64,3
2010	11 (2)	19 (7)	9 (1)	2 (0) 1 Oct.	42 days	90,0
2011	9 (1)	14 (3)	20 (4)	4 (0)	47 days	81,3

In brackets the number of days with MUF >200MHz. The 2011 numbers show that the level of 2m Es still remains relatively high, if we look on the count of the UTC calendar days. May be we have achieved a point now, where our proxy for the Es level, namely "UTC calendar" days starts to show weakness. The reasons could be that nowadays almost any little opening with just 1 QSO or a single beacon spot is detected, reported, and counted. Tools like the great LiveMUF software, realtime warnings and fast internet access also in countries in Eastern EU and remote areas are the reason. This was for sure not the case 10 years ago for Eastern and remote countries and 15 to 20 years ago also in western Europe. Thus the total number of observed 2m Es UTC days may be on a higher level now compared to 10 or 20 years ago. Due to the many available and exact date for sure it would make sense to switch to a more exact measure now, namlely the observed hours (or minutes) of 2m Es. We have calculated this number for the last 3 years, see table above. We already see a remarkable difference vs. the UTC day result:
2010 to 2011 was 42 to 47 UTC Es days, but 90 to 81 Es hours! Thus 10% less, if we count the hours.
The figure for the Es hours was gained from the above published reports of the single openings. On the web there are published automated evaluations of the 2m Es time which were gained from the "2m Es open status" from alert systems. These give the following numbers for the 2m Es hours: 2009 (140), 2010 (153), and 2011 (146). One can see that these numbers are too far away from the reality.
In 2011 3 Es calendar days result from observations of only the CU8DUB beacon, 2 of the days were observed only by CT1HZE. So, one can see that without CU8DUB and/or CT1HZE the day count would have been already less. 10 and more years ago there was no CU 2m beacon (and no CT1HZE). So we can not compare the total day levels from 10 and 20 years ago with nowadays, but we have to look very carefully on the tendencies.

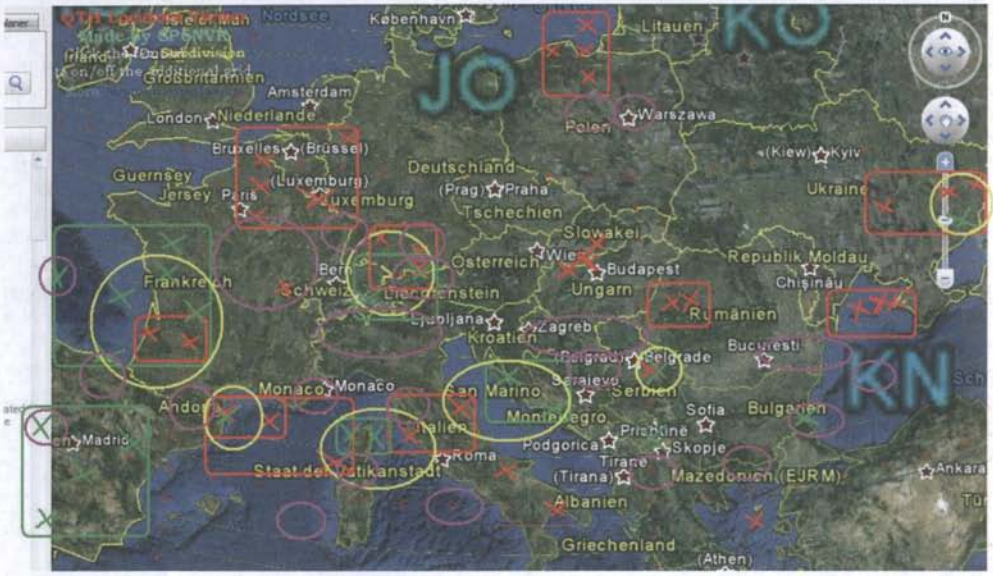
It is also interesting to check again for Es hot spots on consecutive days. In 2011 for Europe there are 11 (2010: 7 and 2009: 15) pairs of consecutive days where a perfect or very good geografical correlation can be found:

May: 24 to 25
June: 1 to 2, 2 to 3, 3 to 4, 14 to 15, 17 to 18, 28 to 29, 29 to 30, 30 to July 1
July: 15 to 16, 26 to 27

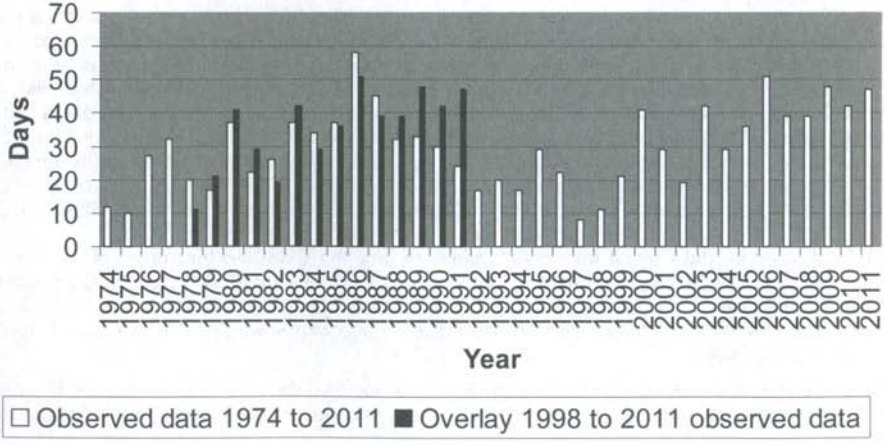
For North America there is again just 1 of such pairs (2010: 1, 2009: 3):
June: 11 to 12

As already presented in DUBUS 1/2012 on p. 124/125 in Australia/New Zealand the number of 2m Es days in the southern summer season 2011/2012 was only 8. (vs. 13, 15 and 18 in the 3 previous years).

The next map shows the spots over Europe with MUFs > 180 MHz for the years 2009 (GREEN), 2010 (RED) and 2011 (PINK). Again we can see that in certain areas there seems to be a higher probabilitiy for Es than in others.



Map: PINK circles denote 25 spots with MUF >180 MHz on 18 different calendar days in 2011 – RED are the areas with MUF >180 MHz in 2010 (16 days) and GREEN are the areas with MUF>180 MHz in 2009 (17 days). Yellow are the overlapping areas from 2009 and 2010.



The above figure shows the annual numbers of observed 2m Es days in Europe from 1974 to 2011 (white bars). In total 1128 days were observed. The black bars are overlay data from 1998 to 2011. The white bars from 1992 onwards are also the current forcast for the years from 2012 onwards.

In 2011 the total number of UTC calendar days with 2m Es openings in Europe was 47 (vs. 42 in 2010). Although the absolute number of openings in general is still high now due to the prolonged solar cycle minimum and may be also due to better alert possibilities and cluster network than 20 years ago, we see a decrease of 2m Es hours in EU by 10% from 2010 to 2011. If the theory and forcast as presented in [1] are right, we should expect also significantly less 2m Es days and hours in 2012 and the following years for EU and NA. In VK/ZL we have already seen a very sharp drop in the 2011/2012 season.

[1] Joachim Kraft, DL8HCZ/CT1HZE: Midlatitude Sporadic E on VHF in correlation to the 22-year Magnetic Cycle of the Sun, DUBUS 1/2008, p.9-23.

Kompakte 1 KW Hochleistungs-endstufe für 432 MHz mit 2 x MRFE6VP5600H – Teil 2

von Remco den Besten, PA3FYM (mit Hilfe von Michel Rousselet, F5FLN)

Einleitung

Als aktives Mitglied einer Kontestgruppe in den Niederlanden bin ich immer auf der Suche nach Optimierungen für unsere Kontest-Station. Unsere 70cm-Station arbeitet seit mehr als 20 Jahren fehlerfrei. Obwohl ein bekannter Spruch lautet „man solle nie eine gewinnende Station" verändern, gibt es doch einen Parameter, der immer weiter optimiert werden kann: Das Gewicht.

Gerade als ich einige anfänglichen Berechnungen anstellte und über ein einfaches und leichtes (!) Design für eine KW-SSPA für 70cm philosophierte, publizierte Michel, F5FLN, seine SSPA für 50 MHz [1]. Wenn man diese 50-MHz-PCB aus dem „UHF-Blickwinkel" betrachtet, fallen einem die Eingangs- und Ausgangsleitungen ins Auge. Der 50-MHz-PCB-Aufbau wurde also für 432MHz modifiziert und einige Prototypen aufgebaut. Die Ergebnisse wurden in der letzten DUBUS-Ausgabe veröffentlicht [2].

Dieser Artikel beschäftigt sich nun nochmal weiter mit dem Design, der Verwendung alternativer Bauteile und einem günstigeren Combiner zur Zusammenschaltung der beiden Platinen. Das Ergebnis ist eine leichte, lineare Kilowatt-PA für 432 MHz nach dem Stand der Technik. Das Gewicht meiner Platinen, des Kühlkörpers und des Gehäuses beträgt 3.5kg. Mein Netzteil wiegt 6,5kg, so dass es insgesamt 10kg sind, d.h. 10 Gramm pro Watt!

Wie Michel in seinem Originalartikel [2] bereits betont hat, möchte ich auch hier nochmal darauf hinweisen, dass Erfahrung mit Hochleistungsendstufen (SS) vorhanden sein muß, um dieses Design erfolgreich nachbauen zu können.

Beschreibung des Designs einer Platine

Mein Motto ist immer "man soll verstehen, was man baut". Besonders bei dieser Art von Verstärkern und diesen Leistungen für den Amateurfunkgebrauch. Deshalb hier noch mal eine kurze Rekapitulation einiger der Anmerkungen von Michel (die auch meine sind!), die im Artikel in [2] erwähnt wurden.

Eingangskreis: Ein ca. 1/4λ 50Ω-Koaxialbalun transformsiert den unbalancierten 50Ω-Eingang zu zwei phasenverschobenen balancierten ca. 25Ω-Ausgängen. In der Praxis scheint hier eine kleine Induktivität in Serie mit dem Eingangsbalun notwendig zu sein, um die Eingangsanpassung realisieren zu können.

Mittels Streifenleitungen und Kondensatoren werden die balancierten ca. ~25Ω-Impeanzen in 3 Schritten auf die komplexen konjugierten Eingangsimpedanzen von jedem Chip (Zin = ~0.5 + j1.2 Ω) des LDMOS-FETs transformiert. Die balancierte Ausführung des Eingangskreises ermöglicht, dass die Anpassungs-kondensatoren floaten können. D.h. sie benötigen keine Erdung und ihre Kapazitäten entsprechen der Hälfte des Wertes der Einzelnen. Die Eingangsanpassung wird mit einem Trimmer optimiert. Also ist der Balun Teil der Anpassung, was ganz bewusst so bei der Wahl des Designs gemacht wurde.

Ausgangskreis: Die Ausgangsimpedanz eines Chips bei 432MHz wurde gemessen als $Zout$ = ~1.3 + j0.3 Ω mit Vdd = 48V, Idq = 1A, Pout = 500W. Diese Ausgangsimpedanz wird in 3 Schritten mittels Streifenleitung und Kondensatoren auf ca. 25Ω transformiert. Der Ausgangskreis ist vor dem Ausgangsbalun balanciert, so dass die Anpassungskondensatoren ebenfalls floaten. Die balancierten 2 x ca. 25Ω-Ausgänge werden gleichzeitig umgekehrt phasenverschoben und in einen unbalancierten 50Ω-Ausgang kombiniert unter Verwendung eines ca. 1/4λ 50Ω-Koaxialbaluns. Die Länge des Baluns ist in der Realität ca. 10% kürzer als 1/4λ. Die endgültige Anpassung des Ausgangskreises wird mit einem 3-16 pF Glas-Trimmer hoher Güte optimiert. Einige Leser mögen dies nicht für die „schönste" Lösung halten, aber für den Amateurgebrauch und die Praxis hilft es drastisch, wenn der Balun „in der Anpassung" ist.

Hinweise und Tipps für den Aufbau

PCB: Die TC350-PCB ist "Hochleistungsmaterial" und man wird schnell merken, dass man einen heißen Lötkolben (mit einer kleinen Spitze) braucht, damit das Lot fließt. Als erstes die SMD-Komponenten, Kupferfolie und die ATC-Kondensatoren einlöten. Hinweis: Mit dem Einbau der 4 x 5.1 pF ATCs im Ausgangskreis noch warten, siehe weiter unten. Wenn alle Komponenten auf der PCB montiert sind, überschüssiges Flussmittel mit Aceton oder einem anderen polaren Lösungsmittel entfernen.

Ausgangskreis:

Balun: Dafür wird 0.141 Zoll Semirigid-Koax (z.B. SM.141, KTR 141-50) verwendet. Man bekommt es relativ leicht geformt und es bleibt auch in der Form. Auch wenn man RG142-Koax auch verwenden kann, braucht man hier doch viel Mühe, um davon 11cm so zu biegen, dass es schön auf die PCB passt und keine Verspannungen bleiben. Jedes HF-Board besteht in der Tat aus zwei Verstärkern. Aus der HF-Perspektive könnte man damit eventuell nicht einverstanden sein, aber aus meiner Perspektive, wenn ich die Eingangs- und Ausgangsbaluns montiere, muss man ihre jeweiligen Positionen beachten: Man muß sicherstellen, dass die Eingangs- und Ausgangsbaluns auf jedem Board zueinander spiegelbildlich sind. Folglich müssen Innen- und Außenleiter von sowohl Eingangs- und Ausgangsbaluns mit den selben Transistor-Chips verbunden werden.

ATC-Kondensatoren: Wie Michel bereits in seinem Artikel [2] erwähnt hat, fließen aufgrund der niedrigen Ausgangsimpedanz des Transistors hohe (HF)-Ströme im Drain-Breich. Auf den ersten Impedanz-transformationsschritt muss deshalb besonderes Ausgenmerk gelegt werden. Es scheint, dass die ESR-Werte von normal erhältlichen Hochstrom-Kondensatoren (z.B. ATC100B) nicht ausreichen, um nur einen einzelnen ca. 20 pF Kondesator für diese Leistungen und Frequenz einsetzen zu können. Michel hat hier spezielle CLX 18 pF Kondensatoren von Temex verwendet. Ich habe stattdessen 4 x 5.1 pF ATC100B Kondensatoren parallel verwendet. Die Eigenschaften von (überlicherweise) erhältlichen Kondensatoren scheinen der limitierende Designfaktor für eine 1-Transistor-Lösung mit z.B. dem MRFE6VP61K25H auf 432 MHz zu sein. Ich habe einige Berichte und Gerüchte von professionellen HF-Ingenieuren und Amateuren gehört, die bei alternativen Designs bzw. Versuchen mit 500 Watt auf 432 MHz explodierende bzw. schmelzenzde Kondensatoren im Ausgangskreis hatten.

Die 4 x 5.1 pF ATCs vertikal so nebeneinander einsetzen, dass die Gesamtlänge der Kondensatorbank kleiner (ca. 8mm) ist, als wenn sie horizontal (die "normale" Postition) montiert wären.
Die Position dieser ATCs ist sehr wichtig, um die 500 Watt Output bei einer vernünftigen Effektivität zu erreichen. Wenn die zweite Anpassungszelle, d.h. die Streifenleitung zwichen den 4 x 5.1 pF und dem 10 pF Kondensator zu kurz ist, verkleinert das die Strommenge, die man in die FETs „pumpen" kann, weil an den Drains eine zu hohe Impedanz gesehen wird. Ich habe die besten Ergebnisse erhalten, wenn ich den „ersten" 5.1 PF ATC ca. 9mm entfernt vom FET-Gehäuse eingelötet habe.

Abb. 1: Nahaufnahme des Anpassungskreises im Ausgang.

Drain-Induktivitäten: Die Drain-Induktivitäten in Richtung Netzteil (V*dd*) wurden mit 50 nH berechnet, z.B. also 3 Windungen 1mm CuAg mit 7mm Durchmesser. Aufgrund der hohen Ströme habe ich mich hier aber mit dickerem Draht besser gefühlt. Um die selbe Induktivität zu erhalten, habe ich 3 Windungen 1.6mm CuEm mit 8mm Durchmesser verwendet.

Eingangskreis: Hier gibt es keine Besonderheiten. Entweder verwendet man das gleiche Koaxkabel wie im Ausgangsbalun, oder Koax mit kleinerem Durchmesser, wie z.B. RG178 oder SM.186.

Kühlkörper: 2.5mm Löcher bohren: Beim Bohren mit Methylalkohol oder Alkohol schmieren und kühlen, um ein Stocken oder Brechen des Bohrers zu vermeiden. Wenn man geeignete Kühlkörper für diese Leistungen verwendet, beträgt die Tiefe dieser Löcher ca. 8 bis 10 mm. Aluminium kann leicht schmelzen, wenn man Löcher dieser Tiefe bohrt. Mit einem M3-Gewindeschneider nun die Gewinde für die M3-Schrauben schneiden. Wenn man eine Bohrmaschine fürs Gewindeschneiden verwendet, muß die schwächste Position gewählt werden, um ein Abbrechen des Schneiders zu vermeiden. Auch hier mit Methylalkohol oder Alkohohl kühlen/schmieren, um das Risiko eines im Kühlkörper steckenden abgebrochenen Gewindeschneiders zu minimieren, inkl. der damit verbundenen Frustration.
Man verwende nicht den 35.56mm Montageabstand ('G') für die Transistoren (NI-1230 Gehäuse), wie er im Freescale-Datenblatt angegeben ist. Besser ca. 1 mm mehr nehmen. Die Köpfe der meisten M3-Schrauben haben nämlich solche Durchmesser, dass diese sich sonst in das keramische Material des Transistors eindrücken und die Schraube ggf. auch nicht richtig sitzt.
Die Transistoren nicht auf eloxierten (z.B. schwarzen) Aluminium-Kühlkörpern montieren. Mit einer Fräse einen ca. 10mm breiten und 1.0mm tiefen Streifen in den Kühlkörper fräsen, um die Transistoren abgesenkt montieren zu können, so dass dessen Anschlüsse schön passend auf der PCB liegen.

Kontrollieren, ob die Oberfläche der Transistorverbindung eben und schmutzfrei ist.
Obwohl nicht zwingend nötig, ist ein Kupferwärmeverteiler doch sehr empfehlenswert. Wärmeleitpaste (z.B. Arctic Silver 5) unter den Tranistoren verwenden. Nicht zu viel davon, nur gerade so viel, wie nötig. Dann die Transistoren über die Fläche des Kühlkörpers reiben und fühlen, wie sie durch die Adhäsionskräfte „kleben". Dann die Transistoren festschrauben. Die Muttern dabei nicht bis ¼ Drehung vorm Zerbrechen anziehen, da die Spannung auf die mechanische Transistorverbindung zu hoch werden könnte, so dass die Chips innen unter Spannung geraten könnten, wenn sie heiß werden. Ich habe das Drehmoment bei mir nicht gemessen, aber wenn man mit einem elektrischen Schrauber auf der 2. kleinsten Stufe anzieht, sind die Transistoren fest genug montiert.

Transistoren: Wie im ersten Artikel vorgeschlagen, sollte man die Oberfläche mit PM1200-Schleifpapier auf einer Glasunterlage glätten, in dem man achtförmig darüber geht. Michel verwendet den MRFE6VP5600H. I verwende (weniger robust, aber billiger) den MRF6VP2600H, der etwa 2 dB weniger Verstärkung hat. Die Ausgangsleistungen und Effektivitäten bei 432 MHz sind bei beiden gleich. Der 5600H ist aber besser gegen Fehlanpassung geschützt. Das kann eine Designentscheidung sein, wenn man nur ein Board aufbaut. Wenn man zwei Boards zusammenschaltet, agiert der Combiner im Ausgang gleichzeitig als Schutz gegen Fehlanpassung (siehe weiter unten).
Wie zuvor erwähnt, fließen hohe Ströme in und um die Drain-Bereiche. Die Sources der FETs werden durch den Kühlkörper geerdet. Das erfordert fehlerfreie HF- und elektrische Leitfähigkeit zwischen PCB und Kühlkörper. Um auf der sicheren Seite zu sein und um „ungewöhnliche Phänomene" zu vermeiden, empfehle ich, zwei Lötösen unter den M3-Muttern bei jedem Transistor zu legen. Diese werden dann mit der Massefläche auf der PCB verlötet. Siehe Abb. 1.

Inbetriebnahme der einzelnen Boards

Zur Inbetriebnahme der HF-Boards bitte nochmals Michels Artikel [2] konsultieren. Den Ruhestrom (ca. 1A) einjustieren unter Verwendung eines Netzteils mit Strombegrenzung. Die Grenze zwischen „kein Strom" und „zu viel Strom" ist recht scharf. Die Steuerleistung nochmals überprüfen, um sicherzustellen, dass die Boards nicht übersteuert werden. Diese LDMOS FETs sind Leistungs-FETs, d.h. sie sind schon dafür gebaut, „Strom fließen zu lassen". Sie werden das also sicher tun .... bis zu einer bestimmten Grenze. Der „Spielraum" bis dahin ist nicht sehr groß, wenn die FETs vernünftig angepasst sind. Die Eingangskreisanpassung kann anfangs ohne Drain-Spannung erfolgen, d.h. mit einer „kalten" Platine. Dazu ca. 1 Watt Treiberleistung anlegen und den Eingangstrimmer auf minimale Reflektion stellen. Wenn die Platine den vollen Output liefert, kann er noch mal nachjustiert werden. Dann den Ausgang der Platine über ein Wattmeter an einer geeigneten 50-Ohm-Last anschließen. 1 Watt Steuerleistung anlegen (mit allen Spannungen nun). Wenn man nun nicht sofort ca. 150 Watt Output sieht, bei ca. 10 A Drainstrom, sofort stoppen und nochmals die Ein- und Ausgangskreise genau kontrollieren. Wenn nun alles gut aussieht, langsam die Steuerleistung erhöhen. Mit ca. 7 Watt Input sollten ca. 500 Watt Output erzielt werden, bei einer Effektivität von ca. 67% (50V/15A). Wenn das nicht der Fall sein sollte, stimmt etwas nicht. Die Effektivität des Boards kann mit dem Glas-Trimmer im Ausgangskreis optimiert werden. Es ist möglich, auch noch mehr Output zu erhalten, aber unter Verlust von Linearität.

Bekannte Probleme

Es kann passieren, dass die Platine (weit) unterhalb 500W in Sättigung gerät, d.h. man nicht „genug Strom fließen lassen kann". Höchstwahrscheinlich sieht der Transistor dann keine ausreichend niedrige Impedanz an seinen Drains, d.h. die Anpassung der ersten Stufe ist suboptimal. Die Neupositionierung von einem oder einigen der 5.1 pF ATCs kann hier ggf. Abhilfe schaffen. Dazu den am weitesten Richtung Drain liegenden 5.1pF ATC in Richtung Drain versetzen und die Effektivität des Boards mit dem Output-Trimmer neu abstimmen, um zu sehen, ob es eine Verbesserung gibt. Ich habe ca. 500 Watt erreicht, als der erste 5.1pF ATC ca. 9mm vom FET-Gehäuse entfernt lag, siehe Abb. 1. Das kann aber individuell variieren.

Zusammenschaltung der zwei Boards

Im Original-Artikel [2] werden zwei HF-Boards mittels eines kommerziellen (und teuren) 90-Grad-Kopplers zusammengeschaltet. Ich habe die Hybridkoppler im Eingang und Ausgang mittels 1/4λ-Stücken (d.h. 120mm) aus 75Ω PTFE-Koaxkabel realisiert.

Abb. 2: Die Anordnung des Hybridkopplers im Ausgang zur Zusammenschaltung von 2 Platinen.

Ein Hybrid-Koppler kann auf verschiedene Weisen angeschlossen werden. Ich habe die Variante nach Wilkenson gewählt. Folglich gibt es keine (zusätzliche) 180-Grad-Phasenverschiebung für die eine Hälfte,

wenn man die „Ausgangsseite" betrachtet. Als 50-Ohm-Last wird ein „HF-Widerstand" verwendet, der auf dem Kühlkörper montiert ist. Die Konfiguration des Ausgangskopplers ist in Abb. 2 gezeigt. 180-Grad-Phasenverschiebung von einer Seite in Richtung Last wird realisiert durch Verdrillen von Innen- und Außenleiter von einem 1/4λ-Stück. Ich habe eine Sonde für eine mögliche VSWR-Schutzschaltung hinzugefügt. Wenn die Anpassung des Verstärkers suboptimal ist, oder wenn man „vergessen hat", eine passende Last anzuschließen, kann damit die PA abgeschaltet werden. Schaltungen dafür wurden bereits genügend publiziert. Abb. 4 zeigt meine Interpretation des Hybridkopplers im Ausgang.

Abb. 3: Gemessene Ausgangsleistung vs. Treiberleistung bei zwei zusammengeschalteten 2600H-Boards.

Beim Eingangskoppler werden die Ein- und Ausgänge vertauscht, und die 50-Ohm-Last kann kleiner sein. Der VSWR-Schutz wird hier weggelassen und das Koaxkabel kann dünner sein. Ich habe RG179 verwendet.

Inbetriebnahme der zusammengeschalteten Boards

Sobald die beiden Platinen separat auf maximalen Output und Effektivität abgestimmt worden sind, ist die Inbetriebnahme in Kombination nicht mehr schwierig. Man macht es genau so, wie bei einer einzelnen Platine. Sobald die volle Steuerleistung (d.h. ca. 15 Watt) erreicht wurde, werden zuerst die Eingangstrimmer auf maximalen Output und maximalen Strom justiert. Dann werden die Ausgangstrimmer auf maximale Effektivität justiert. Die Ergebnisse meiner Experimente sind in Abb. 3 dargestellt. Die gemessene Effektivität beträgt 68% bei 1050 Watt Output. P1dB ist ca. 900 Watt.

Abb. 4: Nahaufnahme des Ausgangs-Hybridkopplers, der aus zwei Stücken RG302 und zwei HF-Widerständen KTR-141 75 besteht.

Schluß

Da NXP keine Muster anbietet, konnte ich nicht ausprobieren, ob dieses Design auch mit den Äquivalenttypen von NXP arbeitet. Zum Zeitpunkt des Erstellens dieses Artikels kann ich versichern, dass auch noch kein funktionierendes Design mit z.B. einem BLF574 im 500-Watt-Bereich auf 432 MHz publiziert wurde oder darüber berichtet wurde.

Danksagung

Vielen Dank an Michel, F5FLN für seine großartige Unterstützung und die guten und ertragreichen Diskussionen, die wir bezüglich dieses Designs und über HF-Leistungsdesigns im allgemeinen hatten. Dank an John, PA7JB für das Fräsen der Vertiefungen in meinem Kühlkörper und an Hans, PE1CKK für das Abkanten des Aluminiums und Leihen des 50V-Netzteils.

Referenzen

[1] Michel Rousselet, F5FLN, A compact 50MHz High Power Solid State Amplifier using the MRFE6VP6125KH, DUBUS, 4/2011 pp 9

[2] Michel Rousselet, F5FLN, A Compact 1kW 432 MHz High Power Solid State Amplifier using 2 x MRF6VP5600H, DUBUS 1/2012, pp 9

Abb. 5: Bestückung der Platinen. Hinweis: Anfangs wurden die ATC-Kondensatoren im Ausgang gleich mit eingelötet, die Praxis zeigte aber, dass ihre Positionen sehr kritisch sind. Ein Justieren ihrer Positionen scheint unumgänglich. Foto: PA7FA

Abb. 6: Der KW-Verstärker in einem temporären Gehäuse. Gewicht: 3,5 kg. Der Kühlkörper ist ein Kühlaggregat, Abmessungen 200 x 125 x 75mm. Die Lüfter sind vier kleine 12V-Lüfer in Serie. Das 50V/60A-Netzteil (links) wiegt 6.5 kg, was insgesamt in 10 Gramm pro Watt für den ganzen Aufbau resultiert! Foto: PA3FYM

Development and Real World Replication of Modern Yagi Antennas (I)

by Justin Johnson, G0KSC

In this article I will look at the design and construction of an OWL (Optimised Wideband Low impedance) Yagi, which is fed with a folded dipole to create a directly-fed 50 Ω Yagi antenna (12.5 Ω with split dipole). I have chosen to describe a mechanical construction method which I do not favour (in addition to favoured methods) because others may be happy with a Yagi antenna constructed this way.

After initial publication of the original OWL concept and several designs within the pages of DUBUS and on my website (www.g0ksc.co.uk), development did not stop. In fact there is now a rather large set of antenna design files within the G0KSC vault which show extremely good results in terms of gain, bandwidth, F/B, noise temperature and ultimately G/T.

Over the last couple of years I have experimented with several optimisation methods including some very sophisticated software packages. However, it seems that use of any of these (and perhaps others too) could quite easily uncover the same pitfalls in each and not provide exceptional results unless re-optimisation is carried out again and again (to establish better results and where the optimiser self-guidance has it wrong) while at the same time, limiting the control of certain parameters to the optimiser, where if left to its own devices, the optimiser would guide itself along a less than optimum path.

I think the general shape of the Yagi today (in terms of pattern, bandwidth and accepted F/B) is largely due to common optimisation directives being left to the optimiser to handle itself and thus remaining unchallenged by the antenna modeller, who leaves too much control to the software. Everyone has their 'wish list' when designing antennas and one of mine was adopted from the Yagi design Guru and my mentor YU7EF, that of a 50 Ω feed point impedance. I still believe that ***if an antenna is designed correctly, it does not need to be matched to 50 Ω, it should already be 50 Ω!***

The main difference between what I am doing now and the fantastic achievements of modern-day designers such as YU7EF and DK7ZB, is that I am looking to reshape elements within the early sections of the Yagi (or driver cell, in DG7YBN's terms) to modify the impedance to 50 Ω exactly. The reason for this element modification is due to the limitations that can be seen in a 50 Ω dipole-fed Yagi with traditionally straight elements over lower impedance dipole-fed Yagis. In a previous article in DUBUS I discussed the experiments I had conducted with a 2 m Yagi model where in order to achieve good levels of F/B and reduced side lobes, bandwidth had to be sacrificed within a 50 Ω split dipole Yagi, yet when I re-optimised the same antenna with a feed-point impedance of 40 Ω instead of 50 Ω, a much wider bandwidth was possible without having to sacrifice any other performance parameter. In fact, better F/B and more highly suppressed side lobes were seen as well as a small increase in gain.

So why not just install a matching device? For me, this is one of the biggest Yagi issues still not appreciated by amateurs largely because we accept the common methods of optimisation in use as being correct and having no impact on performance. As I have discussed previously, programs such as YO (Yagi Optimiser by K6STI) have the ability to model with a variety of different matching devices installed on the antenna being optimised. However, these programs (which are now many years old) **were never then, and are still not able to model the physical presence of a matching device** and the impact it can have on the performance of the Yagi. These programs were only ever capable of predicting the likely impedance change the device would have on the antenna, that's all. Therefore, in the absence of any software capable of modelling such arrangements accurately every time, the results are often a lottery.

Attempts to model such arrangements can result in false calculations due to convergence errors in even the most current calculation engines (such as NEC4.1) and therefore practical modelling of such arrangements is very difficult to achieve and thus real world testing is the only real option to confirm such an antenna is working correctly (or not, as the case may be).

Various different types of matching device and the way in which they are installed provide varying levels of distortion and/or impedance shift. However, any issues created by such devices can often be difficult to establish. Due to the nature of the device, adjustments are made to the match until a good SWR figure is seen, so any issues created by its own presence may therefore be hidden and the designer/builder unaware of the performance degradation that has occurred.

When I have conducted tests upon lower impedance antennas requiring matching, I found that DK7ZB style match to have no detrimental effects in terms of pattern distortion. This is largely due to the fact that it is coaxial and taking the route any coax cable would normally take, and provided it remains close to the boom any potential issues will remain small. However, the same input power limitations remain with this match as with other matching methods and if good quality coax is not used, heating and break-down (flashing to the boom is one example) could occur at moderate input powers.

One thing is for sure, the physical impact of any matching devices on HF frequencies is quite small (although efficiency losses remain) but as we move into and beyond 50 MHz the impact of such devices becomes quite marked. One of the most sensitive areas of change due to the placement of matching devices is F/B and this is one of the areas where LFA Yagis excel. Not for their lack of F/B but for the exceptional levels of F/B seen by new owners/builders. Many examples and comparisons can be found on the Internet particularly on YouTube where experimenters show 59+ signals turning into noise as the Yagi is pointed away from the target signal while the compared Yagi (complete with its matching device) struggles to reduce any signals by more than a few S points.

DK1MAX recently installed 2 x 6el (5.8 m long) LFA2 Yagis which replaced his 20 m long 11el Yagi. Max told me the F/R was incredible and he could take his TX/RX signals from 59+ to S1 levels by simply rotating his new array 180 degrees.

With the above in mind, I decided that I needed a new approach. The LFA employs a full wave loop (which possesses an additional control parameter over the traditional dipole-fed Yagi in respect of optimisation) to ensure a constant 50 Ω direct feed, and with this arrangement, the whole complete antenna is optimised with nothing added at the time of build that could possibly distort or destroy the antennas pattern or performance.

My new antennas such as the OP-DES (Opposing Phase Driven Element System) and OWA2 (I'll talk about this another time!) involve the use of non-conventional element structures ensuring lower impedance antenna performance with a wide flat bandwidth, from an antenna presenting a 50 Ω feed point. While the folded dipole OWL is more simplistic than some of the above, it is a very much more traditional antenna in its look and layout, which has been shaped using the design parameters I have already mentioned. Namely, a lower impedance Yagi with a direct 50 Ω feed point which possesses wide bandwidth, excellent levels of gain, F/B and also minimum side lobes too.

I would now like to come back to something I mentioned earlier.. Through the use (and abuse!) of computer optimisers, I believe that antenna developers have created a 'shaping' of the Yagi and the way it looks in terms of length and element spacing for a given band. What I would like to share with you are the results I have obtained from countless re-optimisations of the same Yagi with both fixed first and last elements (resulting in the optimiser having to look for the best results within the search space between the reflector and final director).

When developing my OP-DES Yagi, I was able to achieve very flat impedance curves over a wide bandwidth with all performance parameters being good apart from F/B which was always some way off my target of 30 dB. It was not until one of my countless return visits to optimise the OP-DES Yagi for better results that I decided to try drastically shortening the boom length before allowing the optimiser to do its work with fixed first and last elements. I was pleasantly surprised to see the F/B had improved but was still short of my target 30 dB, so I shortened the boom further and re-optimised. The antenna continued to show better F/B results until I reached a point where, despite constant optimisation, the F/B started to get worse and therefore I had achieved the optimum boom length for this antenna over the bandwidth I wanted it to cover. This 5el 50 MHz OP-DES was amazingly good now, just 2.6 m long and a lot shorter than most 4 element Yagis for the 50 MHz band! However, one of the surprises here was that when looking at gain per metre of boom, despite having over 30 dB F/B, gain levels were excellent and still, impedance was flat for more than 1 MHz.

So why the surprise? As those who have experimented with antenna optimisers will know, if pushing a design hard to achieve high levels of F/B or bandwidth (or both), other performance parameters can suffer to unacceptable levels. What this set of experiments had established is that once the optimum boom length (for a given bandwidth you are looking to achieve) has been found, very little compromise of any other parameter has to be made in order to achieve all round excellent results.

What was very interesting was applying this theory to other antenna designs such as the LFA and OWA; none had the same 'optimum' boom lengths but all (including the OWA) had this 'hot spot' for achieving excellent results within all performance parameters. My 50 MHz OWA designs now available on my G0KSC website show these results. For example, in my first presentation of the OWL within the pages of DUBUS, it was clear to see the physical difference between traditionally spaced Yagis and the spacing within the OWL driver cell which was very tight. In the later designs, this spacing has become even tighter

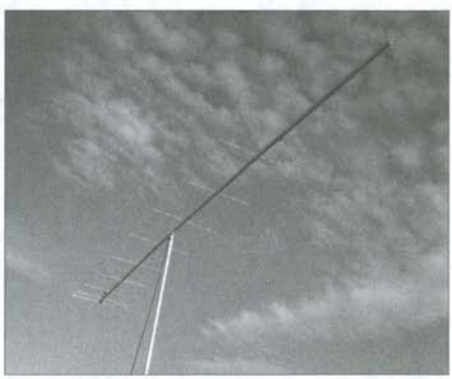
although in longer versions the overall length is not too dissimilar to more traditional designs. This is because the further along the boom you go, the wider the element spacing becomes.
The OWL design presented here was optimised with the folded dipole in place and this can result in a much higher F/S (front to side ratio) than if the antenna were optimised with a dipole-fed Yagi which was then simply replaced by a folded dipole.

Now let us take a look at one of the new-style OWL Yagis in build phase. In Fig. 3, the first three elements appear along the boom within a space normally occupied by only 2 of the closest spaced elements on a Yagi for this band, so how did I come to 'force' these elements into such a small space? This is how to achieve wide bandwidth from a low impedance antenna! Note also that the feed point arrangement in Fig. 3 was not final, this was one of the test arrangements which I will discuss in another article, where I will play-off the various real-world feed point compromise arrangements against one another in order to establish the feed point method with least impact upon the antenna.

I have many different Yagi optimisers at my disposal. Some old, some new and some that I have had developed to my specifications using modern optimisation algorithms and techniques but still, much guidance (in terms of optimiser direction) has to be given by the author in order that the best results are seen. Discussion of the pros and cons which practical experimentation uncovered for both through-boom and above boom mounted elements, and also a method of stacking which eliminated elevation pattern distortion caused by the FD and parasitic elements being off-set, will also be in a future article

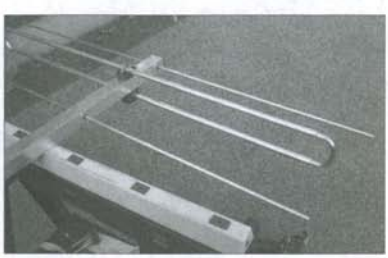
The 14el OWL listed below has been designed to be built upon a 30mm boom with the use of Stauff 'PP' (polypropylene) clamps above the boom. The folded dipole is designed to be supported by a single Stauff clamp either side of the boom.

Boom	Position (mm)	Element length (mm)
Ref:	0	1026
DE:	96	956
D1:	243	959
D2:	619	942
D3:	1228	923
D4:	1946	905
D5:	2753	892
D6:	3591	881
D7:	4490	871
D8:	5394	863
D9:	6323	851
D10:	7252	843
D11:	8181	840
D12:	8994	862



Overall loop width (outside edge to outside edge) is 956 mm. Elements are calculated using 8 mm aluminium tube/rod. Loop section is 12 mm with 10 mm end sections. Stacking distances for this antenna are 4.3 m x 4.09 m, Sky temp: 221.9 K, G/T -0.81 dB.

As always, if you have any questions, mail me at Justin@g0ksc.co.uk Until next time, 73 Justin



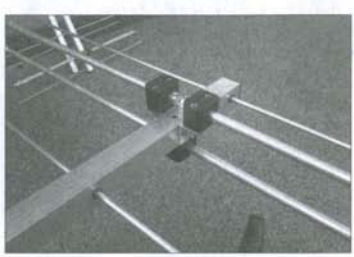
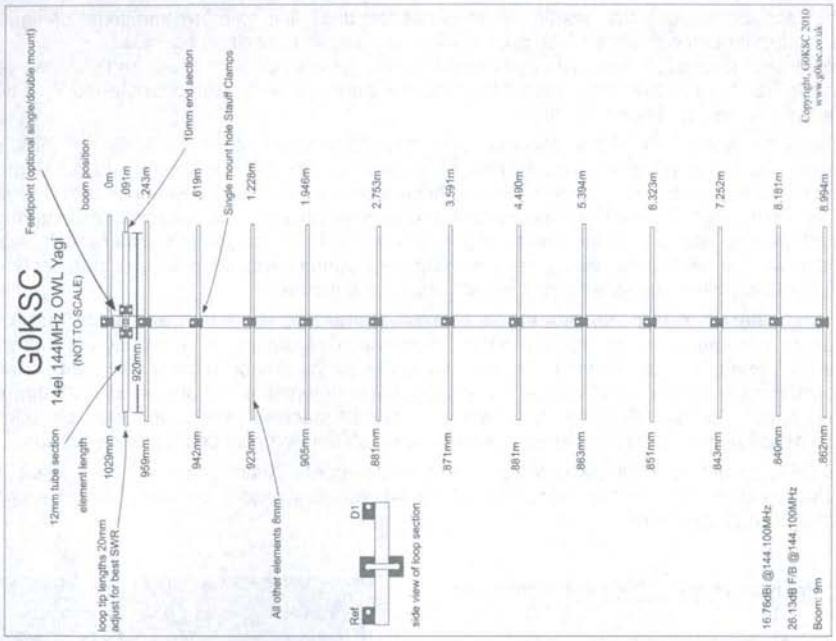
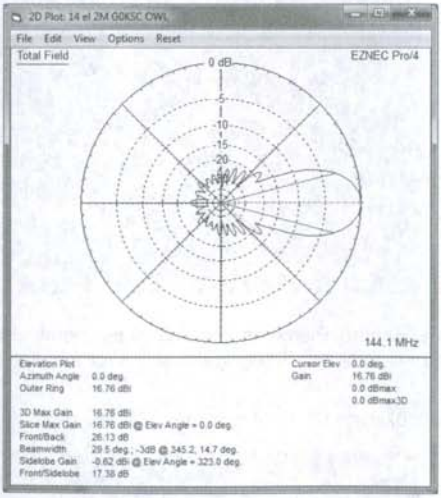


Fig. 1: (above on the right side): 12 el. OWL with close-spaced driver cell on test at G0KSC

Fig. 2: Through-boom elem. experiment with FD using single Stauff clamps either side of the boom

Fig. 3: Dual Stauff feed point on the test antenna





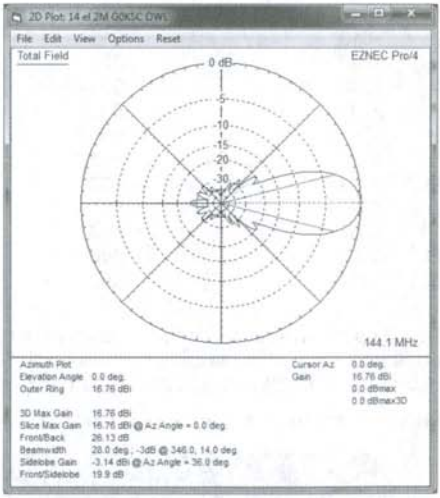
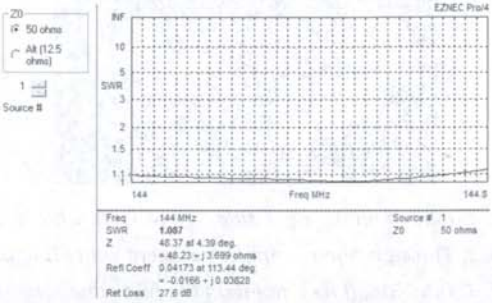


Fig. 4 (top): Layout for the 14 ele. OWL

Fig. 5 (middle, left): Simulated Elevation plot for the 14 ele. OWL

Fig. 6 (middle, right): Simulated Azimuth plot for the 14 ele. OWL

Fig. 7 (bottom, right): Simulated SWR plot for the 14 ele. OWL



Entwicklung und Realisierung moderner Yagi-Antennen (I)

von Justin Johnson, G0KSC

In diesem Artikel geht es um die Methoden für das Design und die Konstruktion einer OWL- (Optimised Wideband Low impedance) Yagi, die mit einem Faltdipol gespeist wird, um so eine direkt mit 50 Ohm speisbare Yagi-Antenne zu erhalten. Entwicklung der OWL und Experimente bei der Konstruktion der OWL werden diskutiert und die Ergebnisse präsentiert. Der Autor hat sich entschlossen, eine mechanische Konstruktion vorzuschlagen, die er nicht unbedingt bevorzugt (zusätzlich zu den bevorzugten Methoden), unter dem Aspekt, dass andere mit den Vorteilen einer solchen Methode eventuell zufriedener sein könnten. Nach der Erstveröffentlichung des originalen OWL-Konzeptes und diversen Designs in DUBUS und auf der Webseite von G0KSC, ging die Entwicklung weiter. In der Tat gibt es inzwischen eine ziemlich große Zahl von Antennendesigns im „Tresor" von G0KSC, die extrem gute Ergebnisse bei Gewinn, Bandbreite, F/B, Rauschtemperatur und letztlich G/T aufweisen.

In den letzten Jahren habe ich mit diversen Optimierungsmethoden experimentiert, einschließlich einiger sehr anspruchsvoller Softwarepakete. Die Anwender dieser (und vielleicht auch anderer) Softwarepakete scheinen aber ziemlich leicht in die Falle zu tappen und keine außergewöhnlich guten Ergebnisse zu sehen, sofern sich nicht viel Zeit genommen wird und immer wieder reoptimiert wird (um bessere Ergebnisse zu erhalten und dort, wo die Richtung des Optimierwerkzeugs des Programms falsch liegt). Zur gleichen Zeit würde, wenn man bestimmte Parameter durch den Optimierer limitiert, dieser sich selbst in Richtungen leiten, die nicht den optimalen Weg darstellen.

Ich bin der Überzeugung, dass die heute übliche Form einer Yagi-Antenne (bezüglich Diagramm, Bandbreite und akzeptiertem F/B) zu einem großen Teil aufgrund gebräuchlicher Optimierungsdirektiven, die durch das automatische Optimierungswerkzeug des Programms selbst angewendet wurden, zustande gekommen ist und dann durch den Entwickler selbst nicht mehr angezweifelt wurden. Er überlässt der Software zu viel Kontrolle bezüglich Richtung und Ergebnissen.

Jeder hat seine eigene „Wunschliste", wenn er Antennen entwickelt, und einer meiner Wünsche wurde vom Yagi-Design Guru und meinem Mentor YU7EF übernommen: Die 50-Ohm-Fußpunktimpedanz. Ich glaube noch immer, dass, **wenn eine Antenne korrekt designt ist, sie nicht an 50 Ohm angepasst werden muss; sie sollte bereits schon 50 Ohm aufweisen!**

Der Hauptunterschied zwischen dem, was ich mache und den fantastischen Errungenschaften heutiger Antennenentwickler wie YU7EF und DK7ZB liegt darin, dass ich versuche, die Elemente am Anfang der Yagi (oder der „Treiberzelle", wie DG7YBN es nennt) anders zu formen, um die Impedanz exakt auf 50 Ohm zu bekommen. Der Grund für diese Modifikation der Elemente liegt in den Grenzen begründet, die man bei einer dipolgespeisten 50-Ohm-Yagi mit traditionell gestrecken Elementen gegenüber dipolgespeisten niedrigimpedanteren Yagis sehen kann. In einem früheren DUBUS-Artikel habe ich Experimente diskutiert, die ich mit einem 2-m-Yagi-Modell durchgeführt habe, bei dem, um gutes F/B und niedrige Nebenzipfel zu erhalten, Bandbreite geopfert werden musste, wenn ein gestreckter 50-Ohm-Dipol verwendet wurde. Wenn aber dieselbe Antenne anstatt mit 50 Ohm mit 40 Ohm Fußpunktimpedanz reoptimiert wurde, war eine viel größere Bandbreite möglich, ohne dass irgendetwas von den anderen Leistungsparametern geopfert werden musste. Tatsächlich wurden sogar ein noch besseres F/B und besser unterdrückte Nebenzipfel bei ebenfalls leicht besserem Gewinn erreicht.

Also, warum nicht einfach ein Anpassungsglied installieren? Für mich ist dies eines der größten Probleme bei Yagi-Antennen, das noch immer von den Funkamateuren nicht ausreichend gewürdigt wird. Das ist zum großen Teil durch die üblichen Methoden bei der Antennenoptimierung begründet, die noch immer verwendet werden und als korrekt akzeptiert werden. Ich habe dies bereits früher schon mal erwähnt: Programme wie YO (Yagi Optimiser von K6STI) können mit einer Anzahl verschiedener, an der zu optimierenden Antenne installierter Anpassungsglieder modellieren. Aber, diese Programme, (die nun viele Jahre alt sind), **waren nie und sind noch immer nicht in der Lage die physikalische Anwesenheit des Anpassungsglieds zu modellieren** und den Einfluß, den es auf die Leistung der Yagi haben kann. Diese Programme waren lediglich in der Lage, die wahrscheinliche Änderung bei der Impedanz vorherzusagen, die das Anpassungsglied bei der Antenne bewirken würde, das war alles. Folglich sind Ergebnisse ohne eine Software, die solche Anordnungen jedes Mal ganz exakt modellieren kann, oft wie eine Lotterie. Versuche derartige Anordnungen zu modellieren, können aufgrund von

Konvergenzfehlern sogar bei den neuesten Programmen (wie NEC4.1) zu falschen Berechnungen führen, so dass ein tatsächliches Modellieren solcher Anordnungen sehr schwierig durchführbar ist und deshalb nur Tests in der realen Welt die einzig wirkliche Option sind, um festzustellen, ob solch eine Antenne korrekt arbeitet (oder nicht, wie es hier der Fall zu sein scheint).

Verschiedene Arten von Anpassungsgliedern und die Weisen, wie diese installiert sind, führen zu verschiedenen Graden von Störungen und/oder Impedanzverschiebungen. All diese Probleme aber, die durch solche Anpassungsglieder hervorgerufen werden, können oftmals nur schwer erkannt werden.

Aufgund der Natur der Anpassungsgliedes werden damit Justierungen gemacht, bis ein gutes SWR gesehen wird, so dass Probleme, die durch die Anwesenheit des Gliedes selber hervorgerufen werden, dadurch verdeckt werden und der Designer/Erbauer im Dunkeln über den aufgetretenen Leistungverlust, der aufgetreten ist, bleibt.

Als ich Versuche mit Niedrigimpedanz-Yagis, die eine Anpassung benötigen, gemacht habe, fand ich heraus, dass die Anpassung nach DK7ZB keine nachteiligen Effekte auf das Diagramm hatte. Das ist größtenteils dadurch begründet, dass sie koaxial erfolgt und dem Verlauf eines „normalen" Koaxkabels nahe dem Boom entspricht, so dass jegliche möglichen Probleme klein bleiben. Wie bei anderen Anpassungsmethoden, bleiben aber auch hier die Probleme bezüglich der maximal möglichen übertragberen Leistung bestehen. Sofern kein sehr gutes Koaxkabel zum Einsatz kommt, kann bei mittleren Leistungspegeln ein Aufheizen und Kaputtgehen (Durchschlagen zum Boom) erfolgen.

Sicher ist, dass der physikalische Einfluß von Anpassungsgliedern auf KW-Frequenzen ziemlich gering ist (die Effektivitätsverluste aber bleiben), aber wenn wir zu 50 MHz und darüber gelangen, wird der Einfluß solcher Glieder bemerkenswert. Eine der sensibelsten Stellen für die Beeinflussung durch die Platzierung eines Anpassungsgliedes ist das Vor-Rückverhältnis F/B und das ist ein Bereich, bei dem sich die LFA-Yagis hervortun. Nicht für ihren Mangel an F/B, sondern für die außergewöhnlich hohen F/B-Verhältnisse, die von den Besitzern/Nachbauern beobachtet werden. Viele Beispiele und Vergleiche gibt es inzwischen dazu im Web, speziell auf Youtube, wo gezeigt wird, wie 59-Signale im Rauschen verschwinden, wenn die Yagi vom Ziel weggedreht wird, während die Verleichsantenne (zusammen mit ihrem Anpassglied) damit kämpft, Signale um mehr als ein paar S-Stufen abzusenken.

DK1MAX hat vor kurzem 2 x 6 Ele. (5.8m lange) LFA2-Yagis installiert, die nun seine 20m lange 11el M2 Yagi ersetzen. Max hat mir berichtet, dass das F/B-Verhältnis unglaublich ist und er seine Signale (bei RX und TX) von S9+ auf S1 bringen kann, indem er einfach seine neue Antenne um 180 Grad dreht.

Mit dem eben Gesagten im Hinterkopf, entschied ich mich etwas anderes zu probieren, um neue und andere Ergebnisse zu bekommen. Die LFA verwendet eine Ganzwellenschleife (die einen zusätzlichen Kontrollparameter gegenüber der traditionellen dipolgespeisten Yagi bezüglich der Optimierung besitzt), um eine konstante direkte 50-Ohm-Speisung sicherzustellen. Die ganze komplette Antenne wird optimiert, ohne dass irgendetwas noch beim Bauen hinzugefügt wird, das das Antennendiagramm oder die Leistung verschlechtern oder zerstören könnte.

Meine neuen Antennen, wie die OP-DES (Opposing Phase Driven Element System) und die OWA2 (diese werden ein anderes Mal besprochen werden!) verwenden auch unkonventionelle Element-strukturen, die eine Leistung wie bei niedrigimpedanten Antennen und große Bandbreite sicherstellen, aber eine Antenne mit 50-Ohm-Fußpunkt darstellen.

Während die OWL mit Faltdipol simpler als einige der oben erwähnten Konzepte ist, ist sie in Aussehen und Layout, das mittels der bereits erwähnten Designparameter gestaltet wurde, eine eher traditionellere Antenne. D.h. sie ist eine niedrigimpedantere Yagi mit direktem 50-Ohm-Speisepunkt, die große Bandbreite, hohen Gewinn, F/B und minimale Nebenzipfel besitzt.

Nun zu etwas, das ich anfangs bereits erwähnt hatte: Durch den Gebrauch (und Missbrauch!) von Computeroptimierung, glaube ich, dass Antennenentwickler eine „Formung" von Yagis geschaffen haben und eine bestimmte Weise, wie sie für ein gegebenes Band bezüglich Länge und Elementabständen aussieht. Ich möchte hier meine Ergebnisse mitteilen, die ich durch endlose Reoptimierungen ein und derselben Yagi bei fixiertem ersten und letztem Element erhalten habe (was darin resultiert, dass der Optimierer für die besten Resultate innerhalb des festen Abstands zwischen Reflektor und letztem Direktor sucht).

Als ich die OP-DES-Yagi entwickelt habe, konnte ich sehr flache Impedanz-Kuven über eine große Bandbreite erreichen, wobei alle Leistungsparameter gut waren, mit Ausnahme des F/B, das immer etwas unterhalb meines Ziels von 30 dB lag. Nach endlosen Optimierungsversuchen der OP-DES-Yagi für noch bessere Ergebnisse, entschied ich mich die Boomlänge drastisch zu verkürzen, bevor ich dem Optimierer erlaubte, mit fester erster und letzter Elementposition weiter zu arbeiten. Ich war positiv überrascht zu sehen, dass sich das F/B verbessert hatte, aber es lag immer noch unerhalb meines 30-dB-Ziels. Deshalb verkürzte ich den Boom weiter und optimierte erneut. Die Antenne zeigte wieder besseres F/B,

bis ein Punkt erreicht wurde, bei dem das F/B trotz konstanter Optimierung wieder schlechter zu werden begann. Folglich hatte ich also die optimale Boomlänge für diese Antenne für die Bandbreite, die sie abdecken sollte, erreicht.

Diese 5 Ele. 50 MHz OP-DES war erstaunlich gut bei den jetzt gerade mal 2.6m Länge und damit viel kürzer als die meisten 4-Element-Yagis für das 6m-Band! Eine der Überraschungen jedoch war, dass wenn man den Gewinn pro Boommeter betrachtete, dieser, trotz des F/B von über 30 dB, exzellent war und die Impedanz immer noch über einen Bereich von über einem MHz flach war.

Warum also diese Überraschung? Allen, die mit Antennenoptimierern experimentiert haben, ist bekannt, dass wenn man ein Design dahin presst, dass man hohes F/B oder Bandbreite (oder beides) erreicht, andere Leistungsparameter auf unakzeptable Niveaus abfallen. Diese Experimente haben gezeigt, dass, sobald das Optimum für die Boomlänge (für eine gegebene Bandbreite, die man erreichen will) gefunden wurde, kaum noch Kompromisse für die anderen Parameter eingegangen werden müssen, um rundum exzellente Resultate zu erreichen.

Interessant war nun diese Theorie auf andere Antennendesigns, wie die LFA und OWA, anzuwenden: Keine hatte dieselben „optimalen" Boomlängen, aber alle (inkl. der OWA) hatten diesen „Hot Spot", um exzellente Ergebnisse für alle Leistungsdaten zu erhalten. Meine 50-MHz-OWA-Designs, die nun auf meiner G0KSC-Webseite gezeigt werden, zeigen diese Ergebisse. Meine erstmalige Präsentation der OWL in DUBUS z.B. zeigte klar den physikalischen Unterschied zwischen traditionell angeordneten Yagi-Elementen und der Anordnung bei der OWL-Treiberzelle, die sehr eng war. Bei den späteren Designs wurde die Anordnung noch enger, bei längeren Versionen aber unterscheidet sich die Gesamtlänge nicht wesentlich von derjenigen bei traditionelleren Designs. Das liegt daran, dass je weiter man mit der Boomlänge geht, desto größer werden die Elementabstände.

Das hier präsentierte OWL-Design wurde mit einem eingesetzten Faltdipol optimiert. Das kann zu einem viel besseren F/S (Vor-Seiten-Verhältnis) führen, als wenn die Antenne mit einem gestreckten Dipol optimiert worden wäre und dieser danach einfach durch einen Faltdipol ersetzt worden wäre.

Nun wollen wir einen Blick auf eine neuartige OWL-Yagi werfen. Auf der obigen Abb. 4 des Antennenlayouts erkennt man, dass die ersten drei Elemente auf dem Boom den Platz einnehmen, der normalerweise nur von zwei Elementen bei einer Yagi für dieses Band belegt wird. Wie kommt es also, dass ich diese Elemente auf so wenig Platz gequetscht habe? Dies ist ie Lösung, um große Bandbreite bei einer Antenne mit niedriger Impedanz zu erreichen!

Hier noch der Hinweis, dass das Arrangement für den Speisepunkt in dieser Abb. 4 noch nicht festgelegt war, sondern es sich um einen Test handelte. Ich werde dieses Thema in der nächsten Folge des Artikels behandeln, wo die verschiedenen Kompromisse realer Fußpunktanordnungen gegeneinander gestellt werden, um zu zeigen, welcher davon den geringsten Einfluß auf die Antenne hat.

Ich habe viele verschiedene Programme zum Optimieren von Yagis zur Verfügung. Einige sind älter, einige neuer, andere habe ich nach meinen Bedürfnissen mit modernen Optimierungs-Algorithmen und Techniken entwickelt, aber noch immer muss viel „Anleitung" (bezüglich der Richtung für das Optimierprogramm) durch den Designer selbst gegeben werden, um die besten Ergebnisse zu erzielen.

Nächstes Mal werden außerdem die Pros und Contras diskutiert, die praktisches Experimentieren für Montage der Elemente durch den Boom und über dem Boom ergeben haben. Außerdem wird eine Methode für die Stockung besprochen werden, die Störungen beim Elevationsdiagramm eliminiert, die durch den Faltdipol verursacht werden.

Die hier gezeigte 14 Element OWL-Yagi, wurde für einen Boom mit 30mm Durchmesser gerechnet und mit der Verwendung von Polypropylen-Haltern von Stauff auf dem Boom. Der Faltdipol wurde so ausgelegt, dass er mit jeweils einem Stauf-Halter auf jeder Boomseite befestigt wird. Elementpositionen und Längen: Siehe Tabelle oben im engl. Text!

Die Weite der Schleife (von Außenkante zu Außenkante) beträgt 956mm. Die Elemente bestehen aus 8mm (Aussendurchmesser) Alu-Rohr. Die Schleife des Dipols wird aus 12mm Material mit 10mm Endstücken hergestellt. Bei Fragen, wie immer, eine email an den Autor senden an: Justin@g0ksc.co.uk

Bis zum nächsten Mal, 73 Justin

Abb. 1: (oben rechts): 12 El. OWL mit eng angeordneter Treiberzelle im Test bei G0KSC.
Abb. 2: Experiment mit Elementen durch den Boom, mit Faltdipol mit je einem Stauff-Halter auf jeder Boomseite.
Abb. 3: Speisepunkt mit zwei Stauff-Haltern bei der Testantenne.
Abb. 4 (oben): Layout für die 14 Ele. OWL.
Abb. 5 (mitte, links): Simuliertes Elevationsdiagramm für die 14 Ele. OWL.
Abb. 6 (mitte, rechts): Simuliertes Azimutdiagramm für die 14 Ele. OWL.
Abb. 7 (unten, rechts): Simuliertes SWR-Diagramm für die 14 Ele. OWL.

Aurora Reports

Editor: Stefan Heck, LA0BY
LA0BY@darc.de

Dear fellow VHF enthusiasts!
Again we saw a few nice Aurora openings over the last three months. The current solar cycle 24 is predicted to peak late in 2012 or during the first half of 2013. The graph at the end of the column confirms it is still a lot weaker than the previous solar cycle 23. 73, Stefan (LA0BY)

GM4ILS in IO87IP wkd on 50 MHz:

2012-01-22

1729	SM5EDX	JO89FP	57A	45°
1731	OH2ZZ	KP20HI	57A	45°
1741	ES1EX	KO29YX	55A	45°
1744	OH2SIX/B	KP20DH	55A	45°
1745	OH3MF	KP20FR	55A	45°
1749	OZ3ZW	JO54RS	55A	45°
1931	G4HBA	IO93LT	55A	45°
1934	M0PNN	IO82TS	55A	45°
1937	GM4XQJ	IO85DX	55A	45°
1939	G7RAU	IO90IR	55A	45°
1941	EI6GF	IO62RG	55A	45°
1942	G4GIR	IO92SD	53A	45°
1943	SM6FGN	JO78BX	55A	45°
1946	SM5FUG	JO89GP	53A	45°
1956	PA4VHF	JO32JE	55A	45°
2004	SM5EPO	JP80MC	55A	45°
2005	G0PQO	IO92UA	53A	45°
2007	GM4UYE	IO86AC	55A	45°
2009	SM4CMO	JO79OC	56A	45°
2011	LA9DAA	JO48LO	55A	45°
2013	SM4KYN	JO79BH	55A	45°
2014	LA8AV	JO49WS	55A	45°
2017	SM6LJP	JO68WI	55A	45°
2020	G3OIL	IO91CB	55A	45°
2023	LA1QDA	JP20QS	53A	45°
2030	GM4ZNC	IO75SP	57A	45°

2012-02-15

1600	SM5EDX	JO89FP	55A
1621	G4KUX	IO94BP	55A
1700	LA8WF	JO59GV	55A

tnx for report, Ron

GM4ILS in IO87IP wkd on 144 MHz:

2012-01-22

1759	OZ1BUR	JO46HI	56A
1803	SM7GVF	JO77GA	57A
1821	SM6GYB	JO86GW	57A
1824	SM6BFE	JO68DQ	55A
1826	G7RAU	IO90IR	55A
1831	DK0OY	JO52CX	52A
1833	G4YHF	IO92XW	53A
1835	DL6YBF	JO31OX	53A
1837	DH8BQA	JO73CE	52A
1838	DL4KU	JO64PB	53A
1844	SM6OPX	JO58RG	53A
1844	PA3BIY	JO22SB	55A
1851	SM7NWS	JO65MN	53A
1854	DH6JL	JO32NI	53A
1856	PA4PS	JO53GH	55A
1859	G0JJG	JO02LE	53A
1900	DL0BFA	JO52PL	53A
1903	MM0CYR	IO88CO	53A
1906	DJ3OC	JO52GJ	53A
1907	PA2DW	JO22GD	55A
1910	G0UWK	IO83VK	57A
1913	G4DCV	IO91OF	55A
1916	G4RGK	IO91ON	55A
2139	GM4VVX	IO78TA	55A

2012-02-15

1642	SM4BDQ	JP80FG	53A

tnx for report, Ron

LA0BY in JO59IX/FW wkd on 144 MHz:

2012-03-06 (from JO59IX)

2117	OH6NG	KP03TC	59A	58A	20°
2119	OH6UW	KP22WH	57A	57A	20°
2122	OH6QR	KP22BN	55A	55A	20°
2128	OH3A	KP20FW	55A	55A	20°
2135	OH1F	KP01TK	55A	55A	20°

2012-03-15 (from JO59FW)

1635	RA1WZ	KO47DT	55A	57A	30°
1637	EU4AG	KO13VQ	53A	55A	30°
1638	YL2QW	KO17OD	55A	57A	30°
1640	YL2LW	KO16KA	55A	59A	30°
1642	DL3WW	JO60FL	55A	55A	30°
1644	DL6BF	JO32QI	56A	59A	30°
1645	SP2MKO	JO93CB	59A	59A	30°
1647	YL3DW	KO26CW	55A	59A	30°
1648	YL2GD	KO37ML	57A	59A	30°
1649	DG5CST	JO60DS	55A	55A	30°
1652	UA2FL	KO04GQ	59A	59A	30°
1700	RA3LE	KO64AT	56A	52A	30°
1706	SO1RON	JO73RL	52A	55A	30°
1708	DD0VF	JO61TB	54A	55A	30°
1709	ES5QA	KO38OM	52A	57A	30°
1711	YL3IQ	KO17OD	55A	55A	30°
1713	DL2HRE	JO51TQ	52A	55A	30°
1718	DK2OY	JO44WS	57A	55A	30°
2152	ES2NJ	KO29NK	52A	55A	30°
2154	DL4KUG	JO64PB	55A	57A	30°
2206	OH5LK	KP30ON	55A	57A	30°

This was the best Aurora since many years for me. ODX was RA3LE over 1406 km.

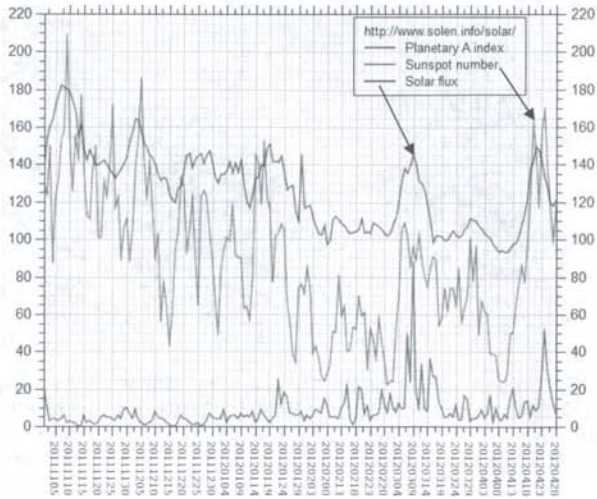
SM6CMU in JO57XK wkd on 144 MHz:

2012-03-07

1514	DL6NAA	JP50VF	57A	55A
1515	DF9CY	JO54AL	58A	59A
1516	DL6YBF	JO31OX	56A	55A
1517	OK1FPR	JO80CE	57A	59A
1519	SM2MKO	JO93CB	55A	55A
1521	SP2HPD	JO94JC	56A	57A

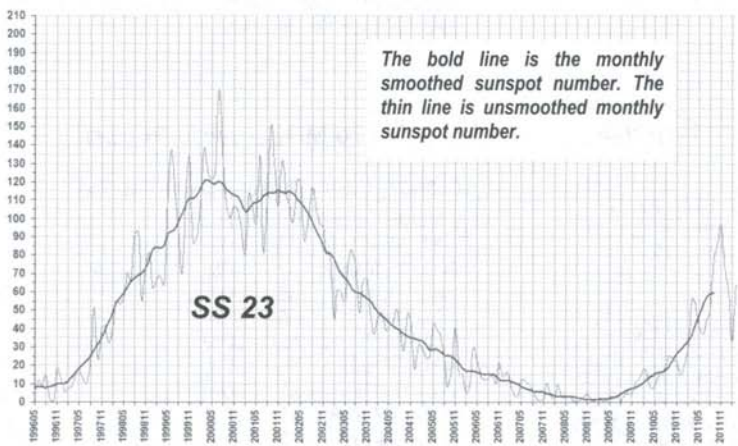
1522	OK1TEH	JO70FD	55A	55A
1531	SP7HKK	JO91QI	55A	55A
2012-03-09				
1558	PA3CWN	JO33AH	57A	57A
1600	DL6NAA	JO50VF	57A	57A
1610	PA4VHF	JO32JE	56A	56A
1612	DK9OY	JO52CK	58A	57A
1615	DL6YBF	JO31OX	57A	53A

tnx for report, Ingo



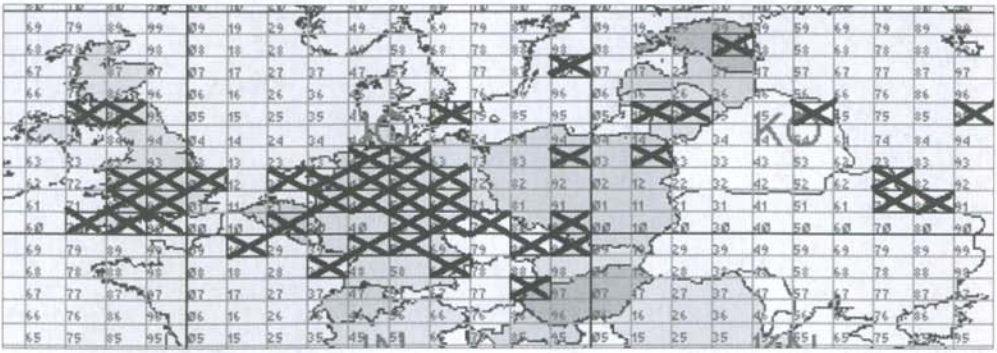
Right: Geomagnetic activity 5.11.2011 - 28.4.2012

Below: Solar cycles 23 and 24



There is a template for sending your reports available, see **www.mydarc.de/la0by/DUBUS_Aurora_reportform.xls**
Listing the QTF is useful for a decent evaluation of the data.

Map below: Squares worked on 2m CW Aurora by SM7GVF (JO77GA) on March 9th, 2012.



Map: Squares worked on 2m CW Aurora by SM7GVF (JO77GA) on March 15th, 2012. DL8HCZ (JO53CN) hrd SM7GVF as the only Aurora signal on band on a l/2 vertical antenna with max. 52A.

On **March 15th** 1541z 9A1CAL JN86 wkd OZ1FDH JO65 and YT3I KN04 hrd G4DHF IO92 on 2m Aurora in CW. This is the first time for many years that Aurora signals managed to get south of the Alps.

The best (known) QSO of this opening took place on 1652z when PA3BIY (JO22EB) wkd OH5LK (KP30ON) over 1681km. At 1736z ON4KHG (JO10XO) hrd OH5LK (KP30ON) over 1817km with 52A

70 cm Aurora Reports

14. February

1632z SM4IVE JO79 hrd OH2UHF/B KP20 52A
1643z OH6KTL KP02 hrd OH2UHF/B KP20 53A
1715z OH6KTL KP02 hrd SM4IVE JO79

15. February

1414z OH6KTL KP02 hrd OH2UHF/B KP20 52A
1654z YL2OK KO37 wkd SM4IVE JO79
1709z YL2OK KO37 wkd SM5DIC JO89 55A
1727z SM4IVE JO79 wkd RA1TT KO68 1061 km
1734z SM4IVE JO79 wkd RD3FD KO95 1406 km
1735z OH6KTL KP02 hrd SM4IVE JO79 55A

27. February

1725z SM4IVE JO79 hrd OH2UHF/B KP20 59A
1736z SM4IVE JO79 hrd OZ7IGY/B JO65 59A

7. March

1038z SM4IVE JO79 hrd OH2UHF/B KP20 52A
1046z SM4IVE JO79 hrd SK1UHF/B JO96 52A
1345z SM4IVE JO79 hrd OH2UHF/B KP20 52A
1537z SM4IVE JO79 wkd YL2GD KO37

9. March

1357z RA3LE KO64 wkd SM5DIC JO89 1064km
1447z RA3LE KO64 wkd LY3UE KO24
1539z SM7GVF JO77 wkd DL6NAA JO50 57A

27. March

1511z OH6KTL KP02 hrd OH2UHF/B KP20 53A
1547z OH6KTL KP02 wkd UA3MBJ KO87 57A

70 MHz Aurora Report

DL8HCZ, JO53AP, hrd on 4m with 6 el. Yagi:

9. March - all from 00 to 10 deg az:

1434z LA4VHF/B 55A JO28
1438z OZ1BNN 55A JO55
1443z PA2M 55A JO21
1443z G4KUX 55A IO94
1444z PA7F 52A JO33
1451z OZ1DJJ 59A JO65
1502z OK1TEH 52A JO70
1505z OZ7IGY/B 53A JO65
1516z GM4JYB 42A IO88

15. March

1624z LA3EQ 57A JO59
1645z PA0O 54A JO33
1651z GM4JYB 54A IO88
1720z DJ9YE 42A JO43 on 69.990 MHz
1722z G4ZTR 54A JO01
1723z PF7M 57A JO33
1735z PA2M 57A JO21
2043z LA7VHF/B 539 JP99 Aurora-E, 1st time hrd for about 30 mins (hrd OH9SIX KP36 at the same time on 6m).

ON4KHG, JO10XO, wkd:

15. March 2012

1654z GM4JYB IO88HP 56A 54A QTF 0° 1009 km

Transequatorial Propagation on 2m over South America

by FM8DY, Jean-Louis (Grid: FK94MO, Martinique Island)

Date	TEP Observation on 2m (RX reports) by FM8DY	2m QSO by FM8DY	Other TEP QSOs on 2m, info compiled by CT1HZE
28-29/08/2011	First TEP signals: TV channel on 55,250		
01-02/09/2011	PY5GRU repeater on 146,640 S1		
02-03/09/2011	PY5GRU repeater on 146,640 S1		
19-20/09/2011	PY repeater 145,430, 146,610 S3		
21-22/09/2011	PY5GRU repeater on 146,640 S2		
23-24/09/2011	PY5AQ, PY5LF, PU2YEN, PP5XX, PY2REK 59	X	FG5GP to PP5XX and PY5AQ
25-26/09/2011	PY5GRU repeater on 146,640 S1		CX2TQ to KP4EIT
27-28/09/2011	PP5, PY5	X	YV4AKK to LU
29-30/09/2011	PY5, PP5	X	YV4 to LU
30-01/09-10/2011	PY5 PU5 strong	X	
03-04/10/2011	PY5, PP5 weak	X	
04-05/10/2011	PY5	X	KP4EIT to CX6DH, YV4 to LU
05-06/10/2011	PY5 PY2	X	YV4 to LU
06-07/10/2011	PY5GRU repeater on 146,640 S1		
07-08/10/2011	PY5, PU2	X	YV4 to LU
08-09/10/2011	PY repeater input 144,830		
09-10/10/2011	PY5GRU repeater on 146,640 S1		NP2X to PY3+PY5
10-11/10/2011	PY5	X	KP4 to CX2TQ & CX6DH, YV4 to LU
11-12/10/2011	PY5 (NP2X via Tropo)	X	KP4 to CX2TQ, NP2X to PY3 + PY5, YV4 to LU
12-13/10/2011			CX to KP4, NP2X to PY5
13-14/10/2011	PY5, PY2	X	CX to KP4, NP2X to PY5, YV4 to LU
14-15/10/2011	PY5 PY2 PU5 PP5 PU2	X	NP2X to PY3 & PY5, YV4 to LU
15-16/10/2011	PY5	X	CX to KP4
16-17/10/2011	PY5 PP5	X	NP2X to PY3 & PY5
18-19/10/2011	PY5GRU repeater on 146,640 S4		KP4 to CX, YV4 to LU
19-20/10/2011	PU2 PY5	X	KP4 to CX, YV4 to LU
20-21/10/2011	PY5GRU repeater on 146,640 S4		
20-21/10/2011	Araucaria PY VHF contest: 12 QSOs PY5 PP5 PU5 PY2 PU2	X	
22-23/10/2011	PY5 PU5 PP5 PU2	X	KP4 to CX, YV4 to LU/CX
	23/10 to 28/10 FM8DY was not QRV		
23-24/10/2011			YV4AKK to LU
24-25/10/2011			KP4 to CX, YV4 to LU/CX
25-26/10/2011			KP4 to CX, YV4 to LU
26-27/10/2011			KP4 to CX, NP2X to PY5 & CX, 9Y4VU to PY5
27-28/10/2011			KP4 to CX, LU7FA; YV4 to LU, CX; 9Y4D to PP5;
28-29/10/2011	PY repeater 147,360		KP4 to PY5&PY2; YV4 to LU; YV4 to PY5;
30-31/10/2011	PY2COY	X	KP4 to LU; YV4 to LU, CX; PY5 to YY4
31/10/01-11/2011	PY5 strong (NP2X via Tropo)	X	KP4 to CX, PY2; YV to LU/CX big opening
01-02/11/2011	PY5GRU repeater on 146,640 S5		
02-03/11/2011	PY repeaters S5		CX to KP4&YV4, YV4 to LU
03-04/11/2011	PY5GRU repeater on 146,640 S4		KP4 to CX; YV4 to LU/CX
04-05/11/2011	PY5CTV repeater S5		KP4 to CX; YV4 to LU; NP2X to PY5
05-06/11/2011	PU2YEN, PY5	X	KP4 to CX; YV4 to LU
06-07/11/2011	PY repeaters S5		KP4 to CX; YV4 to LU
07-08/11/2011	PY5	X	KP4 to CX;

			NP2X to PY5 & PY3 & ZP9SC
08-09/11/2011	PY repeaters S2		KP4 to CX; NP2X to CX; YV4 to LU
09-10/11/2011	PY repeaters S5 (8P9MS hrd via Tropo)		KP4 to CX; LU to NP2X hrd
10-11/11/2011	-		KP4 to CX; NP2X to PY3
11-12/11/2011	PY5	X	KP4 to CX; NP2X to PY3; YV4 to LU
12-13/11/2011	PP5	X	KP4 to CX; NP2X to PY3; YV4 to LU
13-14/11/2011	PY2 PP5	X	KP4 to CX + LU1FVE; NP2X to PY3; 8P9MS to PY2GN
14-15/11/2011	PP5	X	KP4 to CX; KP4 to LU1; YV4 to LU
15-16/11/2011	PY5CTV repeater S7		KP4 to CX & LU7FA; NP2X to PY5 + LU5FF & LU7FA; YV4 to LU
16-17/11/2011	PY5GRU repeater on 146,640 S4		KP4 to CX; YV4 to LU
17-18/11/2011	PY2JZW repeater S5		KP4 to CX; YV4 to LU
18-19/11/2011	PY2JZW repeater S4		
19/11-01/12 not qrv	FM8DY was not QRV	-	
19-20/11/2011			KP4 to CX2TQ
20-21/11/2011			YV4 to LU
23-24/11/2011			KP4 to LW2DKF & LU5FF & CX6DH; YV4 to LU
24-25/11/2011			KP4 to LU7FA & CX6DH
26-27/11/2011			KP4 to CX; YV4 to LU
27-28/11/2011			9Z4BM to PY5HOT; YV4 to LU
28-29/11/2011			KP4 to CX; YV4 to LU; LU4EFC hrd KP4EIT
29-30/11/2011			YV4 to LU big opening
30-11/01-12/2011	PY5 PU5	X	
01-02/12/2011			KP4EIT to CX1TH
02-03/12/2011	Repeater PY 146,650		
03-04/12/2011	PY FM 146,550 S4		YV4 to LU
04-05/12/2011	PY5GRU repeater on 146,640 S4		KP4 to CX; YV4 to LU
05-06/12/2011	PY5GRU repeater on 146,640 S3		KP4 to CX & LU
06-07/12/2011			KP4 to CX2TQ; YV4 to LU
07-08/12/2011	PY5GRU repeater on 146,640 S6		KP4EIT to LU5FF
08-09/12/2011	PY5GRU repeater on 146,640 S6 PY5	X	KP4EIT to CX2TQ & LU7FA
09-10/12/2011	PY5GRU repeater on 146,640 S6		KP4EIT to CX6DH
10-11/12/2011	PY5GRU repeater on 146,640 S6		CX2TQ to KP4EIT
11-12/12/2011	PY5GRU repeater on 146,640 S3		
12-13/12/2011			KP4 to CX; YV4 to CX&LU
13-14/12/2011			KP4 to CX, YV4 to LW2DKF
14-15/12/2011	PY5GRU repeater on 146,640 S3		
15-16/12/2011			YV4 to LU
16-17/12/2011	PY5CTV repeater S3		
17-18/12/2011	PY 146,530 S2		
19-20/12/2011	PY5GRU repeater on 146,640 S3		
21-22/12/2011	PY5GRU repeater on 146,640 S2		
25-26/12/2011	PY5GRU repeater on 146,640 S3		
27-28/12/2011			KP4 to CX; YV4 to LU (big!)
28-29/12/2011	PY2REK, PY5LF strong	X	YV4AKK to LU
29-30/12/2011	PY5GRU repeater on 146,640 S7		
30-31/12/2011	PY5GRU repeater on 146,640 S4		YV4AKK to LU
31-01/12-01/2011-2012	PY5GRU repeater on 146,640 S6		
01-02/01/2011	PY5GRU repeater on 146,640 S2		
02-03/01/2011	NIL		
03-04/01/2011			YV4AKK to LU & CX
04-05/01/2012	NIL		
05-06/01/2012	PY5GRU repeater on 146,640 S3		
06-07/01/2012	PY5GRU repeater on 146,640 S1		

09-10/01/2012	NIL		
10-11/01/2012	PY2 PU5 PY5EE	X	YV4AKK to LU
11-12/01/2012	PY5GRU repeater on 146,640 S4		YV4AKK to LU
12-13/01/2012	PY5 PU5 strong	X	
13-14/01/2012	PY5GRU/R S7 PY2JZW/R S9		
14-15/01/2012	PY5GRU repeater on 146,640 S2		
16-17/01/2012			KP4 to CX6DH (10w)
17-18/01/2012	PU2	X	
18-19/01/2012	PY repeaters S4		
20-21/01/2012	PY5GRU repeater on 146,640 S7		
21-22/01/2012			YV4AKK to LU
22-23/01/2012			YV4AKK to LU & CX
23-24/01/2012	PY5GRU repeater on 146,640 S3		
24-25/01/2012	NIL		
25-26/01/2012	PU5 PY5 PY2	X	YV4AKK to LU
26-27/01/2012			9Z4BM to PY5HOT
28-29/01/2012	PY5GRU repeater on 146,640 S6		9Z4BM to PY2 & PY5 & PP5 YV4AKK to LU
29-30/01/2012	PY5 strong, PU5 PY2 PP5	X	9Z4BM to PY2 & PY5 YV4AKK to LU
30-31/01/2012	PY5GRU repeater on 146,640 S3		YV4AKK to LU & CX
31-01/01-02/2012	PY5GRU repeater on 146,640 S3		
01-02/02/2012	PY repeaters S6		
02-03/02/2012	PY2 PY5	X	PY5 to 9Y; YV4AKK to LU
03-04/02/2012	PY5GRU repeater on 146,640 S7		
04-05/02/2012	PY2REK	X	FG5GP to PY5JR
10-11/02/2012	PY2REK + PY2ABN	X	
18-19/02/2012			KP4EIT to LU2ICA
19-20/02/2012	PY5		YV1 to LU
21-22/02/2012		X	YV4AKK to LU
22-23/02/2012	PP5 PU2	X	YV4AKK to LU; PU2YEN to FG4NN & FM1HM
23-24/02/2012			YV4AKK to LU
24-25/02/2012			PU2&PY2 to FG4NN & FG5GP; YV4 to LU; 9Y4VU to PP5EK

Table: 2m TEP observations by FM8DY, FK94MO (100w, 16 el.), in autumn and winter 2011/2012. From Sept. 1, 2011 to February 29, 2012 FM8DY has observed 92 days with TEP openings on 2m. On at least another 29 additional days 2m TEP QSOs were reported from other stations (YV4, LU, KP4, CX, KP2, 9Y, FG, ZP). Thus on at least 121 days of 182 days 2m TEP QSOs took place. That is 66% in the 6 months from Sept. to February. New compared to the year before was the good activity from CX stations who worked mostly into KP4 but also to YV4 and the activity from NP2X from US Virgin Isl. who worked into PY2, PY3, PY5, but also into LU, CX and ZP.

Typical 2m TEP paths in SA are in the 4500 km range from Martinique (FM), Guadeloupe (FG) and Trinidad (FK90) to Brazil (PY3, PY2, PY5), about 5000km from YV4 to LU and up to 5700km from KP4 to LU. Unfortunately many stations and expeditions in that region are not aware about these great DX possibilities which the amateurs in Europe can only dream about.

Best TEP time on 2m in this reagion is 23:00 to 02:00 UTC, sometime starting earlier from about 22:00 UTC and sometimes extending until 03:00 UTC.

Map: 2m TEP QSO paths from FM8DY to PY stations in 2011/2012

VHF South America

by Flávio Archangelo, PY2ZX

VHF Expeditions: Malpelo Island

Fig. 1: Manu LU9ESD and Franz DJ9ZB climbing the highest point of the island where one of the stations was built. Laying on the rocks, the 50 MHz beam waits for the moment to be erected. (Photo: HK0NA)

One of the most important expeditions of the world happened from December 31, 2011 to February 05, 2012: HK0NA, Malpelo Island, 12th DXCC most wanted entity on DX Magazine's list. 378 km far from the Colombian Pacific coast, the island presented huge topographic challenges. A team of 20 DXers was selected among the main DX groups. VHF was not forgotten and 6m activity was provided. According to Peter Sprengel, PP5XX, one of the HK0NA members, the expedition presented so high risks to the DXers that the first goal became the security, and then "giving at least one QSO on any band for a higher number of amateur radio operators around the planet". Two locations were used for the stations, one near the shore and another on the top of the island with 4 transceivers, one especially for 6 m: "The top was hard, it was very hot during the day and a lot of wind at night, but it was a fantastic place for VHF DX. We didn't have any obstacle, 360 degrees of free horizon".

The 6 meters station consisted of a K3 Elecraft (100 W) and 8 elements Yagi with 10 m boom. Peter told us that the antenna was too big and directive for expedition purposes but they managed 484 QSOs on 6m with 3 continents and 27 countries: "We had few QSOs, but all were terrific. The most interesting was E51EME, South Cook". Peter also worked on other bands and the final was very positive: the break of the record for the total QSO number made by an expedition, from former 183.000 to now 195.400 contacts!

Checking the bands

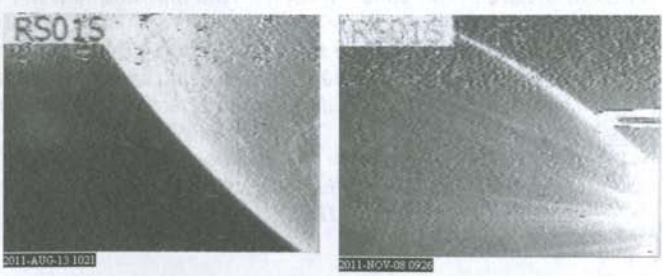


Fig. 2: ARISAT-1 SSTV images captured by Roland Zumerley PY4ZBZ at Três Lagoas/MG. The left photo shows us clearly the curvature of the Earth and on the second we see the terminator zone with the Sunshine on the lower right side of the picture. (Photos PY4ZBZ)

6m: Brazil had openings to the U.S. on 26 and 28/01 (DD/MM) and 11, 12 and 13/02. Fred PY2XB (GG66pi) described the last one as "TEP + Es skewed path", beaming EA8 to find USA. Stations in south and southeast Brazil worked: 8P6AZ, 8P9ER, 9Y4D, 9Y4VU, AB5EB, AC4TO, CE2WZ, CT1ETX, FM1FV, FG4NN, FM1FV, FM1HM, FM5AA, HC5VF, HP1AVS, HK0NA, HK2NPH, HK3DES, HK3O, HK3R, J8/JA7SGV, KP2BH, K1TOL, K2ZD, K2MUB, K5RK, N4NL, N5DG, N9HF, NW0W, OA4TT, P43L, P49MR, TI2ALF, TI2VLM, TI7/N5BEK, VP2ETE, VP2EKG, W3EP, W5PR, W5HNK, W8IF, WA4JQS, WD5IYT, WU0R, WZ8D, YS1AG, ZP5SNA. Luiz PP5/PY2OC (GG50cq) worked in January: CU3EQ, ZF1EJ and heard FY7THF/B. CU3/K0RUI worked PY2LED, PY2XB and PY1ON on 27/01. In the beginning of February UT1FG/MM activated several grids at CU and HP: GM82, GM50, GL14, FL81, FJ04, FJ09. PY7RP (HI22) worked CP6UA and J69MV on 21/02.

2m: Luiz PP5/PY2OC activated in January GG50cq (Passo de Torres, border between Rio Grande do Sul and Santa Catarina) on 70 cm, 2m and 6 m. Contacts with PY2ANE (GG66sh) and PY2REK (GG65pu) happened even with bad Tropo conditions on 144 MHz. By TEP he made QSOs with 9Z4BM with very strong signals. Still by TEP FM8DY worked PY2REK on 25 and 29/01. He was also heard by Pablo PU2PJA, located more to north at GG57sd on 26/01.

EME: Bruce PY2BS/PY1KK (GG76rs) made in the beginning of 2012 the first South American EME contacts on 6 cm (5,7 GHz). He used a DB6NT transverter, SSPA mounted on the RA3AQ feed (60 W), GPS G3RUH, antenna controller by OE5JFL and a 4 m dish. QSOs were made in SSB, CW and JT65 with OK1KIR, OH2DG, OK1KIR, SP6GWN, PA7JB, G3LTF, W5LUA, LX1DB, F2TU, PA0BAT, ES5PC, S59DCD, G4NNS and F1PYR. At the same time Bruce made his first EME QSOs on 2 m with a 14 element cross Yagi and 600 watts. He worked more than 40 stations, all in JT65. From Europe he wkd: F6FHP, DF2ZC, DL9MS, DF7KF, UA3PTW, OZ1LPR, UR3EE, PE1L, F1AFJ, K9MRI, OH6UW, DL8GP, DK5SO, SM5CUI, KB8RQ, I3LDP, UX0FF, LZ2FO, SM5DIC, I2FAK, PA1GYS, HA6NQ, S52LM, G4ZFJ, G4FUF, RN6DJ, SV8CS, I2RV, DM1CG, EA2AGZ, IK1UWL, RU1AA, I3MEK, F1DUZ, PA3FPQ, DK1CO, OH4LA, DK3WG, LZ1DP, F6HVK. From USA: K1JT, K6MYC, N9XG, K5GW, N7NW, AD4TJ, K5QE. During the same period Bruce was also active on 70 cm and 6 m EME.

Satellites: Roland PY4ZBZ (GH70un) and Luciano PY5LF (GG54jm) heard in the beginning of January the last signals of ARISSat-1 (KEDR/Radioscaf-B) in SSTV and TLM over Brazil. Curiously PY4ZBZ already heard the same satellite before the liftoff! The astronaut Dimitri Kondratyev has turned the satellite "on" when it was still inside the ISS (#70103 orbit), so the RS01S recorded voice messages could be heard on 145,950 MHz FM. The first stations to hear that uncommon emission were UA0QJ, JA0CAW and PY4ZBZ on 10/02/2011. The last reception of ARISSat-1 happened in Japan on 04/01/2012 #2411. PY4ZBZ also worked PY5AJ/MT, CX1TH, PY2SAD and PU2MHO via VO-52, PY3RAA via SO-50, PY2SAB via FO-20 and ZS2BK via AO-7 mode B #169.995. Also he heard the signals from UO-11, the 28 years old satellite with 150.001 orbits. PY5AJ worked PY3RAA via VO-52, while PY4RR heard ZP9SC in QSO with PY5LF via VO-52 on 13/02.

TV-FM: On 20/01 Fran PY2FGJ (GG66nf) noted Es to LU between 1930-2230z on 89,9, 91,1 and 96,3 MHz: "Unfortunately I was not able to identify them, but I believe they came from Rosario's region since I was receiving the "Canal Tres" (Ch3A, 60/66 MHz) of that area with very strong levels". The same Ch3A was used to copy "SBT Tangará da Serra" from PY9 area on 29/01 between 1800-2000z and north PT7: "For that direction we have night time apertures, normally from 2330 until 0230z with different levels".
Fran also heard Northeast Brazil at 91,1 MHz around 1800-2000z on 14/01, "Radio Euclides da Cunha FM" from Bahia (PY6). On the same day Daniel Rocha from Aracaju (HH19lc, PP6) heard "TV Globo" of São Paulo on Ch5A (76/82 MHz). That was the opposite side of the same propagation.
Via TEP Fran heard in January several Caribbean VHF-FM stations on 89,4 MHz Saphir (FG); 91,1 MHz The Observer (V2, more frequently and strong signal); 95,0 MHz RFO (FG), 95,5 MHz (VP2E); 95,9 MHz, 97,1 MHz, 101,1 MHz Slam (8P).
29/01 was the day of strongest TEP, when Samuel Cássio, located in São Carlos (GG67bx, PY2) also heard between 2330 and 0230z signals from 8P on 90,7, 92,1, 92,9, 94,7, 97,5, 98,1, 100,7 and 101,1 MHz; WP4 on 88,9 and 92,5 MHz and V2 on 91,1 MHz.
Rubens Ferraz Pedroso (GG56) heard from north PY5 more than 35 Caribbean stations in Jan. and Feb. NBCSVG (J8) 107,5 MHz was the highest one, on 16/02 at 2350z. Luiz PY2OC (GG66nt) also heard The Observer on 91,1 MHz and an unknown French speaking station on 88,5 MHz 02/02 at 2340z.
PP5/PY2OC GG50 heard English speaking stations on 91,1, 93,5, 95,5, 96,1, 98,7 and 99,1 MHz. Marcelo Munani (GG10qr) from west PY3 heard CE on 88,5 MHz "Concierto FM" of Santiago and on 88.9 MHz "Futuro FM", both by Es on 28/01 2340z.

EME News

70cm & up

Editor: Bernd Wilde, DL7APV

Intro

EME NET SAT/SUN 15:00 UT 14.345 MHz

Several expeditions did show up and Dubus Contest on 432 caused a lot of noise. SM4IVE seems to have to top position.

Bad WX over central EU caused problems during the 13cm EU EME contest weekend.

Next dates:
May 26/27 DUBUS/REF 23cm EME contest
& ARI Digital EME Contest
June 23/24 DUBUS/REF 5.7 GHz EME Contest

SSB contest

Several stations on the nothern hemisphere were frozen or/and had snow in their dishes. Winter in Eu kept activity low.

VK3UM 432 What a difference, you in Europe are copping it and here it was +30 at 0400 local. Total fire ban and winds of 90kph and high 30c's forecast today. Conditions terrible with deep fading polarity swinging wildly. Worked 6 on SSB and about the same on CW. 73 de Doug

G3LTF Had a few problems with a faulty tube in the 1296 PA but with my newly fitted filament switches I was able to isolate it and the power was then only slightly down. We had a 10cm fall of wet snow Saturday but it melted from the dish on Sunday morning. On 432 SSB I worked 10 and, 1 on CW. On 1296 MHz I worked 20 and on CW 3 more. Good fun, tnx for all the QSOs 73 Peter

Expeditions

The **M&M-team**, **DL1YMK**, is preparing the next EME-DXpedition, taking place in May 2012. We will set out for our destination just after having returned from the Swedish EME Meeting, organised by Lars, SM4IVE, on the weekend 12/13th of May in Örebro. We hope to get QRV on, 17th of May on 23 cm, 70 cm on 18.5 and 19.5. we will be on 13 cm, 20.5. again on 23 cm. For the first time during an EME-DXpedition, we intend to get also operational on 6 cm with our old, but proven stressed dish and a new superb feed made by our friend Tommy, WD5AGO. 6 cm will have an experimental character despite some 100 W out, as we couldn't test so far, if the under-illuminated dish will work up that high in frequency. Our plan is to give it a try on Monday, 21th May. Also, we intend to get active on 3 cm with a separate solid dish, which of course is a lot smaller. During the DUBUS contest on 26/27 May, we will of course be active on 23 cm in order to boost activity in the moonbounce contest of contests. Our last day of operation will be Thursday, 31 May. This year's DXpedition will be the **9th EME-DXpedition** in a sequence for us. Vy 73, Michael and Monika

4U1ITU wkd on 70 cm 8 EME and 1 tropo qso. Our antenna was on the roof of the 5 stock building directly next to the higher one. The 16 stock building blocked our complete moonset. This situation made it almost impossible to work W6 and W7 stations. We want to thank Attila Matas, the ITU stationmanager, for his hospitality. We had a great time! 73 Chris PA2CHR, Johan PA3FPQ, Jurgen PE1LWT and Rene PE1L

3W4TC, XV2A, YL from Phu Quoc, XV4HP

DL2NUD & DJ4TC were arv as **XV4HP and 3W4TC** from Vietnman in April and a new country for many of us on 70 & 23cm. Herrman and Peter used a 13wl M2 and abt 30W and on 1296 a 5m yagi and abt 120w. Many tnx!

5X1EME, after some very successfull DXpeditions to the Gambia, Bonaire and Curacao, Rene, PE1L will now try again to make Moonbounce QSOs from Uganda on 432 MHz. Uganda the pearl of Africa. If all ok, we will have a small 70cm setup with us. From May 25th (Eltjes birthday!) 5X1EME will be active from Uganda, the locator will be KJ60gh, near Kampala on the equator. We want to be active at least during two whole weekends when there is good activity in combination with good moon conditions. Internet possibility is unsure but we try to send at least once a day a update via MoonNet, MMMonVHF and our mailinglist. 73 Rene PE1L and Eltje PA3CEE

J52EME was qrv on 432 MHz with 2 homemade LFA antennas 18 elements & amplifier ITB Colibrì 600w. They had a good signal, but due to the big drift of their TRX they made only a handful qsos. It was a humanitarian/ham-radio expedition so

donations will go to a good purpose. They worked on 70cm on 4. April 2012, 2034 to 2224z: UA3PTW, HB9Q, DL7APV, LZ1DX, OK1DFC and OZ4MM. All in JT65.

EY8ZF (DL8YHR & PE1L) wkd 16 on 432 on their first moon pass in the end f April with very good signals. Too many things got damaged this trip as one dipole on 70cm, lost some sparbars, needed to modify local rig to be stabel on qrg, 1 combiner dead, stacking cabels lost, two 2m dipols bad and much more...

WAS W1QA: Some of you may remember back in the 1980's when I assisted Frank NC1I with a few 70cm EME DXpeditions to Rhode Island (RI) and Vermont (VT). Though I have heard and read mention of states people need I really don't have a good feeling for which ones. To find out I put together a quick web based survey in an attempt to gather info on what states EME'ers need to complete their WAS awards. Though I'm focusing strictly on 70cm I figured it would be fairly easy to also include 2&23. I'll keep the survey open through the end of May 2012 and provide a summary of its results sometime thereafter. Here's the link: **www.surveymonkey.com/s/EMEstates1** The plan is to have a station that would be something better than a typical holiday DXpedition setup with the goal to hopefully provide as many people as possible a QSO and at the same time make it easier to complete QSOs from the DXpedition side. Thanks in advance to those of you who take the time to fill out the survey.
73 Bob W1QA

KG7HF: I plan on replacing my home eme array early this summer and using the 4x4wl for array at our summer camp in VT. I should be qrv in VT in July and Aug for anyone needing that state. If there is a need, I could also take my amp which would mean I have about 400W at the ant. 73 Paul

Dubus contest 432 MHz

OK1DFC Hello EME guys, I am curious if anybody around had same problems as I had during past Moon window. I had many QSOs where I got 599 or 579 to me and did not have own echo. In opposite I hade own echo very strong and has no chance to be received by station on opposite site. I did not recognize so strange conditions as it was during this Moon pass. First part I had problems to have my own echo at all. First I thought that anything wrong with LNA or so, but stations as VK3UM, SM4IVE 599 on S-meter, OZ4MM 579-599, JA6AHB or JA9BOH were so strong. I was running new PA with TH293 with full power, so I think I had RF enough. I do not know if any electromagnetic fault in the Ionosphere or so but really never saw so strange conditions in my 16 ears EME experience. I was struggling with KL7HFQ, I was not able read him three or four periods and suddenly he was 559 easy copy and goes back to deep fade in the end of QSO. Worked 30 stations in first pass. GL & 73, Zdenek

DL7UDA Dietmar wkd 9 in cw, but he reports signals were low compared to the received reports. Loudest was SM4IVE but only 599 and no echos heard till around 2200. After contest he removed the power devider, relay and preamplifier to check at home. 73 Dietmar

G3LTF As I said some weeks back "432MHz EME is not for wimps!" Until sunset my echoes were absolutely zero, even on SDR, That is until I rotated the feed (it goes fast enough to do >90 degrees in 2.5 seconds). When I did that echoes were fine, so faraday was ~90 degrees or a bit less which is pretty normal for daylight, but there is usually some polarisation spread, very little yesterday. But there was something very strange going on, normally I peak the feed angle on VK3UM, give a couple of calls and we have a quick 559/569 QSO. yesterday I peaked the feed but... no reply ...until I turned the feed back by about 90 degrees. The same thing happened on some other stations, notably DL7UDA. There were also very obvious short term (15 second) enhancements in signal level; whether due to polarisation or absorbtion I dont know. Historically these effects are not new but I think that after a long time of quiet sun activity we have become used to "normal" conditions. I worked 34 on 432 MHz, and 13 on 9cm. Thanks for the nice QSOs, 73 Peter

DL9KR I could only spend half an hour March 3 and one hour March 4 on moonrise. Checking echoes on Saturday caused me to suspect an intermittent plus possibly water-soaked preamp and relay. UA3PTW was a shadow of himself, so was OK1DFC on Sunday. BTW, antenna box was perfectly dry and the whole system normal. Obviously, we had a sharply defined pol (90deg) with some unexplained deep QSB. Can't remember such weird condx. GL & 73! Jan.

SM4IVE as you remember I told you about the gemagnetic activity. As Peter G3LTF said, we have forgotten this behavior as we have had a long periode of low sun activity. Anyhow I did work 52 stations 48 multiples for a 249600 points, I went to bed @ 19.30, so maybe I missed some stations. New initials were: F6HZL, KØCIY, WQØP 2y & 400w, JE1TNL. 73 de Lars

DJ3JJ Was only qrv on sunday 04.04.12 and did work: SM4IVE, UA3PTW, OK1DFC, SV1BTR, OZ4MM, G3LTF, F2TU, I1NDP, SM2CEW, missed

LZ1DX and K5GW. Thanks a lot to everybody for the nice cw qsos. 73s Andreas,

VK3UM Thought I should add my experiences from down under. Yes I agree it was different to anything I have experienced on 70 over the past 3 decades and certainly added a lot of interest in making a QSO. As some one said correctly, 70 is not a band for 'wimps' and a degree of finesse has always been required on that band. I always have enjoyed 70cm EME for that very added challenge. How were signals ? .. just fascinating .. some were totally unreadable and the number of E5EE and I5II stations that were on was amazing (and combinations there of) but I resisted calling them! Some were plain loud but the rapid 'machine gun QSB' made it difficult to copy straight off but I implemented my 'deep search Doug decoder set to aggressive decode with maximum sensitivity but without computer aid nor chat room coordination, I still ended up working 30 odd! Amongst them was Phil VK4CDI whom I provided him with his first ever CW EME QSO. Besides this was the first occasion I can recall in > 30 years where we experienced conditions like last week end. 73 Doug

K3MF I thought my system was not up to snuff but after reading some of the reports about the conditions on 70 cm this past weekend.... my system is probably alright. Being "stuck" on H pol signals were weak on my end but stations in EU were giving me 559 reports. SM4IVE who is usually a "beacon" was weaker than usual as was UA3PTW and K5GW. Heard SV1BTR for a few sequences but by the time my amp warmed up, he was gone. I noticed deep QSB. 73, Wayde

N8CQ The weather hampered progress of my new setup in North Carolina. I was able to get access to a bucket truck and get the OK1DFC style loop feed installed on the dish. Some mechanical issues of weight / balance need to be addressed but at least I have a feed-horn and cabling installed at the dish now. Optimistic in the near future I will finally have the new setup operational. Gary

SP7DCS It was a real fun on 70cm eme this weekend after few months of inactivity. I was qrv on cw random with help of my son Maciek SP7MC. Conditions indeed were difficult and strange. Sometimes signals were very difficult to read. I spent most of the contest using V pol and I could not hear my echo during very long periods. So, rotable feed was very very helpful. There were times when I could detect very sharp polarization peaks of signal, but on the same weekend after a few hours I could find polarization somehow undefined. Final score is 25 qsos what is best score on 70cm so far - so I am very satisfied. 73 Chris

WA6PY was QRV in EU EME Contest. On 432 QSO'd SV1BTR OZ4MM SM4IVE and on my CQ UA3PTW F2TU SP7DCS K2UYH. During QSO with SM4IVE I was 10 Hz away from a strong bird and I was able to copy Lars only because he was extremely strong. Bird was coming with horizontal polarization and SM4IVE was also sharp on horizontal. On vertical bird was very weak, but Lars was completely gone. During my operating time all signals came with horizontal polarization while my echoes came 90 deg rotated. I heard LZ1DX SM2CEW K5GW, but could not find them calling CQ. vy 73 Paul

N4GJV completed 21 random CW QSOs. I experienced the same strange condx that others have mentioned, including abrupt changes in signal strength, extremely deep, rapid QSB, disappearing signals, etc. However, without any means of switching or rotating polarity, I was clueless about the cause of the issues. At times, however, conditions were very good, especially considering the fact that the moon was nearly at apogee. Many thanks to DUBUS for sponsoring the awesome fun, and to all of the participants!! 73 de Ron

23cm

ON0EME is the call from the new 23cm EME beacon. HB9BBD, ON4BCB & ON7UN made this fantastic project real. Planned in Oerebro 2011 at the EME meeting the rig is a 3.7m dish and 0,5 MW ERP. The beacon is on when the moon in nothern Belgium is above 10deg el. QRG is 1296.000 GPS locked and TX pwr is stable +/- 0,2dB. Big JOB guys!! See online status at **www.on0eme.org** See also report further down!

OK1TEH after 3 years I'm back on 23cm EME with my QRPP rig (17dBd 1m dish), linear pol. ring feed, about 250W at feed however poor RX. QRG is fixed by rubidium normal. I know that such a station isn't anything special, however during last days I worked in JT65C G4CCH (-25/-23), I1NDP (-27/-17) and PY2BS (-27/-25dB) and stations with 3m dish saw me -27dB. 73 & tnx Matej

DUBUS 9cm contest

WA6PY QSO'd OK1CA K5GW OK1KIR G3LTF K2UYH DL1YMK OZ6OL K2UYH again and W5LUA. Heard S59DCD ES5PC and WA9FWD. In sked after the contest with WA9FDW I could not find John although I heard my echoes.

OK1CA I am back via EME for 8 months and I worked OZ6OL and DL7YC before the contest on Friday. I was QRV only on Saturday in the contest and I worked ES5PC, G3LTF, K2UYH, K5GW, WA6PY, WA9FWD#, W5LUA, OZ6OL, VE6TA, OK1KIR, PA3DZL#, DL1YMK, S57NML #35,

S59DCD, DL7YC and PA0BAT. I had QRM from tropo stations worked in the I. Subregional Contest. See www.ok1ca.cz 73 Franta

LA8LF was QRV on 9cm EME for the first time in the contest on Sunday and worked 12 initials. All heard, all worked. First qso ever from Norway on 9cm EME was with Viljo, ES5PC. Worked were ES5PC, OZ6OL, OH2DG, S59DCD, LZ1DX, PA0BAT, PA3DZL, DL1YMK, DL7YC, LX1DB, K2UYH and K5GW. Gerald was 589!! Equipment is SSPA with 2ea. Toshiba combined for 85W out, 80 at feed which is a scaled down version of my 13cm feed with 5 step septum. LNA DDK but no idea of NF. SSPA, Kuhne transverter and PSUs are located behind dish like on 13cm. Measured 16.4 dB Sun noise at 109 Flux, Moon noise 0.6dB. 73 Anders

DL7YC just for the first time I participated in a 9cm EME contest. I had a 2.4m prime focus dish only and currently don`t know: Are my results good or bad? Wrkd Sat: OK1CA (outstanding signal from his 10 m dish - peaking sometimes S7), DL1YMK, OK1KIR, DF9QX, ES5PC, PA0BAT, K5GW (loudest EME-signal I ever heard on any microwave band), K2UYH, W5LUA, Sun: S59DCD, G3LTF, LA8LF, OH2DG, LX1DB, OZ6OL and heard but not worked PA3DZL, an unidentified W-stn and saw a lot of faint signals in the PERSEUS-SDR. Due to my power of 115w at the feed there was no problem about my signal. But I had some difficulties to copy stns below a certain level. My dish is too small for 9cm! This should be improved in the future. It seemed to me, 3400 MHz signals in the contest where a bit worse, compared what I know from earlier qsos. vy 73 Manfred

OK1KIR wkd OZ6OL, S59DCD, G3LTF, VE6TA, WA6PY, K2UYH, K5GW, ES5PC, OK1CA, PA3DZL, PA0BAT, DL1YMK, S57NML, DL7YC, OH2DG, WA9FWD, W5LUA. WD5AGO for 18 QSOs. Hrd was WW2R O and LA8LF 559.
Tonda & Vlada for OK1KIR

10 GHz DUBUS contest

PA7JB had a nice weekend. He made 10 qsos and 6 off them were new. DL7YC, F2TU, OK1KIR, LX1DB #, UR7D #, DL0EF very strong #, ES5PC, SM7FWZ #, OK1CA #, and what a signal from Jim W7CJO #. He likes to thank you all and till next time and he hopes to have 3 dB more power and a better preamp. Rig 18 watt in a 2,4 meter offset dish, RA3AQ feed and 1,5 dB moonoise. GL John

OK1KIR wkd ES5PC, G4NNS, F2TU, R3YA, HB9SV, DL0EF, SP7JSG, OH2DG, PA7JB, PA0PLY, LX1DB, IK2RTI, SM7FWZ, W7CJO, SV3AAF, WA6PY, W5LUA, VK3NX, F5JWF, OK1CA, F1PYR, UR7D. Total 23 x 23.

DL7YC could identify 22 stations and wrkd 19 of them: PA7JB, F2TU, OK1KIR, HB9SV #, OH2DG #, G4NNS #, ES5PC, LX1DB, DL0EF #, W7CJO #, IK2RTI #, PA0PLY #, WA6PY #, SM7FWZ #, W5LUA, R3YA #, UR7D # and OK1CA #21. Hrd: SP7JSG, F5JWF & SV3AAF. The day before (Friday 30.3) I worked W3SZ in FN20 as initial # 9. Tnx for all the nice contacts & sri for my "hearing problems". My dish is to small and the LNA cannot be mproved further (should I reduce pwr ??, hi).
Station in detail: 2.4m solid precision prime focus dish (f/D; 0.385) with VE4MA Super-feed, 80-85 watts @ HL-switch direct behind the feed (from RW1127 TWTA), 0.7dB DB6NT LNA, DB6NT 10 GHz/144MHz G3 Transverter. PERSEUS SDR for help, but sigs sounds better from IC-910H with view on SPECTRAN program. Automatic tracking by computer. Sun-noise this weekend: 14.1dB / Moon-noise this weekend 1.3 - 1.4dB (sometimes I measured 1.8 dB peak under perfect conditions - at other days). I am VERY interested in skeds on 3cm and I am qrv 6cm and 9cm too (skeds welcome). My 24 GHz setup is also fully qrv and I need 1 hour "to go". Vy 73 Manfred,

SM7FWZ: thank's for a nice first weekend, worked 13 stns and heard a few more. Wkd: OK1KIR, F2TU, LX1DB, DL0EF, W5LUA, DL7YC, VK4NX, OH2DG, OK1CA, UR7D, PA7JB, ES5PC, F1PYR. Heard: W7CJO, WA6PY, SP7JSG, R3YA, PA0PLY. Was heard by JA1WQF who reported 439 on HB9Q chat. I'm using a 4m f/D 0.4 solid dish, scalar ring feed, DB6NT 0.8dB NF, NEC TWT 23W. Using a coaxial system so I estimate some 0.3dB extra loss in both Rx and Tx. Copy my echoes pretty well. 73 de Ronny

OK1CA reports: The wx during the DUBUS EME Contest 2012 - 3cm part was very bad. I had high wind and rain with snow on Saturday in my QTH, the situation was better on Sunday. I worked first QSO on 14 UT Sunday with F2TU and followed with OK1KIR, F5JWF, F1PYR #45, SM7FWZ #46, OH2DG #47, LX1DB, DL0EF, UR7D #48, PA7JB #49, ES5PC, DL7YC #50 and very strong WA7CJO. The six initials are three new countries, a good result for me. I was QRV with 3m dish and 23W output at the feed. Franta

F2TU made 23 QSOs: ES5PC, R3YA, HB9SV, G4NNS, OK1KIR, DL7YC, PA7JB, OH2DG, LX1DB, DL0EF, IK2RTI, PA0PLY#, W5LUA, SM7FWZ #, WA6PY, W7CJO, VK3NX, F5JWF, OK1CA, IZ2DJP, UR7D, F1PYR, SV3AAF, W7CJO (DB). Heard SP7JSG short time loud, nil after, qrt? And on 04/04 qso W5LUA 559 /559, W3SZ #71 529/559 but O/O with storm(!).
Best 73 Philippe

24 GHz

OK1KIR: On Sunday 01.04. we moved to 24GHz and during the libration maximum wkd at 18:31 LX1DB 559/569; 19:08 G4NNS O/O and 21:20 W5LUA O/O. Only 3 QSO and 3 multipliers gave 900 pts. Moon noise measured 2,2 dB (high RH during late eve). Spectran waterfalls of all three stns can be found on hp. Tonda & Vlada.

Reports

PA3DZL made his first 6cm EME QSO with Philippe, F2TU O/O and 529/529 # 1. Also heard Al, W5LUA with very strong signals 559! Next days he added G3LTF # 5 on sked. Signals from Peter were not very strong but good copy. K5GW #6 on random. Gerald had SUPER strong signals, was moving the S-meter! Strongest signals heard on 6cm up to now. Rig: 3.7m dish 18W@feed.
73s Jac

PA0BAT: My new dish with 3 cm set-up is ready: 3.7 m solid dish, lin. pol. Sun noise 16 dB, moon noise 1.95 dB. 0.8 dB NF, 18 W RF, good own echoes. If anyone likes to try today, please let me know. 73, Gerard PA0BAT

OZ1FF worked LX1DB on 24 GHz as his initial #1. Kjelds rig is a: 1,8 m Prodelin offset dish with 10 W from a SSPA in a W1GHZ 10/24 GHz dual band feed. DB6NT preamp with 1,4 dB NF and DB6NT XVTRs to a Flex 1500. He also tried with OK1KIR but signals to weak. He measured Sun noise up to 11,8 dB and Moon noise 1,4 -1,8 dB. Later he had sked with W5LUA, Al was armchair copy with his 100 W and he could hear my 10 W, but not strong enough for a complete contact. Then he made easy QSO's with DL7YC #3 and DF1OI #4.
Vy 73 de OZ1FF Kjeld

W5LUA reports that after 24 plus years he retired from Avago at the end of April..... so he should have more time for fun stuff... (we will see, hi apv). On Jan 6th I worked PY1KK on 5760 MHz to give me WAC. I received my 5760 MHz WAC certificate dated March 20, 2012.... I also worked on 5760 MHz SP6GWN for initial #49. I also worked on 5760 MHz F1PYR for initial #50 and DL7YC for initial #51 on Feb 26th. On 3400 MHz, I worked on March 2/3 OK1KIR, PA3DZL (#42), DL7YC (#43), OK1KIR (WSJT), OK1CA, PA3DZL, K5GW, WA9FWD, OZ6OL, S59DCD, K2UYH (#44), VE6TA, DL1YMK, G3LTF, DL7YC, WD5AGO, WA6PY, and WW2R. On March 25th, I added LA8LF for # 45 on 3400 MHz. I also worked F2TU on 5760 MHz on March 25th. On March 28th I worked on 5760 MHz OK1KIR and PA3DZL for initial #52. On March 30th, I worked WA1ZMS on 1296 for his first initial and my initial # 353. On March 30th, I worked K2UYH on 10 GHz for initial #82. On March 31st, I worked on 10 GHz DL0EF, OH2DG, F2TU, G4NNS, W7CJO, R3YA (#83), IK2RTI, LX1DB, PA0PLY (#84), OK1KIR, SM7FWZ (#85), and DL7YC. ON April 1st, I worked on 24 GHz, OK1KIR, LX1DB and G4NNS. Also on April 1st, on 10 GHz I worked OK1KIR, ES5PC, DL7YC, UR5D, WA6PY, F1PYR and F2TU. 73 Al

RA3EME (RK3WWF) is QRV on 24 GHz EME since April and wkd OK1KIR # for the 1st QSO. Rig: 2m dish, 20w, 1.8db LNA. Alex, RK3WWF

Contest High Scores

Winner ARRL 2011 :	
Category	CALL
Single Operator, CW Only, All Band	SV1BTR
Single Operator, All Mode, All Band	K5GW
Single Operator, CW Only, 144 MHz	OZ1HNE
Single Operator, All Mode, 144 MHz	KB8RQ
Single Operator, All Mode, 432 MHz	OK2POI
Single Operator, CW Only, 432 MHz	DL9KR
Single Operator, CW Only, 1.2 GHz	G4CCH
Single Operator, All Mode, 1.2 GHz	OK2DL
Single Operator, All Mode, 2.4 GHz	ON5TA
Multioperator, CW Only, All Band	SP7DCS
Multioperator, All Mode, All Band	K1JT
Multioperator, CW Only, 144 MHz	J48OAA
Multioperator, All Mode, 144 MHz	RU1AA
Multioperator, All Mode, 432 MHz	OH2PO
Multioperator, CW Only, 1.2 GHz	N2UO
Multioperator, All Mode, 1.2 GHz	RA3AUB
Multioperator, All Mode, 2.4 GHz	SP6OPN
Multioperator, All Mode, 5.7 GHz	SQ6OPG
Multioperator, All Mode, 24 GHz	OK1KIR

Winner ARI EME Marathon 2011	
432 MHZ. CW/SSB 1B	DG1KJG
432 MHZ. Digi Mode 2B	DL7APV
1296 MHz. QRP 1C CW	IK5QLO
1296 MHz. QRO 2C CW/SSB	G4CCH
1296 MHz. 3C DigiMode	PA3FXB
2.3 GHz. 1D CW/SSB	CT1DMK
5.7 GHz. 1E CW/SSB	OK1KIR
10 GHz. 1F CW/SSB	OK1KIR
24 GHz	OK1KIR

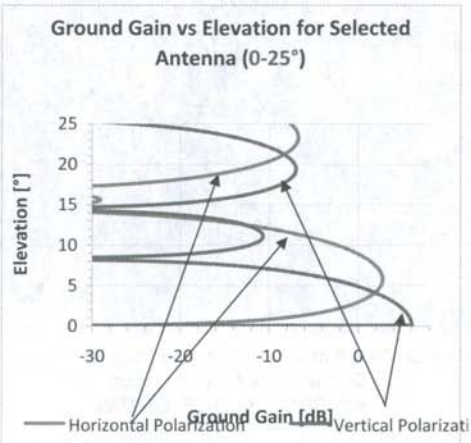
Last

Saturday April 28 was the last day of operations for about one year at **PI9CAM**. The BIG restoration will begin and we hope to be back with an as good as new dish in April 2013. 25 m Dwingeloo dish. 73 from the PI9CAM team

The special call **SN2012GAM** wkd 42 QSOs in the 13cm DUBUS EME contest on April 28/29.

Some comments from ON4KHG about the 432 MHz Ground gain report from VK7MO & DL7APV:

I have read in DUBUS that you think you have experienced ground gain on 70cm. This is very likely to be possible. I have simulated your system. With the antenna at 1,2m agl (over a perfect ground), I come up with a ground gain enhancement of 2,7 dB for H-pol and 6 dB for V-pol. For H-pol, the maximum of the lobe is building at 11,8m from the antenna and the elevation angle is 5,8°. For V-pol, it is 687m @ 0,1° elevation (not very realistic).



So, you assume you get GG given the antenna agl is low and hence the surface on the ground where the lobes build is limited higher probability the ground stays flat enough, correct!
Low agl = low elevation angle, this is not correct, the lower the agl, the higher the elevation angle! However, 5,8° elevation seems to cope with the 4° and 10° respectively you mention.
With the 1,2m agl you mention, the lobe maximum is building when the wave front from the antenna is hitting the ground with a 8,3° angle. This should cope with the -3dB opening angle of your antenna. If your antenna would have been higher agl, both the elevation angle and the angle between wave front from the antenna and ground would have been lower (5,8° and 8,3° to become lower) BUT the surface on the ground would have been higher lower probability the ground stays flat over the whole area. All this can also be measured thanks to sun noise:
www.on4khg.be/EME_Gr_Gain.html

73, Gaëtan

Find all links on my homepage:
www.mydarc.de/dl7apv and click on links

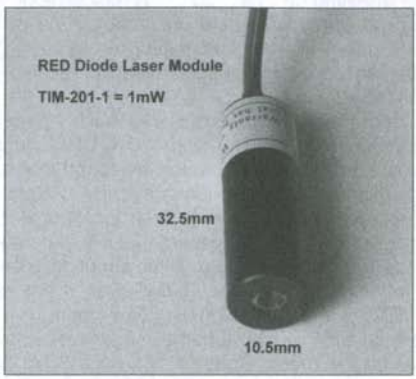
73 Bernd DL7APV

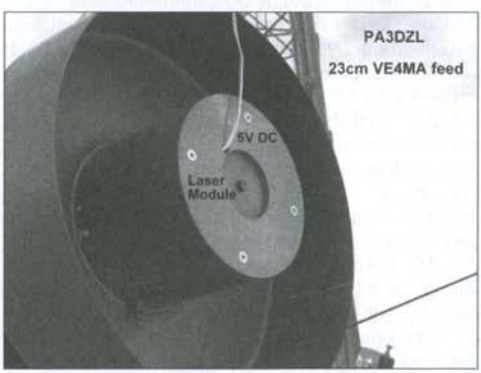
Technical

How to get your feed in the centre of your dish?

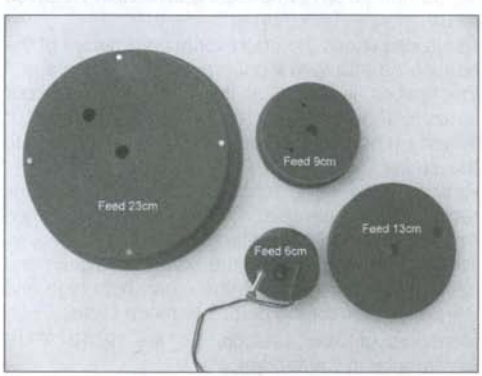
by Jac de Bruijn, PA3DZL

For this I use a small laser with a mount/socket which I can put in the waveguide of the feed. Easy and very simple!





I use it for my 23, 13, 9 and 6cm feeds.



The ON0EME Moon beacon

Many of the active 1296 EME stations have noticed a signal on 1296.000 sending "de ON0EME" (4 times) followed by 10 seconds of pure carrier and 20 seconds of silence. What you hear is an automatic station tracking the moon when the moon is 10° or higher on its horizon, and stops when the moon is +10° before setting (License restrictions).

The idea started in Orebro Sweden during the EME meeting in May 2011. A discussion was going on how to promote our hobby. One of the idea's was a beacon transmitting a signal on the moon, encouraging people trying to receive the weak reflections.

An Idea was born. On our way back home we (HB9BBD, ON4BCB and ON7UN) further discussed the possibilities and we found that a lot of hardware was in our hands already to start this project. We started to look for a location, a high power license, started to search for equipment and started to build equipment. After about 11 months of intensive work, the baby was born and ON0EME was transmitting direction moon.

The total EIRP is about half a megawatt of power following the moon. Antenna is a solid 3,7m dish. The system is completely automatic and a the beacon starts when the moon is on the east side +10 degrees, by turning the antenna from the point where it stopped the moon cycle before (moon set in the west +10°).

We designed the beacon having following design criteria on mind: Frequency must be GPS locked and the transmit frequency must be 1296.000000. Frequency accuracy is 3 x 10-11. A second feature is that the timing of the beacon is also GPS controlled, the beacon will start transmitting at the minute. Further the amplitude of the signal is within +/- 0,2 dB amplitude, giving a very stable signal. Antenna pointing is being updated every 0,4° good enough for a 3,7m reflector.

We have complete remote monitoring and control of the beacon, measuring voltages, power, temperatures so complete housekeeping can be seen.

Users can check the operational parameters of the beacon on http://www.on0eme.org you can see if the beacon is active, if the moon is above our horizon, if the beacon is OK to transmit (+10° elevation) and even when the PTT is being send to the exciter.

Reports have been received from small stations receiving the beacon. Please post reports on "moon" or "moon-net" reflectors.

The beacon is located in the north of Belgium and having a good visibility to the moon both high and low declination for the complete moon cycle.

More about the beacon at the 2012 EME Conference in Cambridge.

The ON0EME moon beacon on its final location in JO21 with its founders from left: HB9BBD, ON4BCB, ON7UN.

The 30m Jamesburg Dish is for sale for 3.000.000 $. Any takers? ☺

UR7D – 10 GHz EME in DUBUS contest

The 2012
144 MHz Digital EME Championship

sponsored by DUBUS and REF

The 144 MHz Digital EME Championship is intended to encourage world-wide activity on 2m moonbounce. Each different call prefix forms a multiplier.

1. Championship Date

July 21st 00:00 UTC to July 22nd 23:59 UTC (48 hours) 2m Digital only

2. Sections and Awards

No sections! The first 10 places will get an award. **The winner will get a 1 year free DUBUS subscription and a 250 € shopping voucher from InnovAntennas.** The second place will get a 125 € voucher and the third place a 75 € voucher from InnovAntennas.

3. Rules

For the purpose of the contest only one scoring per valid QSO with the same other callsign can be logged. No other limitatons! Use of loggers and cluster is allowed.

4. Contest Exchange

For a valid EME QSO, both stations must have copied all of the following via the EME radio path:
4.1 Both callsigns from the other station
4.2 Signal report from the other station
4.3 R, from the other station, to acknowledge complete copy of 4.1 & 4.2

5. Logs

Logs should be in usual logbook format. Exported files from logging software are acceptable.
Each QSO: Date/Time, Callsign, Report sent, Report received
Bottom line: Total QSO points, total multipliers, total claimed score.

6. QSO Points

1 point for each QSO completed (random = sked)

7. Multipliers

Each different call prefix is a multiplier (e.g. CT1, DK9, SM2, SM3, S51, S54, G6, KM5, W5, JA6, VK4, WA6, K6, PA1, PE1, etc). See example of WPX Contest rules for further details on prefix multipliers.

8. Total Score

Score = Total of QSO points * Total of multipliers.

9. Contest Entries

Copy of the log with details of points, multipliers and total points. Also add name(s) and call(s) of operator(s) and grid locator. Other info is welcome: Comments, conditions, station details, photographs, etc.

10. Sending Your Entry

Contest entries **MUST** be sent no later than **14 days via Email only** after the end of the contest weekend

(i.e. by **August 5th, 2012**) to: **FUNK-TELEGRAMM@t-online.de**

All email entries will be acknowledged within 5 days. If not, pse resent your entry!

Good Luck and 73! Joachim Kraft, DL8HCZ/CT1HZE

Tropo Reports

2m, 70cm and up

Editor: Michael M. Dienel, DG7SFL
dubustropo@mmdienel.de

2m

DK3WG, JO72GI, wkd on March 13, 2012:

G4RRA	IO80BS	1279km
GW8JLY	IO81JM	1215
F6EOQ	IN78RJ	1415
F1MPR	IN78TM	1398
F1SAH	IN88LT	1295
F4ELJ	IN78RJ	1418
G8VYK	JO01FO	964
G4DCV	IO91OF	1057
F6DWG/p	JN19EL	906
2E0NEY	IO81VK	1149
F6CGJ	IN78RK	1413
F2GL	JN17ST	928
F6FEO	JN09NW	969
F1UVN	JO10HE	859
F8BRK	IN99VF	1088
F0FIG	JO10JE	848
F1CXX	JN18AT	961
F6KIF/p	JN19XH	812
F4DNK	JN09IM	1014

G4LOH, IO70JC wkd on March 13, 2012:

1902	DD3SP	JO72en	1383km
1935	OK1TEH	JO70fd	1398km
1949	I2SVA	JN45nt	1170km
2005	I3MEK	JN55sj	1354km
2018	F1USF	JN23cn	1021km
2108	IW2DAL	JN45nn	1183km
2127	IZ3KGJ	JN65iw	1410km
2205	IZ4BEH	JN54vk	1425km
and on 14 March 2012:			
0904	OE3FVU	JN78ve	1538km
0913	OE2UKL	JN68la	1340km
0920	OK2AF	JN89ar	1520km
0927	**SQ9QU**	**JO90kk**	**1707km**
0934	**OK2PM**	**JN99ao**	**1660km**
0958	OK1DMP	JN79ix	1418km
1523	SQ9QU	JO90kk	1707km

GW8JLY, IO81JM, wkd >1000km on March 14:

07:16	DK3WG	JO72GI	1221km
08:18	DF1CF	JN57FP	1076km
08:24	OE2UKL	JN68LA	1225km
08:47	OE5OLL	JN68SI	1250km
08:50	DF3RU	JN59UL	1080km
08:55	OE3FVU	JN78VE	1411km
09:18	DB6NT	JO50VJ	1059km
10:49	DK2EA	JO50UF	1058km
11:15	DF9RJ	JN68GS	1164km
11:21	DL9GK	JO50VJ	1059km
11:33	OK1TEH	JO70FD	1251km
13:32	DK1FG	JN59OP	1040km
14:25	DF0HF	JO50SF	1046km
15:49	DG5CST	JO60DS	1086Km
17:07	DL3WW	JO60FL	1101km

70cm

OE2WPO/P, JN67NT, wkd on March 14, 2012:

16:29	M0IKB	IO94SG	1188km
16:32	G4EAT	JO01HR	997km
16:32	GW8ASD	IO83LB	1282km
16:34	G6CQC	IO94DT	1288km
16:35	G4DHF	IO92UU	1103km
16:37	G4KIY	IO92WN	1079km
16:37	G0NNF	IO92AL	1191km
16:38	G8HGN	JO01FO	1002km
16:40	GW3ATZ	IO83LE	1287km
16:41	G8JVM	IO82SP	1229km
16:43	G0TRB	IO92EO	1175km
16:43	G3ZEZ	JO01NT	968km
16:45	G4PBP	IO82WO	1206km
16:46	G4ZTR	JO01KW	989km
16:48	G3LQR	JO02QF	971km
16:50	G3WZT	IO90UX	1032km

Rig: FT-847 2x21 El. Yagi

23cm

DK7QX, JO42KH, wkd on 23cm (>600km):

Time	Call	LOC	QRB	Remark
21 Feb 2012				
20:10	SM6AFV	JO67GQ	642km	AR
13 Mar 2012				
21:27	G4PBP	IO82WO	745km	TD
21:33	G3OHH	IO83VC	751km	TD
21:50	G4CBW	IO83UB	757km	TD,SSB
14 Mar 2012				
09:02	F6APE	IN97QI	875km	TD
18:15	G3LTF	IO91GG	719km	TD,SSB
18:51	G0EWN	IO93FK	710km	TD,SSB
20:27	G4BRK	IO91HP	705km	TD
20:34	G0MJW	IO91IO	701km	TD
15 Mar 2012				
07:06	G4CBW	IO83UB	757km	TD,SSB
07:22	G4RGK	IO91ON	667km	TD
07:34	G0EWN	IO93FK	710km	TD,SSB
08:02	G8JVM	IO82SP	768km	TD,SSB
09:01	G0WUU	IO92SR	633km	TD,SSB
24 Mar 2012				
19:37	SM6AFV	JO67GQ	642km	TD,SSB
21:39	G3YJR	IO93FJ	709km	TD,SSB
21:48	G4KUX	IO94BP	756km	TD,SSB
21:57	LA3EQ	JO28XJ	701km	TD
22:06	G4NBS	JO02AF	601km	TD,SSB
22:09	G7LRQ	IO91TQ	637km	TD,SSB
22:32	G4KIY	IO92WN	610km	TD,SSB
22:42	G8CUL	IO91JO	695km	TD,SSB
22:53	SM6AFV	JO67GQ	642km	TD,SSB
23:15	SM6EAN	JO57WQ	627km	TD,SSB
25 Mar 2012				
06:49	G4CBW	IO83UB	757km	TD,SSB
07:50	G4IDR	IO93BP	734km	TD,SSB
26 Mar 2012				
20:04	G8PNN	IO95EF	761km	TD,SSB

AR: Airplane Reflection TR: Tropo Ducting
TS: Troposcatter RIG: 180W, MGF1302, 44 Ele Yagi

DL1SUZ, JO53UN, wkd on 23cm:

25 Mar 2012

07:53 PE9GHZ JO11WL 578km

08:39	G4KIY	IO92WN	797km
26 Mar 2012			
17:26	GM4LBV	IO86RQ	968km
18:40	G4KUX	IO94BO	892km
19:35	G4DDK	JO02PA	720km
20:07	G8PNN	IO95EF	881km

G8ARM, IO70GD wkd on 23cm on March 16:

F6DKW	JN18SC	693km	SSB

OK1DFC, JN79GW, wkd:

13 March 2012				
2033	G4EAT	JO01FR	57 57	996km
2048	F6DKW			
2114	G3LTF	IO91GG	559 wkd	1137km
14 March 2012				
0645	GB3USK/B	IO81QJ	max 579 hrd	
0713	G4CBW	IO83UB	559	1213km

OE5VRL, JN78DK, wkd on March 14, 2012:

1912	GB3USK	IO81QJ	539 hrd	1252km
1930	G0EWN	IO93FK	wkd	1232km

OZ1FF, JO45BO, wkd on 23cm:

Date	Time	Call	LOC	QRB
2012/01/17	19:37	DF9IC	JN48IW	742km
2012/01/17	19:43	SK0CT	JO99BM	737km
2012/01/17	20:29	G3XDY	JO02OB	600km
2012/01/17	20:32	G8OHM	IO92AJ	748km
2012/01/17	20:57	GM4CXM	IO75TW	781km
2012/02/21	18:58	DF9IC	JN48IW	742km
2012/02/21	19:20	SK0CT	JO99BM	737km
2012/02/21	21:56	GM4CXM	IO75TW	781km
2012/03/13	21:55	F9OE	IN78QG	1192km
2012/03/14	09:13	F6APE	IN97QI	1097km
2012/03/14	16:16	GM3SBC/P	IO86JF	709km
2012/03/14	22:34	OE5VRL/5	JN78DK	901km
2012/03/20	18:44	SK0CT	JO99BM	737km
2012/03/20	18:47	SM0FZH	JO99HI	752km
2012/03/20	19:20	SM0DFP	JP90JC	804km
2012/03/20	19:48	DF9IC	JN48IW	742km
2012/03/20	20:34	GM4CXM	IO75TW	781km
2012/03/20	21:05	G8OHM	IO92AJ	748km

SM7ECM, JO65NQ, wkd on 23cm (>500km):

Date	Call	LOC	QRB
2012-01-14	DL1HTT	JO61FR	
2012-01-17	SM0EUI	JO99ES	551 km
2012-01-17	SM0DFP	JP90JC	594 km
2012-01-17	PA0EHG	JO22HB	687 km
2012-01-17	PA0S	JO21FW	705 km
2012-01-17	SM3BEI	JP81NG	663 km
2012-01-17	SK0CT	JO99BM	520 km
2012-01-17	SK4AO	JP70TO	566 km
2012-01-17	DF9IC	JN48IW	809 km
2012-02-21	SM0EUI	JO99ES	551 km
2012-02-21	SK4AO	JP70TO	566 km
2012-02-21	PA0S	JO21FW	705 km
2012-02-21	DF9IC	JN48IW	809 km
2012-02-21	SM3BEI	JP81NG	663 km
2012-02-21	SK0CT	JO99BM	520 km
2012-02-21	DK2MN	JO32MC	564 km
2012-03-20	SK4AO	JP70TO	566 km
2012-03-20	SM0DFP	JP90JC	594 km
2012-03-20	DB6NT	JO50TI	602 km
2012-03-20	PA0S	JO21FW	705 km
2012-03-20	PA3AWJ	JO21GW	701 km
2012-03-20	SM3BEI	JP81NG	663 km
2012-03-20	DK2MN	JO32MC	564 km
2012-03-20	SM0FZH	JO99HI	524 km
2012-03-20	DF9IC	JN48IW	809 km
2012-03-20	SK0CT	JO99BM	520 km
2012-03-24	PA2M	JO21IP	715 km
2012-03-24	G4EAT	JO01HR	934 km
2012-03-24	G4KIY	IO92WN	932 km
2012-03-24	G3YJR	IO93FJ	981 km
2012-03-24	G7LRQ	IO91TQ	995 km
2012-03-24	G4NBS	JO02AF	939 km
2012-03-25	M1BXF	JO02BE	937 km

13cm

DL1SUZ, JO53UN, wkd on 13cm:

Time	Call	LOC	QRB	Remark
26 Mar 2012				
20:28	G8PNN	IO95EF	881km	

OZ1FF, JO45BO, wkd on 13cm:

Date	Time	Call	LOC	QRB
2012/01/24	18:41	DF9IC	JN48IW	742km
2012/01/24	20:55	GM4CXM	IO75TW	781km
2012/02/28	19:34	G3XDY	JO02OB	600km
2012/02/28	21:06	GM4CXM	IO75TW	781km
2012/02/28	21:39	G8OHM	IO92AJ	748km
2012/03/13	22:23	F6DWG/P	JN19AJ	803km
2012/03/14	22:47	OE5VRL/5	JN78DK	901km
2012/03/27	18:18	G3XDY	JO02OB	600km
2012/03/27	19:17	DF9IC	JN48IW	742km
2012/03/27	19:37	G8OHM	IO92AJ	748km
2012/03/27	19:51	GM3UAG	IO87XJ	654km
2012/03/27	19:55	GM4LBV	IO86RQ	671km
2012/03/27	20:05	G8PNN	IO95EF	616km
2012/03/27	20:08	GM4CXM	IO75TW	781km
2012/03/27	20:12	GM4JTJ	IO86RP	670km
2012/03/27	20:28	G4CBW	IO83UB	731km
2012/03/27	20:51	G4NBS	JO02AF	648km
2012/03/27	20:56	G4BRK	IO91HP	764km

TNX for report!

SM7ECM, JO65NQ, wkd on 13cm (>250km):

Date	Call	LOC	QRB
2012-01-24	OZ9PP	JO47VA	254 km
2012-01-24	SM0DFP	JP90JC	594 km
2012-01-24	SM3BEI	JP81NG	663 km
2012-01-24	OZ1FF	JO45BO	314 km
2012-02-28	SM6HYG	JO58RG	305 km
2012-02-28	SM3BEI	JP81NG	663 km
2012-02-28	OZ1FF	JO45BO	314 km
2012-03-24	G4KIY	IO92WN	932 km
2012-03-24	G4BEL	JO02BI	927 km
2012-03-27	SM6HYG	JO58RG	305 km
2012-03-27	DB6NT	JO50TI	602 km
2012-03-27	SM6BTT	JO68QO	325 km
2012-03-27	SM0DFP	JP90JC	594 km
2012-03-27	DL1SUZ	JO53UN	254 km
2012-03-27	SM3BEI	JP81NG	663 km
2012-03-27	DC6UW	JO44VJ	257 km
2012-03-27	OZ9PP	JO47VA	254 km
2012-03-27	DK1ZD	JO44WE	267 km
2012-03-27	OZ1FF	JO45BO	314 km

9cm

SM7ECM, JO65NQ, wkd on 9cm (>250km):

Date	Call	LOC	QRB
2012-01-24	SM0DFP	JP90JC	594 km
2012-02-28	SM6HYG	JO58RG	305 km
2012-03-24	DL6ABC	JO62OM	353 km
2012-03-24	G4BEL	JO02BI	927 km
2012-03-24	G4BAO	JO02CJ	920 km
2012-03-27	SM6HYG	JO58RG	305 km
2012-03-27	DB6NT	JO50TI	602 km
2012-03-27	SM0DFP	JP90JC	594 km
2012-03-27	DL6ABC	JO62OM	353 km
2012-03-27	DL1SUZ	JO53UN	254 km
2012-03-27	DK1ZD	JO44WE	267 km

6cm

G4ALY, IO70VL, hrd on 6cm:
14 Mar 2012
HB9G RST 549 QRB 883km

SM7ECM, JO65NQ, wkd on 6cm (>250km):

2012-01-24	SM0DFP	JP90JC	594 km
2012-02-28	SM6HYG	JO58RG	305 km
2012-02-28	SM3BEI	JP81NG	663 km
2012-02-28	OZ1FF	JO45BO	314 km
2012-03-24	G4EAT	JO01HR	934 km
2012-03-24	G4BEL	JO02BI	927 km
2012-03-27	SM6HYG	JO58RG	305 km
2012-03-27	DB6NT	JO50TI	602 km
2012-03-27	SM0DFP	JP90JC	594 km
2012-03-27	DL1SUZ	JO53UN	254 km
2012-03-27	SM3BEI	JP81NG	663 km
2012-03-27	DC6UW	JO44VJ	257 km
2012-03-27	DK1ZD	JO44WE	267 km
2012-03-27	OZ1FF	JO45BO	314 km

3cm

DC6UW, JO44VJ, wkd on March 13, 2012:
2125 F6DWG JN19AJ 59+ 769km
(also wkd F6DWG on 6cm at 2118 with 59+)

DK7QX, JO42KH, wkd on 3cm (>300km):

Time	Call	LOC	QRB	Remark
03 Mar 2012				
17:29	DL0VV	JO64AD	293km	
04 Mar 2012				
08:15	PA3AWJ	JO21GW	299km	
09:41	DL6ABC	JO62OM	295km	
13:49	PA0S	JO21FW	304km	RS,SSB
14 Mar 2012				
22:13	F6DKW	JN18CS	614km	TD
15 Mar 2012				
08:52	G4BEL	JO02BL	594km	TD,SSB
09:55	G4EAT	JO01HR	568km	TD
24 Mar 2012				
22:57	SM6AFV	JO67GQ	642km	TD,SSB
23:53	OZ6OL	JO65DJ	409km	TD

RS: Rainscatter TR: Tropo Ducting
TS: Troposcatter RIG: 2W, 55cm Dish

G4PBP, IO82WO, wkd on March 14, 2012:
1950 DB6NT JO50TI 59 983km

OE5VRL/5, JN78DK, wkd on March 14, 2012:

1958	F5ZTR/B	JN18FK	599	hrd	870km
2007	F6DKW	JN18CS	59+	wkd	888km
2029	F1PYR/P	JN19BC	59	wkd	894km
2030	F6DWG	JN19AJ	59+	wkd	900km

OZ1FF, JO45BO, wkd on 3cm:

Date	Time	Call	LOC	QRB
2012/01/24	21:30	SM7ECM	JO65NQ	314km
2012/02/28	21:32	SM7ECM	JO65NQ	314km
2012/03/26	18:21	DJ1LP	JO64BC	305km
2012/03/26	19:43	G4KUX	IO94BO	645km
2012/03/27	17:03	DJ1LP	JO64BC	305km
2012/03/27	18:43	SM6AFV	JO67GQ	356km
2012/03/27	19:07	SM7DTE	JO75CN	382km
2012/03/27	19:24	G3XDY	JO02OB	600km
2012/03/27	20:34	SM7ECM	JO65NQ	314km
2012/03/27	20:46	G4CBW	IO83UB	731km

SM7ECM, JO65NQ, wkd on 3cm (>250km):

Date	Call	LOC	QRB
2012-01-24	OZ9PP	JO47VA	254 km
2012-01-24	SM0DFP	JP90JC	594 km
2012-01-24	OZ1FF	JO45BO	314 km
2012-02-28	OZ1FF	JO45BO	314 km
2012-03-24	PA2M	JO21IP	715 km
2012-03-27	DC6UW	JO44VJ	257 km
2012-03-27	DK1ZD	JO44WE	267 km
2012-03-27	OZ1FF	JO45BO	314 km

1.5cm

OZ1FF, JO45BO, wkd on 1.5cm:

Date	Time	Call	LOC	QRB
2012/03/27	17:59	OZ1CTZ/P	JO46HE	72km
2012/03/27	18:31	DC6UW	JO44VJ	171km

SM7ECM, JO65NQ, wkd on 1.5cm (>250km):

2012-03-25	OZ2LD	JO54WW	115 km
2012-03-27	OZ2TG	JO65FP	43 km
2012-03-27	SM7DTE	JO75CN	70 km
2012-04-12	OZ2LD	JO55XK	79 km

SM7LCB, JO86GH, sent the following info:
Nothing to report because my remote station have been offline for some month and but that I have nothing to report. But now I'm back and hopefully I will have something to report for the next DUBUS.
My web is now at these URL:
http://sm0lcb.dyndns.org http://sm7lcb.dyndns.org/
73 de ULF / SM7LCB in JO86GH

DL7QY, JN59BD, sent the following info:
Super Tropo Condx to England on 14th/15th March 2012 on microwave: wkd on **3cm, 9cm, 13cm, 23 cm, 3cm** G4CBW in IO83UB 539/539 970km for a new grid on 13/9/3cm and new ODX on 9+3cm! G4CBW was 539 on 3cm at 2235z on March 14. On **3cm** G0EWN IO93FK 55/55 SSB 940km and on 23cm 579. Wkd on **23cm:** G4PBP IO82WO 940km, G4BRK IO91HP, G3LTF IO91GG, F6APE IN97QI 820km and hrd beacon GB3USK in IO81JQ 599, More info on my homepage www.dl7qy.eu 73 de Claus DL7QY

Many TNX to all who sent reports!!!

DX and Measurements on 76 and 122 GHz

by Philipp Prinz, DL2AM

In February 2012, Alex DL2GWZ, and myself DL2AM, undertook some DX tests on 122 GHz again. We tried paths of 60.5 and 42 km as we had done in 2011. DL2GWZ was located in JN57AL and DL2AM in JN47XU and JN47WA. DL2GWZ was on Mt. Hochgrat, 1718 m a.s.l. and DL2AM was 750 m a.s.l. On 76 GHz the S-meter showed 40 dBµV, but on 122 GHz absolutely nothing was heard, although we tried for 5 hours. The WX conditions at DL2GWZ were not optimal, with a light snow fall and fog at -15 °C. At DL2AM`s QTH the sky was blue, the temperature was -17 °C and the dew point -33 °C. See fig. 1. We both used GPS locked frequencies. Thus we can see that one needs good conditions on the entire path for a QSO on 122 GHz. We have worked on 122 GHz using SSB over the 42 km path between Hochgrat and Wachbühl (JN47WA) successfully twice in the past. See fig. 2. This latest negative test motivated me to carefully check again all the equipment that we used on 76 GHz and 122 GHz.
On the TX side everything was working perfectly, the output power of my separate CW transmitter on 122 GHz was indeed 2 mW, see fig. 3. Now, I was very interested to find out what input sensitivity (limiting sensitivity) I could calculate on 76 GHz and 122 GHz. My idea and approach was to find out by how many dB I could attenuate signals of 5 µW (-23 dBm) on 76 GHz and 3 µW (-25 dBm) on 122 GHz, and still be able to just make a CW QSO. So I checked my capability for doing this in practice. I am able to measure power quite accurately. However, my recently aquired Flann 2711 rotary attenuators (WR10, adjustable attenuation up to 70 dB) were only specified from 73 GHz to 112 GHz; they have 1 dB insertion loss and 1% accuracy. The readout accuracy from 0 dB to 1 dB attenuation is an amazing 1/100 dB (fig. 4).

First I made measurements in order to check if there is any change in attenuation, using these attenuators on 122 GHz. I was surprised to find only a very small difference when I checked using 25 dB attenuation on 122 GHz, which I am just able to measure properly. Thus the attenuators were good for my purposes and I connected them together in series. The entire setup was switched on two hours before I started e measurements, in order the get stable results.

I fed a 20 µW 122 GHz signal, that was locked to a Rubidium reference, into a 6 dB WR8 attenuator and measured a stable 5 µW power. This signal was then fed to the two Flann attenuators, at the output of which my 122 GHz receiver was connected with WR8. The receiver contains two antiparallel zero bias HSCH9161diodes. The driver was an FT290R in CW mode with 2.4 kHz bandwidth, see fig. 5. When I set the first and the second attenuators to 45 dB each, I still heard my signal well. This level was just sufficient for a CW QSO (sensitivity limit). By the way, the best way to detect a very weak signal is to tune rapidly over the signal`s frequency. So, this was the limit. With more attenuation I could not hear anything at all. Thus all my WG flanges must have been tight. At the end I checked my input power again, it was still 5 µW.

My calculation is: -45dB for the first attenuator plus -45 dB for the second attenuator plus -23 dBm (5 µW) = -113 dBm (-6 dBµV). I had not expected such a good result. In the same way I checked another 122 GHz transverter that uses a single MA4E1317 diode harmonic mixer. For this transverter I measured -105 dBm as the limit for a CW QSO. For me these results on 122 GHz are extremely important for future calculations.

The same tests were then made on 76 GHz. I used my 76 GHz transverter with 76 GHz filter and mechanical changeover. The amplifier with mechanical changeover (by DB6NT) has 22 dB gain and about a 9 dB NF. Again an FT290R in CW mode was used as the driver in the same way as on 122 GHz and again 5 µW (-23 dBm) were fed, via an isolator, to the Flann attenuators. I noticed immediately that the system was leaking, as with both attenuators set to 70 dB I still heard a weak signal. The cause was quickly found. I wrapped some aluminium foil around the isolator and the WG flange at the input (fig. 6) and now all was OK. But where was the leak, was it the isolator, the flanges or both?

Here the is calculation: -58 dB for the first attenuator plus -50 dB for the second plus -2 dB insertion loss plus -23 dBm (5 µW) = -133 dBm (-26 dBµV). At -133 dBm I was still able to make a CW QSO. Yes, I know, that an SSB receiver with 2.5 kHz bandwidth and 9dB NF can exhibit a sensiitivity of at most -131 dBm. Another test was made with different 76 GHz transverter with a DL2AM harmonic mixer with the

antiparallel diode MA4E1318 and 76 GHz filter. Now I was able to adjust the two attenuators to -48 and -50 dB (fig. 7). Calculation: -48 dB plus -50 dB plus -23 dB (5 µW) plus -2 dB insertion loss =-123 dBm (-16 dBµV). The accuracy of the Flann 2711 attenuator on 76 GHz is very good. For all tests I assume that the measured 5 µW on 76 GHz and 122 GHz was true. Without the alignment pins in the WG flanges an exact measurement is impossible on 122 GHz and 76 GHz. On 122 GHz the deviation would be worse. With the precision Flann attenuator it is possible to adjust the power to the WG power measurement heads and to calibrate or adjust them if necessary. A new 144 MHz transceiver with a narrower CW filter could make some improvement, but this FT290R is low-maintenance... More tests to follow.
Enjoy making your own measurements! 73 de Philipp - DL2AM, www.DL2AM.de

Literature

Philipp Prinz, DL2AM, More power on 122 GHz, Dubus 4/2011 p. 52
Philipp Prinz, DL2AM, Transverter for 122 GHz, Dubus 2/2008, p. 47

DX und Messungen auf 76 und 122 GHz

von Philipp Prinz, DL2AM

In der ersten und letzten Woche im Februar 2012 hatten Alex, DL2GWZ, und ich, DL2AM, erneut versucht Weitverbindungen herzustellen. Der Fokus richtetete sich auf 122 GHz. Die Entfernungen zwischen uns beiden waren 60,5 und 42 km, wie schon im Jahr zuvor. Die QTH-Kenner waren JN57AL bei DL2GWZ und JN47XU bzw. JN47WA bei DL2AM. Alex befand sich bei beiden Tests auf dem Hochgrat, 1.718 Meter über NN, und ich war auf 750 Meter über NN. Auf 76 GHz war das S-Meter bei 40 dBµV angelangt, aber auf 122 GHz ging einfach nichts, obwohl wir uns 5 Std. Zeit nahmen. Die Bedingungen bei Alex waren nicht optimal, leichter Schneefall und Nebel bei -15 °C. Bei mir war strahlend blauer Himmel und die Temperatur lag bei -17 °C bei einem Taupunkt von -33 °C (Foto 1). Wir beide hatten Geräte mit GPS-gesteuerten Frequenzen. Daraus ersieht man, dass eben auf der ganzen Teststrecke gute Übertragungsbedingungen sein müssen. Die 42 km Entfernung zwischen Hochgrat und Wachbühl, JN47WA, hatten Alex und ich schon zweimal auf 122 GHz in SSB überbrückt (Foto 2). Diese nicht erfolgreiche Erfahrung veranlasste mich, alle die benutzen Geräte für 76 und 122 GHz erneut zu überprüfen.

Sendemäßig war alles in Ordnung, denn die Ausgangsleistung meines seperaten CW-Senders auf 122 GHz war tatsächlich 2 mW (Foto 3). Was mich jetzt aber am meisten interessierte war, mit welcher Eingangsempfindlichkeit (Grenzempfindlichkeit) ich auf 76 und 122 GHz rechnen kann. Meine Vorstellung war, mit wieviel dB kann ich ein Signal von 5 µW (-23 dBm) bzw. 3 µW (-25 dBm) absenken, um noch ein analoges CW-QSO zustande zu bringen.

Abschätzen der Möglichkeiten

Ich versuchte abzuschätzen, welche Möglichkeiten ich habe, um dies festzustellen. Leistung kann ich ziemlich genau messen, aber meine neu erworbenen zwei Flann 2711 Rotary-Dämpfungsglieder (Attenuators) mit WR 10 und bis 70 dB einstellbarer Dämpfung sind leider nur spezifiziert von 73 bis 112 GHz und haben eine Einfügungsdämpfung von 1 dB laut Datenblatt und eine Genauigkeit von 1 %. Die Ablesegenauigkeit von 0 bis 1 dB Dämpfung ist erstaunlicherweise 1/100 dB (Foto 4).

Als erstes machte ich Messungen, inwieweit eine Dämpfungsabweichung vorhanden ist, wenn ich diese bei 122 GHz benutze. Ich war erstaunt, dass bis -25 dB eingestellter Dämpfung, was ich noch vernünftig messen kann, nur eine kleine Abweichung einschließlich des Verlustes von 1 dB bei 122 GHz vorhanden war. So konnte ich diese zwei Dämpfungsglieder hintereinander schrauben, um mein Vorhaben zu verwirklichen. Meine gesamte Messeinrichtung ließ ich 2 Stunden warm laufen, so erreichte ich stabile Ergebnisse. Als erstes wurde bei 122 GHz ein 20 µW - und an Rubidium angebundenes Signal erzeugt und nach einem 6 dB WR 8 Dämpfungsglied die Leistung gemessen. Es waren stabile 5 µW vorhanden. Diese Leistung speiste ich in das erste Dämpfungsglied ein und am Ende des zweiten Dämpfungsgliedes schraubte ich mit WR 8 meinen 122 GHz-Empfänger, der im Mischer mit zwei antiparallelen Zero-Bias-

Dioden HSCH9161 bestückt ist, an. Als Nachsetzer diente ein FT290R in Stellung CW, 2,4 kHz Bandbreite (Foto 5). Ich war überrascht, dass ich das erste Dämpfungsglied auf 45 dB drehen konnte und das zweite ebenfalls auf 45 dB: Ich hörte mein Signal immer noch gut. Für ein analoges CW-QSO reichte es noch gerade (Grenzempfindlichkeit). Am besten stellt man ein leises Signal fest, wenn schnell über die Signal-Frequenz gedreht wird. Das war das Limit, höher gedreht war absolut nichts mehr zu hören, d.h. meine Hohlleiter-Flansche waren alle dicht.

Meine Rechnung sieht jetzt so aus: -45 dB beim ersten Attenuator plus -45 dB beim zweiten plus -23 dBm (5µW) = minus 113 dBm (-6 dB µV). Dies lässt sich gut sehen. Ich hätte diese guten Werte nicht erwartet. Meine Eingangsleistung habe ich nochmals kontrolliert, sie stimmte noch, es waren 5 µW. Mit der gleichen Messtechnik habe ich auch einen 122-GHz-Transverter mit einer MA4E1317 Single-Diode im DL2AM Oberwellen-Mischer getestet. Bei dieser Konstellation konnte ich -105 dBm messen, um ein CW-QSO machen zu können. Für mich sind diese Messergebnisse auf 122 GHz von großer Wichtigkeit für weitere Berechnungen.

Dasselbe versuchte ich nun auf 76 GHz: Dazu benutzte ich meinen 76-GHz-Transverter mit 76-GHz-Filter und Wendeverstärker. Der Wende-verstärker (DB6NT) hat etwa 22 dB Gain und eine Rauschzahl von ca. 9 dB. Dazu nahm ich wieder ein FT290R in Stellung CW. Die Vorgehensweise war dieselbe wie bei 122 GHz. Ich versuchte es mit einem vorgeschalteten Isolator und stellte die Ausgangsleistung auf 5 µW (-23 dBm) ein, die ich dann in das erste Dämpfungsglied einspeiste. Gleich stellte ich fest, dass das System nicht dicht war. Ich konnte beide Dämpfungsglieder auf 70 dB drehen und hörte immer noch ein leises Signal. Die Ursache war gleich gefunden. Ich nahm eine Alu-Folie und wickelte diese um den Isolator und den HL-Verbindungs-Flansch am Eingang (Foto 6). Jetzt war alles dicht. Wo war die undichte Stelle, war es der Isolator, die beiden Flansche oder beides?

Hier sieht meine Rechnung so aus: -58 dB beim ersten Attenuator plus -50 dB beim zweiten plus -2 dB Einfügungsdämpfung plus -23 dBm (5 µW) = minus 133 dBm (-26 dBµV). Bei -133 dBm hätte ich noch gut ein CW-QSO machen können. Ja, ich weiß, dass ein SSB-Empfänger mit einer Bandbreite von 2,5 kHz und einer Gesamt-Rauschzahl von 9 dB eine Grenzempfindlichkeit von höchstens -131 dBm haben kann. Einen weiteren Messversuch machte ich mit einem 76-GHz-Transverter, mit 76-GHz-Filter und einem DL2AM-Harmonic-Mixer mit der Antiparallel-Diode MA4E1318. Die zwei Dämpfungsglieder konnte ich auf -48 und -50 dB stellen (Foto 7). -48 dB plus -50 dB plus -23 dB (5 µW) plus -2 dB Einfügungsdämpfung = 123 dBm (-16 dBµV). Die Messgenauigkeit des Flann 2711 auf 76 GHz ist sehr präzise. Bei den ganzen Messversuchen gehe ich davon aus, dass meine gemessenen 5 µW auf 76 und 122 GHz stimmen. Ohne Pass-Stifte in den Hohlleiter-Flanschen ist eine genaue Messung bei 122 und 76 GHz nicht möglich. Bei 122 GHz ist die Abweichung am größten. Mit dem Präzisions-Flann-2711-Dämpfungsmesser sind die Hohlleiter-Leistungsmessköpfe sehr gut zu kontrollieren und eventuell zu kalibrieren. Eine weitere Verbesserung wäre bei Empfang ein neuerer 144-MHz-Portabel-Transceiver mit einem schmaleren CW-Filter, aber der FT 290R ist eben pflegeleicht. Weitere Versuche werden folgen.
Viel Freude am Messen wünscht Philipp - DL2AM, www.DL2AM.de 73, de Philipp - DL2AM

Literatur: Siehe oben

Fig. 1: Setup for 76 and 122 Ghz and GPS RX at DL2AM/P in JN47WA in February 2012

Foto 1: Funkgeräte Equipment für 76 und 122 GHz + GPS-Empfänger bei DL2AM/P in JN47WA im Februar 2012

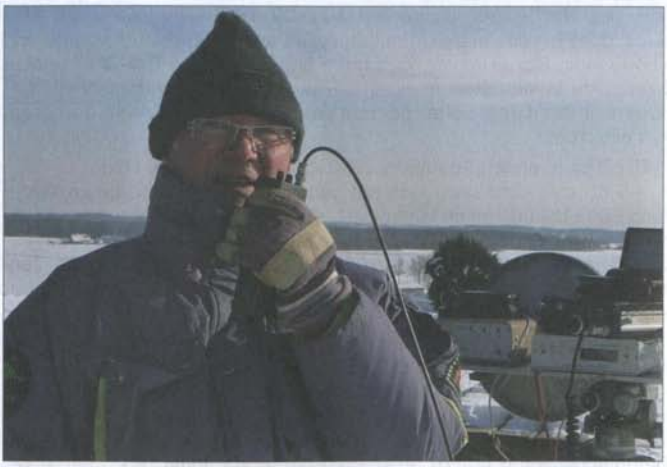


Fig. 2: First QSO on 76 GHz over 60.5 km at -17 °C in 2011.

Foto 2: Erstes QSO auf 76 GHz, 60,5 Km bei -17 °C bei DL2AM.

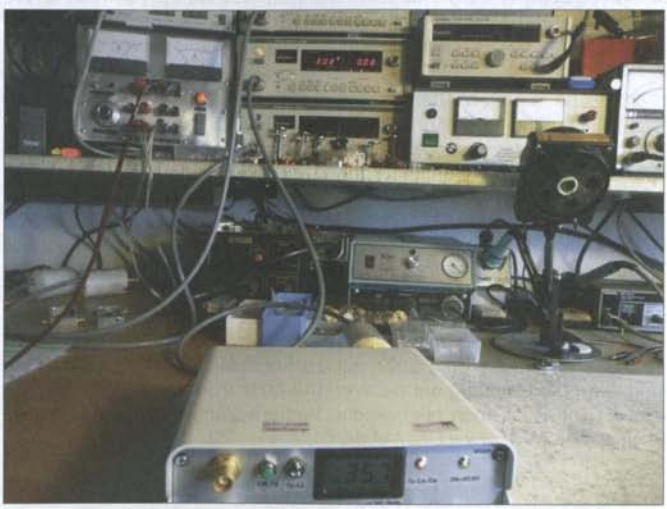


Fig. 3: Power measurement on 122 GHz.

Foto 3: 122 GHz Leistungs-Messeinrichtung.

Fig. 4: Flann Rotary Attenuator 2711 with up to 70 dB attenuation.

Foto 4: Flann Rotary Attenuator 2711 mit bis zu 70 dB Absenkung.

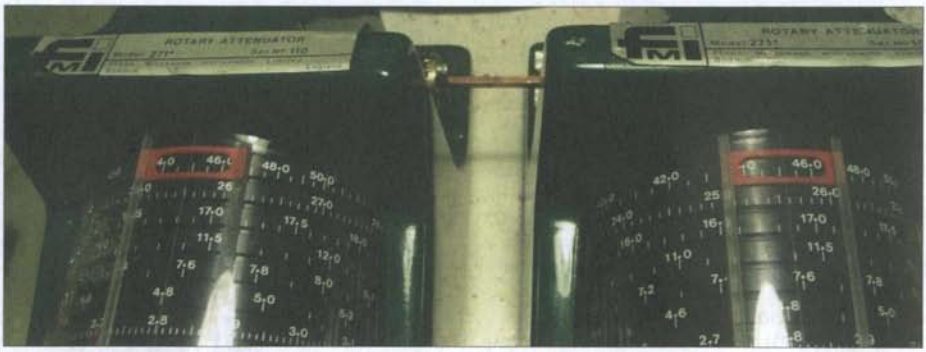


Fig. 5: A CW QSO on 122 GHz is still possible with these settings.
Foto 5: Ein analoges CW-QSO bei dieser Einstellung möglich bei 122 GHz.

Fig. 6: A leaky isolator and flange on 76 GHz.

Foto 6: Undichter Isolator bzw. Flansch auf 76 GHz.

Fig. 7: Measuring setup for single MA4E1318 diode on 76 GHz.

Foto 7: Messeinstellung bei eingebauter Diode MA4E1318 bei 76 GHz.

Literatur

Philipp Prinz, DL2AM, Mehr Leistung auf 122 GHz, Dubus 4/2011 S. 52ff
Philipp Prinz, DL2AM, Transverter für 122 GHz, Dubus 2/2008, S. 47ff

VHF News
Australia

"Nearly" 421 km JT65c QSO on 24 GHz

On February 24, 2012 David VK3HZ and Rex VK7MO have exchanged decodes on 24 GHz over a 421 km path and while a QSO was not completed the potential of using JT65c for DX on 24 GHz has been demonstrated. More details are available at: **http://www.vk3hz.net/microwave/24GHz_Tests_1.pdf**

Aircraft Scatter on 24 GHz

On March 13, 2012 David VK3HZ and Rex VK7MO have completed the first 24 GHz aircraft scatter contact in VK over 255 km across Bass Strait. More details can be found at: **http://www.vk3hz.net/microwave/Aircraft_Scatter_Contact_24_GHz.pdf**

King Island 10 and 24 GHz DXpedition

From 12 to 14 April, 2012 Rex VK7MO supported by Eric VK7NFI undertook a DXpedition to King Island in Bass Strait between Victoria and Tasmania. King Island is at the crossing point of four grid squares of which three are only accessible from the Island and have never before been activated on 10 GHz. All three rare grid squares were worked from on 10 GHz and one on 24 GHz – some 14 stations were involved on 10 GHz with most working all three rare grid squares and 4 on 24 GHz being worked from the closest square.

Results (QSOs) on 10 GHz:

QF10: VK3HZ, VK3PY, VK3AKK, VK5DK, VK3ZQB, VK3HY, VK3MQ, VK3PF, VK3NX, VK3BQJ, VK3TPR, VK3WRE, VK3QM and VK3ALB; Best distance VK3BQJ at 393 km -13/-15 dB JT65c.

QE19: VK3HZ, VK3MQ, VK3TPR, VK3HY, VK3PY, VK3AKK, VK3QM, VK3NX, VK3ZQB and VK5DK. Best distance VK5DK at 372 km -12/-20 JT65c.

QF20: VK3HZ, VK3NX, VK3PY, VK3AKK, VK3QM, VK3MQ, VK3HY, VK3PF and VK3BQJ. Best distance VK3BQJ 400 km -15/-17 dB JT65c.

Results (QSOs) on 24 GHz:

QF10: VK3NX, VK3QM, VK3AKK, VK3ALB and VK3HZ. Best distance VK3HZ 226 km

Worked paths from VK7MO/p to VK3 and VK5 on 10 GHz

More details are available at:
http://www.vk3hz.net/microwave/King-Island-10-and-24-GHz-DXpedition.pdf

An ecstatic Rex VK7MO after the 24 GHz QSOs with 24 GHz dish and system (3W output)

King Island (VK7) is located northwest of Tasmania (VK7) and has about 1500 inhabitants.

Intial 10 GHz EME tests with small 64 cm portable station

Alan VK3XPD has been using his 50 watt 3 metre 10 GHz station to test, if it is possible to work Rex VK7MO on EME on his 8 watt 64 cm portable 10 GHz station using JT65c. The technique used was to automatically tune Rex's IC-910-H IF transceiver to compensate for Doppler on both TX and RX so Alan did not have to tune for Doppler (the program for automatic Doppler correction was written by Glen VK1XX for the IC-910H and picks up the Doppler value from WSJT – it can be made available to others who may wish to use it with an IC-910H by contacting Rex VK7MO at rmoncur @bigpond.net.au). Also both stations were GPS locked or intended to be. The tests were also run at a time of low libration spreading as predicted with GM4JJJ's Moonsked program. The following are examples of the signals received by Rex (there was a problem with Alan's GPS locking which explains the DF of around 720 Hz and some drift in the tests as below). The figure in the last column show the predicted libration spreading. It is noted that the reported signal level on WSJT increased from about -22 dB when spreading was low at around 4 Hz to around -26 dB when spreading increased to around 40 Hz.

UTC		dB		dF							lib
070300	4	-22	2.2	725	5 *	VK7MO	VK3XPD	QF22	0	10	4
070500	2	-22	2.3	723	6 *	VK7MO	VK3XPD	QF22	0	10	4
070700	2	-22	2.3	723	5 *	VK7MO	VK3XPD	QF22	0	10	5
070900	1	-25	2.4	725	6 *	VK7MO	VK3XPD	QF22	0	10	6
071100	3	-21	2.3	731	6 *	VK7MO	VK3XPD	QF22	0	10	7
071300	4	-24	2.3	731	7 *	VK7MO	VK3XPD	QF22	0	10	8
071500	6	-23	2.3	734	7 *	VK7MO	VK3XPD	QF22	1	10	10
071700	2	-24	2.3	736	8 *	VK7MO	VK3XPD	QF22	0	10	12
071900	6	-22	2.3	739	7 *	VK7MO	VK3XPD	QF22	0	10	14
072100	2	-25	2.3	739	7 *	VK7MO	VK3XPD	QF22	0	10	15
072300	4	-22	2.3	742	9 *	VK7MO	VK3XPD	QF22	0	10	16
072500	5	-23	2.2	744	9 *	VK7MO	VK3XPD	QF22	0	10	19
072700	4	-23	2.3	752	8 *	VK7MO	VK3XPD	QF22	0	10	21
072900	4	-24	2.3	752	11 *	VK7MO	VK3XPD	QF22	0	10	23
073100	3	-24	2.2	752	9 *	VK7MO	VK3XPD	QF22	0	10	24
073300	3	-25	2.3	752	12 *	VK7MO	VK3XPD	QF22	0	10	26
073500	3	-24	2.3	752	11 *	VK7MO	VK3XPD	QF22	0	10	28
073700	2	-25	2.3	747	7 *	VK7MO	VK3XPD	QF22	0	10	29
073900	3	-26	2.3	750	15 *	VK7MO	VK3XPD	QF22	0	10	31
074100	4	-24	2.3	755	12 *	VK7MO	VK3XPD	QF22	0	10	33
074300	3	-24	2.3	752	12 *	VK7MO	VK3XPD	QF22	0	10	35
074500	3	-25	2.3	750	9 *	VK7MO	VK3XPD	QF22	0	10	36
074700	4	-25	2.3	747	11 *	VK7MO	VK3XPD	QF22	0	10	38
074900	2	-26	2.3	739	10 *	VK7MO	VK3XPD	QF22	0	10	40

While Alan could see Rex's signal he did not achieve a decode which is not surprising given the power difference and the Doppler spreading. He may also not have sorted things out to find Rex's signal until later in the tests when the libration spreading was wider. It is intended to run the tests again at a time of low spreading in the hope of achieving a two way QSO. (Many tnx to VK7MO for the above reports!)

Microwave Japan

Seiji Fukushima, Ph.D, JH6RTO
jh6rto@m.ieice.org

More 24 GHz activity from Japan

Yoshiro Mataka, JA4BLC, reports:

Following to my first Japanese 24 GHz license, as reported in the DUBUS issue 3/2011, one of my colleagues successfully obtained a license as well. Last July Shichiro Mori, JA6CZD, was permitted to output 30 Watts. He already built a 2.4 metre offset dish and observed sun noise of 13 dB, moon noise of 1.7 dB, and ground noise of 2.6 dB. A Kuhne preamplifier employed has a waveguide input interface. A 30-Watt power amplifier was developed by Yukio, JA8CMY. Until beeing fully qrv some more patience is needed.

Microwave USA

Editor: Kent Britain, WA5VJB
WA5VJB@flash.net

Falcon 2000 aircraft

N0SP/AM on 10 GHz

On February 17, 2012 N0SP flew across much of the US with a 10 GHz rig and a beacon in a private Falcon 2000 jet aircraft at 15.000 Meters. The beacon is a 10 dBm (30 mW) system with a 15 dBi horn and a keyer for ID. QRG was 10.368303 GHz. At the speed the jet was flying, the Doppler shift was up about 10 KHz. Coordination was on 14.185 MHz and 7.167 MHz. He took along his 2 watt 3 cm transverter and an FT-817 as the IF in a flight from Kansas City, Kansas to San Jose California making many SSB and CW QSOs.

Dennis tells of very strange scatter phenomenon, Over the Horizon propagation, Doppler shift characteristics and the discovery of many unpublished 3 cm beacons. A much longer paper on these 3 cm effects is still in work.

N0SP/AM 10 GHz 30 mW beacon transmitter in the front window of a private jet aircraft at 15000 Meters

Microwave Update - MUD 2012

Again we want to remind everyone of Microwave Update 2012. This year Microwave Update will be held in Santa Clara, California near San Francisco this October 18-21. Watch www.microwaveupdate.org for more details.

VHF News
New Zealand

A late in the season 144 MHz Tropo occurred on the 14 April 2012, with Bob ZL3TY in the South island working across to VK3DUT, ZL2BCC and VK2ZT, and in the North Island Steve ZL1TPH/p across to VK2BCC and VK2ZT, with path distances from 2010 to 2237 km. (tnx for this report to ZL1TPH!)

Microwave Europe

Editors:
Guy Gervais, F2CT
F2CT@wanadoo.fr
John Quarmby, G3XDY
g3xdy@btinternet.com

Report from France – 24 GHz

Hello to all! March 2012 was a very nice month for SHF activity especially on 24 GHz due to high atmospheric pressure and very low humidity rate. In southern France in the end of March the atmospheric pressure was often higher than 1035 hPa and the humidity rate was below 25 % between 1400 and 1600 ut. So some qsos up to 400 km range were achieved on March 25th during "French Activity Journey" dedicated to 24 GHz and up. Below you can see "profiles" of these qsos between Pyrénées mountains, to Bordeaux (F6CBC/IN94), Cahors (F5JGY/P/JN04), Brive (F6BHI/P/JN05), Montauban (F1VL/P/JN04) and Mont Aigoual (F1FIH/P/JN14) up to 400 km. All qsos started in CW after prepointing on 10 GHz and were achieved finally also on SSB!

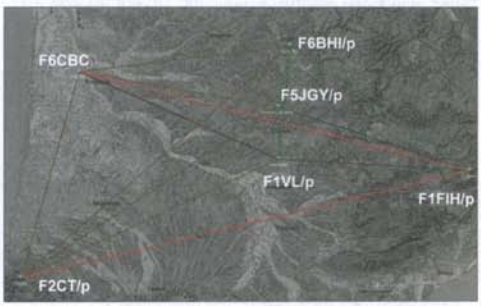
March 14th 2012
F2CT/P, JN15BP, wkd:
F6DKW, JN18, 347km, 52/53, SSB;
F1PYR/P, JN19, 384km, 53/55, SSB. 73 Guy F2CT

March 24/25th 2012
"SPECIAL FRENCH ACTIVITY DAYS 24 GHz and up:

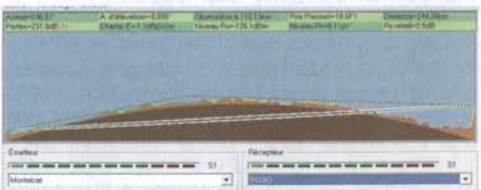
F1VL/P, JN04SF, 500mW/50 cm wkd:
F6BHI/P, JN05TC, 98 km; F5JGY/P, JN04RO, 46 km; F2CT/P, IN93IG, 250 km; F1FIH/P, JN14SC, 160 km and F6CBC, IN94QV, 187 km.
Some records are on:
http://www.youtube.com/watch?v=D_yWmXWMXBo
73 Chris F1VL

March 25th 2012
F1FIH/P, JN14SC, Mont Aigoual, 1500 m asl, wkd:
F1VL /P, JN04SF and
F2CT/P, IN93IG, 399 km, 51/51 CW/SSB
73 Michel F1FIH - http://f1fih.over-blog.com

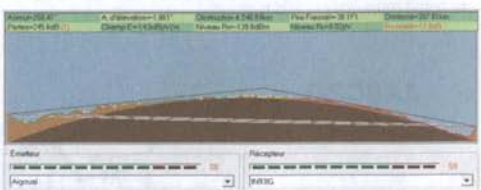
F2CT/P, IN93IG, 1000 m asl,
12 W SSPA, 80 cm offset, 1,5 dB NF, wkd:
F1VL/P, JN04SF, 251 km, 59/59 SSB;
F5JGY/P, JN04RO, 265 km, 53/55 SSB;
F6CBC, IN94QV, 188 km, 53/55 SSB;
F6BHI/P, JN05TC, 309 km, 53/53 SSB;
F1FIH/P, JN14SC, 399 km, 52/51 SSB.



24 GHz paths on March 24/25



Profile from F1VL/P JN04SF to F2CT/P IN93IG = 244 km



Profile from F1FIH/P JN14SC to F2CT/P IN93IG = 398 km

F1BZG, JN07VU, wkd:
F4CKC/P, JN19, 137 km; F4BUC/P, JN08, 111 km;
F1PYR/P, JN19, 137 km; F5DQK/P, JN18, 111 km and
F6DKW, JN18, 102 km.

March 27th 2012
F1BZG, JN07VU, wkd:
F6DWG/P, JN19, 168 km, 55/55 SSB;
F1DBE/P, JN09, 137 km, 56/56/SSB.
73 F1BZG Philippe

March 28th 2012
F2CT/P, JN15JO, wkd:
F6CXO, JN03SL, 256km;
F6CBC, IN94QV, 281 km, 55/55 SSB.

March 29th 2012
F2CT/P, JN06UX, wkd:
F6DKW, JN18, CW/SSB, 52, 202 km;
F6DWG/P, JN19, CW/SSB, 53, 270 km;
F1BZG, JN07, SSB, 55, 97 km;
F1HNF/P, IN97, SSB, 57, 135 km;
F6APE, IN97, CW/SSB, 51, 181 km;
F5HRY, JN18, CW/SSB, 52, 196 km;
F1DBE/P, JN19, CW/SSB, 52, 238 km.

F6AJW/P, JN18

F1PYR/P with G4ALY

F1DBE/P

April 14th 2012
A nice meeting in Hondarribia with Iñaki EB1RL, Poli EA2DR, Jack F6AJW and Guy F2CT to exchange some ideas about 10 GHz equipment. Now the team EA2DR, EA2TO, EA2BFM and EB1RL is qrv on 10 GHz with 9 W into 90 cm offset dish. Some nice DX qso will be now possible from Spain Picon Blanco IN83FD to France and Northern Europe!

F2CT EB1RL F6AJW EA2DR

SHF DXpedition to Andorra

From June 15th to June 25th F2CT, F1FIH and some other guys will activate SHF with C37SHF from Pico Maïa 2600 m asl JN02UN. QRGs: 1296,137; 2320,137; 5760,137; 10368,137 and 24048,137 MHz. Talk back: 144,390 MHz, qsx 144,337 MHz, KST

Good luck during next RS season! 73 Guy, F2CT

Report from U.K.

Recent Activity

Tropo conditions were well above normal during long periods in March. One of the highlights was the strong signal from OK1DFC's 23cm EME system into the UK on the 13-15 March, with several contacts over 1000km logged. DB6NT and OE5VRL/5 also featured in several 23cm logs. On 10GHz G4CBW (IO83) was hearing the French beacon F1ZAP (IN88) for an extended period, and worked a number of French stations from Brittany to Paris. He also worked DL7QY (JN59) on 13cm and 9cm at 970km, and DF9IC (JN48) on 9cm at 895km.

Later in the month 23cm was open to SM for a period, with SM7GVF in JO77 putting in a loud signal to eastern England. G4KUX (IO94) and G4PBP (IO82) worked several DL/PA/OZ stations on 10GHz during this period.

G4CBW has been running some successful tests with GM0USI/P (IO76) on 9cm, it is good to see activity on 9cm in GM increasing. The number of stations appearing for the UK Activity Contests on this band also appears to be on the up.

UK Microwave Group Contests

The first UK Microwave Group contest of the year took place on the 4th March on 1.3, 2.3 and 3.4GHz. Conditions were poor and activity rather limited so scores were lower than for last year's event. The April event, held on the 22nd, also had average conditions, but entries on the two higher bands appear to be rising. The next UK Microwave Group events are the 5.7/10/24GHz contests on 27th May, 24th June, 29th July, and the 1.3/2.3/3.4GHz event on the 3rd June that overlaps with the microwave contest in Germany and the French Championship contest.

Expedition to Guernsey

Last year the Telford and District club organised a successful expedition to Guernsey which covered all bands from HF to 24GHz, using the callsign GP3ZME/P. They must have enjoyed it as they are going back again this year for the period June 22 to June 27, and will again be taking microwave gear for all bands from 1.3GHz to 24GHz. The main site locator is IN89QK but they may use other sites on the island to optimise paths.

Microwave Round Tables

Attached are some pictures from the Microwave Round Table at **Martlesham on 28/29 April**. A full lecture programme took place over two days and the usual measurements lab was available for checking noise figures and filter performance, with nearly 50 preamps and transverters tested over the two days. The **RAL Round Table**, organised by Harwell Amateur Radio Society, will take place on Sunday **June 10th** from 1000 – 1615, with lectures from G8CUL, M0BTZ, VK4OE and GW4DGU. The location is at the Rutherford Appleton Laboratories, near Didcot . Full details on registration, the programme and location can be found on their web site at **http://www.ntay.com/hars/RAL2012.html**

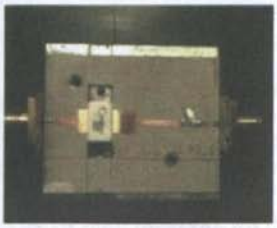
In July the **Finningley Round Table** takes place on the **14th and 15th** at Finningley Amateur Radio Society's club house in North Lincolnshire, handily located near the motorway network. This is a friendly event with some great bargains on the trader tables (some very nice 13cm amplifiers last year, and some high power 28V switched mode power supplies too), plus measurements and lectures. This year there will be a "nanowave workshop" on the Saturday where kits for getting started on lightwave communication using high power LEDs will be available for building and testing More details can be found at: http://www.microwavers.org/events.htm

73 John G3XDY

The audience at the Martlesham Microwave Round Table lectures (picture thanks to G4DDK).

G4TWJ, G8DKK and G6GXK calibrating a 47GHz power meter at the Martlesham Microwave Round Table. (picture by G3XDY)

G3WDG talking about GaN power amplifiers (Picture thanks to G4DDK)



Vd=30V

SS Gain: 16.7dB

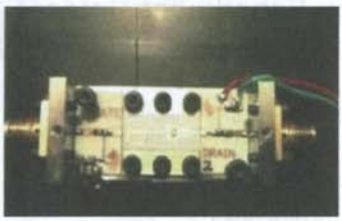
Power Gain: 14.4dB

Power out: 57.3W

PAE: 50%

A 50 W 9cm Test Amplifier by G3WDG using the GaN-Transistor T1G4005528-FS from TriQuint

G3WDG held a lecture about amplifiers with GaN transistors at the Martlesham RT. He presented pictures and data from his amplifiers for 9cm, 6cm and 3cm using GaN devices from UMS (CHK040A-SOA) and Triquint (T1G4005528-FS, TGF-2023-05). On 9cm these PAs usually deliver up to 50w output with one single device, on 6cm up to 30w and on 3cm up to 15W. The transistors need 30V or 50V DC for supply. They are also usable as LNA. Currently the prices are in the order of about 5 € per Watt. G3WDG recommends to use free software from Sonnet for designing the input and output networks. Currently GaN transistors are developed for frequencies up to 18 GHz, but in the future the possible limit will be in to range between 30 and 40 GHz. (CT1HZE)



Vd=30V

SS Gain: 12dB

Power Gain: 10dB

Power out: 15W

PAE: 47%

15 W GaN PA by G3WDG

Microwave Activities in Eastern Europe

LY2BAW who is very well known among the 6m DXers recently became very active also on the Microwave bands.

In summer 2011 several experiments were made and on June 28th, 2011 the first ever QSO on 24 GHz between Poland and Lithuania took place between SP4/LY2VA (KO14KI) and LY2BAW (KO24BJ). The distance was 82 km.

On April 14, 2012 LY2BAW made the next first ever contact with Belarus when he was portable in KO35EG and worked EW6FS from KO35JC. Distance is 38.5km. QSOs were made in CW and SSB.

LY2BAW worked with a DB6NT tvtr, 1.2 W PA and 60cm dish. EW6FW worked with homemade tvtr, 1mW and 60cm dish.

LY1VP from KO35DG was also qrv and worked with LY2BAW on 24 GHz. They had already made their first ever QSO on March 17th. EW6FS worked also with EU6AF on 24 GHz and 5.7 GHz, which were firsts for Belarus.

It is nice to see that also in other regions of Europe there is raising interest in Microwave DX. Next target for LY2BAW in 2012 is a QSO on 47 GHz with EW.

LY2BAW/p in KO35EG

4X1GA: VHF/UHF/SHF from Israel

Arcady, 4X1GA, is one of the very few amateurs in Isreal who are interested also in DX on VHF/UHF and SHF. In summer 2011 he made a nice Es QSO with G7RAU with his antenna setup on his balcony that is shown on the photo below. Arcady reports that during summer he often works to Malta (9H) on 2m and 70cm via Tropo. The SV5VHF beacon is audible every day with 339 to 599 reports over a distance of 820km. Currently the setup consists of a Dualband 5/5 ele Yagi and 60w on 2m and 30w on 70cm. On 23cm he has a 9 el and 10w. The station is located on a balcany on the 8th floor about 120 m a.s.l. and 7km from the Mediterranean Sea. Locator is KM72KD. In summer 2012 tests on 23cm are planned with 5B4AHY and 9H1GB. An upgrade on 23cm to 4 x 33 el is planned. Also 3cm activity is planned with 12w and a horn antenna. On 2m the station will be upgraded to a 9 el Yagi and 600w and on 70cm to a 18 el Yagi and 120w.

A 2m beacon will run with 5W from the QTH of 4X1UN during the Es season.

4X1GA take off to Europe

Please send YOUR reports, observations and information for next issue 3/2012 until August 1st to DUBUS@t-online.de

4m News

Reports, Expeditions, Infos
Editor: Joachim Kraft, DL8HCZ

New beacons

A92C/B 70.085 MHz, LL56HE, 10w, V dipole, 20 m a.s.l., F2A, is on air since 10. February 2012.

CS5BALG/B 70.159 MHz, IM67AH, is a proposal for May/June 2012.

D44TD/B 70.220 MHz, HK86NO, 5 W, 4 ele Yagi, 15 deg, F1A, is on air since April 26, 2012. May be the call will change sometime in the future.

EA1DG/B 70.160 MHz, IN62AL, 2W, 555 m a.s.l., CW and telemetry, is new on air since March 2012.

ES1VHF/B 70.037 MHz, KO29IK, 10w, F1A, dipole, SW/NE, 30m a.g.l., is a proposed to go on air any day in May 2012. This beacon TX was sponsored by HA1YA.

IZ1DYE/B 70.105 MHz, JN35PA, 5W, H dipole, N/S, 1300m a.s.l. is on air now, until Dec. 31st, 2012.

SV8FOUR/B 70.072 MHz, KM08HQ, 15W, H dipole, 1150m a.s.l., is a proposal for June.

V51VHF/B 70.005 MHz, JG82IE, 35 W. 6 ele Yagi, QTF N, is new on air since March 2012.

WE9X..../B 70.005 MHz, FM07FM, WA1ZMS is currently trying hard to get another permit for an experimental beacon for summer 2012. If all goes well, the beacon could go on air again sometime in June.

Nordic Expeditions

Iceland: TF3ML has announced that during summer 2012 he will be qrv from several grids on the southern coast of Iceland also on 4m

Greenland: OX/DL3GCS will be qrv from 12. to 25. June from GP70JD on 6m, 4m and 2m.

I2ADN qrv from JM67

Angelo, I2ADN, will be qrv as IF9/I2ADN from about May 25 to mid June from JM67 on 4m and 6m.

New Countries on 4m in 2012

Poland (SP): The range from 70.1-70.3 MHz (max. 20 W ERP) was released to amateur radio in April on a secondary base, but real starting day was expected to be in May.

Lavia (YL): The range from 70.0-70.5 MHz will be released to amateur radio in August/September. Max. pwr is 100 W.

Hungary (HA): The range from 70.0-70.5 MHz will be released for hams any day.

Extended 4m allocations in 2012

Belgium: It looks like that Belgium will get also the range 70.2 to 70.4 MHz with 10W on a secondary base soon for amateur radio additionally to the existing 69.950 MHz QRG. Also CEPT operation may be permitted from ON then.

Norway: In Norway the additional segment from 70.1875 to 70.2625 MHz may be allocated to amateur radio in 2012.

Denmark: From June 1st, 2012 the following segments will be allocated additionally to amateur radio on a secondary base: 69,9375-70,0625, 70,0875-70,1125 and 70,1625-70,5125 Mc.

70 MHz and Cross-Band Contest 2012

Tony, I0JX, reports that the Rome section of the Italian Radio League (ARI) has announced the second edition of the "70 MHz and Cross-Band Contest" (the first edition was in 2008), The contest takes place on 10 June 2012 from 0700-1700 UTC. There are sections for countries with 4m allocations and for the other there is a crossband 4m/6m section. Full rules at: **www.ariroma.it/docs/vari/70cont_2012_eng.pdf**

First ever TEP QSO on 4m from Italy to ZS

IZ8DWF, Frank, finally managed to work ZS6NK via TEP on 4m on April 22nd, 2012 at 18:07z using the digital ISCAT mode. From about 17:50z he hrd already the ZS6WAB beacon on 70.025. On several occasions in 2011 Frank had also heard this beacon and ZS6 stations on 4m, but had no TX licence at that time. Italy just got 4m back on February 1st, 2012. – ZS6WAB himself is QRT now on 4m for good.

First ever TEP QSO from Rhodes to ZS

On March 15th, 2012 SV5BYR wkd ZS6WAB on 4m SSB for the first ever SV5 to ZS6 on this band. Also SV2DCD KN00 wkd ZS6WAB KG46 on this occasion with 59.

6m News

Reports, Expeditions, Infos
Editor: Joachim Kraft, DL8HCZ

CT 6m band extended

Since April 26th 2012, CT hams have access to the "full" 6m band from 50.0 to 52.0 MHz. Prior that date only the first 500 kHz of the band had been allocated. Anyway who really needs the additional spectrum...

DX on 6m in Spring 2012

In March TE and/or Spread F propagation sometimes was reaching areas north of the Alps: On March 3 Southern DL wkd to ZS, V5, TR, on March 9 to TR and 6W, on March 10 to TR, on March 20 to ZS, on March 27 to ZS and TR and on March 31 to V5 and TR. On April 2 Southern DL wkd to ZS, on April 3 to TR, on April 7 to V5 and TR.
On April 22 OE wkd to ZS and 9J.

First real long F2 QSOs were worked from EA8 in March:
On March 18 EA8AK IL18UL wkd VK4DDC QG62PB over 19.000km. On March 19 EA8AK wkd ZL1RS RF64VS, over 18805km. The path was open from 2043-2145z. Also other EA8 stations (EA8CQS, EA8BLL) hrd ZL1RS.

On March 11, 17 & 22 the CE8B beacon from FD46 was hrd via F2 from EA7 and CT. On April 19 the CE8B beacon was hrd again from EA7 and CT. On April 20 this beacon was hrd from SV, I, EA7 and CT and CE8BHI from FD46 worked just 1 QSO with CT1HZE over 11.691km.

The first real big TE + Es opening occured on April 25th, 2012, when many stations north of the Alps even up to SM, OZ, LA, N-DL wkd/hrd V5, ZS6, 9J, FR and 3B8. Note that there was Es from DL to SV3, from CU to CT/EA, so definitely there was an Es link at the northern end of the paths. On April 29th and 30th 3B8DB, FR4NT and FR1GZ wkd again to central EU (DL, OE, PA, OK, SP and many other countries. On May 1st there

was nice TEP from SA plus 1 Es hop into G/DL/PA/ON.

F2 propagation in lower latitudes has been also exiting: DU worked to Eastern-Africa, A9 to VK, A6 to South America (PY, LU) etc.

From southern EU (EA, CT, SV, IT9) and 4X/5B many F2 and TEP openings took place in March and April into Southern Africa, Central Africa and South America.

TEP openings from Japan to Australia, ZL and other Pacific DXCC occur regularly now.

Beacon News

LU5FF/B **50.051.5 MHz, FF99**, 20W, F1A, is on air at times from LU5FF shack.

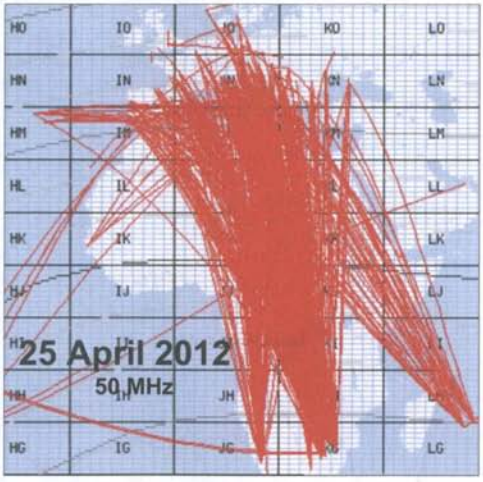
TG9ADV/B **50.011 MHz, EK44** is on air in test operation, the final callsign will be TG9SIX.

6V7SIX/B **50.014 MHz, IK14LK**, 50W, 2 x H Loop, 15m a.g.l., A1A, is a proposal for June 2012. Keeper is 6W7RT.

CP6B/B **50.041 MHz, FH82JE,** 40W, H loop, 420m a.s.l. on air since 11. April 2012. Keeper is CE3SX.

KH9/WA2YUN will activate a 6m beacon from Wake Island on 50.014 MHz very soon. 30W, H loop, Locator is RK39HH.

SR8FHS/B 50.405 MHz, KO10AN, 3w, GP, new 4/12



Expeditions & OPs

4J **Azerbaidschan:** 4J9M moves to DL in the end of May and will be QRT on 6m.

6O **Somalia:** J28AA was supposed to be active also on 6m as 6O3A in the end of May. Another big international group will be active with the same call for 2 weeks in November and may be also a second time earlier in the summer.

6W **Senegal:** On March 1st, 2012 the 6m band was released to amateur radio in Senegal. This was the reason why 6W7RT was qrv on 6m with the special call 6V7SIX from IK14LK. According to 6W7RT any prior 6m operation from 6W has been illegal.

A5 **Bhutan:** JA1JQY (A52JY), JK1EBA (A52BA), JA3MCA (A52MA), JA1KJW (A52KJ) and JA8VE (A52VE) will be active from Bhutan between June 6 to 14, 2012. They will have an emphasis on 6 metres. A beacon will be on 50.125 around the clock.

CN **Morocco:** F4CYZ is qrv as CN2YZ from Tanger also on 6m. Loc. IM75CS.

CY9 **St. Paul Isl.:** VE3EN will be the 6m OP during the CY9M expedition from July 26 to August 10. QRG: 50.104 MHz with 100w + 5 ele. Info: www.cy9m.com

D2 **Angola:** D2CQ moved about 200km further east and will be qrv from a new grid on 6m in autumn.

D6 **Comoros:** A multinational group will be qrv as D64K in August. EA3AKY will be the 6m OP. Rig: 1 kw + Yagi.

FP **Miquelon:** FP/KV1J will be active also on 6m from 10.-17. July. Loc.: GN17. www.kv1j.com/fp/July12.html

FJ **St. Barthelemy:** FJ/W6JKV will be qrv in the end of June for about 10 days only on 6m with QRO and Yagi.

FR **Reunion:** FR4NT is qrv with 80w + 5 ele from LG89.

HH **Haiti:** HH4/W3CMP will be qrv on 6m from 19.-28.6. with 200w and 5 el. qrv. Loc.: FK39.

JX **Jan Mayen:** LA9JKA is qrv also on 6m as JX9JKA until March 2013. Loc.: IQ50OV.

KG4 **Guantanamo:** K4RX etc. may be qrv on 6m from the end of June (or otherwise may be in 2013).

KH2 **Guam:** KH2/N2NL is returning to Guam on 17th June, 2012 and will remain there for three years.

KL7 **Alaska:** KB7Q will be active during summer 2012 on 6m with QRO via Es and EME.

S9 **Sao Tome:** K0KKO + K0GUV had cancelled their long announced March expedition without prior notice.

SV2 SV2/SM4KYN will be active from May 25 to June 16 from rare **KM16BW** with 100w and 3 el. on Es/MS.

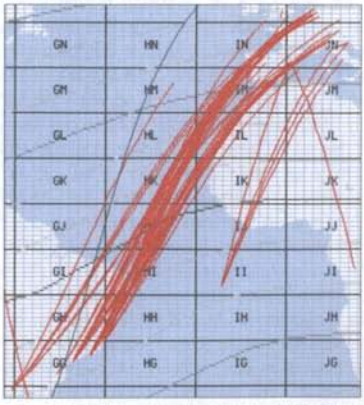
TN **Kongo:** TN5SN (now may be TN9SN) seems not to come back on 6m, he will leave TN in July 2012.

VP2V **British Virgin Isl.:** VP2V/W9DR is qrv on 6m from 21.6. to 2.7. QRG: 50.115 MHz. QSL: HC.

W5 **DL79, 88, 89** K5N and N5K will be active from these rare grids on 6m from June 20 to 25.

ZK2 **Niue:** W7GJ is qrv from 7.-21.9. as ZK2GJ via EME in JT65. 8 ele and QRO. Loc.: AH51.

K7BV Dennis is not on expedition this summer, but relocated from California to his new East coast QTH in FM04VX, where is erecting 8 x 10 el LFA Yagis by G0KSC on a 190 ft (63m) rotating tower...



1. May 2012: TEP + Es: PY/LU into G/PA/OZ/DL

KH6/K6MIO comments on Solar Cycle 24

Figure 1 shows that the rise of 12-month-smoothed Ri has slowed down a bit over the last few months, although the shorter smoothed values were still climbing. Looking more deeply into the numbers, the various smoothed values are affected strongly by the very low value posted in February (2012). The February drop was seen in both the northern (24.7) and southern (8.4) solar hemispheres. Then abruptly, March showed a nice flurry of activity in both hemispheres, and posted better numbers (35.2 and 29.0, respectively). This is the first month in a very long time in which the southern activity index was fairly close to that of the north.

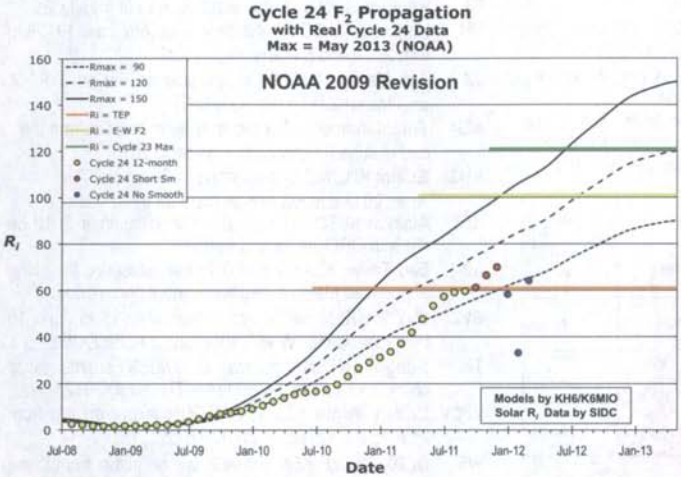


Fig. 1: Solar activity with actual data through March 2012

It's too early to interpret what the February dip might mean. It is a fact that month-to-month values can and do vary wildly. Another benign possibility is that the Sun was just shifting the solar longitude location of its principal activity. In each of the northern and southern solar hemispheres, it is quite common to see the active regions clustering around some specific range of solar longitudes. Since the Sun rotates on its axis about every 27 or 28 days, a result is that there will be about two weeks when the active side of the Sun is facing the Earth, followed by another two weeks or so when the Earth sees relatively little activity. (As a result, F2 also can have a quasi-periodic two-week cycle.) The active longitude region may remain more or less the same for a few, up to several, months. Then, for whatever reason, the activity at that longitude region will fade aware, and within a month or two, a new longitude region may become active for a while. It's not clear that this is what happened, but if it did, this is the sort of signature it would have. The most recent NOAA prediction for the solar maximum was May 2013. For some time now, I've been pointing out that the Sun's residual north polar magnetic field has been decreasing rather more quickly than one might have expected. The hemispheric solar activity maximum is fairly closely associated with occurrence of that hemisphere's polar field smoothed value passing through zero and reversing polarity.

Figure 2 shows the polar field behavior for both the northern and southern solar hemispheres since before the peak of Cycle 23. The northern hemisphere now looks suspiciously like its field is poised to cross zero sometime this year. This implies that the northern solar maximum may be right about now! On the other hand, the southern hemisphere appears to be in no such hurry, and likely will happen rather later. It is entirely possible for the two hemispheres to have activity maxima at different times. The southern solar hemisphere peaked about 1.2 years later than the north in Cycle 23, leading to a double-humped overall activity maximum. The looks like we are in for a similar double maximum this cycle. This suggests that the NOAA May 2013 date might more nearly correspond to the southern maximum. The current activity trajectory shown in Figure 1 still suggests that we may be on a track for an Ri (max) of somewhere around 100, if the more recent dip is just a short-term blip (NOAA predicted 90). This overall value, involving contributions from both the north and the south, might be reached sometime after the maximum in the north. However, there are three cautions about these statements.

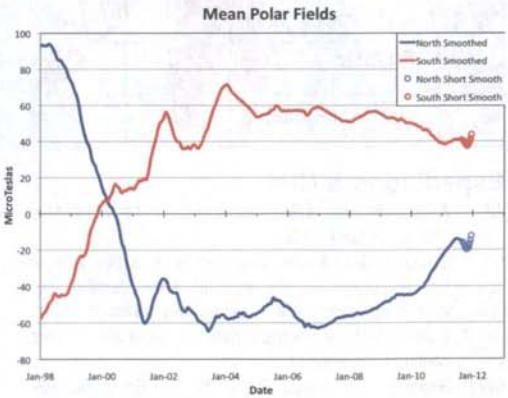


Figure 2: Solar polar field behavior with values.

News & Comments

Editor: Joachim Kraft, DL8HCZ
info@DUBUS.de

Expeditions and OPs

PJ4 Bonaire: N7BHC is now on Bonaire for a couple of years. He will be active soon on 6m, 2m and 70cm with his new call PJ4VHF and is very interested in TEP and TA experiments.
ZA Albania: OK1DFC and team plan a multiband EME (and MS) expedition probably later this year (after August).
KO09 OH0/DJ5HG will be qrv from July 2 to 20 on 2m via MS in PSK2K. Loc. KO09LW.
KQ50 OH6ZZ and OH9GDT plant to be qrv from 11.-16.8. as LA/OH6ZZ on 2m FSK-MS and EME.
GP70 OX/DL3GCS will be qrv from 12.-25. June from GP70JD on 6m, 4m and 2m.
JN40, JN41, JM48, JM49 IS0/ON7ARQ will be qrv from 12.-26. June onf 6m, 2m and 70cm qrv. He will be active from San Pietro Isl. as IM0/ON7ARQ on June 16./17.
JP75/86/95 SM6CMU/2 will be active from 4.-12. August on 6m and 2m via Es and FSK-MS.
GU Guernsey: From June 22.-27. a group from the U.K. will be active as GP3ZME/p on all bands from 6m to 24 GHz.
ZK2 Niue: ZL1RS will be active as ZK2RS from September vom 8.-23. on 2m EME in JT65. Loc.: AH51
ZP Paraguay: W9CPI is a resident and qrv on 2m EME in JT65 as ZP9EH. Rig: 250W and 2 x 9 Ele. Loc. GG22BQ. Also the club call ZP9EE will be activated on 2m EME in the future. QSL via K5WW.
Andorra: A group from France will be active as C37SHF from June 15 to 25 from Pico Maïa 2700 m asl in JN02UN. QRGs: 1296,137 MHz, 2320,137 MHz, 5760,137 MHz, 10368,137 MHz, and 24048,137 MHz. Talk back: 144,390 MHz but only for SHF skeds! If possible they will be on ON4KST chat. Team members are Michel F1FIH, Fred F4BXL, Jean-Claude F5BUU, and Guy F2CT as team leader. QSL exclusively via URA. (tnx for info to F2CT!)

Beacons

SR9LHK 1296.925 MHz, JO90MH, 5 Watt, Alford Slot, is new on air since April 2012. Reports please to sp9bgs@wp.pl
V51VHF/B 144.430 MHz, JG82IE, 10 Ele Yagi, N, on air since March 2012.
6V7TWO/B 144.197 MHz, IK14LK, 350W output, Big Wheel, 15m a.g.l. A1A, keeper is 6W7RT. Later on the antenna will be upgraded to two small yagis (DK7ZB 4el 11dBi), one yagi aimed at PY0/PY7 (~225°) and the other one aimed at CN/CT/EA (~25°).
DB0ZDF (ex 10368.2890 JN49CX) is supposed to come back on air in summer 2012 from the same QTH, may be on same QRG, may be on a new one in the beacon segment. Output power first 45mW, later 1W, WG slot, omni. Keeper is DF4PV. Also a 47 GHz is operating from this QTH now on 47088.090MHz with 20mW. Antenna is a 25cm Procom dish. direction 123 deg.
TG9TWO is supposed to go on air on 2m this summer from Guatemala, EK44. Keeper is TG9AJR.

News

Wally Green, VK6WG, SK

It is great regret that I announce the passing of Wally Green on 7 March, 2012. Even after his 100th birthday celebrations in August last year, Wally continued his activities on 144 MHz and above, continuing a long tradition of providing signals from Albany across the Bight and towards Perth. His pioneering work with the late Reg Galle VK5QR in the late 1970s on propagation across the Great Australian Bight, with world record distances on 1296, 2304 and 3456 MHz using home constructed equipment, set the scene for others to challenge the then accepted theories of propagation at these frequencies. A self-taught man he used his mechanical skills to fabricate parabolic dishes, parts of the "plumbing" required for the waveguide needed for those frequencies, and showed extreme patience in locating the rare components needed and then successfully constructing the transmitters and receivers without elaborate test equipment. More than all of that, Wally has to be praised for his willingness to share his knowledge and experiences with others and "to be there" when conditions were both promising and not so promising for long distance propagation! He will be sorely missed! Vale Wally Green VK6WG (Wally Howse, VK6KZ)

W1JJ Info

W1JJ has sold his ocean close QTH in FN41 in April and will not do any 2m transatlantic beaconing in 2012. He will be back later with new antennas from his 2nd QTH that is a few km more in land.

9cm band released in Poland

In April in Poland the range from 3400 to 3410 MHz was released to amateur radio service on a secondary base.

Problems with the SHF bands in Ukraine

UT5DL writes: "We confirm that there is uncertainty with SHF amateur frequencies in Ukraine. There are three different documents regulating the spectrum allocation up to 300 GHz:
Firstly – The Radio communications Law;
Secondly – The National Frequency Allocation Table (NFAT);
Thirdly – The National Frequency Allocation Plan (NFAP).
The National Frequency Allocation Table corresponds to ITU frequency allocations in 99% of cases. There is one difference though – two different kind of users.
General users and so-called Special users (presidential and government communication structures, defense ministry, internal affairs ministry, police, civil aviation and other structures of the State. According to the recently adopted regulations general users can't share the spectrum with the "special" ones. Ministry of Defense controls almost 50% of the spectrum and amateur 1296 MHz and 24.05-24.25 bands were recently included into special users' allocation. This effectively blocks any ham use of these bands at the present and in the future.
In fact there's a conflict between the NFAP, which is the basic

frequency allocation document, and NFAT, mainly in ham radio parts of SHF spectrum.
Ukrainian amateur radio frequency allocation for 13, 6 and 3 cm bands is different from that of IARU R1 band plan. The assigned frequencies are 2400-2450 MHz, 5650-5670 MHz and 10100 – 10150 MHz. No consultations with UARL prior to adopting these have ever taken place.
The Ukrainian Amateur Radio League (UARL) officially applied to the Ministry of Communications and other government radio communications structures to correct the improper UHF amateur frequency allocation.
On April 19th, 2011, UARL representatives UT7UW and UT5DL took part in an official meeting with the government officials regarding this problem. We were promised that the allocation dispute will be solved in favor of amateurs. Unfortunately, up to now nothing has been done so far. Even worse – 23 cm band was out of amateur radio use in NFAP.
Up to now we are getting just formal answers from Ukrainian officials." Vyacheslav Baranov UT5DL – VHF manager UARL

MAP65 2.2

A new revision of MAP65 2.2 has been posted at
http://physics.princeton.edu/pulsar/K1JT/MAP65_220r578.exe
This version offers major new features. It provides support for single- as well as dual-polarization systems, for sample rates 95238 as well as 96000 Hz, and for JT65 sub-modes A, B, and C. These new capabilities mean that MAP65 2.0 can be used with any of the following hardware and software combinations:

- WSE and Linrad
- IQ+ and Linrad
- SDR-IQ or other RFspace radios, with Linrad or SDR-Radio
- FUNcube Dongle and Linrad or SDR-Radio
- SoftRock (or similar) and Linrad or SDR-Radio

For further details and startup instructions, go to
http://physics.princeton.edu/pulsar/K1JT/MAP65_Beta_Release.pdf
http://physics.princeton.edu/pulsar/K1JT/Beta_Release_of_MAP65_2.0.pdf

EMECalc 8.00

The latest version 8.00 of EMECalc is now available from www.VK3UM.com
Many additional features have now been included in this latest revision along with some minor refinements and enhancements to existing routines.
Hot Sources Jy values updated and the calculation methods refined for this EME application. [ref ITU Rec 733-2 and Astronomical Source Catalogues]
My 400 MHz Sky Temperature map has now been included to help with the interpretation of Y Factor measurements and to assist in finding 'Cold Sky'.
A 'current parked position' sky noise temperature option and the ability to use your mouse to find Az El of sources has been included in the Sky Map.
Home Data with an additional Grid Square input has been added as separate identity tab.
The Receiver Performance Option has been updated and further refined. Dont forget the 'reference set' option to see the significance your changes.
The Help file has been expanded and now includes an Error section to assist with the interpretation sfu measurement.
The sfu retrieval option from IPS has been modified to account for possible multiple receiver failures. (they unfortunately got hit by lightning recently)
Although the user may see only small changes in some of the values calculated, they have been made to reflect methods and terminology used in Radio Astronomy applications. Options provided previously, that could not be substantiated with certainty, have been removed.
My sincere thanks to Luis CT1DMK, Peter G3LTF and Franck F5SE for their considerable help and detailed research that has gone into this revision of the software.
We believe it to be the best compromise between absolute precision and practical results obtainable with our installations. Accordingly, I have limited the
displayed accuracy commensurate with the measurement accuracy expected. Thanks also to Dave G4RGK for his beta testing within the Win 7 environment.
73 Doug VK3UM

PSK2K & SlowPSK Info & Update

Software author DJ5HG writes that PSK2K is running flawlessly since the version 5.0. The latest version is 5.9.
Another new mode was developed in the meantime. It is called SlowPSK. SlowPSK is an advanced specialized digital mode for weak signal applications in amateur radio. The length of the transmission periods is 0.5, 1, 2, 15, 30, 60, or 120 minutes depending on the application area. The packet size is 3360 bits. This results in bitrates of 125, 62.5, 31.25, 4.17, 2.08, 1.04, 0.52 bits/s. SlowPSK uses Binary Phase Shift Keying (BPSK). The digital-to-analog conversion of the bitsequence is done by replacement of every bit by a pulse-function. The pulse-function is sampled at the standard sampling rate 8000 samples/s.The pulse function used in slowPSK is a square-root raised cosine function. –
A special EME submode is under development and may be available in autumn. First tests have shown that at -30dB level still 50% of the signals are decoded DIRECTLY, i.e. without Deep Search or any averaging. At JT65 (without DS) this is the case at -24 dB. More info & downloads are here:
http://www.dj5hg.de/dj5hg_download.html

Reunion on EME

FR5DN plans to come on 23cm EME with a 3.6m dish, higher bands may be as well later on.

AA7XT on EME from DM59

Bill AA7XT plans to become qrv on EME with 4 x LFA Yagis on 6m and 8 x LFA Xpol Yagis on 2m. All antennas will be low sidelobe designs from InnovAntennas.

LinearAmp U.K. Info

LinearAmp U.K. has stopped business in April 2012.

Dates

June 10: RAL Roundtable, U.K.
www.ntay.com/hars/RAL2012.html
July 14-15: Finningley Roundtable, U.K.
August 16-19: 15th International EME Conference
Cambridge, UK. www.eme2012.com
September 14-16: Amsat-UK Colloquium

Holiday Inn, Guildford, Surrey, www.uk.amsat.org/Colloquium
September 14-16: 57.UKW Tagung, Weinheim
www.ukw-tagung.de
September 23: Crawley Roundtable, U.K.
October 18–21; MUD 2012, Santa Clara CA,
www.microwaveupdate.org mud2012@pacbell.net
October 28 - Nov 2: European Microwave Week
Amsterdam, www.eumweek.com
Nov 3: Scottish Roundtable
www.rayjames.biz/microwavert

EME Meeting in Japan

JA6CZD and JA6XED have announced that the All Japan EME Meeting of 2012 will be held in Kurume, Fukuoka, JA6-land, June 02-03, 2012.
A guest speaker JA8CMY will talk about how to tune the microwave power amplifiers and power deviders/combiners, such as he makes them successfully work on 10GHz and 24GHz. Many JA EMEers will get together to the born place of JA moon-bounce, where JA6DR, JA6CZD and other EMEers with five dishes up to 13m diameters located in '70s, to see friends and for technical talks and lectures.
Foreign guest will be welcome of course. Lectures and EME articles for prceedings wil also be very welcome.
If any, please contact JA6CZD, JA6XED, or JH1KRC.
Thanks for your attention, CU & 73's!!

EME 2012 Conference Lectures

The 15th EME conference will take place in Cambridge from

Howard Long G6LVB:
Taking software defined radio into the mainstream
Hannes Fasching OE5JFL:
Gaining extra dBs from a small dish
Ian White GM3SEK & David Stockton GM4ZNX:
Noise Figure measurements: A reality check
Ingolf Larsson SM6FHZ: Unexplored areas of 432MHz feeds
Ingo Gaspard DF1VH: Solid-state broadband uncooled noise generator with noise temperature below room temp.
Jan Van Muijlwijk PA3FXB: PI9CAM history and restoration
Joe Taylor K1JT:
MAP65: A wideband polarization-matching Receiver for JT65
John Worsnop G4BAO:
Converting surplus 1900/2100MHz SSPAs
Manfred Ploetz DL7YC:
For a few dollars - 40 more watts at 3400 MHz
Mike Watanabe JH1KRC:
A brass bar and a rotation mechanism for MAB25 encoders
Murray Niman G6JYB: Frequencies for EME
Paul Marsh M0EYT:
Amateur deep space reception – equipment and techniques
Paul Wade W1GHZ: Horns and septum feeds – Construction tolerances and sensitivity
Peter Blair G3LTF:
How good were the systems of the 60s and 70s?
Sam Jewell G4DDK: An update on the VLNA
Zdenek Samek OK1DFC: EME DXpedition IS0/OK5EME
Zdenek Samek OK1DFC: Loop feed for 432 and 144 MHz