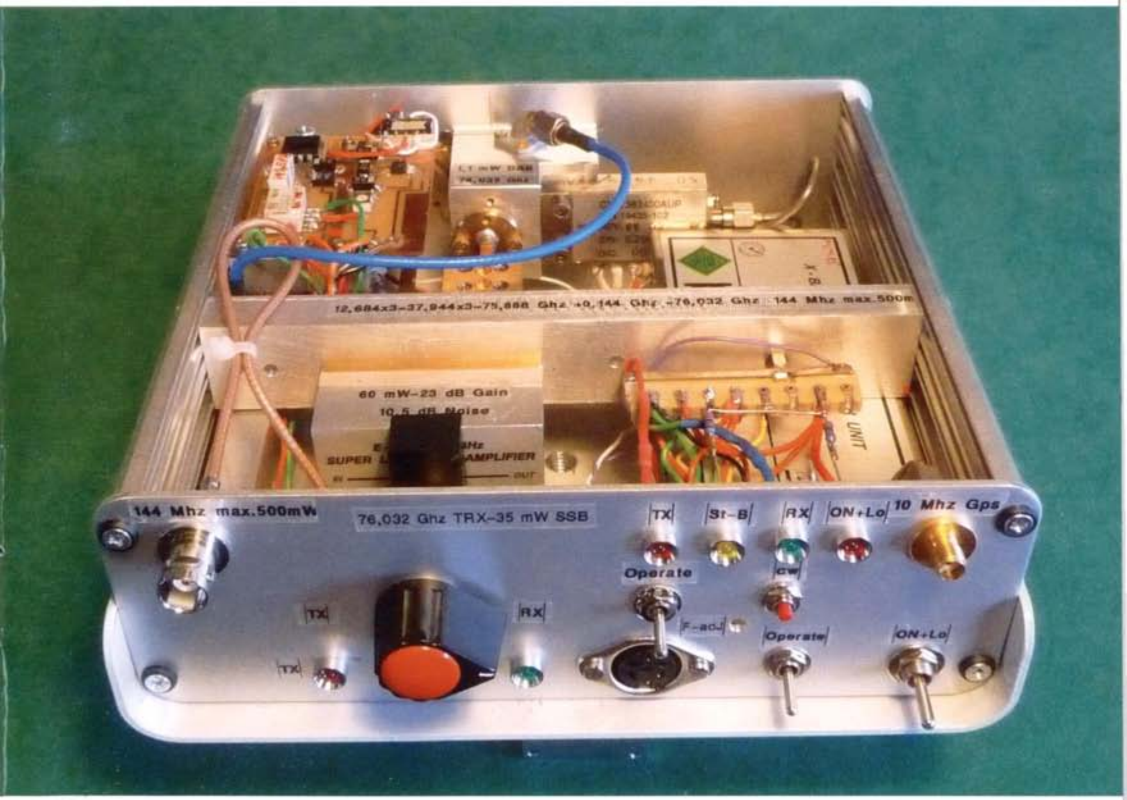
DUBUS

3/2009

Vol.38 3.Quarter

New 76 GHz Transverter



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Editorial

Dear DUBUS Reader!

Here is the summer issue of our magazine. We are already after the main season for Rain Scatter and Sporadic E and a lot of interersting QSOs took place and several records were achieved: We have a new world record on 10 GHz Rainscatter, a new world record on 6m multihop Sporadic E, a new world record on 3m FM BC Sporadic E, a new world on 4m Sporadic E and a new world record on 6m Tropo. Global warming seems to be helpful for higher distances on RS propagation at least.... and the still very quiet sun helped to ensure another great Sporadic E season on 6m, 4m and 2m. There have been several days in Europe with a MUF well above 200 MHz. As we got many technical reports for this issue the full 2009 reports and maps for 2m Es and FAI will be published in next issue 4/2009. All in all the 2m Es day count for EU in 2009 is well in line with the prediction basing on the last 35 years and the magnetic cycle of the sun.

Allthough we have these large numbers of interesting QSOs we receive not too much input and reports from you. Please keep sending your Es, Tropo, FAI and RS logs. Please keep also sending your technical articles. Thank you!

Hope to meet you in Weinheim on September 12th!

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

Liebe DUBUS-Leser!

Hier ist die Sommer-Ausgabe unseres Magazins. Wir befinden uns bereits am Ende der Hauptsaison für Regenscatter und Sporadic-E und es gab eine Menge interessanter QSOs und diverse Weltrkorde: Wir haben einen neuen Weltrekord für 10GHz-Regenscatter, einen neuen Weltrekord für 6m-Multihop-Es, einen neuen Weltrekord für 3m-Rundfunkband-Es, einen neuen Weltrekord für 4m-Es und einen neuen Weltrekord für 6m-Tropo. Die Erderwärmung scheint zumindest für größere Distanzen bei Regenscatter von Vorteil zu sein.... und die immer noch extrem ruhige Sonne hat eine weitere hervorragende Es-Saison auf 6m, 4m und 2m berschert. Es gab in Europa in diesem Sommer mehrere Tage, an denen die MUF über 200 MHz lag. Da wir für diese Ausgabe viele technische Artikel erhalten haben, wird der komplette 2m-Es und FAI-Bericht für 2009 dann in der nächsten Ausgabe 4/2009 erscheinen. Insgesamt liegt die Zahl der 2m-Es-Tage in Europa 2009 sehr gut im Rahmen der Vorhersage, die auf den Daten der letzten 35 Jahre und dem magnetischen Zyklus der Sonne beruht.

Trotz der vielen gelaufenen interessanten QSOs erhalten wir relativ wenige Logs und würden uns freuen, wenn wieder mehr Logs für Es, Tropo, FAI und RS eingeschickt würden. Bitte senden Sie auch weiter Ihre technischen Artikel und an DUBUS, vielen Dank!

Ich hoffe, wir sehen uns in Weinheim am 12.9.!

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

A 76GHz Transverter – with mechanical changeover

by Philipp Prinz, DL2AM

I recently got a 76GHz amplifier from DB6NT, made using wire bonding technology, that was intended for use with a mechanical changeover system. This enables the use of the amplifier for both TX and RX by rotating it mechanically through 180 degrees. See fig. 1. Generally I prefer to build only things which I can do myself in my home lab, but I wanted to give this one a try. According to the datasheet this amp should give 60mW Psat on 76 GHz with a gain of 23dB and a 10.5dB NF. Compared with my previous 76 GHz transverters this would be an improvement of 21dB. And an NF of 10 to 11dB on SSB could be possible. So I started to collect the material to build this transverter, see fig. 2.

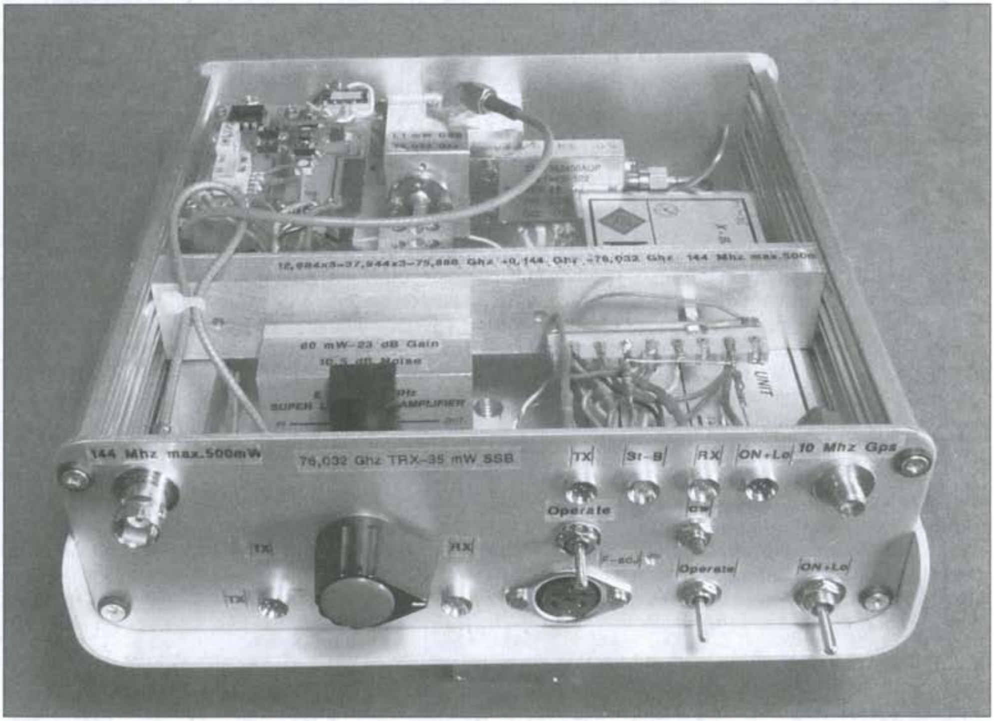


Fig. 1 76GHz Transverter with rotatable amplifier

The case (size W 185 D 180 H 65 mm, No. 70H4000) was from Bürklin (www.Buerklin.com). The mechanical changeover components and filters are from Hubert Krause (www.micro-mechanik.de). The 12.648GHz frequency source is the MKU-LO-PLL from DBN6T (www.db6nt.de), which can be locked to a 10MHz GPS reference. The transverter is mounted in a Uni casw from DL2AM, (www.dl2am.de) and uses PCB No. 45 from DB6NT (Pout of 1.1mW DSB). The tripler has an output power of 120mW on 37.944GHz. The IF amplifier is mounted separately in an extra aluminium housing. The assembly of these modules was described in detail in previous articles, so I will not write too much about them here.

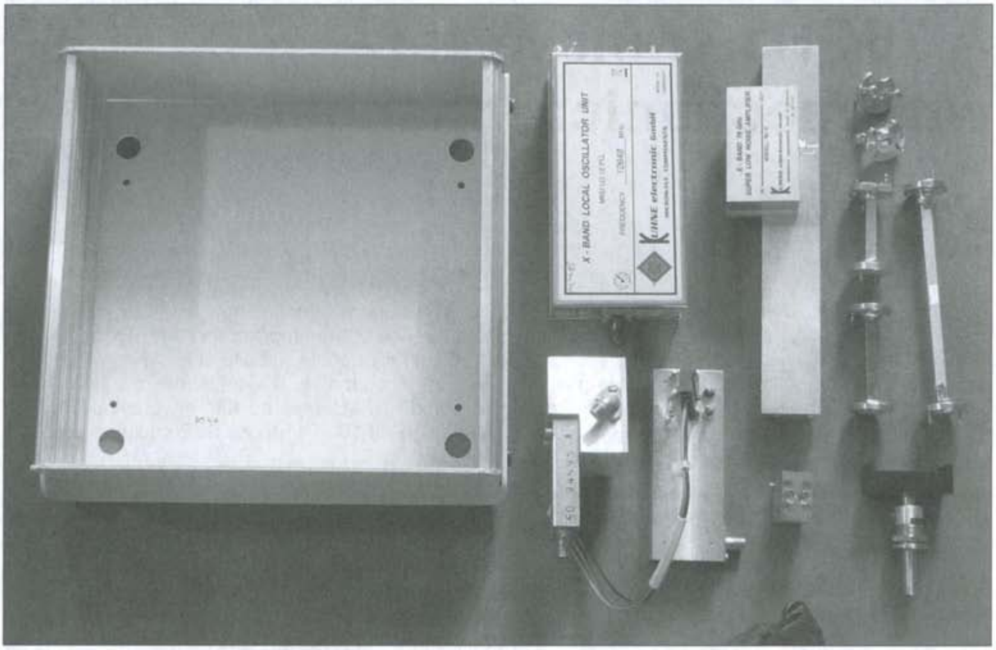


Fig. 2 Components of the transverter

The biggest problem was the resonator filter. Several people expressed skepticism and indeed my first attempts with a scaled down OE9PMJ two cavity filter failed. But when I inserted WR 12 isolators before and after this filter the good repeatable results were obtained. See fig. 3, fig.4 and fig. 5. So I learnt my lesson. The dimensions of the filter are 5.7 mm for the aperture diameter and 4.3mm for the clearance height. The diameter of the tuning elements is 1.8mm. The coupling hole (also called an iris) between the two resonator chambers has a big influence on the passband width. A few µm can make a significant difference. I used a taper reamer (from 1mm to 1.5mm diameter and 40mm length) in order to carefully open out this hole to the optimum size. The actual figure is 1.23mm diameter. The measured attenuation is 3.4dB on 76.032GHz. The LO signal is attenuated by 36dB and the lower sideband by 37dB. See fig. 10, fig. 11 and fig. 12 later.

Note that screwing in the tuning elements increases the frequency, and that half a turn will shift the frequency ouside the wanted range. Warming and cooling with freezer spray gives a change in attenuation of about 0.5 dB. When the coupling iris had a diameter of 1mm this change of temperature had a significantly larger effect than a 0.5dB. Back to the filter: If I used the changeover amplifier without this filter my output power on USB would be 24mW according to the caculation: 60mW Psat from the amp/ 2 = 30 mW - LO ~ 6 mW = 24 mW out.

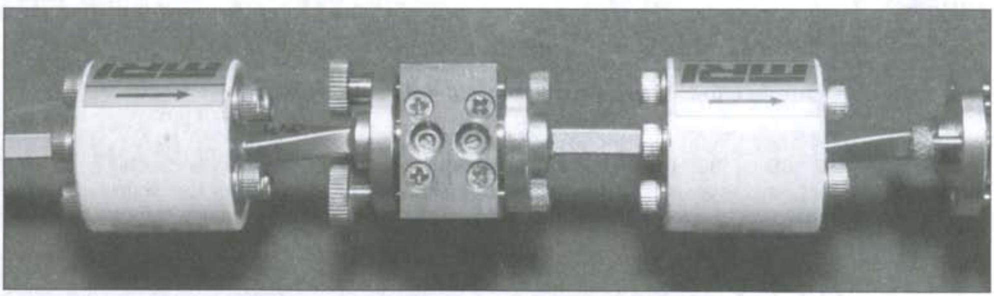


Fig. 3 OE9PMJ design high Q filter for 76GHz

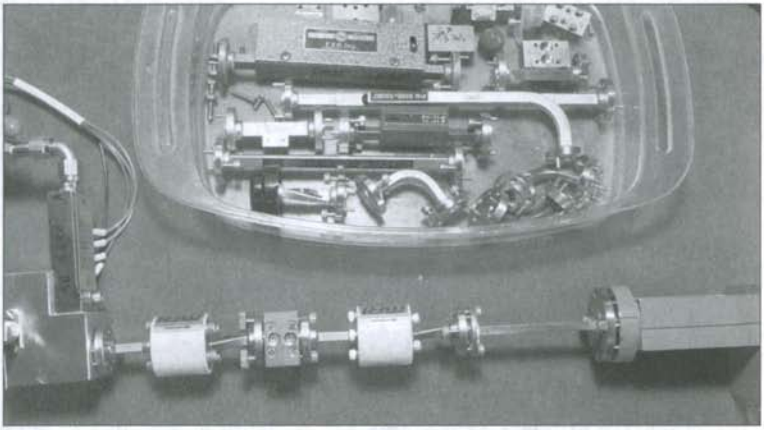


Fig. 4 Measurement assembly with 2 isolators in WR12

Fig. 5 Some WG stuff

Now work continued. I wanted to have a module that could be mounted separately. See fig. 6. The two 30mm and the one 103.8mm long pieces of WG WR12 with flanges need to be milled concentrically, in order to allow an axial arrangement of the WG, see figure 7. The Uni casing is screwed to the back cover and two holes are drilled for the adjustment of the 38 and 76GHz signals, see fig. 8. The mounting bar for the changeover mechanism is made from an aluminium bar the length of the internal width of the case.

Now everything can be screwed together to form one module. Then the module is laid into the case. Using 30mm spacers on both sides on the bottom of the casing enables to measure and drill the holes for the mounting bar on the outer profile. When using 30mm the changeover mechanism can still turn smoothly inside the 60mm internal height of the case. It is advantageous to use just one countersunk screw on each side of the bar. This gives a little play when the module is being fitted. The WG feed-through for the dish mount was also made by Micro-Mechanik. Next the WG WR 12 for the output can be measured, cut and inserted. I needed a length of 103.8mm. Now thea major part of this project is done. I refer to you an article from DC0DA in DUBUS 2/2006 where he has described a similar transverter for 47 GHz.

The front plate can be designed as you prefer, see my version in fig. 1. For indicating the position of the changeover mechanism I used two microswitches, which are actuated by an arm attached to the changeover mechanism shaft.

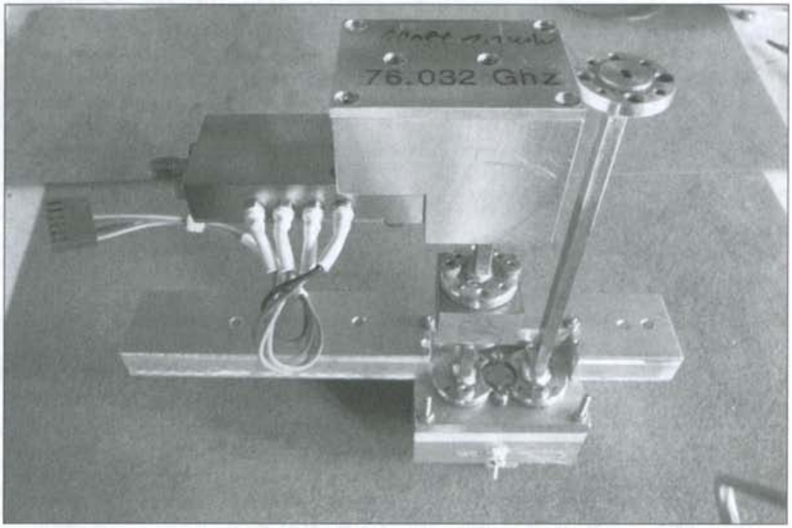


Fig. 6 Mounting bar with amplifier

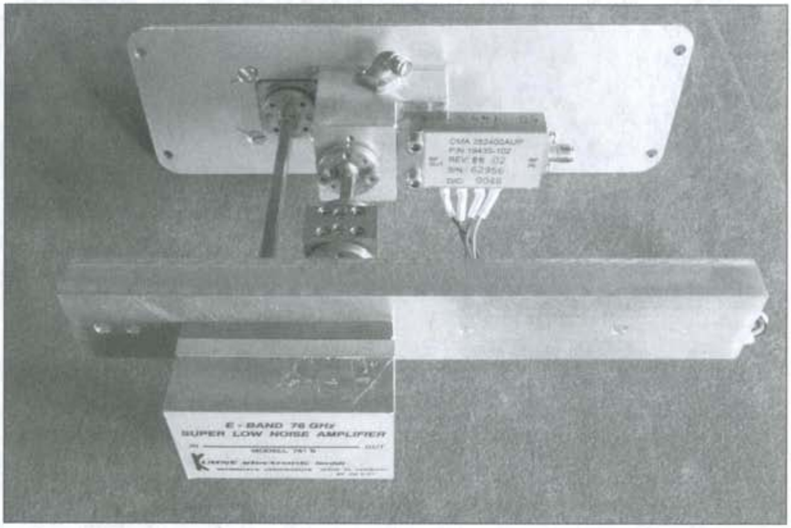


Fig. 7 Mounting bar, back cover and filter

These switches drive 2 LEDs and a relay that switches off the amplifier supply voltage whilst it is being rotated. The supply for the multiplier is built in the same way as that was published in the article "76GHz Transverter by DL2AM" in DUBUS 3/2007. On RX the +5V supply voltage has to be set to about +3.6V. This results in the best NF. On TX the voltage has to be adjusted with maximum power input to the mixer and the 144 MHz drive level has also to be adjusted at the same time for the best results. The TX supply voltage can be up to +6.1V . This test should be done first with just the transverter. Fig. 13 shows the results for my transverter. One can see that the diode really works well at higher drive levels.

Now first tests can be made. The changeover mechanism should only be rotated after all debris has been removed using compressed air. After several rotations of the changeover mechanism the shouldered center screw became loose and there was more play between the rotation plate and amplifier.

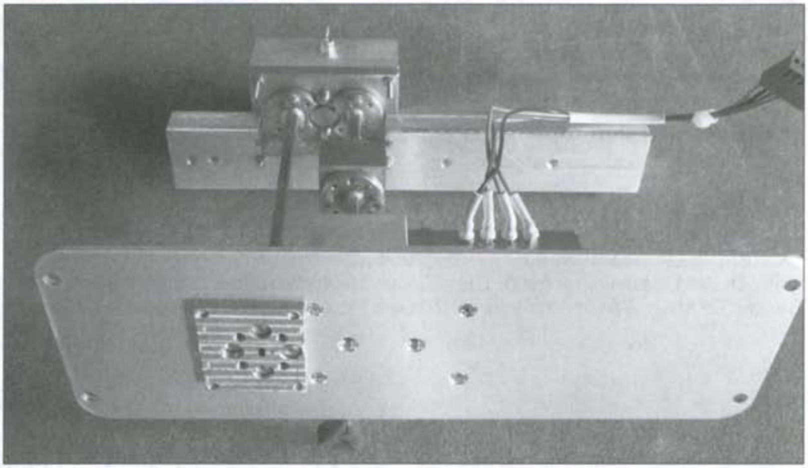


Fig. 8 Back cover of the casing with WG feed-through for dish mounting and 2 holes for transverter adjustment – view from the bottom side

I was apphrehensive when I realised all the work needed for disassembly. So I made a special tool to turn this shouldered screw without first having to disassemble the WG flanges. Here the modular concept was a winner as just one unit had to be removed. I placed a tiny ring of 0.3mm diameter copper wire over the threaded part of the screw up against the rotating flange and screwed it in again until there was just a slight play of the turnaround plate. In the end the screw could be only turned stiffly, which was fine. This assembly may be not the best solution, maybe a crinkle washer would give a more a uniform pressure. Pressing and pulling slightly on the changeover mechanism and WG hardly made any difference in output power. This clearly shows that this is a very good system. I think that this changeover mechanism has less loss then a WG switch as only a very short length of WG is necessary. One has to take into account that the WG loss on 76GHz is 6dB/m.

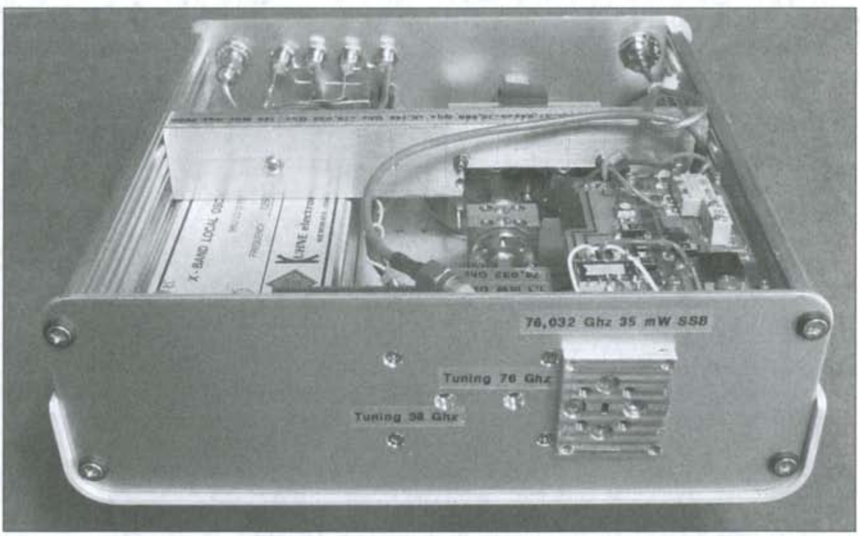


Fig. 9 76GHz transverter rear side

Now everything was complete and instead of the dish, I fitted an Anritsu WG12 power meter to the output port. Fig. 14 shows the measured values of power. Then I attached the HP8563E mixer to the output and checked the upper sideband, the LO suppression and the lower sideband. See fig. 10, fig. 11 and fig. 12. In the spectrum of fig. 12 the mixer is approaching saturation. A noise measurement gave a result of about 11 dB (USB). Finally the filter can be adjusted again if one has the necessary measurement equipment.

I hope this article will help some readers to realise their aspirations on 76GHz.

Literature

1. Jürgen Dahms, DC0DA, Transverter for 47 GHz, Dubus 2/2006
2. Philipp Prinz, DL2AM, Transverter for 76 GHz, Dubus 3/2007 and www.DL2AM.de
3. Roland Becker, DK4RC, Wendeverstärker für 76 GHz - 32. Tagungsband Dorsten 2009

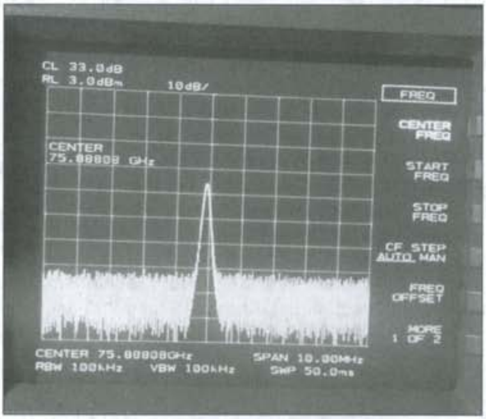


Fig. 10 LO Spectrum on 75,888GHz

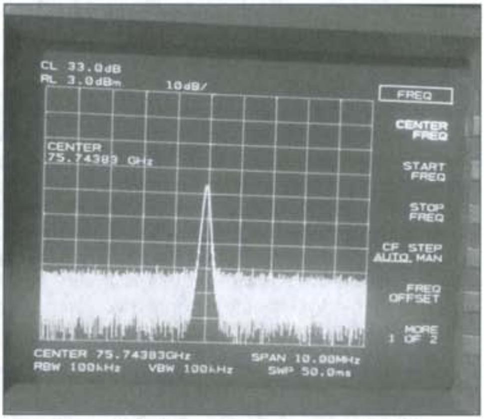


Fig. 11 USB Spectrum on 75,7438GHz

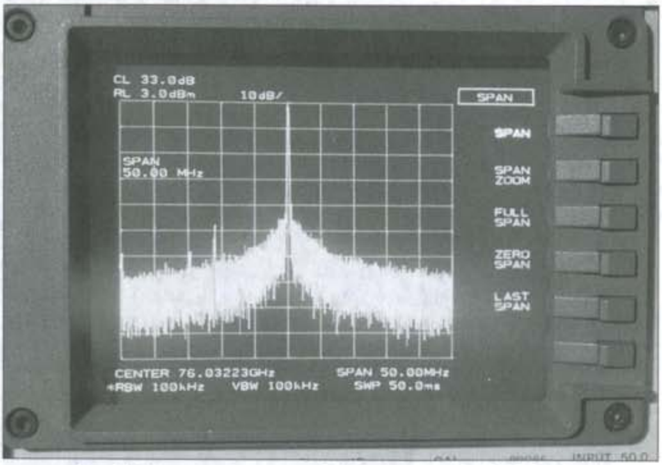


Fig. 12 Spectrum upper Sideband on 76,032200GHz

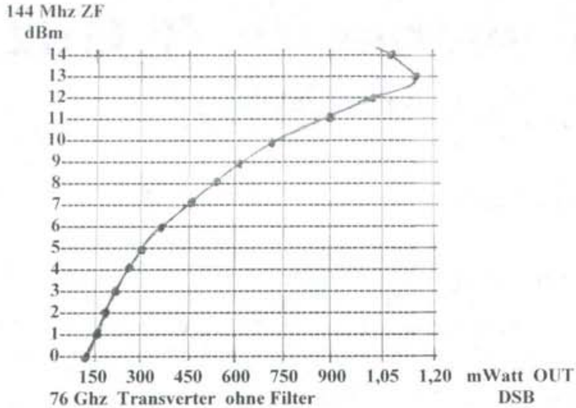


Fig. 13 Transverter output power vs. 2m IF power

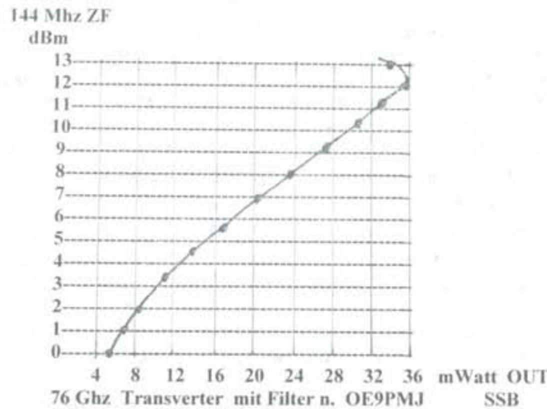


Fig. 14 Transverter output with amplifier vs. 2m IF power

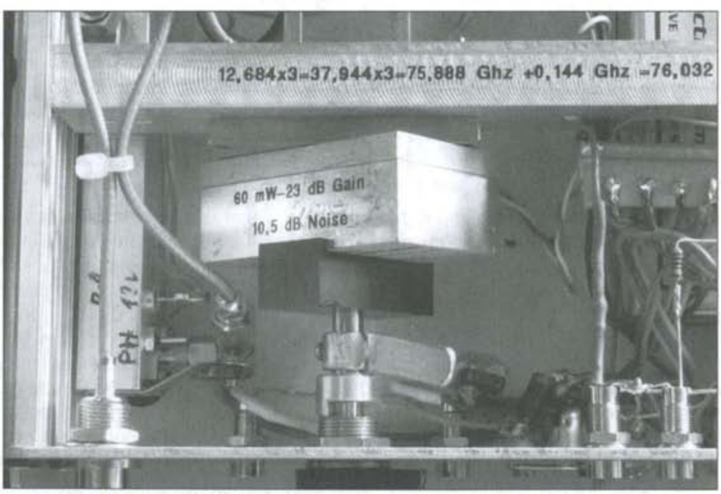


Fig. 15 Close view to the rotatable mechanics

Ein Transverter für 76 GHz - mit Wendeverstärker

von Philipp Prinz, DL2AM

Bei einem GHz-Treffen hat mir Michael, DB6NT, einen Verstärker für 76 GHz übergeben, der in Bond-Technik ausgeführt ist und für eine Wendemechanik vorgesehen ist, die es möglich macht, den Verstärker für Senden und Empfang durch Drehen um 180 Grad zu verwenden. Siehe Abb. 1.
Mein Vorsatz war eigentlich immer nur das zu bauen, was ich selber zu Hause in meinem Labor machen kann. Laut Daten soll dieser Verstärker bei 76 GHz 60 mW Psat machen und eine Kleinleistungsverstärkung von 23 dB bei 10,5 dB Rauschen haben. Dadurch ist eine Leistungserhöhung gegenüber meinen zwei vorhergehenden 76-GHz-Transvertern von ca. 21 dB zu erwarten und eine Rauschempfindlichkeit von minimal 10 – 11 dB bei Einseitenband möglich. Nun ging es an die Materialbeschaffung zum Anfertigen dieses Transverters, siehe Abb. 2.

Das Gehäuse (B 185 T 180 H 65 Außenmaße, Nr. 70H4000) ist von Bürklin (www.Buerklin.com). Die Wendemechanik und die Filter fertigte Hubert Krause (www.micro-mechanik.de). Die Frequenzaufbereitung von 12,648 GHz ist von DBN6T (www.db6nt.de) mit der Bezeichnung MKU-LO-PLL. Diese kann an 10 MHz GPS angebunden werden. Der Transverter befindet sich in einem Uni-Gehäuse von DL2AM, (www.dl2am.de) mit der PCB Nr. 45 von DB6NT (Ausgangsleistung 1,1 mW DSB). Der Multiplier x 3 dafür hat eine Ausgangsleistung von 120 mW bei 37,944 GHz. Der ZF-Verstärker ist abgesetzt in einem separaten Alu-Gehäuse. Zum Aufbau dieser Baugruppen sind schon viele Details geschrieben worden, so werde ich mich darüber kurz fassen.

Mein größeres Problem war das Resonator-Filter. Ich hörte so verschiedene Urteile, die nicht gerade vielversprechend klangen. Die ersten Versuche dieses von OE9PMJ herunter gerechneten 2-Topf-Filters waren nicht Erfolg versprechend. Erst als ich vor und nach dem Filter einen WR 12 Isolator anbaute, waren die Ergebnisse reproduzierbar, siehe Abb. 3, 4 und 5. So habe ich dazu gelernt. Bei diesem jetzt von mir zuletzt verwendeten Filter ist der Durchmesser der Öffnung 5,7 mm, die lichte Höhe 4,3 mm und die Tuning-Elemente haben 1,8 mm Durchmesser zum Abgleichen. Die so genannte Iris bzw. Koppelbohrung zwischen den beiden Resonator-Kammern hat sehr großen Einfluss auf die Durchlassbandbreite. Schon ein paar µm Vergrößerung verändern diese. Ich besorgte mir eine Konusreibahle von 1 auf 1,5 mm bei einer Länge von 40 mm, um diese Bohrung auf optimale Größe zu bringen. Das jetzige Maß ist 1,23 mm Durchmesser. Die gemessene Durchgangsdämpfung bei 76,032 GHz ist 3,4 dB. Der LO ist um 36 dB und das untere Seitenband um 37 dB abgesenkt, siehe Abb. 10, 11 und 12. Zu beachten ist, dass beim Reindrehen der Tuning-Elemente die Frequenz höher wird und schon ein Verdrehen um ½ Grad die Frequenz daneben liegt. Das Erwärmen und Abkühlen mit Kältespray hat eine Änderung von ca. ½ dB in der Durchgangsdämpfung erwirkt. Mir ist aufgefallen, dass, als die Iris noch 1 mm Durchmesser hatte, eine Änderung der Temperatur des Filters eine wesentlich größere Änderung als ½ dB erbrachte. Um nochmals auf das Filter zu kommen: Wenn ich diesen Wende-Verstärker ohne Filter betrieben hätte, wäre meine Ausgangsleistung im oberen Seitenband ca. 24 mWatt gewesen. Rechnung: 60 mW Psat vom Verstärker : 2 = 30 mW – LO ~ 6 mW = 24 mW out.

Nun ging es an weitere Arbeiten. Ich wollte ein Modul haben, was mechanisch separat zu montieren war, Siehe Abb. 6. Die zwei Stück 30 mm langen und das eine Stück 103,8 mm HL WR12 mit Flanschen müssen zentrisch abgedreht werden, um eine axiale Anordnung der HL zu bekommen, siehe Abb. 7. Das Uni-Gehäuse schraube ich an die Rückwand und bohre die zwei Öffnungen zum Abgleich des 38 und 76-GHz-Signals gleich durch diese, siehe Abb. 8. Die Befestigungsschiene für die Wendemechanik ist ein Aluprofil mit der Länge von der Breite des lichten Gehäuses. Nun kann alles zu einem Modul zusammen geschraubt werden. Jetzt lege ich das Modul in das Gehäuse. Wenn Abstandshalter von 30 mm Höhe vom Boden des Gehäuses beidseitig eingelegt werden, kann die Bohrung für die Befestigungsschiene an dem Außenprofil ausgemessen und gebohrt werden. Bei diesen 30 mm kann sich die Wendemechanik noch gut drehen im 60 mm hohen Gehäuse-Innenmaß. Es ist vorteilhaft, nur eine Senkschraube zum Befestigen der Schiene auf jeder Seite zu benutzen, so ergibt sich ein kleiner Spielraum beim Einpassen dieses Moduls. Die HL-Rückwanddurchführung für das Anbringen eines Parabol-Spiegels hat auch Micro-Mechanik gefertigt. Jetzt kann der HL WR 12 für den Ausgang eingemessen, angefertigt und eingebaut werden. Bei mir war dieser 103,8 mm lang. Jetzt ist ein wesentlicher Teil dieses Vorhabens geschafft. Ich möchte auch auf die Veröffentlichung von DC0DA im Dubus Heft 2/2006 hinweisen, wo er einen 47 GHz-Transverter ähnlicher Art beschrieben hat.

Die Frontansicht kann beliebig gestaltet werden, siehe Abb. 1. Zur Anzeige der Endstellungen des Wendeverstärkers verwende ich zwei Micro-Tastschalter, die mit einem Hebel von der Achse der Wendemechanik aus betätigt werden. Siehe Abb. 15. Diese Micro-Taster steuern 2 LEDs und gleichzeitig ein Relais an, das beim Drehen des Verstärkers dessen Versorgungsspannung abschaltet. Die Versorgungsspannung für den Multiplier ist aus der Veröffentlichung, 76 GHz-Transverter DL2AM, Dubus Heft 3, 2007. Mit dieser ist bei Empfang die + 5 Volt Betriebsspannung auf ca. + 3,6 Volt einzustellen. Dies ergibt den besten Signal-Rauschabstand. Beim Senden ist diese Spannung, sie kann bis zu + 6,1 Volt betragen, auf maximale Mischleistung des Transverters zu stellen, bei gleichzeitiger Veränderung der Eingangsleistung des 144-MHz-Sendesignals. Dieser Test sollte vorher mit dem Transverter alleine gemacht werden. Die Abb. 13 zeigt die Daten dieses verwendeten Transverters. Man sieht daraus, dass bei höherer Ansteuerung die Diode erst munter wird.

Nun können die ersten Tests beginnen. Die Wendemechanik sollte erst bewegt werden, wenn das montierte Gehäuse mit Druckluft ausgeblasen wurde, um alle Schmutzteile von der Wendemechanik fernzuhalten. Nach mehreren Drehungen der Wendemechanik hat sich die mittlere Bundschraube gelöst und es hat sich ein größerer Spielraum zwischen Wendeplatte und Verstärker ergeben. Mit Schrecken sah ich die große Arbeit beim Auseinanderbau. Einen Spezialsteckschlüssel fertigte ich an, um diese Bundschraube herausdrehen zu können, ohne Abschrauben der HL-Flansche. Da hat sich die Modulbauweise doch sehr bewährt, da nur eine Einheit ausgebaut werden musste. Ich legte nach dem Gewinde vor den Drehansatz der Bundschraube einen Kupferdrahtring von 0,3 mm Durchmesser und drehte diese wieder rein bis ein leichtes Spiel der Wendeplatte vorhanden war, die Bundschraube drehte sich am Schluss schwer, was gut ist. Diese Anordnung ist noch nicht die beste Lösung, vielleicht könnte eine Wellscheibe die Lösung sein, die einen gleichmäßigen Andruck möglich macht. Durch leichtes Auseinander- und Zusammendrücken der Wendemechanik und leichtes Versetzen des HL änderte sich die Ausgangsleistung kaum. Daraus ist zu erkennen, dass das System sehr gut ist. Ich denke, dass diese Wendemechanik verlustärmer ist, als ein Hohlleiter-Schalter, da durch dieses System der verwendete Hohlleiter sehr kurz ist. Zu bedenken ist auch, dass die HL-Dämpfung bei 76 GHz und 1 Meter Länge 6 dB beträgt.

Nun endlich die Inbetriebnahme. Am Ausgang anstelle des Parabol-Spiegels schraubte ich ein Anritsu Leistungsmesser mit HL WR 12 an. Die Abb. 14 zeigt die gemessenen Leistungswerte. Wenn ich dabei das Spektrum in Abb. 12 anschaue, ist die Sättigung des Mischers ganz schön fortgeschritten.
Nun schraubte ich den Mischer vom HP8563E an den Ausgang an und schaute mir das obere Seitenband, die Unterdrückung des LO und des unteren Seitenbandes an. Es sieht ja ganz gut aus. Siehe nochmals die drei Abb. 10, 11 und 12 vom Spektrum-Analyzer HP8563E. Eine Rauschmessung hat gezeigt, dass dieses bei etwa 11 dB (oberes Seitenband) liegt. Das Filter kann jetzt nochmals nachgeglichen werden, vorausgesetzt, dass die dazu nötigen Messmittel zur Verfügung stehen. Wenn beide Tuning-Elemente des Filters auf maximalen Output abgeglichen werden, ist die LO- und USB-Unterdrückung aber schon ganz gut. - Ich hoffe, dass durch diesen Beitrag einige Wünsche wieder in Erfüllung gehen, zumindest aber in den Vorstellungen.

Bildunterschriften:

Abb. 1 76 GHz-Transverter mit Wendeverstärker
Abb. 2 Teile für das Anfertigen dieses Transverters.
Abb. 3 High-Q-Filter für 76 GHz v.OE9PMJ
Abb. 4 Messanordnung mit 2 Isolatoren WR 12
Abb. 5 Verschiedene Hohlleiter-Apparaturen
Abb. 6 Befestigungsschiene mit Wendeverstärker
Abb. 7 Befestigungsschiene + Rückwand und Filter
Abb. 8 Rückwand des Gehäuses mit HL-Durchführung für Spiegelbefestigung und 2 Öffnungen für Transverter-Abgleich, das Ganze von der Unterseite gesehen.
Abb. 9 76 GHz-Transverter von der Rückseite
Abb. 10 Spektrum LO 75,888 GHz
Abb. 11 Spektrum USB 75,7438 GHz
Abb. 12 Spektrum Oberes Seitenband 76,032200 GHz
Abb. 13 Diagramm nur Transverterleistung
Abb. 14 Diagramm Transverterleistung mit Wendeverstärker
Abb. 15 Nahaufnahme der Wendemechanik mit Hilfsarm und Microschaltern

Further development of the LFA Yagi

by Justin Johnson, G0KSC

Since I first introduced the LFA Yagi in DUBUS earlier this year, there has been a lot of talk and interest in the design including the fact that Vine Antennas is now manufacturer and sell them commercially. Sadly, I have seen only one set of results of experimentation with the LFA which came from YU1AW (www.qsl.net/yu1aw/3fdf_yagi_feed.pdf). He took my published 18 element 144MHz design and added a second loop or triple dipole as he calls it. Basically, the antenna feed system loop looks like my loop only a little wider along the boom with another cross-member in the middle of the loop. This cross-member in the centre of the loop is where the feed point is placed. The antenna performed well and while it did have around .5dB less gain, the F/B was increased drastically along with the antennas bandwidth which more than doubled.

This was an idea I played around with while developing the LFA but I could not achieve my favoured 50 Ohm feed impedance. This is also the case with the YU1AW design as this antenna is 200 Ohms requiring a simple 4:1 balun at the feed point. While the F/B was very impressive, the feed arrangement on the YU1AW design would be very difficult to engineer for the every-day ham, even more so if it were to be made in order that fine tuning were possible. Further developments to my original 18 element have shown impressive increases to F/B and F/R figures along with a few points of a dB increase in forward gain. Upon forwarding my still work-in-progress design to Lionel VE7BQH, he made the following comments *'There is nothing near as good at that boom length, well done'*. Pattern cleanliness and superior suppression of radiation from 0 to 180 degrees has meant never-seen-before Kelvin figures for sky temperature along with incredible G/T figures. The G0KSC 18el 144MHz LFA 4 bay stands at 6.37 WL, 22.09dBd forward Gain, 213.9 Kelvin and +0.94 G/T. See figure 1.

One benefit that has been established with the LFA is its relatively low noise characteristics. Upon completion of a 144MHz design in most cases, the antenna is lower in sky temperature than any dipole fed array of a similar size. With careful trimming, the LFA can be brought down to exceptional boom length/noise figures

Considering that G/T is the figure of merit used to establish an antennas ability to receive signals, only 4 antennas on the VE7BQH list bettered the 18 element LFA mentioned above. The shortest of these being Lionel's own 7.29 WL array at +0.95 G/T with M2's original 7.71 WL array trailing at +0.90 G/T. Impressive as this is, EME arrays are not the subject of this article. However, a number of 4 bay arrays will be show-cased in issue 4 of DUBUS so don't miss it!

This time we will focus on 6 metre antennas and the ability to create some very impressive DX arrays with very small turning circles. Before we do so, there is another important development I must discuss. As you will know, when I first released details of the LFA it was in very early stages of development and my work focused around very wideband designs. The main reason for this was to ensure any issues or inaccuracies with the design would make a relatively small impact on the final antenna. More on that a little later.

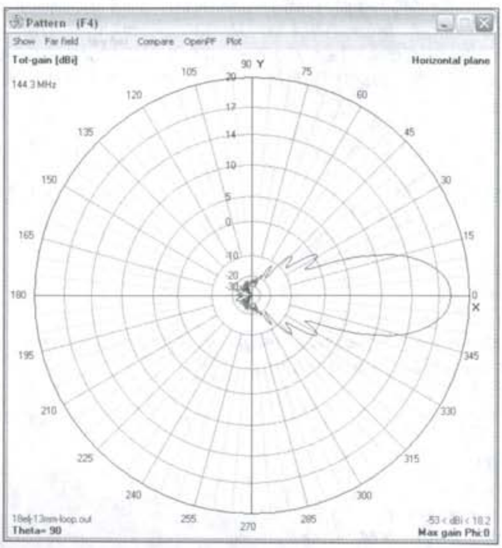


Fig. 1 The re-worked 18 element LFA with even better F/B, forward gain and G/T.

The LFA has been getting a good airing on 6m. Brendon G4DYO reported of his 4 element LFA *'3 July.. I've now worked HV, 7X and TZ using the 4-el LFA. Also heard in deep QSB V2 and 8R... I'm well pleased.'*

I too have had some good reports from my far worse than average location managing to break NA pile ups with 100 watts and one single callsign being sent. A 5 element 6.6 metre long boom version was used in these instances. Joe CT1HZE took delivery of a 7 element 9.4 metre long LFA in early July and has reported very good F/B and F/S figures along with excellent forward performance too in particular into NA and also EME.

Low-Noise LFA

After the first experiments with 144MHz LFAs and establishing the very low noise figure, I decided to look towards developing something which would reduce drastically the noise levels seen in urban/city locations by 6m users. Upon investigation, it was established that most city users have antenna of between 4 and 7 elements long and quite often, make their choice of antenna based upon gain alone. Understandable considering that most hams would choose a larger array if they had the space or could get away with it. Low impedance antennas tended to produce higher gain from less elements (although no additional gain per boom length is achieved) than OWA (Optimised wideband Arrays) arrays. Boom length of the above could be anything between .5 and 1.5 WL long. This just happens to be the worst length of boom we could have within a city location due to the amplitude of vertical plane, noise generating lobes.

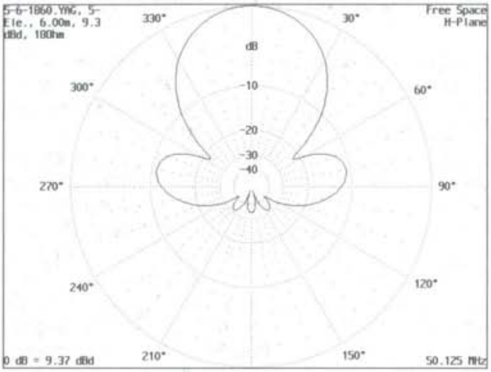


Fig. 2 An 18 Ohm 5 element 6m array showing lobes in the vertical plane

Fig. 2 shows where this unwanted noise comes from. The sharp angle lobes in the vertical plane are around 11dB down on the main forward lobe. This means we have much gain from a lobe pointing downward into our house and those of our neighbours ensuring those ADSL routers and plasma TV sets etc. are received very loudly. This is just one example of the problem that most arrays in the boom length described above are faced with.

Can this be cured with the LFA? Recalling the details from the first article, we know the opposing phase of the LFA loop ends helps drastically reduce any side lobes. However, in the vertical plane, these lobes, while greatly suppressed, are trying to push their way back out again. Through careful modelling, I have been able to greatly suppress lobes in the vertical plane in addition to the horizontal plane on arrays of the above mentioned boom length. In worst cases, this involves pushing the lobe much farther forward than they would normally be. However, often this is to the detriment of forward gain, sometimes as much as 1dB.

This said, in my opinion and certainly in my location, this is an ideal scenario. My current installed antenna is a 5 element low-noise array has 11.5dBi but an exceptional vertical pattern. See figure 3. For the first time ever, with amp2 selected on my FT2000, I have no S meter movement when listening to an empty frequency upon 6. With of course the occasional S meter 'bounce'.

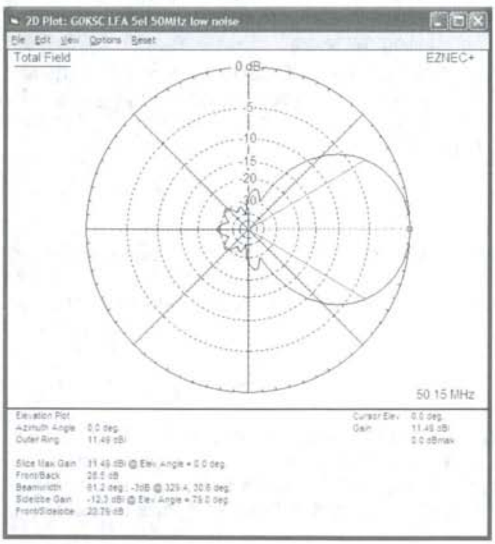


Fig. 3 My own 5 element low-noise LFA Yagi with exceptional vertical plane suppression'

For me, being able to work what I hear effectively is better that the extra 1dB. After all, the amplifier can be switched on if needed. This said, not every LFA design is ultra low noise and there are many versions that have both suppressed lobes and still achieve excellent levels of gain/boom length with better than average F/B at the same time.

An interesting note on model accuracy

Having built many LFA's now and also some narrow band ones too, I have established that both mininec and nec2 based antenna design programs report LFA performance incorrectly. In most cases the error is small. However, they report the antennas LF of its actual operating frequency. This presents a problem when single piece elements are used as it could render all elements throw away if built to the specifications either package suggests. Mininec is more accurate than nec2 based programs with LFAs. Generally, I have found (when comparing final results within EZNEC Pro/4) that only the loop needs adjustment. However, nec2 based options report the whole antenna (all elements) LF. When I first started to model LFAs I cut antennas to the sizes suggested in nec2 based programs and had an antenna too short for the band.

Additionally, development within nec2 based programs was hampered by a stability issue within the thin wire kernel. When pushing designs for maximum performance, huge instability was seen in some cases. This issue does not exist within nec4 and as a result, the models you will see in this article far exceed performance of those seen in the first article. Thanks to YU1AW for identifying the problem here.

The above issues where amplified by the adjustable loop design. With the loop being made of two different tube thicknesses (2 x 12mm plus 2 x 10mm end sections to allow for a trombone tuning effect of the loop see details at the bottom of the article about making the loop) another known issue within nec2 came into play. The best way to model an LFA (assuming you do not have a modelling package with nec4) is to use one single size wire for your loop, within your development program and optimizer. MMana is a good option due to its use of mininec. It has an optimizer built in too which works with the LFA. Once this is complete, finish off with the two diameter element sections manually when building the antenna. Worst case, allow the trombone section plenty of length in order that the antenna can be finished off manually when it is built. This said, if building one of my designs, you should not have any issues. Reading my designs in any program other than one using nec4, will show incorrect results, especially SWR.

I took 'a leap of faith' and purchased the very latest nec4.1 Double Precision engine (500 USD) as I knew 4nec2 supported the use of nec4 as well as the standard nec2. I did not know at that time if nec4 would fix the problem I was seeing. Initial findings were encouraging as the program presented element lengths similar to those I had ended up with upon build completion (having had to lengthen all elements and change the loop size) and building the first nec4 based antennas confirmed it. Since then I have purchased EZNEC Pro/4 (another 650 USD) to aid in the final development of each design.

All of the designs within this article and in future will be produced within nec4.1 or later so please remember, they will not look the same in your everyday modelling package.

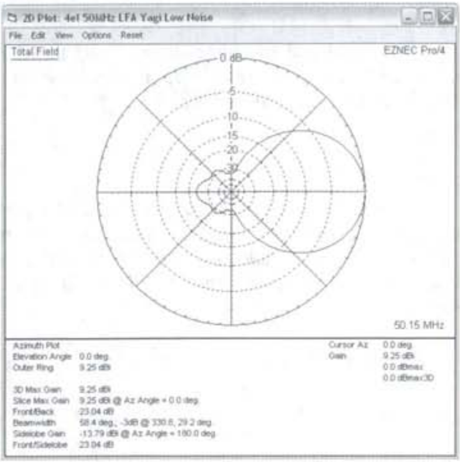
Furthermore, some of the designs that will be published in DUBUS will be DUBUS exclusive designs and will not be published anywhere else. I have added a DUBUS login to my website (www.G0KSC.co.uk) By login in here, you will be able to see all DUBUS exclusive related antenna files and articles in full (if space within an issue has been a problem) upon the download page.

2 compact stacked arrays for 50MHz

Next we shall look at two stacked arrays. The first will be a compact 4 element stack and the second, based on 2 x 5 element arrays. Both arrangements have been modelled for best pattern and bandwidth over optimum gain. In both cases, slightly more gain can be achieved by increasing stacking distance. However, this will be to the detriment of the overall pattern.

2 x 4 stacked array for 50MHz

In order to do something a little different with the LFA, I wanted to produce a DX antenna that was short yet provided sufficient gain that it exceeded the magical 10dBd mark while maintaining bandwidth at the same time. In order to achieve this goal, I designed this 4 element LFA which has a loop consisting of 13/10mm diameter tubing with all parasitic elements being 10mm diameter. Figure 4 shows the horizontal pattern of this antenna.



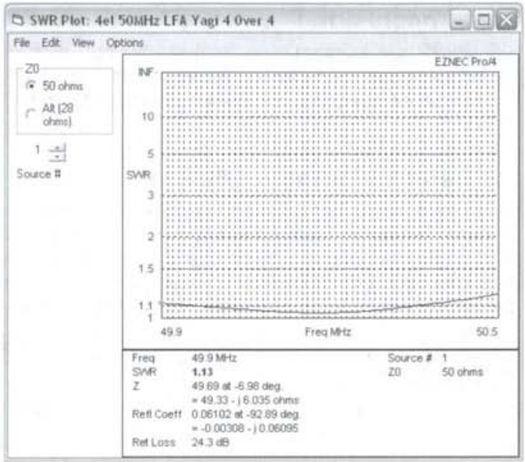
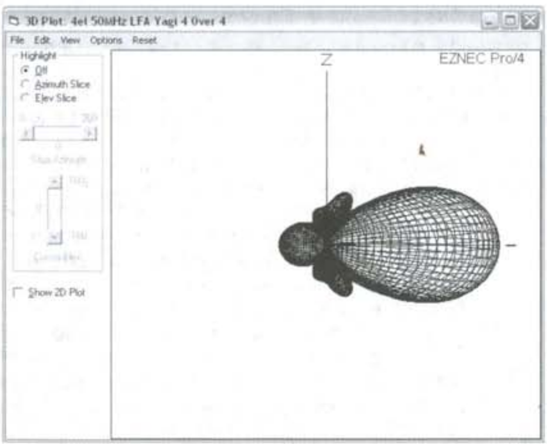


Fig. 4 Good gain, excellent F/B from this compact LFA Yagi'

Fig. 5 SWR for a pair of antennas stacked at only 3.9 metres apart'

Boom length is a fraction under 3 metres and SWR is 1.08:1 at 50MHz which dips to 1.0:1 at 50.210MHz rising again to 1.17:1 at 50.5MHz. This antenna will be sufficient for DX as a single Yagi in many stations with its 9.25dBi forward gain and 23.04dB F/B. Let us now look at a 2 antenna stack.

Personal taste and requirements has a big part to play in the spacing of an antenna when stacking. I prefer to keep the pattern as clean as possible and by stacking at just 3.9 metres a part, this objective has been achieved. Fig. 5 shows the SWR plot for the 2 x 4 el stack. As mentioned above, opening the stacking distance will increase gain further. However, this stack produces 12.01dBi in its current form, not too far away from the ideal 3dB and close to the target of 12.25dBi (10dBd). Increasing to a distance of 4.25 metres sees the gain go up by .17dB in addition to an increase in the small ears in the vertical pattern (above and below the main lobe) to only 15dB down on the main lobe. See fig. 6 and 7.



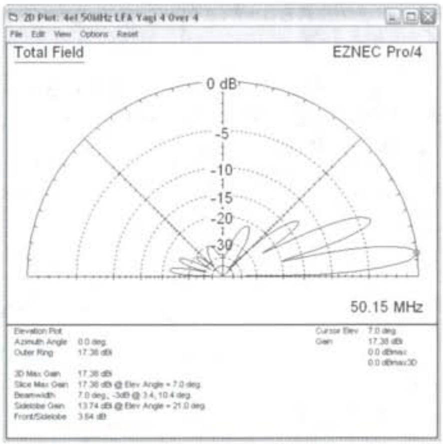


Fig. 6 The 3D plot of 2 x 4 element LFAs stacked at just 3.9 metres apart

Fig. 7 A compact stack with exceptional performance which many hams could justify installing

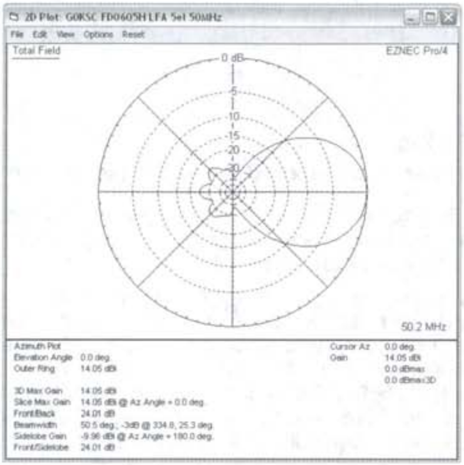
By keeping the lobes to an absolute minimum, we increase dramatically the cleanliness of the final antenna pattern when placed above ground. At just 10 metres up, the 4 over 4 LFA array produces 17.38dBi with a main lobe elevation of only 7 degrees. The familiar high centre lobe in stack arrays has been removed by our choice of a smaller stacking distance. In addition to the obvious pattern benefits, we have sacrificed very little gain while maintaining good F/B and bandwidth.

2 x 4 conclusion

Stacking 2 x 4 element Yagi antennas is not often an option considered by hams. It is hoped that by seeing performance of this LFA version with its relatively close spacing, some maybe inspired the use such an array, especially where small urban lots do not often have an abundance of space.

2 x 5 stacked array for 50MHz

At 5 metres boom length and 6.1 metres stacking distance, this may already be getting a little out of reach for most. However, I wanted to highlight the ability of a stacked array over a single long boom array such as a single 8 element Yagi for example. Unless a very large lot were available, a single 11 to 12 metre antenna is going to be difficult to justify, erect and keep in the air. With an array such as this 2 X 5, small diameter booms can be maintained along with overall weight being kept to a minimum.



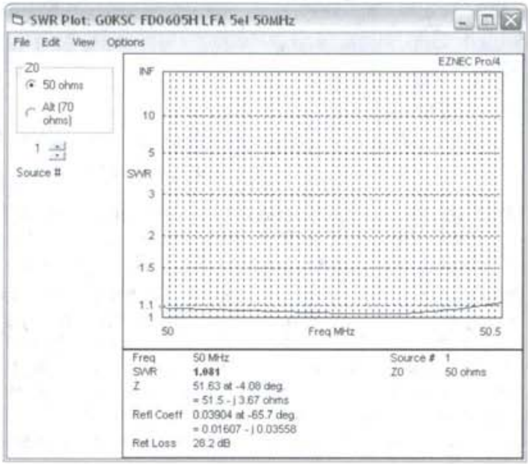


Fig. 8 24dB F/B and 14.05dBi Gain from a turning radius of less than 5 metres

Fig. 9 The 2 x 5 stack shows a flat SWR across the band'

This antenna is a re-work of the FD0605H we saw in the last issue. An additional .1dB Gain has been achieved along with a slight increase in F/B and a shorter boom. While I will contradict my comments above, this antenna does not have the best pattern. However, it stacks extremely well. Gain and F/B have increased by more than 3dB respectively with the array showing 14.05dBi and 24db F/B. SWR remains flat across the bottom end of 50MHz and like the 4 element before it, remains stable in all weather conditions.

Unlike the 4 element array, I have been unable to suppress fully the lobes in an upward and downward direction. This in part is due to one of the main design directives of this antenna; boom length. I wanted to keep it to no more than 5mtrs and achieve 11dBi in a single antenna. This said, the upward lobe is still 20dB down when the bottom antenna in the stack is placed at 10 metres above ground and a nice single lobe extends at just 6 degrees. Gain is a very respectable 19.11dBi at this height, too. See fig. 8, fig. 9 and fig. 10.

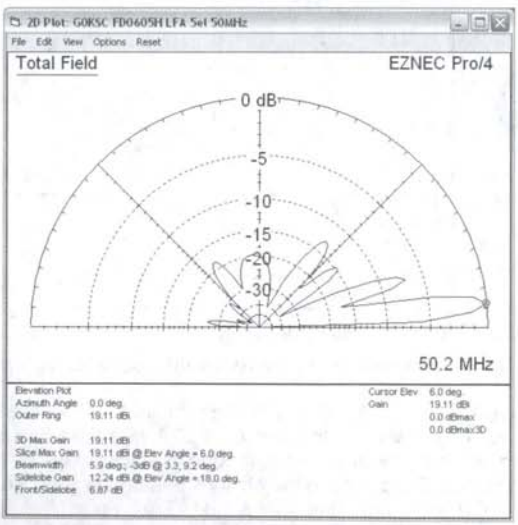


Fig. 10 Good gain, a low angle of radiation and strong main lobe from this 2 x 5 stack

Phasing arrangements

Phasing methods are outside the scope of this article. However, there are plenty of resources on the Internet which can help with this. At the recent RSGB field day, I provided 2 x 9 el 144MHz LFAs and 2 x 4 element 70MHz LFAs to a local club. I used the phasing information in the DK7ZB site to make my choice http://www.qsl.net/dk7zb/. There are a number of both coax and power divider/splitter options upon this page. The installation at field day was going to be a temporary one and due to lack of the correct materials and time, I went with the 75 Ohm satellite TV coax option. The stations where using legal limit on both bands, both arrays performed faultlessly.

LFA Build instructions

The loop is not complicated to make. The best option is to build the 4 element array as if it were a 5 element array and the 5 element array as if it were a 6 element array, counting DE1 and DE2 as separate elements. Once these are installed upon the boom, bend the end sections to slot into the ends of DE1 and DE2. Full instructions and diagrams can be found at: http://www.g0ksc.co.uk/making-the-lfa-loop.html

4 element LFA dimensions

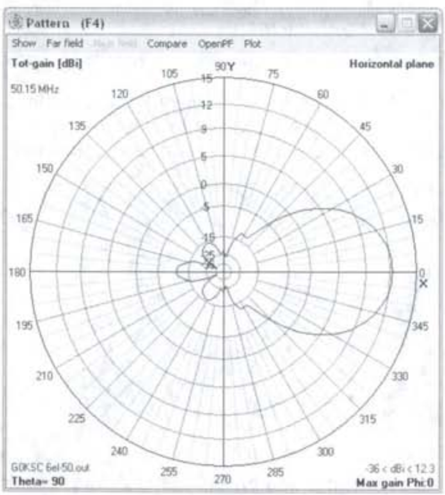
Element	spacing in metres	half length in metres	element diameter
Reflector	0	1.501	10mm
DE1 Feedpoint	.256	1.271	13mm
DE2	.727	1.271	13mm
D1	1.414	1.373	10mm
D2	2.96	1.269	10mm

Note: 1/ Loop end sections slotted into DE1 and DE2 should be 10mm in diameter.
2/ I reduce the main element lengths in the loop by around 30mm in order to allow for the bends in the end sections and with a view that any final compensation trimming can be done upon completion. Until now, no further trimming has been required.

5 element LFA Dimensions

Element	spacing in metres	half length in metres	element diameter
Reflector	0	1.482	16mm
DE1 Feedpoint	.287	1.238	16mm
DE2	.828	1.238	16mm
D1	1.378	1.383	16mm
D2	3.026	1.324	16mm
D3	4.755	1.299	16mm

Note: 1/ Loop end sections slotted into DE1 and DE2 should be 12mm in diameter.
2/ Loop sizing notes as per the 4 element array above.



A 6 element 50MHz LFA Yagi

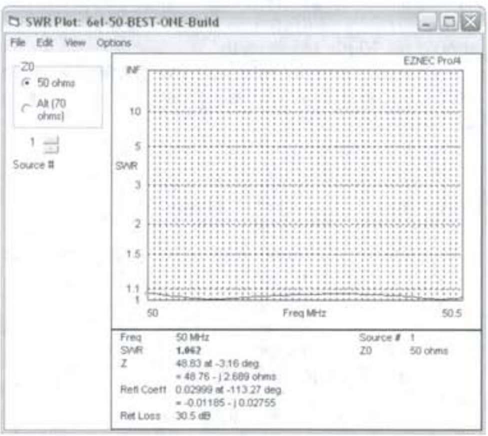
I wanted to 'up scale' from my 6.6 metre long 5 element narrow band LFA to something with a bit more gain but this time, with my preferred wide-band characteristics. Some time ago, I developed the 6 element LFA I have posted on my website which has 11.8dBi and is 6.8 metres long. However, I wanted to try and achieve a little more gain without going to the much longer 7 element array. The result was one of my first LFAs completely finished off in EZNEC Pro/4. The horizontal pattern is shown in figure 11.

Fig. 11 The 6 element wideband LFA Yagi with 12.3dBi and 23dB F/B

I have become very comfortable with the accuracy of the nec4.1 double precision engine. After all, it does have almost 20 years of additional development over the much older nec2. Therefore, I did not feel that the antenna would need to be checked before being installed on the tower. Raising the antenna into place and checking in the shack confirmed this. The needle on the SWR meter scale does not move from 50MHz to 50.5MHz just starting to rise at 50.6MHz. Once I had confirmed tuning was OK, I scanned the band and worked UX1UA and UT3UX by reply to their calls. I was given 559 and 579 reports respectively with just 10 Watts from my FT2000. Later that evening (28th July 2009) I worked CR2F with a 55 report, one of only a handful of G's to work them.
One day on and I have heard ON0SIX and LX0SIX via tropo for the first time ever and GB3BAA is definitely up in strength to what I am used to. All in all I am very pleased with the result.

Design objectives for the 6 el

One of the design objectives was to reduce the visual impact as much as possible with this antenna. This was a different strategy to that used with its predecessor which was designed with out and out performance in mind. This meant I would use much thinner elements without the size of the loop being stepped up in addition to beefing up the boom even more, to keep the requirement for boom guying along with guy support struts away.
The boom is 7.3 metres long and is made from 1.5 inch (38.1mm) box section aluminium with .5 inch/13mm elements. The end sections of the loop are 5/8 inch/10mm. The SWR plots in figure 12 and figure 13 show that there is virtually no difference in tuning between imperial or metric sized elements.



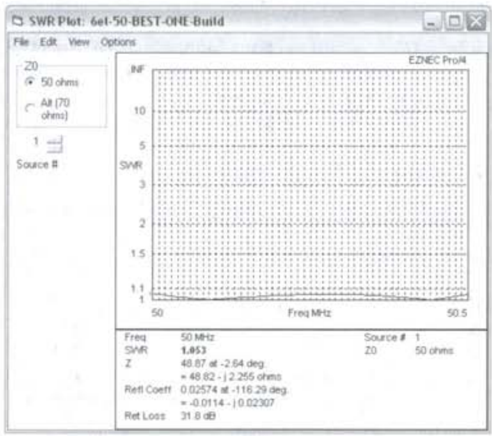
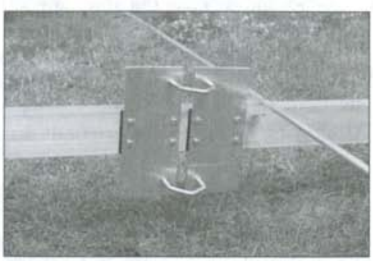


Fig. 12 SWR plot with ½ inch elements with the loop ends being in 5/8 inch

Fig. 13 SWR plot with 13mm elements that have 10mm loop ends

The secondary boom runs for 5 metres below the main boom. Weight was not a problem for me as this is going to be the only antenna on the tower for a while. I also made a dual plate boom to mast, heavy duty clamp to ensure that antenna would stay in place. This uses ¼ inch thick aluminium plate. See figure 14.



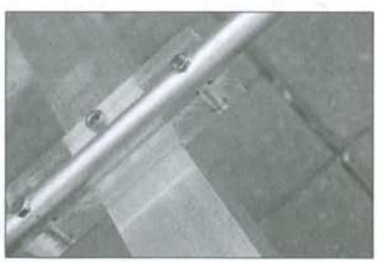


Fig. 14 Heavy duty clamp arrangement ensuring stability and no movement

Fig. 15 A G0KSC insulator in place on the 6el LFA Yagi boom

As always, I used my 15mm thick Plexiglass/Perspex insulators but now I always completely isolate the elements from the boom. The boom width is machined out of the Plexiglass by 2mm below the insulator to ensure no twisting of the elements once they are in place and I machine a curved recess across the top of the insulator for the element to sit within. The insulators are 100mm across and 40mm wide. See figure 15.

A coiled Pawsey stub 1:1 balun is used in order to match the unbalanced coax to the balanced antenna system. See figure 16. This has a short leader terminated by a female N type connector and the coax used within the balun is Westflex 103. After a recommendation from Pop YU7EF, I have used this balun upon my last 3 antennas. It does the job well and uses less material than other 1:1 balun types. Construction info can be found here: http://www.g0ksc.co.uk/creatingabalun.html

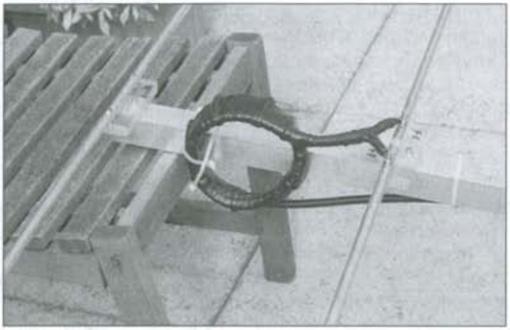


Fig. 16 Pawsey stub balun in place on the boom

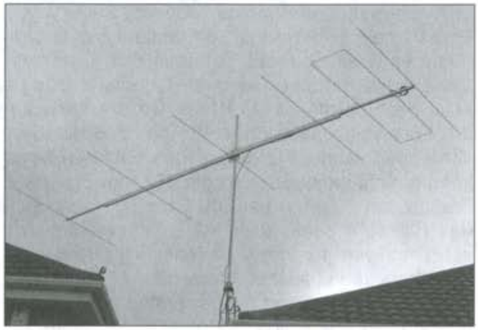


Fig. 17 6 El LFA at G0KSC`s

Results for the 6 el

When on the top of the tower, the antenna does not look as big as it is in reality. See fig. 17. Keep in mind that the stub mast is a 2 inch thick wall aluminium pole and the boom is 3 inches thick where doubled. This 12.3dBi version has more gain but less F/B than the earlier 6.8 metre long version. With additional F/B and being much shorter, the 6.8 metre version will still have a place for many hams. I am sure that performance of this antenna long-term will be very good indeed and should this one be stacked, exceptional results would be seen for sure.

6 element LFA Dimensions

Element	spacing in metres	half length in metres	element diameter
Reflector	0	1.488	13mm or ½ inch
DE1 Feedpoint	.333	1.236	13mm or ½ inch
DE2	.889	1.236	13mm or ½ inch
D1	1.66	1.377	13mm or ½ inch
D2	3.386	1.34	13mm or ½ inch
D3	5.286	1.324	13mm or ½ inch
D4	7.243	1.281	13mm or ½ inch

Note 1/ Loop end sections slotted into DE1 and DE2 should be 10mm or 3/8 inch in diameter.
2/ Loop sizing notes as per the 4 element array above.

Once you have your DUBUS login details to my website, EZNEC files for these antennas will be able to be downloaded but do keep in mind, you will see a different SWR plot to those above. Please, do not change anything unless you are modelling with nec4 or above.

Next time

I am currently working on a number of arrays for 144MHz and within the next issue will present some single and 4 bay LFA arrays for the first time. Pattern, noise and class-leading performance is the objective. - I do not know of anyone else building an LFA as of yet. If you have done or intend to do so, please send me photos. Justin G0KSC - www.g0ksc.co.uk

(Ed.: Due to print deadlines, this article has not been reviewed by the DUBUS Technical Editing team. We are sorry for this, and will make sure it does not happen again.)

Weiterentwicklung der LFA-Yagi

von Justin Johnson, G0KSC

Seitdem ich die LFA-Yagi in der letzten DUBUS-Ausgabe vorgestellt habe, gab es viele Diskussionen und Interesse an diesem Design, einschließlich der Tatsache, dass die Fa. Vine Antennas diese nun herstellt und verkauft. Leider habe ich bisher nur eine Arbeit mit experimentellen Ergebnissen basierend auf der LFA gesehen, und zwar von YU1AW. Siehe www.qsl.net/yu1aw/3fdf_yagi_feed.pdf.
Er hat mein publiziertes 18-Element 2-m-Design genommen und eine zweite Schleife hinzugefügt, er nennt es Dreifach-Dipol. Grundsätzlich sieht sein Loop-Feed wie meines aus, nur etwas breiter entlang des Booms mit einer weiteren Querverbindung in der Mitte der Schleife. Diese Querverbindung in der Mitte der Schleife ist der Punkt, wo der Speispunkt angesetzt ist. Die Antenne arbeitet gut und bei etwa 0.5 dB weniger Gewinn wurde das F/B drastisch verbessert, ebenso wie die Bandbreite, die mehr als verdoppelt wurde. Mit dieser Idee habe ich bereits während der Entwicklung der LFA gespielt, aber ich konnte nicht meine bevorzugte 50 Ohm Speise-Impedanz erreichen. Dies ist auch der Fall beim YU1AW-Design, die Antenne hat 200 Ohm und benötigt einen einfachen 4:1-Balun am Speisepunkt. Auch wenn das F/B sehr beeindruckend ist, die mechanische Realisierung des Feeds beim YU1AW-Design wäre sehr schwer für den Durchschnitts-Amateur zu machen, im Besonderen, wenn es für eine Feinabstimmung ausgelegt werden soll.
Die Weiterentwicklung meiner ersten 18-Element hat beeindruckende Verbesserungen beim F/B und F/S erbracht, sowie einige Zehntel an dB beim Gewinn. Lionel, VE7BQH, hat zu diesem Design, noch während es in der Entwicklung war, gesagt: *„Es gibt nichts, das bei dieser Boomlänge annähernd so gut ist, gut gemacht!"* Die Sauberkeit des Diagramms und die Untderdrückung von Nebenzipfeln im Bereich von 0 bis 180 Grad bedeutet nie gesehene Rauschtemperaturen mit unglaublichen G/T-Werten. Die G0KSC 18 Ele. LFA für 144 MHz 4-fach gestockt bei 6.37 Lambda Boomlänge ergibt, 22.09dBD Gewinn, 213.9 Kelvin und +0.94 G/T. Siehe Abb. 1.

Ein Vorteil, der sich bei der LFA herausgestellt hat, ist die relativ rauscharme Charakteristik. In den meisten Fällen weist ein LFA-Design für 144 MHz eine niedrigere Rauschtemperatur aus, als eine Dipol-gespeiste Antenne ähnlicher Größe. Mit sorgfältigem Optimieren kann die LFA auf extrem gute Werte für Boomlänge/Rauschen gebracht werden.

Unter Annahme, dass das G/T die Zahl für die Güte einer Antenne ist Signale zu empfangen, gibt es nur 4 Antennen in der VE7BQH-Liste, die besser sind als die o.a. 18-Element-LFA für 2m. Die kürzeste von diesen ist Lionels eigene 7.29 Lambda Antenne mit +0.95 G/T gefolgt von der 7.71 Lambda M2 mit +0.90 G/T. Beeindruckend, wie dies auch ist, sind EME-Gruppen nicht der Gegenstand dieses Artikels. In der nächsten Ausgabe 4/2009 werden aber einige dieser 2m-EME-Gruppen vorgestellt werden.
Heute werden wir uns auf Antennen für 6m konzentrieren und die Möglichkeit, sehr beeindruckende DX-Anlagen mit sehr kleinem Drehradius zu gestalten. Bevor wir damit beginnen, soll noch eine andere wichtige Entwicklung angesprochen werden. Wie bekannt, war die Entwicklung der LFA in den Anfängen, als ich die ersten Details veröffentlicht hatte, und meine Arbeit war auf besondere Breitbandigkeit ausgelegt. Hauptgrund dafür war, dass Ungenauigkeiten beim Design oder Fehler nur einen kleinen Einfluss auf die endgültige Antenne haben sollten. Mehr dazu später.

Abb. 1 Die überarbeitete 18-Element-LFA für 2m mit noch besserem F/B, Gewinn und G/T

Die LFA ist auf 6m bereits "on the air": Brendon, G4DYO berichtet von seiner 4-Element-LFA am 3. Juli: *„Ich habe eben HV, 7X und TZ mit der 4-Ele LFA gearbeitet und mit viel QSB V2 und 8R gehört…. Ich bin sehr angetan."* Ich selber habe auch einige gute Ergebnisse von meinem weit unterdurchschnittlichen Standort zu berichten: Ich habe NA-Pilups mit 100 Watt geknackt und dabei nur einmal rufen müssen, wobei eine 5 Element mit 6.6m Boom verwendet wurde. Joe, CT1HZE hat eine 7 Element für 6m mit 9.4m Boomlänge Anfang Juli aufgebaut und von sehr guten F/B und F/S-Werten berichtet, sowie sehr gutem Gewinn, dies besonders bei Öffnungen nach USA und bei EME.

Rauscharme LFA

Nach den ersten Experimenten mit den 2m LFAs und den niedrigen Rauschtemperaturen dort, entschied ich mich dafür, etwas für 6m zu entwickeln, was die Rauschpegel in städtischen Regionen drastisch reduzieren sollte. Ich denke, dass viele 6m Amteure im Stadtbereich oft Antennen von 4 bis 7 Elementen benutzen und nur nach dem höchsten Gewinn auswählen. Verständlich, die meisten würden ja auch eine noch längere Antenne wählen, wenn sie den Platz und die Möglichkeit zum Aufbauen hätten. Antennen mit niedrigerer Impedanz tendieren dazu, hoheren Gewinn mit weniger Elementen zu produzieren (auch wenn kein zusätzlicher Gewinn bezogen auf die Boomlänge vorhanden ist), also OWA (Optimierte Wideband Arrays). Die Boomlängen dieser Antennen liegen irgendwo zwischen 0.5 und 1.5 Lamda. Das ist die ungünstigste Länge, die man aufgrund der Größe der Rauschen verursachenden vertikalen Zipfel in einer Stadtlage nur haben kann.

Abb. 2 Eine 18-Ohm-5-Element-6-m-Yagi mit Nebenzipfeln im vertikalen Diagramm

Abb. 2 zeigt, wo dieses unerwünschte Rauschen herkommt. Die Nebenzipfel in der vertikalen Ebene sind nur 11 dB unterhalb der Hauptkeule. Das bedeutet, dass wir viel Gewinn von einem Zipfel bekommen, der nach unten in unser Haus und das unserer Nachbarn zeigt, von wo dann die Signale der DSL-Router und Plasmafernseher mit Sicherheit sehr schön laut aufgenommen werden. Das ist nur ein Beispiel für die Probleme, die Antennen mit o.a. Boomlängen aufweisen. Kann das mit einer LFA abgestellt werden? Erinnern wir uns an die Details des ersten Artikels: Wir wissen, dass die entgegengesetzten Phasen an den Enden der Schleife der LFA helfen, jegliche Nebenzipfel drastisch zu unterdrücken. In der vertikalen Ebene jedoch, versuchen diese stark unterdrückten Zipfel wieder durchzubrechen. Durch sorgfältiges Modellieren ist es mir aber gelungen, die Zipfel in der vertikalen Ebene zusätzlich zur horizontalen stark zu unterdrücken bei Antennen der oben erwähnten Boomlängen. Im ungüstigsten Fall wird der Zipfel von seiner normalen Lage einfach nur viel weiter nach vorne verschoben. Das jedoch geht oft auf Kosten des Gewinns, manchmal bis zu 1 dB. Das ist meiner Meinung nach – und mit Sicherheit für meinen Standort – ein ideales Szenario. Meine zur Zeit installierte Antenne ist eine 5 Ele. Low Noise mit 11.5 dBi, aber hervorragendem vertikalen Diagramm. Siehe Abb. 3. Zur ersten Mal überhaupt, hatte ich in der Stellung amp2 bei meinem FT-2000 keinen S-Meter-Aussschlag auf einer freien Frequenz auf 6m.

Abb. 3 Meine rauscharme 5-Element LFA-Yagi mit hervorragender Nebenzipfel-Unterdrückung in der vertikalen Ebene

Für mich persönlich ist es effektiver, das zu arbeiten, was ich (besser) hören kann, als das eine extra dB Gewinn. Und sendeseitig kann man zur Not ja auch noch die PA anschalten. Andererseits ist nicht jedes LFA-Design extrem rauscharm und es gibt viele Versionen, die beides haben: unterdrückte Nebenzipfel und trotzdem exzellenten Gewinn/Boomlänge bei gleichzeitig besserem F/B im Schnitt.

Eine interessante Anmerkung zur Modellierungs-Genauigkeit

Nachdem ich nun viele LFAs gebaut habe, inkl. einiger schmalbandiger Versionen, habe ich festgestellt, dass sowohl auf Mininec als auch auf Nec2 basierende Antennendesign-Programme die Leistungsdaten der LFA unkorrekt berechnen. In den meisten Fällen ist die Abweichung gering. Allerdings werden die Antennen in der Frequenz zu niedrig im Vergleich zur realen Arbeitsfrequenz angegeben. Das stellt ein Problem dar, wenn die Elemente aus einem Stück gefertigt sind, weil es dazu führen kann, dass man alle wegschmeissen muss, wenn man nach den Angaben der beiden Programme dimensioniert. Mininec ist bei LFAs genauer als auf Nec2 basierende Programme. Generell habe ich festgestellt, dass (wenn man die endgültigen Ergebnisse innerhalb EZNEC Pro/4 vergleicht) nur die Schleife nachjustiert werden muss. Auf Nec2 basierende Ergebnisse allerdings liegen bei der ganzen Antenne (alle Elemente) in der Frequenz zu tief. Als ich zuerst begann LFAs zu rechnen, habe ich die Antennenabmessungen nach den Angaben von auf Nec2 basierenden Programmen verwendet und bekam eine Antenne, die zur kurz für das Band war. Zusätzlich war die Entwicklung bei auf Nec2 basierenden Programmen wegen eines Stabilitiätsproblems bezüglich der Kerne dünner Drähte erschwert. Sobald das Design auf beste Performance getrimmt werden sollte, gab es in einigen Fällen große Instabilitäten. Dies war bei Nec4 nicht der Fall und als Ergebnis sind die Modelle, die in diesem Artikel vorgestellt werden, in der Leistung weitaus besser als die des ersten Artikels in der letzten Ausgabe. Danke an YU1AW, der hier die Problematik erkannt hat.

Die genannten Probleme wurden bei einem verstellbaren Loop-Design verstärkt. Wenn die Loop aus zwei verschiedenen Rohrstärken (2 x 12mm plus 2 x 10mm Endstücke, um eine posaunenartige Abstimmung zu ermöglichen, Details siehe weiter unten unter Konstruktion der Schleife) besteht, ist das ein weiteres bekanntes Problem für Nec2.

Die beste Art eine LFA zu modellieren (angenommen man hat nicht das Modellierungs-Paket von Nec4 verfügbar), bestet darin, eine einzige Rohrstärke beim Entwicklungsprogramm und Optimierer für die Schleife zu verwenden. MMana ist eine gute Option aufgrund seiner Verwendung von Mininec. Es beinhaltet auch einen Optimierer, der für die LFA funktioniert. Im schlimmsten Fall sollte man für die Posaunen-Sektion reichlich Länge reservieren, um das Antennendesign ggf. manuell zu beenden, wenn die Antenne gebaut wird. Wenn man eines meiner Designs hier nachbaut, sollten aber keinerlei Probleme auftreten. Wenn man meine Designs in irgendeinem anderen Programm als Nec4 nachrechnet, werden unkorrekte Ergebnisse erhalten, speziell beim SWR.

Mit einem Vertrauensvorschuss kaufte ich die neueste Nec4.1 Doppel-Präszisions-Version (500 USD), da ich wusste, das 4Nec2 auch die Verwendung von Nec4 unterstützt, genauso wie normales Nec2. Zu dem Zeitpunkt wusste ich nicht, ob Nec4 das Problem lösen würde, das ich hatte. Erste Ergebnisse waren vielversprechend, weil das Programm Elementlängen lieferte, die ähnlich denen waren, bei denen ich inzwischen durch Bauen angekommen war (ich musste alle Elemente verlängern und die Schleifengröße ändern) und auch das Bauen der ersten auf Nec4 basierenden Antennen bestätige dies. Anschließend habe ich EZNEC Pro/4 gekauft (nochmal 650 USD), um die abschließende Entwicklung eines jeden Designs zu unterstützen.

Alle Designs dieses Artikels und alle zukünftigen werden mit Nec4.1 oder höher erstellt. Man beachte bitte, dass die Ergebnisse mit Otto-Normalverbraucher-Software anders aussehen!
Einige der Designs, die in DUBUS publiziert werden, sind exklusiv für DUBUS und werden nirgendwo anders veröffentlicht werden. Ich habe ein DUBUS-Login auf meiner Webseite erstellt (www.G0KS.co.uk). Wenn man sich dort einloggt, kann man alle DUBUS-exklusiven Antennenfiles und Artikel erhalten.

2 kompakte gestockte Antennensysteme für 50 MHz

Nun wollen wir uns mit zwei gestockten Systemn befassen. Das erste ist eine kompaktes gestocktes System mit 4 Element-Antennen und das zweite besteht aus zwei 5-Element-Antennen. Beide Systeme wurden für bestes Richtdiagramm und beste Bandbreite anstatt optimalem Gewinn modelliert. In beiden Fällen kann der Gewinn leicht erhöht werden, wenn man den Stockungsabstand erhöht. Das allerdings geht auf Kosten des Gesamtdiagramms.

2 x 4 Ele. gestockte Antennen für 50 MHz

Um mal etwas anderes mit der LFA zu machen, wollte ich eine DX-Antenne kreieren, die kurz ist, aber ausreichend Gewinn hat und die magische 10dBD-Marke überschreitet, wobei die Bandbreite gleichzeitig erhalten bleiben sollte. Um dieses Ziel zu erreichen, habe ich eine 4-Element-LFA entwickelt, die eine Schleife mit 13/10mm Durchmesser hat und alle anderen Elemente haben einen Durchmesser von 10mm. Abb. 4 zeigt das horizontale Diagramm dieser Antenne.

Abb. 4 Guter Gewinn und exzellentes F/B der kompakten 4 Ele. LFA Yagi

Abb. 5 SWR für eine gestocktes Paar dieser Antennen mit nur 3.9m Stockungsabstand

Die Boomlänge liegt bei ganz knapp unter 3m und das SWR beträgt 1.08:1 bei 50 MHz und fällt auf 1.0:1 bei 50.210 MHz und steigt wieder auf 1.17:1 bei 50.5 MHz. Als einzelne Antenne wird diese Yagi für viele Stationen mit ihren 9.25 dBi Gewinn und 23.04dB F/B schon ausreichend für DX-Arbeit sein. Betrachten wir nun davon zwei Antennen vertikal gestockt.

Persönliche Vorlieben und Bedürfnisse spielen eine große Rolle beim gewählten Abstand, wenn es um die Stockung geht. Ich ziehe es vor, das Diagramm so sauber zu lassen, wie möglich, und mit nur 3.9m Stockungsabstand wurde das Ziel hier erreicht. Abb. 5 zeigt den SWR-Plot für die 2 x 4 Ele. Anlage. Wie oben erwähnt, erhöht das Vergößern des Stockungsabstands den Gewinn. Allerdings liefert das gestockte System auch so schon 12.01 dBi, also nicht weit entfernt von den idealen 3 dB Stockungsgewinn und nahe am Ziel von 12.25 dBi (10 dBD). Wenn man den Stockungsabstand auf 4.25m erhöht, erhält man 0.17 dB mehr Gewinn und einen Anstieg der kleinen „Ohren" im vertikalen Diagramm (ober- und unterhalb) der Hauptkeule auf nur 15 dB unterhalb dieser abgesenkt. Siehe Abb. 6 und Abb. 7.

Abb. 6 3D-Plot des Diagramms der 2 x 4 Element LFA mit nur 3.9m Stockungsabstand

Abb. 7 Eine kompakte Stockung mit aussergewöhnlicher Leistung, die viele Amateure problemlos aufbauen können

Indem wir die Nebenzipfel auf einem absoluten Minimum halten, erhöhen wir die Sauberkeit des Gesamtdiagramms der Anlage dramatisch, wenn sie über Grund aufgebaut wird. Bei nur 10m Höhe über Grund, produziert die 4 über 4 LFA 17.38 dBi mit einer Elevation der Hauptkeule von nur 7 Grad. Der bekannte hohe zentrale Zipfel von gestockten Systemen wurde durch unsere Wahl eines geringeren Stockungsabstands entfernt. Zusätzlich zu den offensichtlichen Vorteilen beim Diagramm habe wir nur sehr wenig Gewinn geopfert, während gutes F/B und Bandbreite erhalten blieben.

2 x 4 Fazit

Das Stocken von zwei 4-Element-Antennen ist eine Option, die nicht oft von Amateuren in Betracht gezogen wird. Ich hoffe, dass, nachdem die Leistung dieser LFA-Version mit seinem relativ geringen Stockungsabstand sichtbar wurde, einige vielleicht inspiriert wurden, solch eine Anlage aufzubauen, besonders dann, wenn kleine Grundstücke in der Stadt keinen großen Platz bieten.

2 x 5 Ele. gestockte Antennen für 50 MHz

Mit 5m Boomlänge und 6.1m Stockungsabstand liegt diese Anlage eventuell für viele ein wenig außerhalb des Machbaren. Ich möchte jedoch die Leistungsfähigkeit einer derartigen gestockten Anlage gegenüber einer einzelnen Yagi mit langem Boom, wie z.B. einer 8-Element-Yagi herausstellen.
Wenn nicht gerade ein sehr großes Grundstück zur Verfügung steht, ist eine einzelne 11 bis 12m lange Antenne kaum zu rechtfertigen, schwer aufzubauen und oben zu halten. Mit einer Anlage, wie der 2 x 5 Ele., können kleine Boomdurchmesser beibehalten werden und das Gesamtgewicht kann minimal gehalten werden.

Abb. 8 24dB F/B und 14.05dBi Gewinn bei einem Drehradius von unter 5m

Abb. 9 Das gestockte 2 x 5 Ele. Sytem zeigt eine flache SWR-Kurve über das Band

Diese Antenne ist eine überarbeitete FD0605H, die wir in der letzten Asugabe vorgestellt haben. Weitere 0.1 dB Gewinn wurden erreicht zusammen mit einem leicht verbesserten F/B. Ich widerspreche nun meinen bisher gemachten Aussagen: Die Antenne hat nicht das allerbeste Diagramm. Aber sie lässt sich extrem gut stocken. Gewinn und F/B legen dann um mehr als 3 dB zu, wobei 14.05 dBi und 24 dB F/B erreicht werden. Das SWR bleibt flach über das untere Ende des 6m-Bandes und, wie die 4 Ele. zuvor, die Antenne bleibt stabil unter allen Wetterverhältnissen. Im Gegensatz zur 4-Element-Antenne war es nicht möglich, die Nebenzipfel völlig in der Richtung nach oben und unten zu unterdrücken. Das ist zum Teil begründet in einer der Hauptbedingungen für dieses Design, der Boomlänge. Ich wollte diese auf 5m begrenzt halten und 11 dBi mit einer einzelnen Antenne erreichen. Dennoch ist der obere Nebenzipfel immer noch 20 dB abgesenkt, wenn sich die untere Antenne des Systems 10m über Grund befindet und eine schöne einzelne Hauptkeule erstreckt sich bei ca. 6 Grad. Der Gewinn ist repektable 19.11 dBi, ebenfalls bei dieser Höhe. Siehe Abb. 8, 9 und 10.

Abb. 10 Guter Gewinn, ein flacher Strahlungswinkel und eine ausgeprägte Hauptkeule beim vertikal gestockten 2 x 5 Ele. System

Zusammenschaltung

Die Methoden der Zusammenschaltung der Antennen sind nicht Gegenstand dieses Artikels. Es gibt aber ausreichend Quellen im Netz, die hier hilfreich sind. Beim letzten RSGB-Fieldday habe ich dem örtlichen Club 2 x 9 Ele LFAs für 2m und 2 x 4 Ele. LFAs für 6m zur Verfügung gestellt. Ich habe die Angaben zur Zusammenschaltung von DK7ZB verwendet, siehe www.qsl.net/dk7zb/. Auf diesen Seiten gibt es einige Optionen für koaxiale Zusammenschaltung und Anpasstöpfe. Beim Fieldday wurde für die temporäre Installation und mangels Zeit und Material eine Zusammenschaltung mit 75-Ohm-Sat-TV-Koaxkabel vorgenommen. Beide Stationen arbeiteten mit voller legaler Ausgangsleistung und beide Anlagen liefen problemlos.

Hinweise für den Nachbau der LFA

Es ist nicht schwierig die Schleife zu bauen. Die beste Option die 4-Element zu bauen, ist so zu tun, als wäre es eine 5-Element und die 5-Element als wäre es eine 6-Element, wobei DE1 und DE2 als separate

Elemente gezählt werden. Sobald diese auf dem Boom angebracht sind, werden die Endabschnitte so gebogen, dass sie in die Enden von DE1 und DE2 geschoben werden können. Komplette Instruktionen und Diagramme gibt es im Netz unter www.g0ksc.co.uk/making-the-lfa-loop.html .

4-Element LFA Abmessungen

Element	Abstand (Meter)	halbe Länge (Meter)	Elementdurchmesser
Reflektor	0	1.501	10mm
DE1 Speisepunkt	.256	1.271	13mm
DE2	.727	1.271	13mm
D1	1.414	1.373	10mm
D2	2.96	1.269	10mm

Hinweis: 1. Die Endstücke der Schleife, die in DE1 und DE2 geschoben werden, haben 10mm Durchmesser. 2. Die Länge der Hauptelemente der Schleife um etwa 30mm kürzen, damit die gebogenen Endstücke eingeführt werden können und um die Möglichkeit zu haben eine Feinjustierung nach der Fertigstellung zu haben. Bisher war dies in der Praxis aber nie nötig.

5-Element LFA Abmessungen

Element	Abstand (Meter)	halbe Länge (Meter)	Elementdurchmesser
Reflektor	0	1.482	16mm
DE1 Speisepunkt	.287	1.238	16mm
DE2	.828	1.238	16mm
D1	1.378	1.383	16mm
D2	3.026	1.324	16mm
D3	4.755	1.299	16mm

Hinweis: 1. Die Endstücke der Schleife, die in DE1 und DE2 geschoben werden, haben 12mm Durchmesser. 2. Siehe wie bei 4-Element LFA, oben.

Eine 6-Element LFA-Yagi für 50 MHz

Ich wollte meine 6.6m lange schmalbandige 5-Element LFA hochbringen auf etwas mit etwas mehr Gewinn, aber diesmal mit der von mir bevorzugten Breitbandcharakteristik. Vor einiger Zeit habe ich eine 6-Element LFA entwickelt, die auf meiner Webseite veröffentlicht ist, die 11,8 dBi hat und 6.8m lang ist. Ich wollte jedoch noch etwas mehr Gewinn versuchen, ohne zu der viel längeren 7-Element zu kommen. Das Ergebnis war eine meiner ersten ausschließlich mit EZNEC Pro/4 fertiggestellten LFA. Das horizontale Diagramm ist in Abb. 11 zu sehen.

Abb. 11 6-Element Breitband-LFA mit 12.3 dBi und 23dB F/B

Die Genauigkeit der Nec4.1 Doppel-Präzisions-Software ist sehr angenehm für mich. Immerhin beinhaltet sie mehr als 20 Jahre weitere Entwicklung gegenüber der viel älteren Nec2-Sotware. Deshalb glaubte ich nicht, dass es nötig wäre, die Antenne vor der Installation auf dem Mast zu überprüfen. Nach dem Aufbau und der Überprüfung vom Shack aus bestätigte sich dies. Die Nadel des SWR-Meters bewegt sich von 50 bis 50.5 MHz nicht und fängt erst bei 50.6 MHz auszuschlagen. Nach dieser Bestätigung habe ich das Band abgescannt und arbeitete UX1UA und UT3UA und bekam 559 bzw. 579-Rapporte mit nur 10 Watt aus meinem FT2000. Später am selben Abend (dem 28. Juli 2009) arbeitete ich noch CR2F von den Azoren mit 55, nur eine Handvoll G-Stationen erreichte ihn. Innerhalb eines weiteren Tages hörte ich die Baken ON0SIX und LX0SIX das erste Mal überhaupt via Tropo und die Bake GB3BAA ist definitiv lauter als bisher. Insgesamt bin ich mit diesem Ergebnis sehr zufrieden.

Design-Richtlinien für die 6 Ele.

Eine der Design-Vorgaben war hierbei, die optischen Größe der Antenne so gering wie möglich zu halten. Dies war eine andere Strategie als zuvor beim Vorgänger, die nur und nur auf Leistung getrimmt wurde. Das bedeutete, dass ich viel dünnere Elemente benutzen müsste, ohne die Größe der Schleife zu erhöhen und zusätzlich den Boom moch mehr zu verstärken, um das zusätzliche Abspannen der Antenne mit Seil und Seilhaltern zu umgehen.
Der Boom ist 7.3m lang und aus Alu-Vierkantprofil mit 1.5 Zoll (38.1mm) Kantenlänge. Die Elemente haben 13mm (0.5 Zoll) Durchmesser. Die Endstücke der Schleife haben 10mm Durchmesser (5/8 Zoll). Die SWR-Kurven in Abb. 12 und 13 zeigen, dass es offensichtlich keinen Unterschied bei der

Abstimmung gibt zwischen den Elementen mit metrischen und Zoll-Maßen.

Abb. 12 SWR-Kurve mit ½-Zoll-Elementen und Schleifenenden mit 5/8-Zol Durchmesserl

Abb. 13 SWR-Kurve mit 13-mm-Elementen und Schleifenenden mit 10mm Durchmesser

Der zweite Boom läuft zur Verstärkung 5m lang parallel direkt unter dem Hauptboom. Gewicht war bei mir nicht das Problem, da der Mast für eine Zeit nur diese eine Antenne tragen wird. Ich habe auch eine doppelte Mastschelle gefertigt, die sicherstellt, dass die Antenne an ihrem Platz bleibt. Hier kommt eine Alu-Platte mit einer Stärke von ¼-Zoll zum Einsatz. Siehe Abb. 14.

Abb. 14 Schwere Mastschelle für gute Stabilität und keinerlei Spiel

Abb. 15 Ein G0KSC-Isolator montiert auf dem Boom der 6 Ele. LFA-Yagi

Wie immer habe ich meine 15mm dicken Isolatoren aus Plexiglas verwendet. Ich isoliere immer alle Elemente komplett vom Boom. Das Mass der Breite des Booms ist 2mm tief unten in das Plexiglas gefräst, so dass sich der Isolator mit dem Element dann nicht mehr auf dem Boom verdrehen kann. Auf der Oberseite wird entsprechend eine runde Vertiefung für das Element eingefräst. Die Isolatoren sind 100 x 40mm groß. Siehe Abb. 15.

Für die Anpassung vom unbalancierten Koax auf die balancierte Antenne wird ein aufgewickelter Pawsey 1:1 Balun verwendet. Siehe Abb. 16. Dieser hat einen kurzes Stück Koaxkabel mit N-Buchse als Anschluss. Der Balun ist aus Westflex 103 Kabel gefertigt. Nach einer Empfehlung von Pop, YU7EF, habe ich diesen Balun bei meinen letzten 3 Antennen verwendet. Er funktioniert gut und braucht weniger Material als andere 1:1 Baluns. Hinweise zur Konstruktion sind zu finden unter:
www.g0ksc.co.uk/creatingabalun.html

Abb. 16 Pawsey Stub-Balun am Boom angebracht

Ergebnis für die 6 Ele.

Wenn die Antenne oben auf dem Mast ist, sieht sie nicht so groß aus, wie sie wirklich ist. Siehe Abb. 17. Man beachte, dass der Mast 2 Zoll dick ist und der Boom 3 Zoll dick ist, da wo er doppelt ist. Diese 12.3dBi-Version hat mehr Gewinn, aber weniger F/B als die frühere 6.8m lange Version. Durch das zusätzlich F/B und die viel kürzere Länge wird auch diese 11.8dBi-Version für viele ihre Daseinsberechtigung haben. Ich glaube, dass die Leistung dieser Antenne langfristig sehr gut sein wird und eine gestockte Ausführung sicher hervorragende Ergebnisse bringen wird.

6-Element LFA Abmessungen

Element	Abstand (Meter)	halbe Länge (Meter)	Elementdurchmesser
Reflektor	0	1.488	13mm or ½ inch
DE1 Speisepunkt	.333	1.236	13mm or ½ inch
DE2	.889	1.236	13mm or ½ inch
D1	1.66	1.377	13mm or ½ inch
D2	3.386	1.34	13mm or ½ inch
D3	5.286	1.324	13mm or ½ inch
D4	7.243	1.281	13mm or ½ inch

Hinweis: 1. Die Endstücke der Schleife, die in DE1 und DE2 geschoben werden, haben 10mm bzw. 3/8-Zoll Durchmesser. 2. Siehe wie bei 4-Element LFA, oben.

Sobald man sein DUBUS-Login auf meiner Webseite hat, kann man sich EZNEC-Files für diese Antennen herunterladen. Aber man muss immer daran denken, dass man andere SWR-Kurven bekommen wird. Man sollte nichts verändern, sofern man nicht Nec4 oder höher verwendet.

Ausblick

Ich arbeite zur Zeit an einer Anzahl von Systemen für 2m und in der nächsen Ausgabe werden einige einzelne LFA-Yagis und einige 4-fach gestockte Systeme erstmalig präsentiert werden. Diagramme, Rauschtemperatur und führende Leistungsdaten sind die Design-Leitlinien.
Ich weiss nicht, ob sonst schon jemand LFAs nachgebaut hat. Falls ja, würde ich mich über Rückmeldungen und Fotos freuen. Justin G0KSC - www.g0ksc.co.uk

Antenna Noise Temperature - Software Tools

by Rastislav GALUŠČÁK-OM6AA[1], Petra GALUŠČÁKOVÁ[2], Miloš MAZÁNEK[1], Pavel HAZDRA[1]

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Abstract: *Designers of antennas and their associated components presently enjoy the convenience of performing fast, accurate, automated, design-related calculations due to the availability of a multitude of software "design tools" for modeling electromagnetic fields. Computations involved with specific problems such as antenna noise temperature, however, require supplementary software tools to augment the capability of these general purpose state-of-the-art professional programs. To address this need, we have developed the "Antenna Noise Temperature Calculator" software program that utilizes either modeled or measured radiation patterns to calculate antenna noise performance parameters.*

1. Introduction

Design objectives for Cosmic-to-Earth radio communication systems mandate a very low receiver noise budget to permit reception of extremely weak signals. In this respect, antenna-temperature interaction plays a critical role in the receiving chain's noise performance. The antenna temperature performance calculation is conceptually described as multiplying the spatial function of antenna gain by the temperature distribution of the space surrounding the antenna, integrated over all space.

The antenna noise temperature calculation in spherical coordinates is given by the formula:

$$\mathrm{Ta} = \frac{\int_0^{2\pi}\int_0^{\pi} G(\theta,\phi)\,Tb(\theta,\phi)\sin\theta\, d\theta\, d\phi}{\int_0^{2\pi}\int_0^{\pi} G(\theta,\phi)\sin\theta\, d\theta\, d\phi} \qquad (1)$$

Where

Ta is the antenna noise temperature in a given direction
Tb is the environmental noise temperature
G is antenna gain

Our Antenna Noise Temperature Calculator program (also referred to as ANTC) computes antenna noise using antenna radiation patterns input from CST Microwave Studio Software [1], FEKO Software [2] or from an actual antenna measurement. Antenna noise temperature is calculated for elevation angles from 0 to 90 degrees in single degree increments. ANTC also enables the calculation of system noise and average noise temperatures.

2. Axes and Angles Defined

Orientation of axes and angles used with spherical coordinates are shown in Fig. 1. The antenna elevation angle, Alpha, also shown in Fig. 1, ranges from 0 to 90 degrees, from horizon to zenith respectively. The angles and axes convention for measured data is shown in Fig. 2. The incremental angle for radiation pattern data calculated by CST and FEKO software is 1 or 5 degrees for both Theta and Phi or 1 degree Theta increments for a maximum of four angles of measured Phi data. The angles and axes convention [3] for environmental noise temperature is the same as for computed radiation patterns.

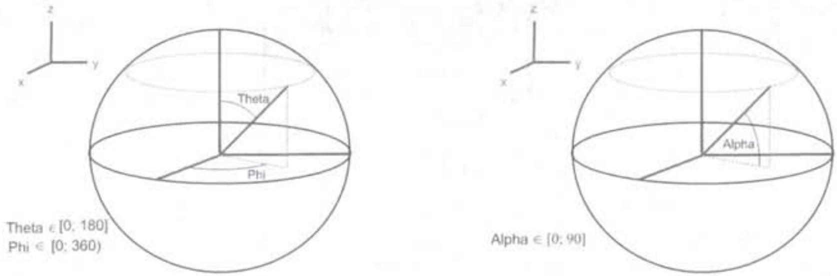

Fig. 1 Definition of spherical coordinates (left) and elevation angle Alpha (right)

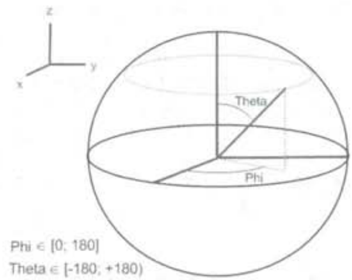

Fig. 2 Definition of spherical coordinates for measured data

3. Main Computation

Developed in Dev-Cpp, our software program is programmed in C++. wxWidgets library is used for the graphical interface and pplot library is used for plotting curves.
The program runs based on formula (1) using the following sequential steps:

a. Read and (if necessary) convert the scale of the radiation pattern and environmental noise temperature
b. Multiply the radiation pattern by the function sin(Theta)
c. Calculate radiated power for antenna radiation pattern normalization
d. Convert environmental noise temperature from spherical coordinates to Cartesian coordinates
e. Multiply the converted table by the Euler matrix (rotate environmental noise temperature by angle around the X-axis)
f. Convert environmental noise from Cartesian coordinates back to spherical coordinates
g. Sort converted and rotated data according to angles Theta and Phi
h. Multiply the rotated environmental noise temperature by the radiation pattern
i. Integrate results from the previous step over angles Phi and Theta
j. Divide the result of this integration by radiated power. This result is the antenna noise temperature for the appropriate angle alpha

Some of the more important attributes of ANTC are described in the following sections.

3.1. Reading the Radiation Pattern and Environmental Noise Temperature

Radiation Pattern

Input radiation patterns may be obtained from antenna simulation software or from direct measurements. The user selects the source of the input radiation pattern (CST, FEKO or Measured) and the scale type (Linear or Logarithmic) using the input switch selector shown in Fig. 3. Input files must have the specified data format associated with the selected file type. This is checked during file reading and an error message appears if an incorrect format is detected. Since data files from CST MW Studio and FEKO software contain more data that ANTC needs, the program loads only the necessary data.

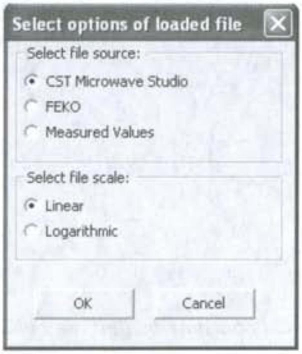

Fig. 3 Input data selector

If the "Measured Values" button is selected, the "Select Measured Files" dialog window is opened. See Fig. 4. Here the user loads and may, optionally, modify the measured data, which are displayed in four tables. At least one and a maximum of four tables must be populated. For measured data, ANTC calculates a mean value from the number of loaded radiation patterns. An axially symetric radiation pattern around the Z axis is created in this manner. The software then transforms the coordinates according to the definition shown in Fig. 1 left.

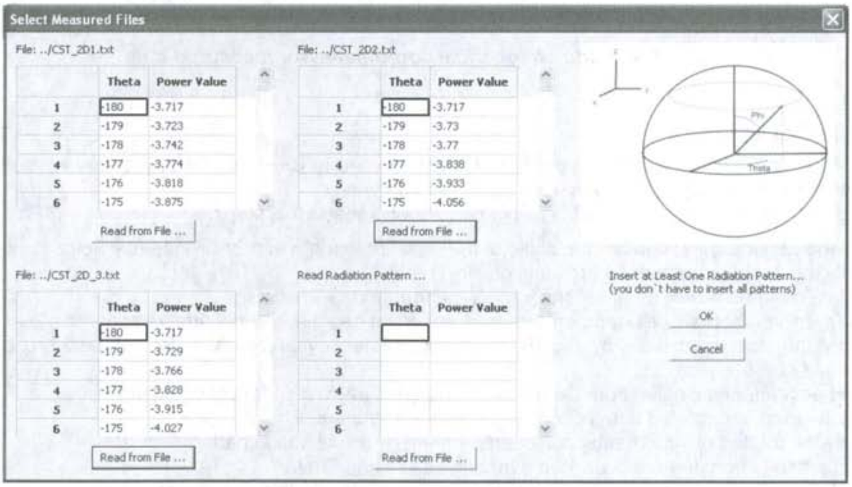

Fig. 4 The measured data dialog window

Environmental Noise Temperature

Environmental noise temperature depends on frequency. Tables of environmental noise temperature for some important frequencies are included in ANTC. These temperature tables were created based on ITU documents CCIR rep. 720-2 [4]. The user may select a frequency implicit noise temperature table in the noise temperature dialog box (see Fig. 5) or define one's own environmental noise temperatures and input them. The data format of an input noise temperature file must be the same as the format of tables of implicit noise temperatures. Environmental noise temperatures for frequencies below 1 GHz are very much affected by galactic and man-made noise. Consequently, implicit values for 0.15 GHz and 0.5 GHz are provided as convenient approximations. For better results, actual measured or defined values should be used.

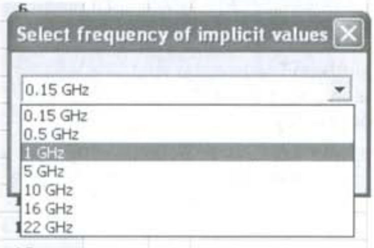

Fig. 5 Environmental noise temperature dialog box

3.2. Enviromental Noise Temperature Matrix Rotation

To calculate antenna noise temperature for a desired angle alpha, we must rotate the enviromental noise temperature matrix or antenna radiation pattern through the angle Alpha. In ANTC, we choose to rotate noise temperature due to its lower range of values, in what is from a mathematical point of view an equivalent operation. Since rotation in spherical coordinates is very complicated, the data is converted to Cartesian coordinates prior to performing a rotation in Cartesian coordinates. To convert the enviromental noise temperature matrix from spherical to Cartesian coordinates the following formulae are used:

$$\begin{aligned} x &= r * \cos(Phi) * \sin(Theta) \\ y &= r * \sin(Phi) * \sin(Theta) \\ z &= r * \cos(Theta) \end{aligned} \tag{2}$$

We then multiply the converted matrix by the Euler rotational matrix around the X axis with parameter Alpha. For our definition of angle Alpha (See Fig.1 right), the Euler matrix for rotation around the X axis is:

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \sin(\alpha) & \cos(\alpha) \\ 0 & -\cos(\alpha) & \sin(\alpha) \end{pmatrix} \tag{3}$$

A 3-D graphical illustration of noise temperature matrix rotation is shown in Fig. 6.

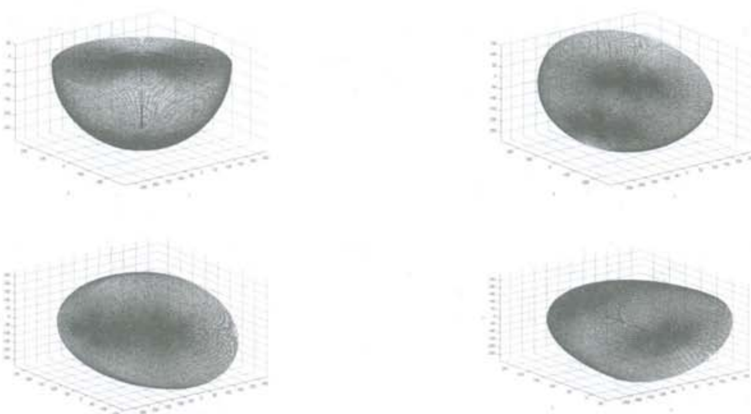

Fig. 6 Rotation of noise matrix around axis X. 0° deg.-top left, 30° deg.-top right, 60° deg.-bottom left, 90°-bottom right

Next, the rotated noise temperature matrix is converted back to spherical coordinates.
The formulae used for converting to spherical coordinates are:

$$\begin{aligned} r &= \mathrm{sqrt}(x^2+y^2+z^2) \\ \mathrm{Phi} &= \mathrm{atan2}(x, y) \\ \mathrm{Theta} &= \mathrm{acos}(z / r) \end{aligned} \qquad (4)$$

The function atan2 converts values within the range [-180; + 180], but the original coordinates were in the interval [0; 360] so we must add the number 180 to each value to get values associated with the desired interval.

3.3. Sorting converted, rotated data in accordance with the angles Theta and Phi

Since transformation of the noise matrix according to formula (2) and reverse transformation of the rotated noise matrix according to formula (4) are based on circular functions, the resulting rotated noise matrix in spherical coordinates has non-linear scales for angles Theta and Phi. For subsequent calculations it is necessary to find the nearest value of noise temperature for the appropriate angles Theta and Phi of the radiation pattern. The most accurate calculation is based on finding the great circle minimum deviation by the formula:

$$\Delta\sigma = 2 r \, arcos \sqrt{\sin^2(|\theta 1 - \theta 2|/2) + \sin\theta 1 * \sin\theta 2 * \sin^2(|\phi 1 - \phi 2|/2)} \qquad (5)$$

where

$\Delta\sigma$ is the minimum distance deviation
r is the great circle radius
$\theta 1$, $\theta 2$, $\varphi 1$, $\varphi 2$ are angles the of radiation pattern and noise temperature expressed in spherical coordinates

Using equation (5) for sorting is very time consuming. To increase computation speed, ANTC sorts based on the following formula:

$$\Delta\sigma\varphi = |\ \varphi 1 - \varphi 2\ | \qquad (6)$$

After sorting data for angles φ in accordance with formula 6, the following, similar, formula for angles θ is applied:

$$\Delta\sigma\theta = |\ \theta 1 - \theta 2\ | \qquad (7)$$

These tradeoff calculations sacrifice some accuracy to gain computation speed.

3.4. Integration of results from previous step over angles Phi and Theta

"Trapezoidal integration," a numerical integration method, is employed to integrate results from the previous step over angles Phi and Theta using the following formula:

$$\begin{aligned} A_T &= \sum_{i=0}^{n} \frac{\Delta x}{2} (f(x_i) + f(x_{i+1})) \\ &= \frac{\Delta x}{2} (f(x_0) + 2f(x_1) + 2f(x_2) + \cdots + 2f(x_{n-1}) + f(x_n)) \end{aligned} \qquad (8)$$

Since double integration over all space must be performed, all values of items with the same angle Phi are added together (the first and the last item with the same Phi angle are added after multiplying these values by ½) thereby performing integration over angle Theta. Then an integration is performed over angle Phi (the first and the last item are added after these values are multiplied by ½).

4. Additional Features

4.1. Plotting

When antenna noise temperature is calculated, a plot with calculated values appears in a pop-up window. Calculated noise temperature is displayed as a function of an elevation angle.

The user may also display the plot by choosing "Tools->Draw Graph of Noise Temperature." The displayed plot may be saved as a ".bmp file" by pressing "Save Plot" in the displayed dialog window.

4.2. System Noise Temperature

When antenna noise temperature is calculated, system noise temperature may be calculated as well. System noise temperature Ts and system G/Ts ratio are calculated from antenna noise temperature for a given elevation angle and receiver noise figure. See Fig. 7.

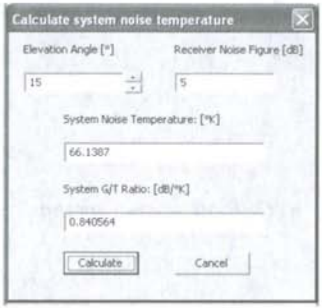

Fig. 7 System noise temperature dialog

4.3. Average Noise Temperature Calculation

The average noise temperature for a given range of elevation angles is a useful parameter for design and optimization of antennas with variable elevation angle. Prime applications are antennas intended for receiving signals from satellites or for EME (Earth-Moon-Earth communication) use. The elevation angle is determinated by low and high limits for these applications. Calculated antenna noise temperature is an arithmetic mean value that corresponds with the angles of this interval.

4.4. Storing Calculated Data

Calculated antenna noise temperature may be saved in text file format. The user selects "File->SaveOutput" in the main menu.

4.5. Log

ANTC records all operations in a log. The file name of the log is "log.txt", which is stored in the software`s working directory. All operations, whether or not successful, and calculated data, including intermediate data, are recorded in the log.

5. Practical Application of ANTC

Courtesy of Sergei, RW3BP, we had the opportunity to check the ANTC software`s accuracy using real-world measured data. Sergei`s antenna consists of a 2.4/3.4 m diameter offset dish for the 23 cm band with an extended mesh reflector on half of the perimeter. The dish was equipped with a dual-mode horn designed by Dmitry, RA3AQ. See Fig. 8. With this antenna system Sergei achieved excellent EME reception. The best measured G/T ratio based on sun noise vs. cold sky noise measurement was 19 dB for elevation angles of approximately 30 degrees.

The first step in making the calculated vs. measured data comparison was to model Sergei`s antenna with CST MW studio software to calculate its radiation pattern applying the MLFMM method (I-solver). The calculated 3D radiation pattern is shown in Fig. 9. From this pattern it is apparent that the major portion of the side lobe points toward the sky, insuring a low antenna noise temperature. The calculated antenna noise temperature dependence on antenna elevation angle is plotted in Fig. 10. Calculated results for the G/T ratio are shown by the dotted line in Fig. 12.

Since Sergei's intent was to optimize his antenna system for the highest G/T ratio, Dmitry designed a new feed having a narrower radiation pattern for this purpose. See Fig.11. The designed system achieved a maximum G/T ratio of about 20dB. Calculated values for this configuration are shown by the solid line in Fig. 12.

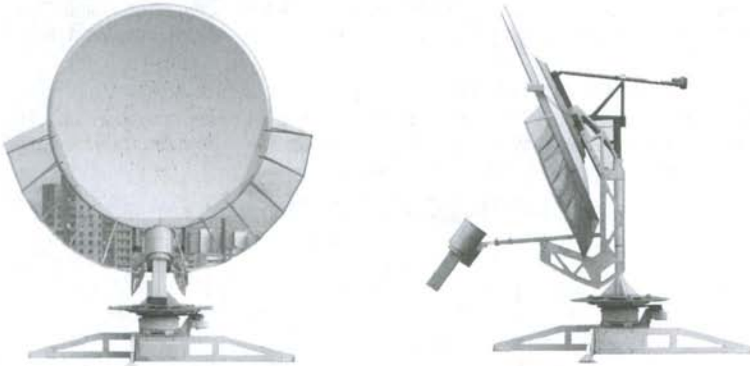

Fig. 8 RW3BP offset dish antenna system

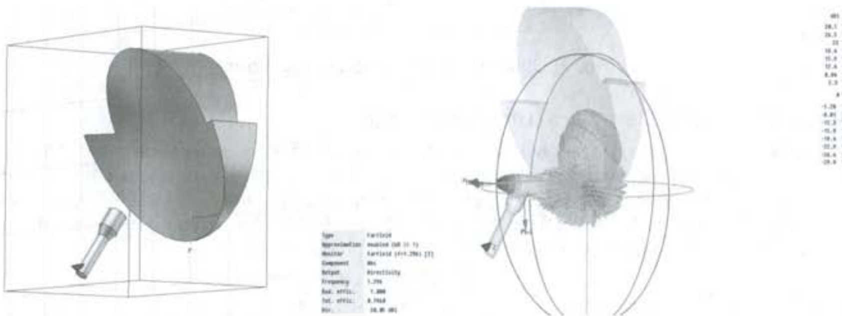

Fig. 9 Antenna model and its calculated 3D radiation pattern from CST MW Studio software

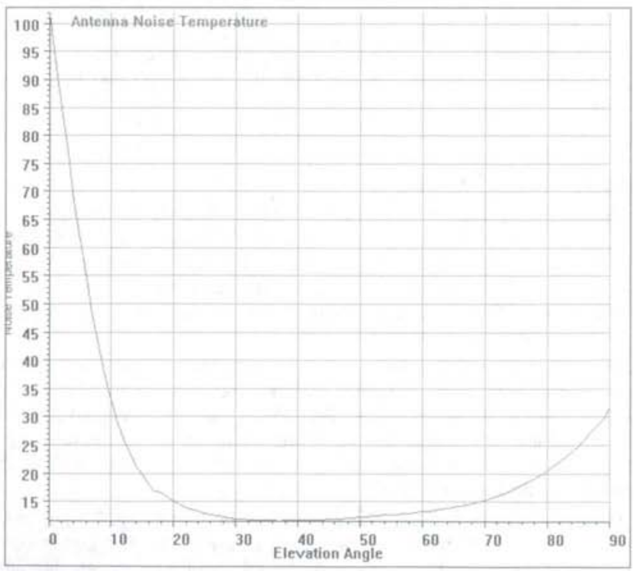

Fig. 10 Calculated antenna noise temperature of the antenna shown in Fig. 8

Fig. 11 Enhanced Antenna Configuration

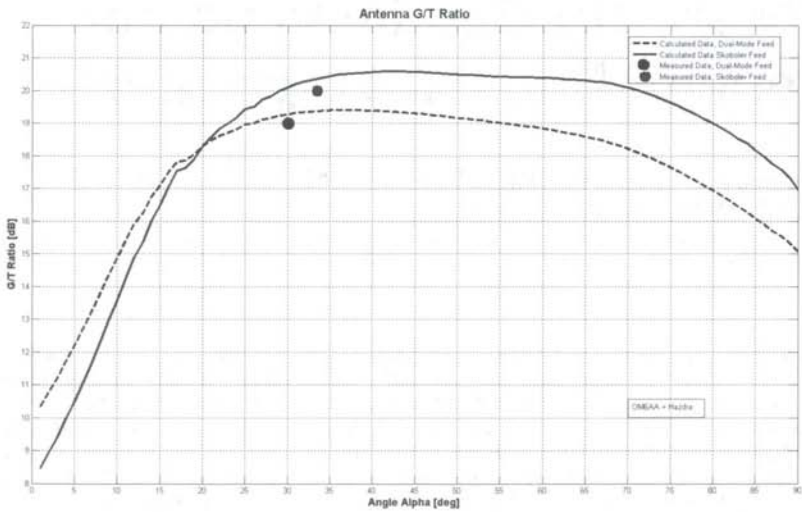

Fig. 12 Calculated Antenna G/T Ratio Dependence on Elevation Angle

6. Summary and Conclusion

ANTC software was developed for parabolic dish antenna optimization. Verified with a real antenna, ANTC used in conjunction with the CST MW Studio program achieves very good accurancy (similar results are expected, though not yet verified, using FEKO software). With the current one degree radiation pattern digitization, the program is able to calculate noise temperature for antennas with gains up to 34 dB. To deal with very fine digitization and immense data volume requirements associated with higher gain antennas, the noise analysis should be modified by dividing it into two tasks. First would be an analysis of the antenna main beam only with very fine digitization followed by an analysis of the remaining radiation pattern with the current 1 degree digitization. This proposed future modification of ANTC software would be necessary for calculation of absolute noise parameters.

If a noise relationship study between the feed and parabolic reflector shapes is required, a scale model should be used for this purpose.

A free download of ANTC software is available at: ***http://www.om6aa.eu***

Acknowledgements

The authors would like to express their thanks to Robert Valenta for his valuable technical and language assistance in creating this article. We would also like to thank Sergei Zhutyaev - RW3BP for providing antenna-measured data and his technical remarks.

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Software zur Bestimmung der Antennen-Rauschtemperatur

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Zusammenfassung: *Designer von Antennen und zugehörigen Komponenten erfreuen sich gegenwärtig der Annehmlichkeit schneller, genauer, automatisierter, designbezogener Berechnungen, die dank der Verfügbarkeit einer Vielzahl von Software-Designwerkzeugen für die Modellierung elektromagnetischer Felder möglich sind. Berechnungen, die spezifische Probleme, wie die Rauschtemperatur der Antenne, berücksichtigen, erfordern jedoch zusätzliche Software-Hilfswerkzeuge, um das Potenzial dieser professionellen Programme, die dem Stand der Technik für allgemeine Zwecke entsprechen, zu erhöhen. Um diesem Bedürfnis zu entsprechen, haben wir die Software "Antenna Noise Temperature Calculator" (Antennenrauschtemperatur-Berechnung) entwickelt, die entweder modellierte oder gemessene Strahlungsdiagramme verwendet, um die Rauschleistungsdaten einer Antenne zu berechnen.*

1. Einleitung

Ziele des Designs bei Funkkommunikationssystemen für die Richtung Himmel-Erde erfordern ein sehr niedriges Budget beim Empfängerrauschen, um den Empfang extrem schwacher Signale zu ermöglichen.

In diesem Zusammenhang spielt der Einfluß der Antennentemperatur eine kritische Rolle für die Rauschleistung in der Empfangskette. Die Leistungsberechnung der Antennentemperatur wird im Konzept beschrieben durch Multiplizeren der räumlichen Funktion des Antennengewinns mit der Temperaturverteilung des den die Antenne umgebenden Raumes, integriert über den Gesamtraum.

Die Berechnung der Rauschtemperatur einer Antenne mit sphärischen Koordinaten geschieht mit folgender Formel:

$$\mathrm{Ta} = \frac{\int_0^{2\pi}\int_0^{\pi} G(\theta,\phi)\,Tb(\theta,\phi)\sin\theta\, d\theta\, d\phi}{\int_0^{2\pi}\int_0^{\pi} G(\theta,\phi)\sin\theta\, d\theta\, d\phi} \qquad (1)$$

mit

Ta	für die Rauschtemperatur der Antenne in einer gegebenen Richtung
Tb	für die Rauschtemperatur der Umgebung
G	für den Antennengewinn

Unser Antennen-Rauschtemperatur-Berechnungsprogramm (hier auch als ANTC bezeichnet) berechnet Antennenrauschen durch Verwendung von Strahlungsdiagrammen, die aus der CST Microwave Studio Software [1], FEKO Software [2] oder von tatsächlichen Antennenmessungen stammen. Die Antennen-Rauschtemperatur wird für Elevationswinkel von 0 bis 90 Grad in 1-Grad-Schritten berechnet. ANTC ermöglicht auch die Berechnung des Systemrauschens und von Durchschnittsrauschtemperaturen.

2. Definition der Achsen und Winkel

Die Lage von Achsen und Winkelm bei sphärischen Koordinaten ist in Abb. 1 gezeigt. Der Elevationswinkel der Antenne, Alpha, auch in Abb. 1 zu sehen, verläuft von 0 bis 90 Grad, bzw. vom Horizont zum Zenit. Die Konvention bei Achsen und Winkel für gemessene Daten ist in Abb. 2 gezeigt. Die Schrittweite beim Winkel für Strahlungsdiagrammdaten, die mit CST and FEKO gerechnet werden, beträgt 1 oder 5 Grad für Theta und auch Phi oder 1 Grad Theta-Schritte für ein Maximum von 4 Winkeln von gemessenen Phi-Daten. Die Konvention der Winkel und Achsen [3] für die Umgebungs-rauschtemperatur ist dieselbe wie für berechnete Strahlungsdiagramme.

Abb. 1 Definition der sphärischen Koordinaten (links) und des Elevationswinkels Alpha (rechts)

Abb. 2 Definition der sphärischen Koordinaten für gemessene Daten

3. Grundsätzlicher Rechenweg

In Dev-Cpp entwickelt, wurde unser Software-Programm in C++ geschrieben. wxWidgets wurde für das grafische Interface verwendet und pplot für das Plotten der Kurven.
Das Programm läuft basierend auf der Formel (1) mit folgenden Schritten:

a. Lesen und (wenn nötig) Konvertieren des Maßstabs des Strahlungsdiagramms und der Umgebungsrauschtemperatur.
b. Multiplizieren des Strahlungsdiagramms mit der Funktion sin(Theta)
c. Berechnung der abgestrahlten Leistung zur Normalisierung des Antennenstrahlungsdiagramms
d. Umwandeln der Umgebungsrauschtemperatur von sphärischen in kartesische Koordinaten
e. Multiplizieren der umgewandelten Tabelle mit der Euler-Matrix (Rotieren der Umgebungsrausch-temperatur im Winkel um die X-Achse)
f. Umwandeln der Umgebungsrauschtemperatur von kartesischen Koordinaten zurück in sphärische.
g. Sortieren der konvertierten und rotierten Daten nach den Winkeln Theta und Phi
h. Multiplizieren der rotierten Umgebungsrauschtemperatur mit dem Strahlungsdiagramm
i. Integrieren des Ergebnisses des vorherigen Schritts über die Winkel Phi und Theta
j. Teilen des Ergebnisses dieser Integration durch die abgestrahlte Leistung. Dieses Ergebnis ist die Antennenrauschtemperatur für den dazugehörigen Winkel Alpha

Einige der wichtigeren Eigenschaften von ANTC werden in den folgenden Abschnitten erläutert.

3.1. Einlesen des Strahlungsdiagrammes und der Umgebungs-Rauschtemperatur

Strahlungsdiagramm

Strahlungsdiagramme für den Input in ANTC können von Antennensimulationssoftware oder durch direkte Messungen erhalten werden. Der User wählt die Quelle des Strahlungsdiagramms (CST, FEKO oder gemessen) und den Skalentyp (Linear oder Logarithmisch) mit den „Input switch selector", der in Abb. 3 gezeigt ist. Input-Files müssen das spezifizierte Datenformat aufweisen, das mit dem ausgewählten Typ assoziiert ist. Das wird beim Einlesen kontrolliert und wenn ein falsches Format festgestellt wird, kommt eine Fehlermeldung. Da die Datenfiles von der Software CST MW Studio und FEKO mehr Daten enthalten, als ANTC benötigt, lädt das Programm nur die benötigten Daten.

Abb. 3 Input data selector – Auswahlbox für den Daten-Input

Wenn das Feld für gemessene Daten ("Measured Values") ausgewählt wird, öffnet sich der Dialog "Select Measured Files". Siehe Abb. 4. Hier lädt der User die gemessenen Daten, die in 4 Tabellen angezeigt werden, und verändert sie optional. Wenigstens eine und maximal 4 Tabellen müssen ausgefüllt werden. Für gemessene Daten errechnet ANTC einen Mittelwert aus der Anzahl geladener Strahlungsdiagramme. Ein um die Z-Achse achsialsymmetrisches Strahlungsdiagramm wird nach dieser Art erzeugt. Dann transformiert die Software die Koordinaten entsprechend der Definitian aus Abb. 1, links.

Abb. 4 Das Dialog-Fenster für gemessene Daten

Umgebungs-Rauschtemperatur

Die Umgebungs-Rauschtemperatur hängt von der Frequenz ab. Tabellen der Umgebungsrauschtemperatur sind für einige wichtige Frequenzen in ANTC enthalten. Diese Temperatur-Tabellen wurden basierend auf den ITU-Dokumenten CCIR rep. 720-2 [4] erzeugt.
Der User kann eine frequenz-implizite Rauschtemperaturtabelle in der Dialogbox für die Rauschtemperatur (siehe Abb. 5) auswählen oder seine eigene Umgebungsrauschtemperatur definieren und eingeben. Das Datenformat dafür muss genauso sein wie das Format der Tabellen der implizierten Rauschtemperaturen. Umgebungsrauschtemperaturen für Frequenzen unterhalb 1 GHz werden sehr stark durch galaktisches und von Menschenhand geschaffenes Rauschen beeinflußt. Folglich werden die implizierten Werte für 0.15 und 0.5 GHz als geeignete Näherungen geliefert. Für bessere Ergebnisse sollten aktuell gemessene oder definierte Werte verwendet werden.

Abb. 5 Dialog-Fenster für die Umgebungs-Rauschtemperatur

3.2. Matrix-Rotation der Umgebungs-Rauschtemperatur

Um die Antennenrauschtemperatur für einen gewünschten Winkel alpha zu berechnen, müssen wir die Matrix der Umgebungsrauschtemperatur oder das Strahlungsdiagramm der Antenne durch den Winkel Alpha rotieren. Bei ANTC haben wir uns für das Rotieren der Rauschtemperatur entschieden, weil hier der Wertebereich niedriger ist, was aus mathematischer Sicht eine Äquivalenzverknüpfung ist.
Da das Rotieren in sphärischen Koordinaten sehr kompliziert ist, werden die Daten in Kartesische Koordinaten umgesetzt, bevor sie in Kartesischen Koordinaten gedreht werden. Um die Matrix der Umgebungsrauschtemperatur von sphärischen in Kartesische Koordinaten umzuwandeln, werden die folgenden Formeln verwendet:

$$\begin{aligned} x &= r * \cos(Phi) * \sin(Theta) \\ y &= r * \sin(Phi) * \sin(Theta) \\ z &= r * \cos(Theta) \end{aligned} \qquad (2)$$

Dann multiplizieren wir die konvertierte Matrix mit der Euler-Rotationsmatrix um die X-Achse mit dem Parameter Alpha. Für unsere Definition des Winkels Alpha (siehe Abb. 1, rechts), ist die Euler-Matrix für die Rotation um die X-Achse:

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \sin(\alpha) & \cos(\alpha) \\ 0 & -\cos(\alpha) & \sin(\alpha) \end{pmatrix} \qquad (3)$$

Eine dreidimensionale grafische Illustration dieser Matrix-Rotation der Rauschtemperatur ist in Abb. 6 gezeigt.

Abb. 6 Rotation der Rausch-Matrix um die X-Achse. 0° - oben links, 30° - oben rechts, 60° - unten links, 90° - unten rechts

Als nächstes wird die rotierte Rauschtemperaturmatrix zurück in sphärische Koordinaten umgewandelt. Die Formeln für das Konvertieren in sphärische Koordinaten lauten:

$$\begin{aligned} r &= \mathrm{sqrt}(x^2+y^2+z^2) \\ \mathrm{Phi} &= \mathrm{atan2}(x, y) \qquad (4) \\ \mathrm{Theta} &= \mathrm{acos}(z / r) \end{aligned}$$

Die Funktion atan2 konvertiert Werte im Bereich [-180; + 180], die originalen Koordinaten aber lagen im Intervall [0; 360], so dass wir 180 zu jedem Wert addieren müssen, um Werte für das erwünschte Intervall zu erhalten.

3.3. Sortieren der konvertierten, rotierten Daten gemäß der Winkel Theta und Phi

Da die Transformation der Rauschmatrix entsprechend der Formel (2) und die Rücktransformation der rotierten Rauschmatrix entsprechend der Formel (4) auf zirkularen Funktionen basieren, hat die resultierende rotierte Rauschmatrix in sphärischen Koordinaten nichtlineare Maßstäbe für die Winkel Theta und Phi. Für die anschließenden Berechnungen ist es nötig, den am nächsten liegenden Wert der Rauschtemperatur für die zugehörigen Winkel Theta und Phi des Strahlungsdiagramms zu finden. Die genaueste Berechnung basiert auf dem Finden des Minimums der Großkreisabweichung mit der Formel:

$$\Delta\sigma = 2r\,arcos\sqrt{\sin^2(|\theta 1-\theta 2|/2)+\sin\theta 1 * \sin\theta 2 * \sin^2(|\phi 1-\phi 2|/2)} \qquad (5)$$

mit

Δσ für die kleinste Abweichung des Abstands
r für den Großkreisradius
θ1, θ2, φ1, φ2 sind Winkel des Strahlungsdiagramms und der Rauschtemperatur ausgedrückt in sphärischen Koordinaten

Die Anwendung der Formel (5) für das Sortieren ist sehr zeitaufwändig. Um die Rechengeschwindigkeit zu erhöhen, sortiert ANTC basierend auf folgender Formel:

$$\Delta\sigma\varphi = |\,\varphi 1 - \varphi 2\,| \qquad (6)$$

Nach dem Sortieren der Daten für die Winkel φ in Übereinstimmung mit Formel 6, wird die folgende, ähnliche Formel für die Winkel θ angewendet:

$$\Delta\sigma\theta = |\,\theta 1 - \theta 2\,| \qquad (7)$$

Dieser Kompromiß bei den Berechnungen opfert ein wenig Genauigkeit, um die Rechengeschwindigkeit zu erhöhen.

3.4. Integration der vorherigen Ergebnisse über die Winkel Phi und Theta

"Trapezoidale Integration," eine numerische Integrationsmethode, wird angewendet, um die Ergebnisse des vorherigen Schritts über die Winkel Phi und Theta mittels der folgenden Formel zu integrieren:

$$\begin{aligned} A_T &= \sum_{i=0}^{n} \frac{\Delta x}{2} (f(x_i) + f(x_{i+1})) \\ &= \frac{\Delta x}{2} (f(x_0) + 2f(x_1) + 2f(x_2) + \cdots + 2f(x_{n-1}) + f(x_n)) \qquad (8) \end{aligned}$$

Da doppelte Integration über den ganzen Raum durchgeführt werden muss, werden alle Werte von Punkten mit dem gleichen Winkel Phi zusammenaddiert (der erste und letzte Punkt mit dem gleichen Winkel Phi werden addiert, nachdem diese Werte mit ½ multipliziert wurden), wodurch eine Integration über den Winkel Theta gemacht wird. Dann wird eine Integration über den Winkel Phi (der erste und letzte Punkt werden addiert, nachdem diese Werte mit ½ multipliziert wurden) durchgeführt.

4. Weitere Eigenschaften

4.1. Plotten

Sobald die Antennenrauschtemperatur berechnet ist, erscheint in einem Popup-Fenster ein Plot mit den Ergebnissen. Die berechnete Rauschtemperatur wird als Funktion des Elevationswinkels angezeigt.
Der User kann den Plot auch anzeigen lassen durch Auswahl von: "Tools->Draw Graph of Noise Temperature." Der angezeigte Plot kann als ".bmp File" abgespeichert werden durch Anklicken von "Save Plot" im angezeigten Dialog-Fenster.

4.2. System-Rauschtemperatur

Wenn die Antennenrauschtemperatur berechnet ist, kann die Systemrauschtemperatur ebenfalls berechnet werden. Die Systemrauschtemperatur Ts und das G/Ts Verhältnis des Systems werden aus der Antennenrauschtemperatur für einen gegebenen Elevationswinkel und der Empfängerrauschzahl berechnet. Siehe Abb. 7.

Abb. 7 Dialog für die Systemrauschtemperatur

4.3. Berechnung der Durchschnitts-Rauschtemperatur

Die Durchschnitts-Rauschtemperatur für einen gegebenen Elevationswinkelbreich ist ein nützlicher Parameter für Design und Optimierung von Antennen mit variablem Elevationswinkel. Hauptanwendung sind Antennen, die für den Empfang von Signalen von Satelliten oder für EME gedacht sind. Der Elevationswinkel ist bestimmt durch ein unteres und oberes Limit bei diesen Anwendungen. Die berechnete Antennenrauschtemperatur ist ein arithmetischer Mittelwert, der den Winkeln dieses Intervalls entspricht.

4.4. Speichern der berechneten Daten

Die berechnete Antennenrauschtemperatur kann in einem Textformat-File abgespeichert werden. Dazu im Hautmenue "File->SaveOutput" wählen.

4.5. Log

ANTC speichert alle Operationen in einem Log. Der Filename des Logs ist "log.txt", das im Arbeitsverzeichnis des Programms abgespeichert wird. Alle Operationen, ob erfolgreich oder nicht, und alle errechneten Daten, einschließlich Zwischenergebnisse, werden im Log erfasst.

5. Praktische Anwendung von ANTC

Dank Sergei, RW3BP, hatten wir die Möglichkeit, die Genauigkeit der ANTC-Software mittels gemessenen Daten aus der Realität zu testen. Sergeis Antenne für das 23-cm-Band besteht aus einem Offset-Spiegel mit 2.4/3.4m Durchmesser, mit einem erweiterten Drahtgitterreflektor von der Hälfte des Durchmessers. Der Spiegel war mit einem Dual-Mode-Horn ausgerüstet, das von Dmitry, RA3AQ, entworfen wurde. Siehe Abb. 8. Mit diesem Antennensystem hat Sergei exzellenten EME-Empfang erreicht. Das beste gemessene G/T-Verhältnis basierend auf Messung des Sonnenrauschens gegen den kalten Himmel war 19 dB für Elevationswinkel von ungefähr 30 Grad.

Der erste Schritt für den Vergleich der errechneten mit den gemessenen Daten war das Modellieren von Sergeis Antenne mit der Software CST MW Studio, um ihr Strahlungsdiagramm mittels der MLFMM-Methode (I-solver) zu berechnen. Das errechnete 3D-Strahlungsdiagramm ist in Abb. 9 gezeigt. Aus diesem Diagramm ist ersichtlich, dass der größte Teil der Seitenzipfel in den Himmel zeigt, was eine niedrige Antennenrauschtemperatur sicherstellt. Die gerechnete Abhängigkeit der Antennenrauschtemperatur vom Elevationswinkel ist in Abb. 10 dargestellt. Die gerechneten Ergebnisse für das G/T-Verhältnis sind mit der gepunkteten Linie in Abb. 12 gezeigt.

Da es Sergeis Absicht war, sein Antennensystem auf bestes G/T-Verhältnis zu optimieren, entwickelte Dmitry für diesen Zweck ein neues Feed mit schmalerem Strahlungsdiagramm. Siehe Abb. 11. Das entwickelte System erreichte eine maximales G/T-Verhältnis von etwa 20 dB. Die berechneten Werte für diese Konfiguration werden durch die durchgezogene Linie in Abb. 12 dargestellt.

Abb. 8 RW3BPs Antennensystem mit Offset-Spiegel

Abb. 9 Antennen-Modell und zugehöriges mit CST MW Studio Software berechnetes 3D-Strahlungsdiagramm

Abb. 10 Berechntete Antennen-Rauschtemperatur der in Abb. 8 gezeigten Antenne

Abb. 11 Verbesserte Antennen-Konfiguration

Abb. 12 Berechnete Abhängigkeit des Antennen-G/T vom Elevationswinkel

6. Zusammenfassung und Schluß

Die ANTC-Software wurde entwickelt, um Parabolspiegel-Antennen zu optimieren. Verifiziert mit einer realen Antenne erreicht ANTC in Verbindung mit dem Programm CST MW Studio eine sehr gute Genauigkeit (ähnliche Resultate werden für die FEKO-Software erwartet, was aber noch nicht verifiziert wurde. Mit der gegenwärtigen 1-Grad-Auflösung des Strahlungsdiagramms kann das Programm Rauschtemperaturen für Antennen mit einem Gewinn bis zu 34 dB berechnen. Um mit sehr feiner Auflösung und den Anforderungen immenser Datenmengen, die mit Antennen höheren Gewinns verdunden sind, zu arbeiten, sollte die Rauschanalyse durch Aufteilen in zwei Arbeitsschritte modifiziert werden. Der erste wäre eine Analyse nur der Hauptkeule der Antenne mit sehr feiner Auflösung, gefolgt von einer Analyse des verbleibenden Strahlungsdiagramms mit der gewohnten 1-Grad-Auflösung. Diese geplante zukünftige Modifikation der ANTC-Software wäre auch nötig, um absolute Rauschparameter zu berechnen. Wenn eine Studie des Rauschverhältnisses zwischen Feed und Parabolreflektorform benötigt wird, sollte für diesen Zweck ein maßstäbliches Modell verwendet werden.
Die ANTC-Software kann kostenlos heruntergeladen werden unter: ***http://www.om6aa.eu***

Danksagung

Die Autoren möchten sich bei Robert Valenta für seine wertvolle technische und sprachliche Hilfe bei der Erstellung dieses Artikels bedanken. Wir möchten uns auch bei Sergei Zhutyaev - RW3BP für das Zurverfügungstellen der gemessenen Daten und seine technischen Anmerkungen bedanken.

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Optimized Dual-mode Feedhorns

by Paul Wade W1GHZ © 2009 - w1ghz@arrl.net

Dual-mode feedhorns for parabolic dishes provide excellent performance over a wide range of microwave bands, especially for offset-fed reflectors. For many commercial applications, the bandwidth of a dual-band horn is too narrow, so corrugated horns are preferred, but bandwidth is rarely a problem for amateur use. While excellent performance is also provided by corrugated horns, they are much more difficult to fabricate with limited machining capabilities, so the dual-band horn is may be an attractive choice when we wish to tailor a feedhorn for a specific dish and frequency.

A recent paper by Skobolev, et al, describes a series of "optimum" geometry dual-mode horns[1]. Simulated performance suggests that these horns can be very high efficiency feeds, and measured results confirm this potential. A simple set of design curves makes it easy to find best dimensions for a specific application.

Dual-mode horn evolution

One of the first dual-mode horns was the Potter[2] type, which uses a step transition in diameter to excite a second mode, TM11, in addition to the normal TE11 mode. The relative amplitudes of the two modes are controlled by the dimensions of the step, shown as **C** in Figure 1. Since the output diameter of the step must be large enough to support both waveguide modes, the input diameter is usually larger than single-mode circular waveguide, **A**, so a gentle flare, **B**, increases the diameter without significant mode conversion. After the step is a phasing section, **D**, to get the two modes to the desired phase relationship, followed by a flare section, **E**, to the aperture diameter needed for the desired beamwidth. Beamwidth is inversely proportional to aperture diameter, while the flare angle affects the beam shape; the right combination can provide high feed efficiency. Once the flare dimensions are chosen, the phase shift of the flare section is calculated and the length of the phasing section adjusted so that the two modes cancel at the rim of the horn. If good cancellation is achieved, there are no edge currents to generate undesired sidelobes. The calculations required to design a Potter horn are fairly complicated.

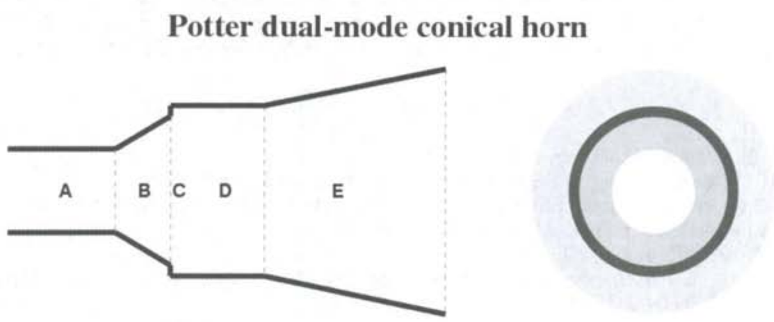

Figure 1 - Sketch of Potter dual-mode horn.

Dick Turrin, W2IMU, invented a small dual-mode horn[3], shown in the sketch in Figure 2, which is much simpler than the Potter horn. The second mode is excited by a flare section directly from the input waveguide diameter, **A**, to the desired aperture diameter, **B**, followed by a phasing section, **C**, to get the two modes to the desired phase relationship at the aperture. The relative amplitude of the two modes is controlled by the flare angle. Calculation of the required dimensions is significantly easier, and fabrication is also fairly simple[4]. The shortcoming of the W2IMU horn is that it is limited to small aperture diameters before additional unwanted modes can propagate in the phasing section. The result is that it is only good for a small range of ***f*/D**, about 0.5 to 0.8 – perfect for common offset-fed dishes.

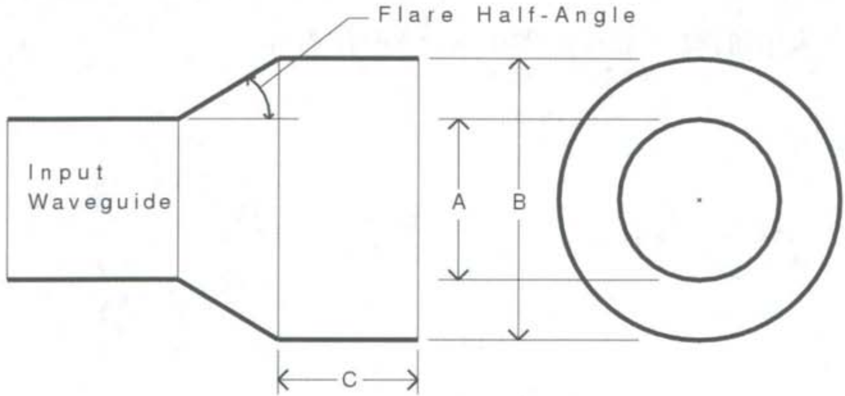

Figure 2 - W2IMU dual-mode horn

For multiple-reflector dishes, like the Cassegrain antenna[5], the best combination of parameters might need a feedhorn providing a small illumination angle, equivalent to a large ***f*/D**. This is often the case if we are trying to use an existing subreflector, rather than machining a new one – a large hyperbolic surface is a challenge. One alternative is to design a Potter horn for the large ***f*/D**. Lyle Patison, VK2ALU, found a simpler approach[6]: he added a flare section to the end of a W2IMU dual-mode horn, shown soldered on in Figure 3. Lyle assumed that the two modes have the desired phase relationship at the end of the W2IMU horn, and used Potter's curves to find a flare length that maintained the desired phase relationship at the larger aperture.

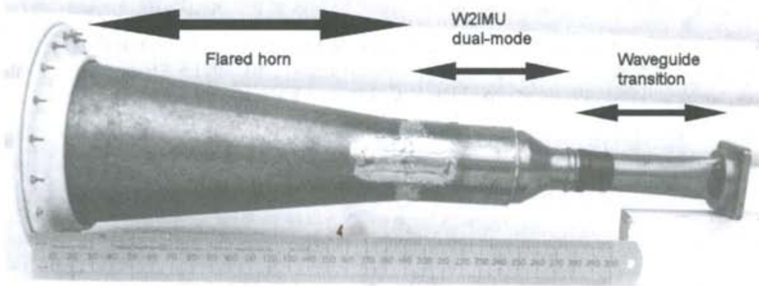

Figure 3 - VK2ALU extended dual-mode horn

The "optimum" geometry dual-mode horns described by Skobolev [1] are sketched in Figure 4. These horns have a step transition to excite the second mode, followed immediately by a flare section to the desired aperture diameter, so the total horn length is minimized. The length of the flare is calculated to get the two modes to the desired phase relationship, and a graph is included to find the flare length for aperture diameters between 2 and 6 wavelengths.

More recently, a paper by Kittara, et. al., described a very similar horn at 700 GHz described as a Pickett-Potter horn[6]. The horn was attributed to a paper by Pickett, et. al., describing a dual-mode horn for submillimeter wavelengths[7]. Both of these horns have larger apertures and longer lengths than any of the Skobolev versions.

Kittara developed electromagnetic software to design and analyze the horn, but Pickett developed his horn before it was possible to do computer analysis of such a large horn. Instead, he used the Potter calculations to determine the required phase shift of the two modes, then shortened the horn by doing all the phase shifting in the flare section. The total phase shift of the Potter horn was 3.6π, or 648 degrees; Pickett removed 2π, or 360 degrees, by shortening while maintaining the required phase relationship between the modes at the aperture. The flared horn is still 10.62λ long with an aperture diameter of 6.4λ, and the Kittara horn is even larger. Measured data in the papers suggest that the horns work well, so we shall include these horns in our analysis.

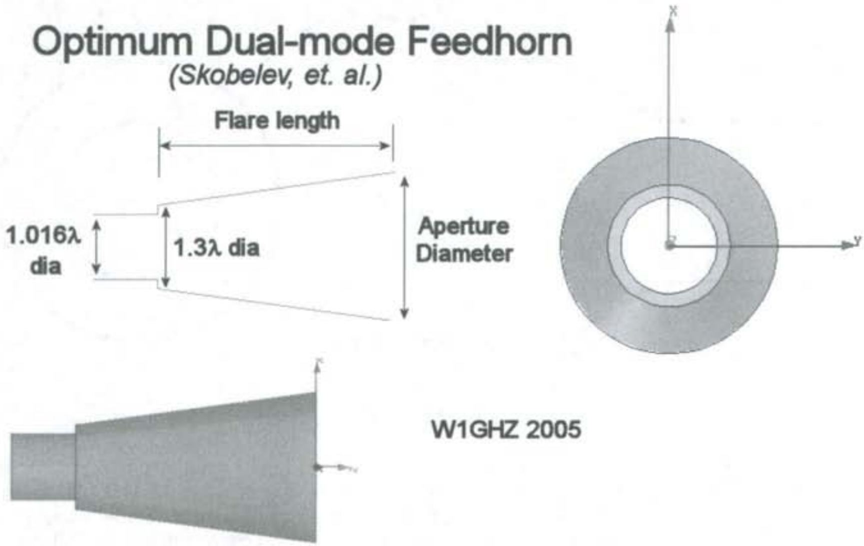

Figure 4 - Sketch of Skobolev optimum dual-mode horn

The graph in the Skobolev paper for optimum aperture diameter and flare length looks close to a straight line, so I used a simple straight-line approximation:

$\text{Flarelength (in } \lambda) = 3.45 \cdot r_\lambda - 0.35$ where r_λ is the radius of the aperture.

Using this approximation, I calculated horn dimensions for aperture diameters of 2, 3, 4, 5 and 6 wavelengths, and calculated radiation patterns for each using Ansoft[8] **HFSS** software. All of the horns had good axisymmetrical radiation patterns with low side and back lobe levels.

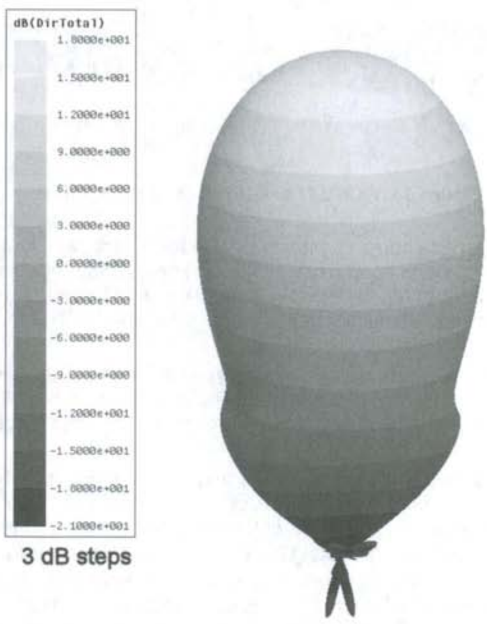

Figure 5 - 3D radiation pattern for 3λ diameter optimum dual-mode horn

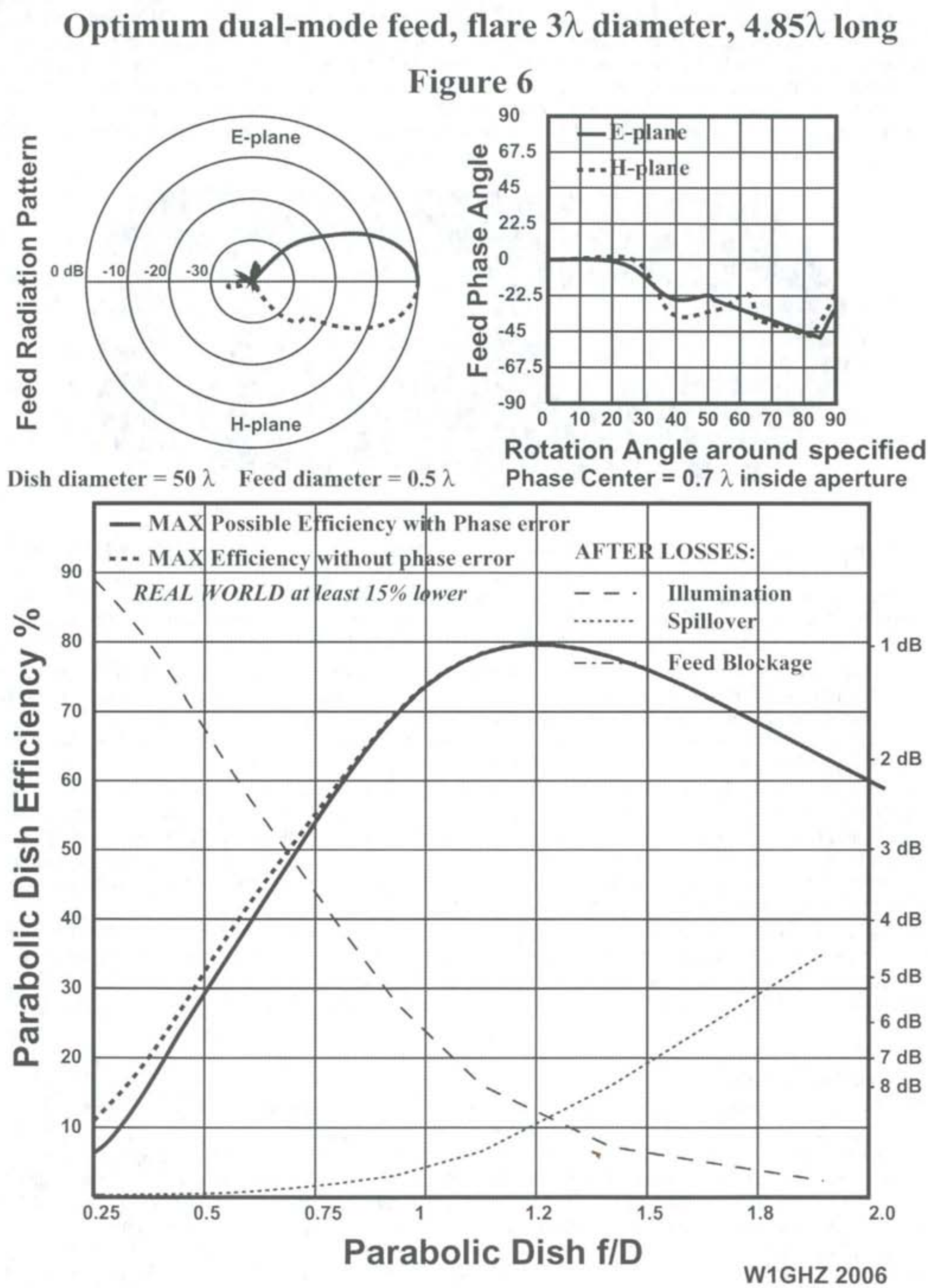

Figure 6 - Calculated feedhorn efficiency for 3λ diameter optimum dual-mode horn

An example ist the 3D radiation pattern for the 3λ diameter horn is shown in Figure 5. As a feedhorn, the calculated efficiency is shown in Figure 6 – 79% efficiency for ***f*/D** around 1.2, with very low sidelobe and backlobe levels. This looks like an excellent feed, only 1 dB below perfection. A near-field plot, Figure 7, demonstrates the dual-mode action: the E-field intensity is high on the H-plane wall of the horn (the top half of the picture) as the wave is launched from the step. As the wave approaches the horn aperture, the electric field near the wall is cancelled by the second mode, resulting in low intensity all around the aperture rim. The result is a pattern with very low sidelobes.

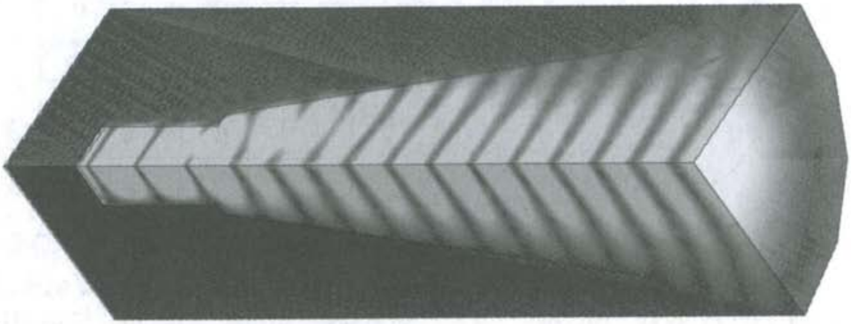

Figure 7 - E-field in 3λ diameter optimum dual-mode horn

Dish efficiency was calculated for these feedhorns by integrating the patterns using the PHASEPAT program[9]. Dish efficiency plots for the horns are shown in Figures 8 thru 11 for aperture diameters of 2, 4, 5, and 6 λ respectively. All show very high calculated efficiency, with optimum ***f*/D** proportional to the aperture diameter, covering a range of ***f*/D** from 0.8 to about 2.0. The patterns are clean with very low sidelobe and backlobe levels, typically better than 30 dB down. All results are summarized in Table 1.

A horn of the very largest size, 6λ in diameter and 10λ long, was contructed by AMSAT-DL for use at 10.4 GHz on the 20M Cassegrain antenna of the Bochum Radio Telescope in Germany, based on my calculations that this was the optimum size feedhorn for the dish. Dr. Karl Meinzer, DJ4ZC, reported a 1.5 dB improvement in gain and G/T, compared to the previous feed. His sketch of the feed is shown in Figure 12, and Figure 13 shows the feedhorn in position on the dish.

The 10.4 GHz feedhorn was used for EVE (Earth-Venus-Earth) tests in 2007, but without success. The AMSAT-DL team concluded that a lower frequency, around 2.4 GHz, was needed for good reflections. The 6λ feedhorn is physically very large at this frequency, but I was unable to suggest a smaller feed that would have comparable performance. The AMSAT-DL team then constructed the feedhorn shown in Figure 14, and used it to successfully receive echoes from Venus[10] – an incredible amateur achievement. The rings on the outside of the horn are simply for mechanical stiffening.

Two additional aperture diameters are listed in Table 1. I was asked for a 10 GHz optimum feedhorn for an ***f*/D** of 0.935 by GW4DGU for his offset dish. I estimated that the required aperture diameter would be 2.3λ, and this proved to be very close. This horn has an extremely high calculated dish efficiency, 80.2%, less than one dB down from perfect. The dish efficiency plot is shown in Figure 15.

DSS offset dishes

The smallest optimum dual-mode horn, 2λ diameter, is best suited to an ***f*/D** = 0.83, and the larger ones for larger ***f*/D**. Since most common offset-fed dishes, like the ubiquitous DSS dishes, need an illumination angle equivalent to 0.7 ***f*/D**, I wanted to make a smaller version. Using the straight-line approximation to estimate flare length, I tried several different sizes, from 1.5λ to 1.9λ in diameter and various flare lengths; most were pretty good, as shown in Table 1. An aperture diameter of 1.7λ with a flare length of 2.57λ came closest, but calculated efficiency was not as good as the larger horns. I then tried flare lengths 10% longer and 5%, 10%, and 20% shorter; the 5% and 10% shorter versions, 2.34λ and 2.44λ long respectively, were the winners, both with a calculated dish efficiency of 79.6%. The dish efficiency plots are shown in Figures 16a and 16b for the two flare lengths – the shorter one favors a slightly higher ***f*/D**, while the longer one is better for a slightly lower ***f*/D**. A 3D plot of the very clean radiation pattern for the 2.44λ long version is shown in Figure 17.

Optimum dual-mode feed, flare 2λ diameter, 3.1λ long

Figure 8

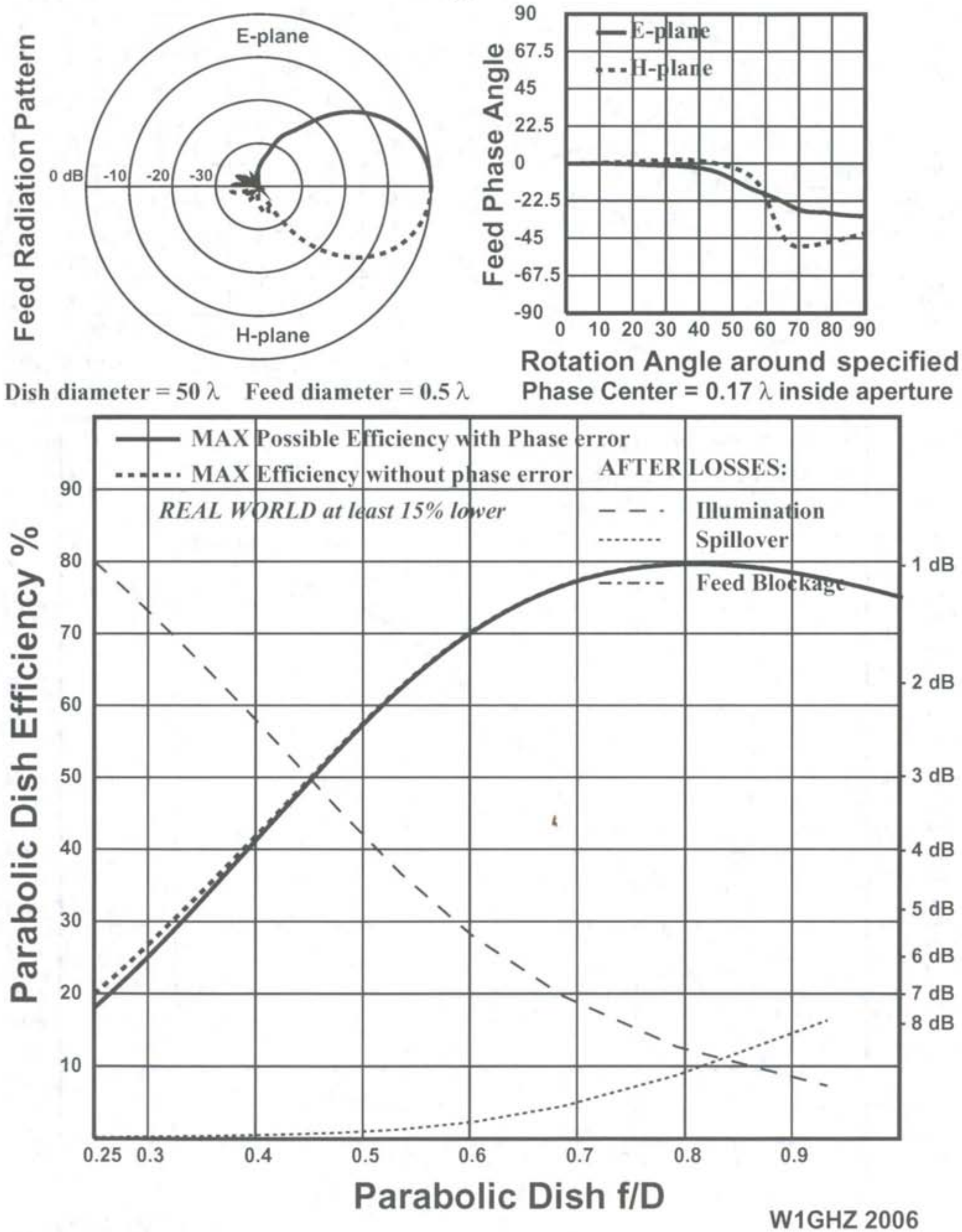

Figure 8 - Calculated feedhorn efficiency for 2λ diameter optimum dual-mode horn

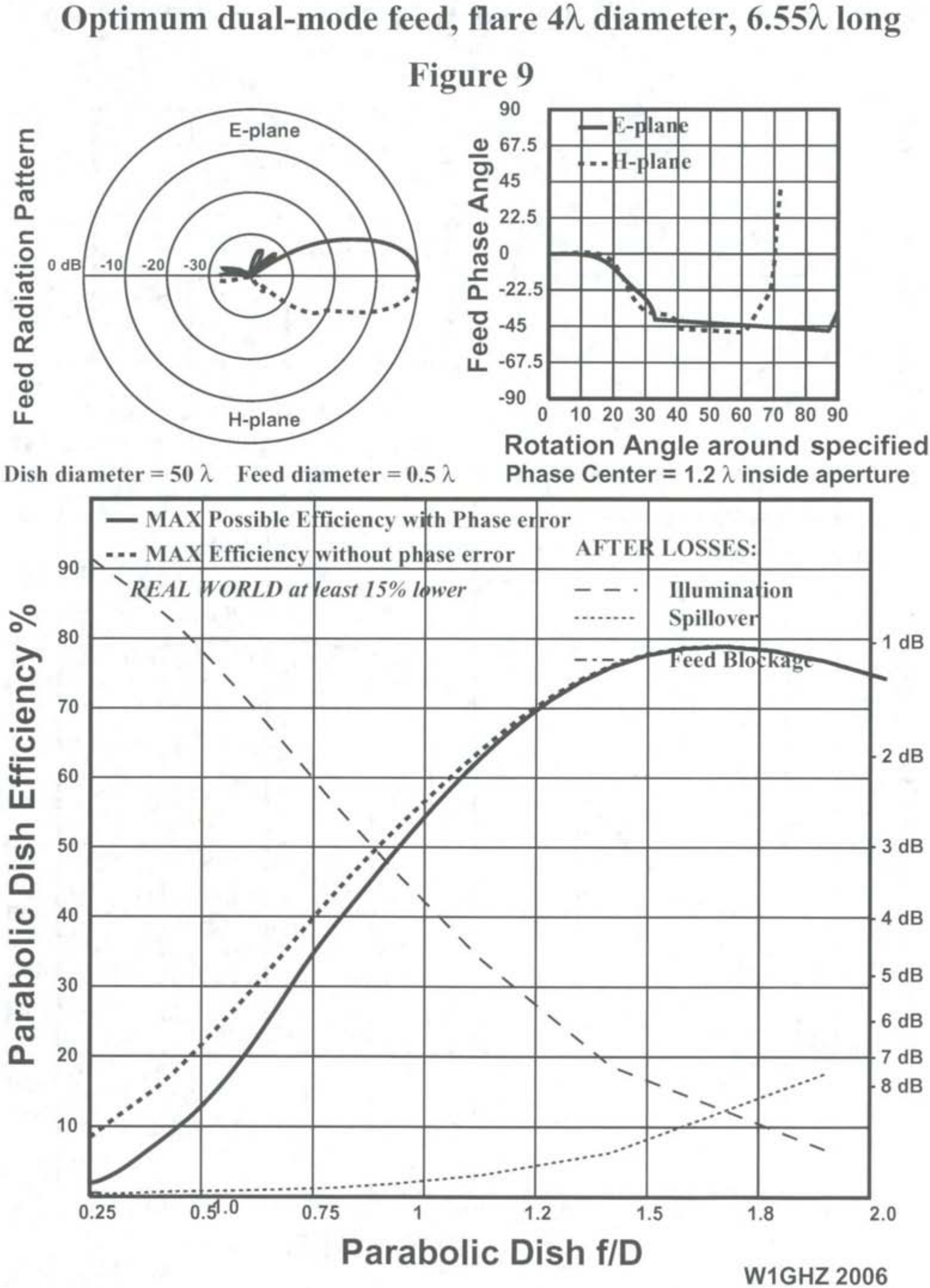

Figure 9 - Calculated feedhorn efficiency for 4λ diameter optimum dual-mode horn

Optimum dual-mode feed, flare 5λ diameter, 8.25λ long

Figure 10

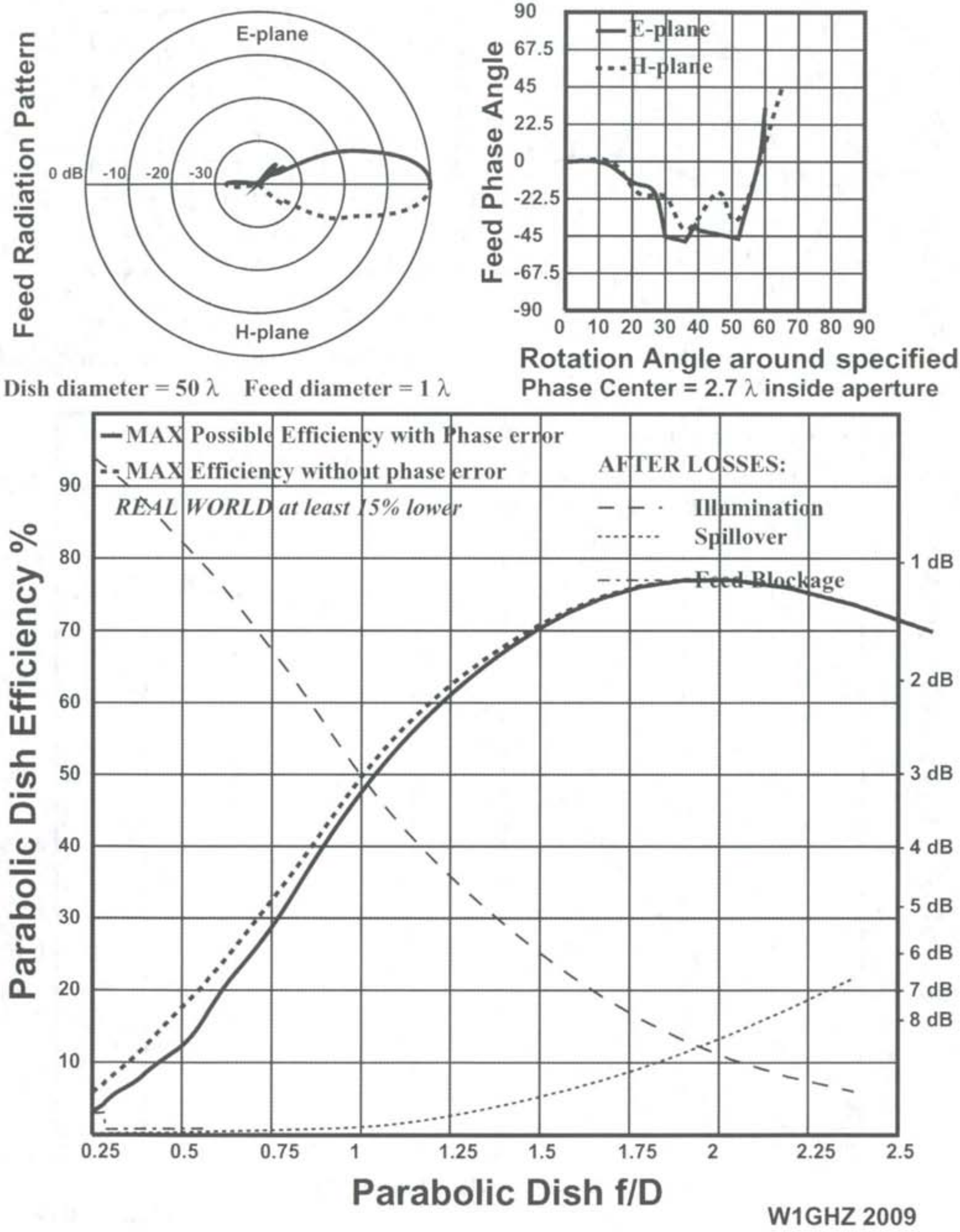

Figure 10 - Calculated feedhorn efficiency for 10λ diameter optimum dual-mode horn

Optimum dual-mode feed, flare 6λ diameter, 10λ long

Figure 11

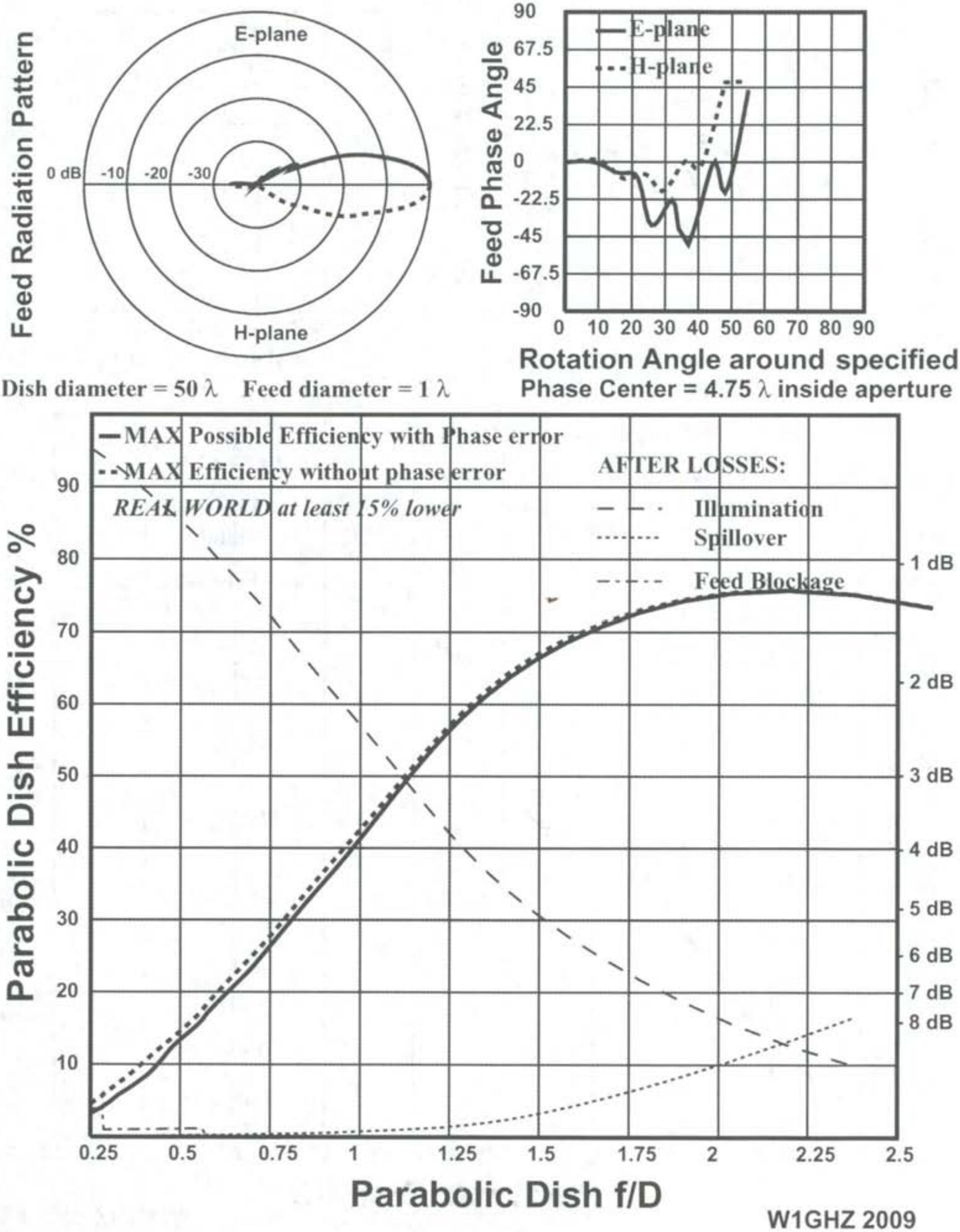

Figure 11 - Calculated feedhorn efficiency for 6λ diameter optimum dual-mode horn

Figure 12 – 10.4 GHz Feedhorn for Bochum Radio Telescope (courtesy Dr. Karl Meinzer, DJ4ZC)

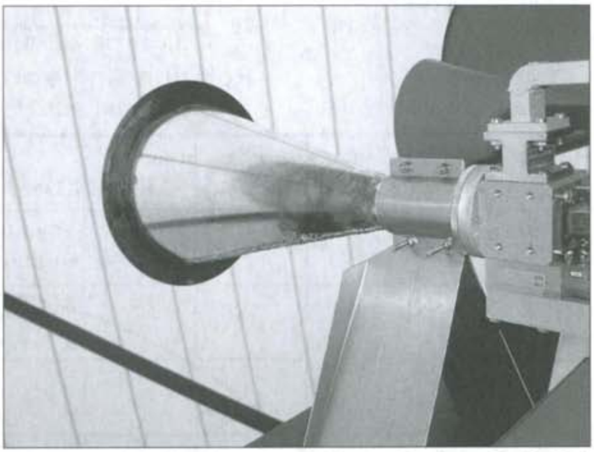

Figure 13 – 10.4 GHz Feedhorn in position at Bochum Radio Telescope

Figure 14 - Prof. Dr. Karl Meinzer, DJ4ZC, with 2.4 GHz feedhorn (courtesy AMSAT-DL)

Optimum dual-mode feed, flare 2.3λ diameter, 3.62λ long

Figure 15

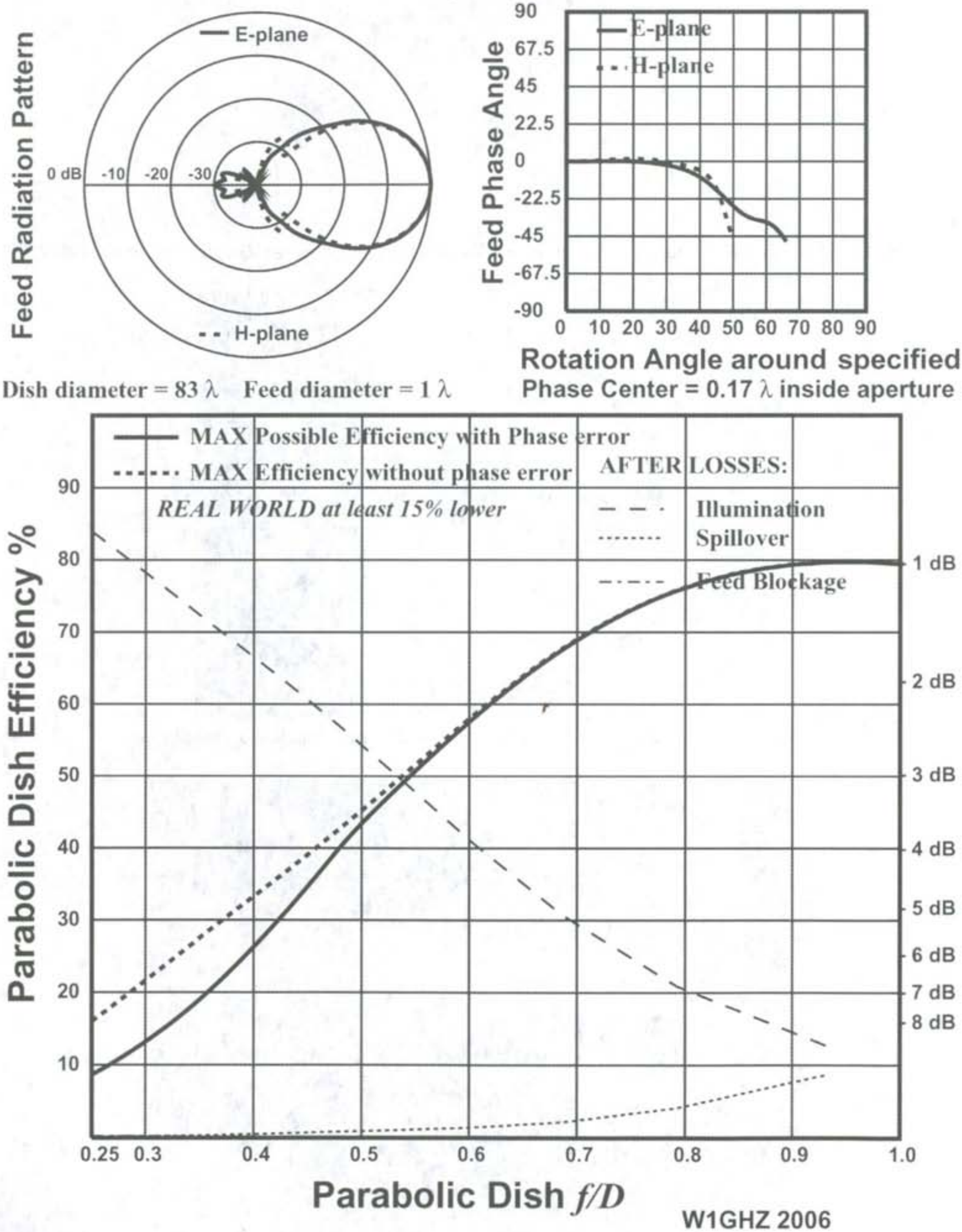

Figure 15 - Calculated feedhorn efficiency for 2.3λ diameter optimum dual-mode horn

Optimum dual-mode feed, flare 1.7λ diameter, 2.34λ long

Figure 16a

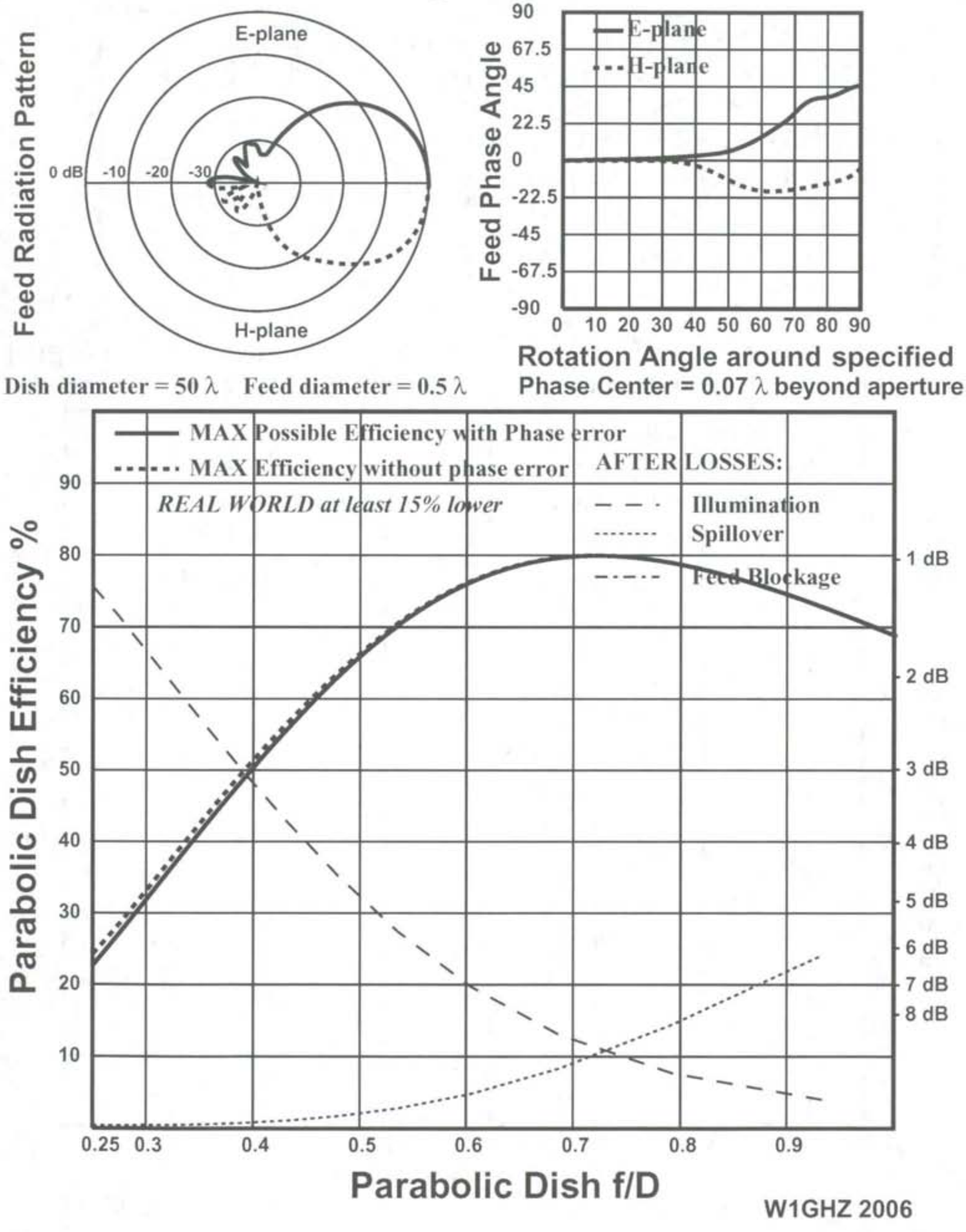

Figure 16a - Calculated feedhorn efficiency for 1.7λ diameter optimum dual-mode horn for DSS offset-fed dish, 2.34λ long

Optimum dual-mode feed, flare 1.7λ diameter, 2.44λ long

Figure 16b

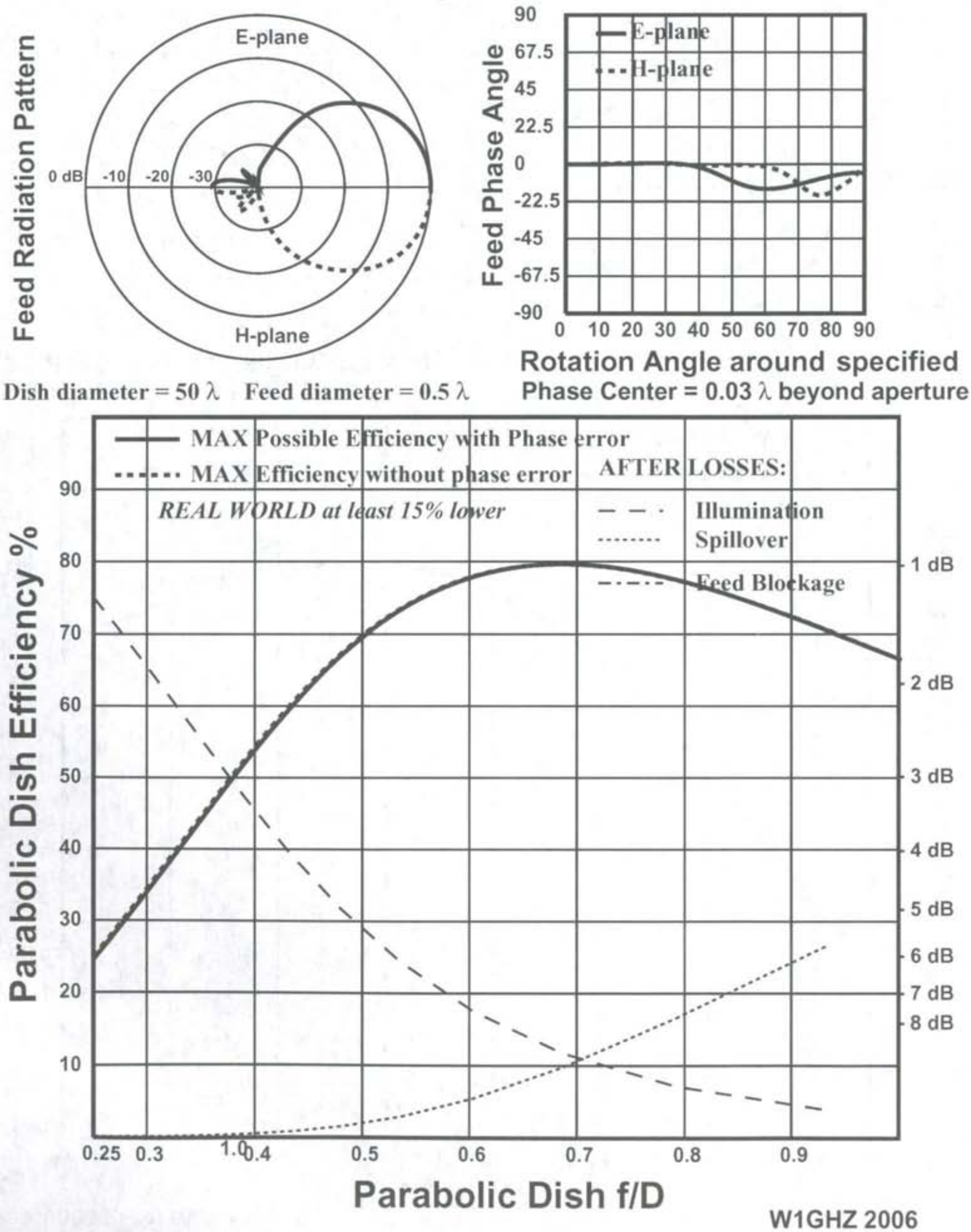

Figure 16b - Calculated feedhorn efficiency for 1.7λ diameter optimum dual-mode horn for DSS offset-fed dish, 2.44λ long

Since the two flare lengths provide equal performance, I chose to split the difference and fabricate horns with a flare length of 2.40λ. Then a reasonable length tolerance, roughly ± 1 mm at 10 GHz, and proportionally smaller at higher frequencies, should not affect performance. A photo of a 47 GHz feedhorn 1.7λ in diameter is shown in Figure 18; it was turned from a 1/2 inch diameter aluminum rod. A later version was made from ¾ inch square aluminum bar to allow connection to a rectangular waveguide flange. A similar feedhorn for 10.368 GHz with matching section to WR-90 is shown in Figure 19. I also made a similar feedhorn for 24 GHz which is being used for EME by Al Ward, W5LUA; he reports receiving 2.2dB of moon noise on a 2.4M offset-fed dish.

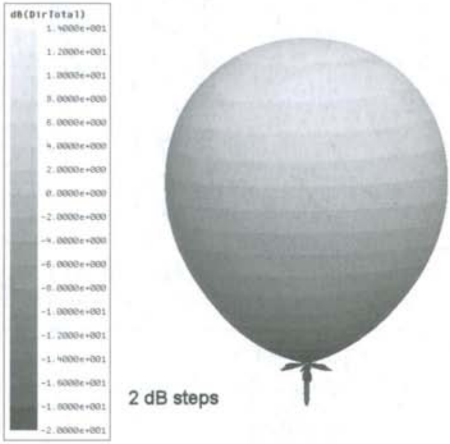

Figure 17 - 3D radiation pattern for 1.7λ diameter optimum dual-mode horn

Figure 18 - 1.7λ diameter optimum dual-mode horn for 47 GHz

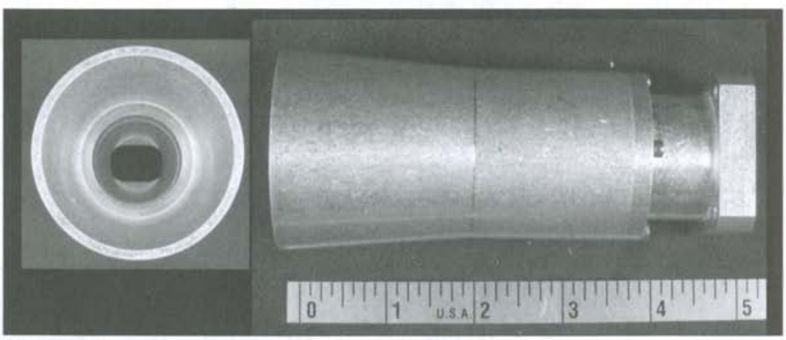

Figure 19 – Optimum dual-mode feed for 10.368 GHz, 1.7λ Aperture Diameter, 2.4λ Flare length

The small horns are relatively easy to make with a small lathe. The larger 10 GHz version and lower frequency horn made by AMSAT-DL take a combination of machining and sheet metal work.

Kittara dual-mode horn, flare 8.456λ diameter, 13.53λ long

Figure 20

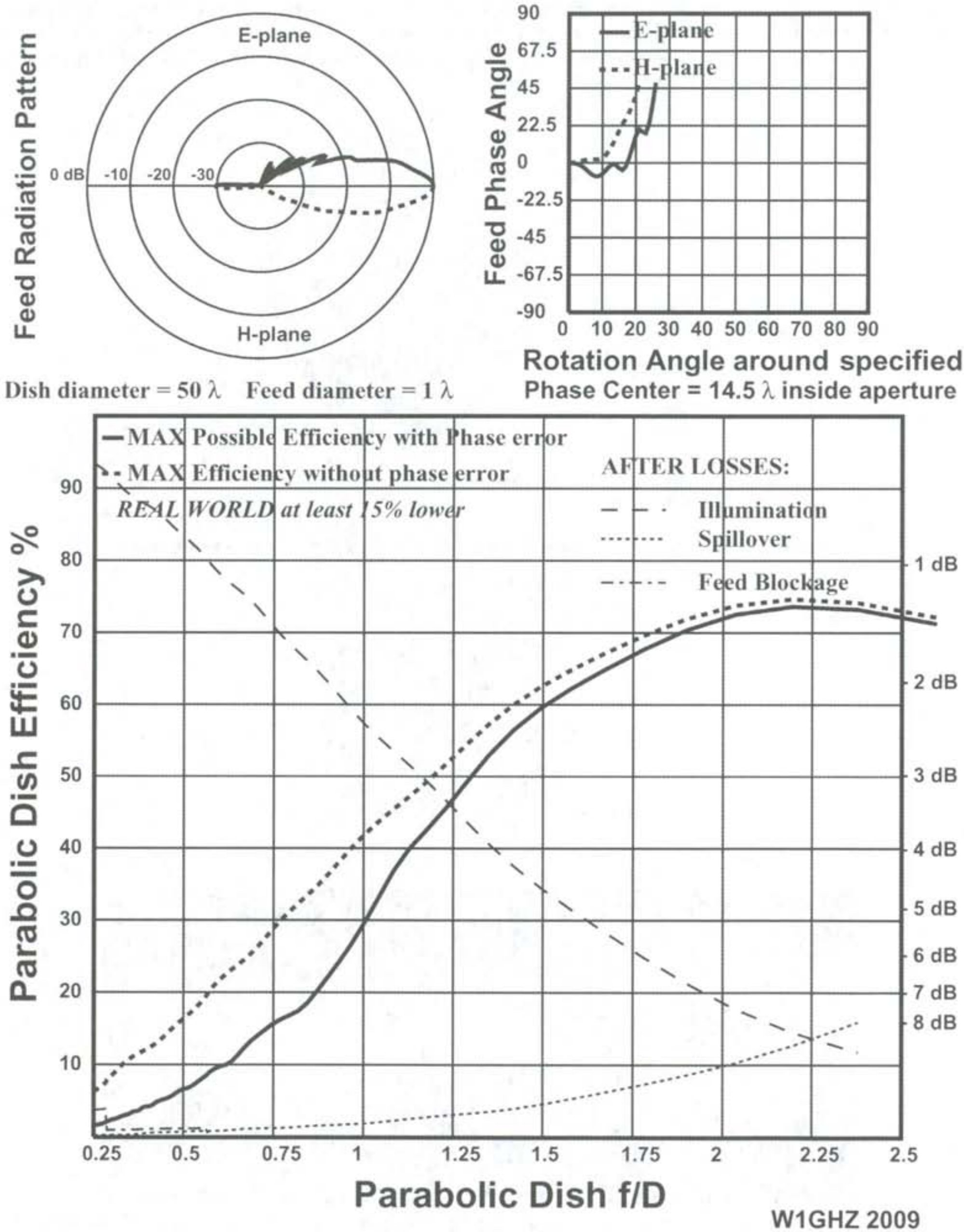

Figure 20 - Calculated feedhorn efficiency for 8.45λ Kittara "Pickett-Potter" dual-mode horn

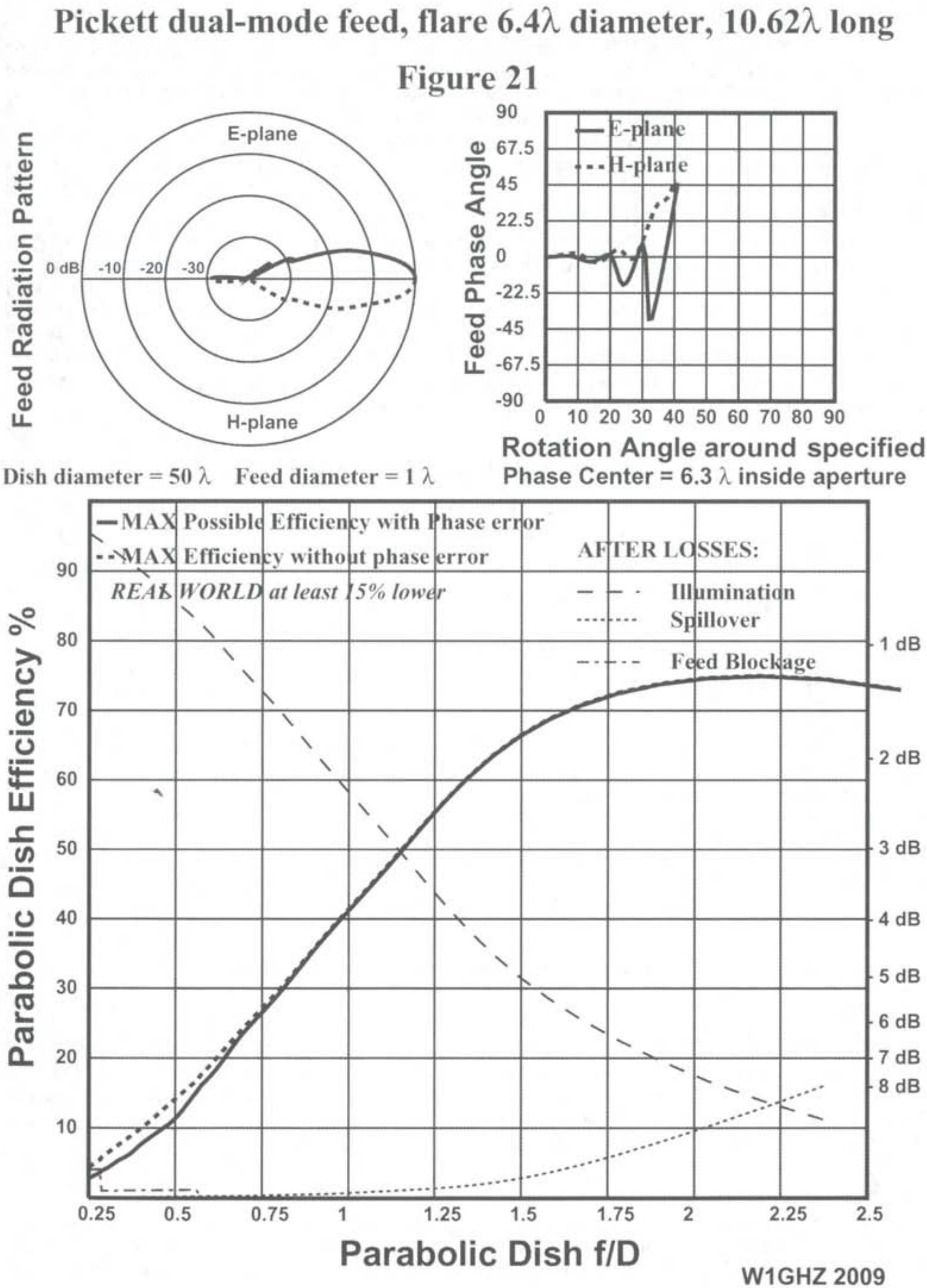

Figure 21 - Calculated feedhorn efficiency for 6.4λ diameter Pickett dual-mode horn

Further Optimization

After seeing how adjusting the length improved efficiency for the small version, I tried length variations on the larger diameters. Only recently has computer memory become cheap enough to permit accurate calculation the largest horns – more than 6 GB of RAM is required for **HFSS**. Most showed some improvement and very high efficiencies were calculated, some over 80%.

The Pickett and Kittara dual-mode horns were also analyzed, with results shown in Figures 20 and 21 respectively. While the performance of both is very good, the best illumination angle for each is comparable to the largest Skobelev horn, equivalent to an ***f*/D** around 2.2. The Skobelev version is smaller than either and has slightly higher calculated efficiency.

All the results are listed in Table 1, with calculated efficiencies plotted in Figure 22 and best ***f*/D** in Figure 23. The best efficiencies are obtained with the nominal length or slightly shorter, but it is clear that the exact dimension is not critical. For a given diameter, shorter horns are better for larger ***f*/D** – they illuminate a narrower angle. Thus, to make a horn longer than the nominal length increases the beamwidth and reduces efficiency; a waste of metal. The best results are summarized in the design curves of Figure 24, which may be used to find optimum dimensions of a feedhorn for any desired ***f*/D**.

These horns also have very clean patterns with low sidelobe levels. The larger ones could be useful as a test antenna with good gain, in excess of 20 dB, as seen in Table 1.

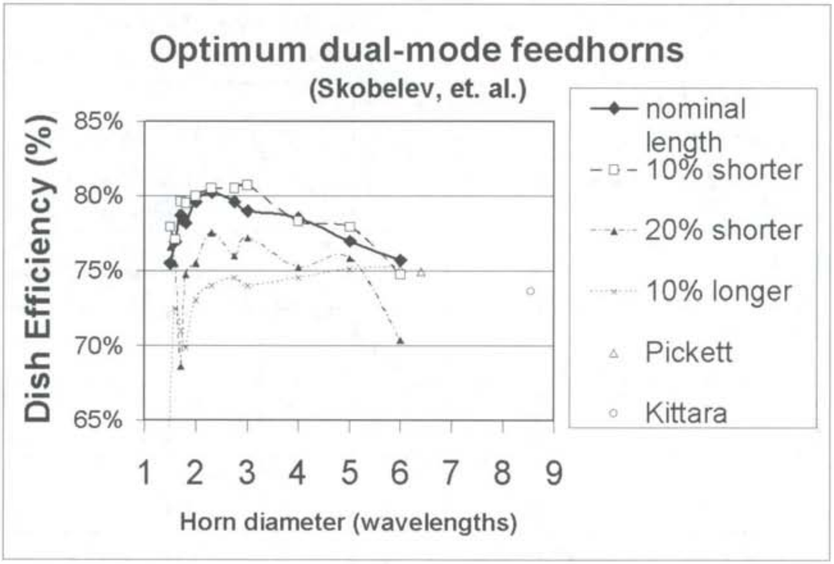

Figure 22 – Optimum dual-mode feedhorn efficiency

Matching

All sizes of the optimum dual-mode horn use the same step diameters, from 1.016λ at the input to 1.3λ at the flare, so the input diameter is larger than single-mode circular waveguide, typically close to 0.7λ in diameter. The calculated return loss for the 1.016λ diameter input waveguide is good, so a matched transition is all that is needed. A gentle flare or multiple steps will work for circular guide, or a rectangular step may be used to transition directly to standard rectangular waveguide.

Summary

A series of "optimum" geometry dual-mode horns originally described by Skobolev and further optimized using HFSS software potentially provide exceptionally high efficiency feeds for offset and multiple-reflector dishes. Results to date on various sizes at frequencies from 10 to 90 GHz are encouraging. More measurement data will be forthcoming as more of these horns are used.

Design curves in Figure 24 should be adequate to choose best dimensions for most applications. Simulations of various sizes suggest that fabrication with reasonable tolerances should be adequate.

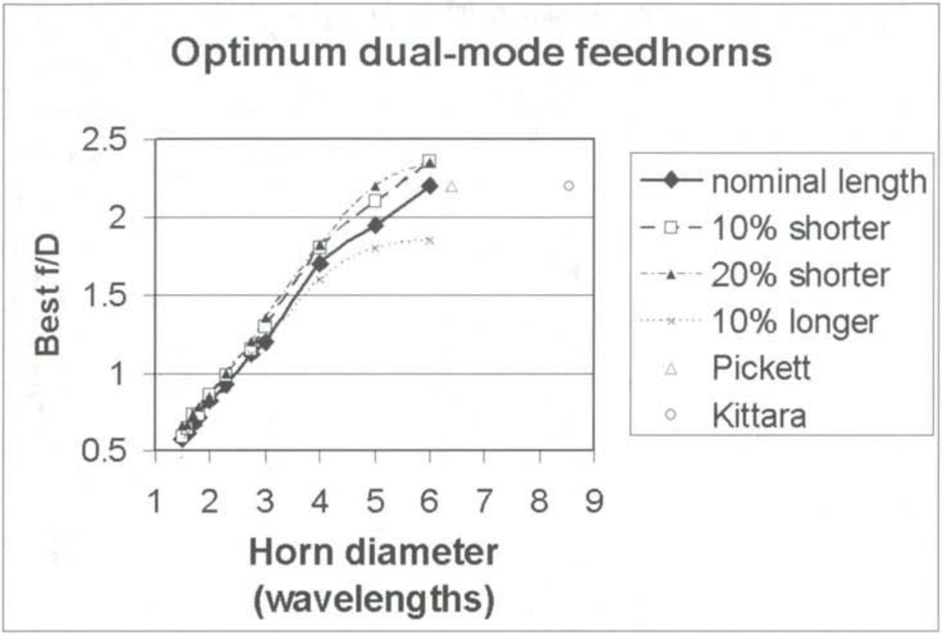

Figure 23 - Optimum dual-mode feedhorn f/D

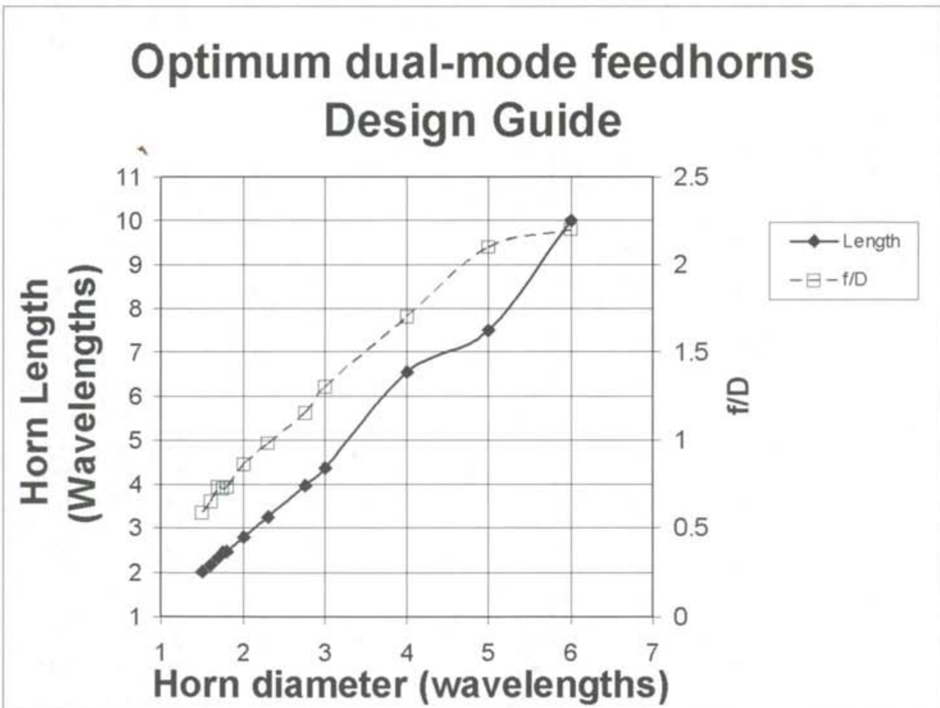

Figure 24 – Design guide for optimum dual-mode feedhorn dimensions

Optimum Dual-Mode Feedhorns

after Skobolev, et al *W1GHZ 2009*

Aperture Diameter λ	Flare Length λ	f/D (best)	Efficiency (dish)	Phase Center λ	Front to Back dB	Sidelobe (worst) dB	Gain (horn) dBi	Beamwidth 10 dB degrees
				Note: negative phase center is inside horn				
Nominal								
1,5	2,238	0,58	75,5%	-0,1	21	-10	11,5	95
1,6	2,41	0,61	76,9%	-0,07	25	-19	11,9	91
1,7	2,57	0,67	78,7%	-0,02	27	-24	12,6	83
1,8	2,755	0,72	78,2%	-0,11	28	-31	13,5	74
2	3,1	0,82	79,6%	-0,17	34	-33	14,3	67
2,3	3,62	0,93	80,2%	-0,23	40	-30	15,6	58
2,75	4,4	1,12	79,6%	-0,46	35,8	-25	17,0	49
3	4,85	1,2	79,0%	-0,7	36	-24	17,9	44
4	6,55	1,7	78,5%	-1,2	32	-32	20,2	33
5	8,25	1,95	77,0%	-2,7	33	-33	21,8	28
6	10	2,2	75,7%	-4,75	34	-22	23,0	25
10% shorter								
1,5	2,01	0,59	77,9%	0,03	31,5	-27	11,5	94
1,6	2,17	0,65	77,1%	0,13	35,8	-20	12,1	87
1,7	2,34	0,73	79,6%	0,07	28,6	-30	12,9	77
1,8	2,48	0,73	79,5%	0,03	45	-38	13,5	74
2	2,79	0,86	80,0%	0	39,5	-32	14,7	65
2,3	3,26	0,98	80,5%	0	30	-28	15,9	56
2,75	3,96	1,15	80,5%	-0,15	28	-25	17,4	47
3	4,36	1,3	80,7%	-0,25	35	-25	18,2	42
4	5,9	1,8	78,3%	-0,9	31	-27	20,6	32
5	7,5	2,1	77,9%	-2,1	31	-29	22,3	26
6	9	2,35	74,7%	-4,6	30	-27	23,4	24
20% shorter								
1,5	1,79	0,66	76,6%	0,16	24	-19	12,0	85
1,6	1,93	0,67	75,5%	0,18	26	-20	12,3	84
1,7	2,06	0,73	68,6%	0,04	22	-15	12,9	75
1,8	2,2	0,78	74,7%	0,13	22	-19	14,0	78
2	2,48	0,85	75,5%	0,13	27	-18	14,7	64
2,3	2,9	1	77,5%	0,13	26	-21	15,9	55
2,75	3,52	1,2	76,0%	0	24	-19	17,7	44
3	3,88	1,35	77,2%	-0,2	26	-22	18,4	40
4	5,24	1,82	75,2%	-1	26	-23	20,8	30
5	6,875	2,2	75,9%	-2,2	33	-24	22,5	25
6	8	2,35	70,4%	-5,4	29	-23	23,5	23
10% longer								
1,5	2,46	0,45	64,5%	-0,21	15	-7	10,7	107
1,6	2,65	0,61	72,5%	-0,14	20	-17	11,9	92
1,7	2,82	0,67	71,0%	-0,21	21	-16	12,5	86
1,8	3,03	0,68	69,9%	-0,34	19	-15	13,0	80
2	3,41	0,83	73,0%	-0,37	23	-16	14,3	67
2,3	3,98	0,9	74,0%	-0,5	27	-16	15,4	59
2,75	4,84	1,12	74,5%	-0,75	25	-15	17,0	48
3	5,34	1,2	74,0%	-1	28	-25	17,7	45
4	7,2	1,6	74,5%	-2,25	30	-29	19,9	35
5	9,08	1,8	75,1%	-2,6	29	-27	21,4	30
6	11	1,85	75,3%	-5,8	28		22,5	27

Table 1

other								
1,7	2,44	0,68	79,6%	0,03	29	-33	12,8	80
6	10,5	1,9	74,9%	-6,5	31	-24	22,5	26
Pickett								
6,4	10,62	2,2	74,9%	-6,3	31	-28	23,4	
Kittara								
8,546	13,53	2,2	73,6%	-14,6	30	-24	24,3	
<u>BEST</u>								
1,5	2,01	0,59	77,9%	0,03	31,5	-27	11,5	94
1,6	2,17	0,65	77,1%	0,13	35,8	-20	12,1	87
1,7	2,34	0,73	79,6%	0,07	28,6	-30	13,0	77
1,75	2,46	0,72	80,0%	0,08	30	-31	13,1	77
1,8	2,48	0,73	79,5%	0,03	45	-38	13,5	74
2	2,79	0,86	80,0%	0	39,5	-32	14,7	65
2,3	3,26	0,98	80,5%	0	30	-28	15,9	56
2,75	3,96	1,15	80,5%	-0,15	28	-25	17,4	47
3	4,36	1,3	80,7%	-0,25	35	-25	18,2	42
4	6,55	1,7	78,5%	-1,2	32	-32	20,2	33
5	7,5	2,1	77,9%	-2,1	30,9	-29	22,3	28
6	10	2,2	75,7%	-4,75	33,8	-22	23,0	26

Large step - 0.68 lambda radius at end of flare

Aperture Diameter λ	Flare Length λ	f/D (best)	Efficiency (dish)	Phase Center λ	Front to Back dB	Sidelobe (worst) dB	Gain (horn) dB	Beamwidth 10 dB degrees	
1,7	2,78	0,64	0,769	-0,11	23	-19	12,37		nom
	2,64	0,64	0,78	0	27	-25	12,43		-5%
	2,5	0,67	0,775	0,08	28	-22	12,62		-10%
	2,22	0,72	0,701	0,22	20	-15	13,07		-20%
	3,06	0,57	0,705	-0,3	18	-9	11,88		10%

Table 1 - continued

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Optimierte Dualmode-Feedhörner

by Paul Wade W1GHZ © 2009 - w1ghz@arrl.net

Dualmode-Feedhörner für Parabolspiegel weisen exzellente Leistungsdaten über einen großen Bereich der Mikrowellenbänder auf und dies speziell bei Offset-Reflektoren. Für viele kommerzielle Anwendungen ist die Bandbreite eines Dualband-Horns zu gering, weshalb gerillte Hörner bevorzugt werden. Die Bandbreite aber ist beim Amateurgebrauch selten ein Problem. Während die Leistung eines gerillten Horns ebenfalls hervorragend ist, ist es aber sehr viel schwieriger bei eingeschränkten mechanischen Möglichkeiten herzustellen, so dass das Dualband-Horn eine attraktive Wahl sein könnte, wenn wir ein Feedhorn für einen bestimmten Spiegel und Frequenz herstellen wollen. In einem aktuellen Aufsatz von Skobolev et al. wird eine Serie von Dualmode-Hörnern mit „optimaler" Geometrie beschrieben[1]. Die simulierten Leistungdaten ergeben, dass diese Hörner sehr effektive Feeds sein können, und die gemessenen Ergebnisse bestätigen dieses Potenzial. Eine einfache Schar von Design-Kurven macht es leicht, die besten Abmessungen für eine bestimmte Anwendung zu finden.

Entwicklung des Dualmode-Horns

Eines der ersten Dualmode-Hörner war der Potter[2]-Typ, der einen Übergangsschritt beim Durchmesser verwendet, um einen zweiten Modus, TM11, zusätzlich zum normalen TE11-Modus zu erregen. Die relativen Amplituden der beiden Modes wird bestimmt durch die Dimensionen des Schrittes, in Abb. 1 gezeigt als **C**. Da der Ausgangsdurchmesser des Schrittes groß genug sein muss, um beide Wellenleiter-Modes zu unterstützen, ist der Eingangsdurchmesser normalerweise größer als für zirkularen Wellenleiter mit einem Modus, **A**, so dass eine sanfte Ausbauchung **B** den Durchmesser erhöht, ohne signifikante Umwandlung des Modes. Nach der Stufe folgt die Phasen-Sektion **D**, um die beiden Modes in dem erwünschten Phasenverhältnis zu bekommen, gefolgt von der aufgeweiteten Sektion **E** bis zum Öffnungsdurchmesser, der für die erwünschte Breite der Strahlungskeule benötigt wird. Die Breite der Strahlungskeule ist umgekehrt proportional zum Durchmesser der Öffnung, während der Winkel der Aufweitung die Form der Strahlungskeule beeinflusst. Die richtige Kombination kann eine sehr hohe Feed-Effektivität liefern. Sobald die Abmessungen der Aufweitung gewählt sind, wird die Phasenverschiebung der aufgeweiteten Sektion berechnet und die Länge der Phasen-Sektion so angepasst, dass die beiden Modes sich am Rand des Horns auslöschen. Wenn eine gute Auslöschung erreicht wird, gibt es keine Kantenströme, die unerwünschte Nebenzipfel hervorrufen. Die Berechnungen ein Potter-Horn zu entwickeln, sind ziemlich kompliziert.

Abb. 1 – Zeichnung eines Potter Dualmode-Horns

Dick Turrin, W2IMU, erfand eine kleines Dualmode-Horn[3], das in Abb. 2 gezeigt ist, und das viel einfacher als das Potter-Horn ist. Der zweite Mode wird direkt vom Eingangswellenleiterdurchmesser **A** an von einer aufgeweiteten Sektion errregt bis zum erwünschten Öffnungsdurchmesser **B**, gefolgt von der Phasensektion **C**, um die beiden Modes in die erwünschte Phasenbeziehung an der Öffnung zu bekommen. Die relative Ampitude der beiden Modes wird durch den Winkel der Aufweitung bestimmt. Die Berechnung der benötigten Abmessungen ist deutlich einfacher und die Herstellung ist ebenfalls ziemlich einfach[4]. Der Nachteil des W2IMU-Horns ist, dass es auf kleine Öffnungsdurchmesser begrenzt ist, bevor sich zusätzliche unerwünschte Modes in die Phasen-Sektion ausbreiten können. Im Ergebnis bedeutet dies, dass es nur für einen kleinen f/D-Bereich gut ist, ungefähr von 0.5 bis 0.8 – perfekt für übliche Offset-gespeiste Spiegel.

Abb. 2 - W2IMU Dualmode-Horn

Für Spiegel mit multiplen Reflektoren, wie der Cassegrain-Antenne[5], kann die beste Kombination der Parameter ein Feedhorn benötigen, das einen kleinen Ausleuchtungswinkel liefert, entsprechend einem großen ***f*/D**. Das ist oft der Fall, wenn wir versuchen, einen vorhandenen Subreflektor zu verwenden, und kaum, wenn wir einen neuen herstellen – eine große hyperbole Oberfläche ist eine Herausforderung.

Eine Alternative ist, ein Potter-Horn für eine großes f/D zu entwickeln. Lyle Patison, VK2ALU, fand einen einfacheren Ansatz[6]: Er fügte eine aufgeweitete Sektion an das Ende eines W2IMU-Dualmode-Horns hinzu, was in Abb. 3 zu sehen ist. Lyle nahm an, dass die beiden Modes, die erwünschte Phasenbeziehung am Ende des W2IMU-Horns haben und verwendete Potters Kurven, eine Länge für die Aufweitung zu finden, bei der die gewünschte Phasenbeziehung bei größerer Öffnung erhalten bleibt.

Abb. 3 - VK2ALU's verlängertes Dualmode-Horn

Die Dualmode-Hörner mit "optimaler" Geometrie, wie von Skobolev [1] beschrieben, sind in Abb. 4 gezeigt. Diese Hörner haben einen Übergangsschritt, um den zweiten Modus zu erregen, sofort gefolgt von einer bis zur benötigten Öffnungsgröße aufgeweiteten Sektion, so dass die gesamte Hornlänge verringert wurde. Die Länge der aufgeweiteten Sektion wird berechnet, um die beiden Modes in die erwünschte Phasenbeziehung zu bringen. Eine Kurve ist beigefügt, um diese Länge für Öffnungsdurchmesser von 2 bis 6 Wellenlängen bestimmen zu können.

Vor kurzem haben Kittara et. al. in einer Abhandlung ein sehr ähnliches Horn für 700 GHz als Pickett-Potter-Horn[6] beschrieben. Dieses Horn ist angelehnt an eine Veröffentlichung von Pickett et al., die ein Dualmode-Horn für Submillimeter-Wellenlängen beschreibt[7]. Beide Hörner haben größere Öffnungen und sind länger als irgendeine der Versionen von Skobolev.

Kittara hat Software entwickelt, um das Horn zu designen und zu analysieren, aber Pickett hat sein Horn entwickelt, bevor eine Computeranalyse für so ein großes Horn möglich war. Stattdessen verwendete er die Berechnungen von Potter, um die benötigte Phasenverschiebung für die beiden Modes zu berechnen. Dann verkürzte er das Horn, indem er das ganze Phasenverschieben in der aufweiteteten Sektion machte. Die gesamte Phasenverschiebung beim Potter-Horn beträgt 3.6π oder 648 Grad. Pickett entfernte 2π oder 360 Grad durch Verkürzung, wobei er die benötigte Phasenlage zwischen den Modes an der Öffnung beibehielt. Das aufgeweitete Horn ist immer noch 10.62λ lang, mit einem Öffnungsdurchmesser von 6.4λ, und das Horn von Kittara ist noch länger. Die Daten von Messungen in diesen Veröffentlichungen legen nahe, dass die Hörner gut funktionieren, so dass wir diese Hörner in unsere Analyse einbeziehen sollten.

Abb. 4 – Skizze eines optimalen Skobolev-Dualmode-Horns

Die Kurve in der Veröffentlichung von Skobolev für den optimalen Öffnungsdurchmesser und die Länge der Aufweitung sieht nahezu wie eine gerade Linie aus, so dass ich eine einfache Näherungsformel verwendet habe:

$\text{Flarelength (in } \lambda) = 3.45 \cdot r_\lambda - 0.35$ mit r_λ für den Radius der Öffnung.

(Flarelength = Länge der Aufweitung in Lambda) Unter Verwendung dieser Näherungsformel habe ich Abmessungen für Hörner für Öffnungsdurchmesser von 2, 3, 4, 5 und 6 Lamba berechnet und für jedes Strahlungsdiagramme mit der Software Ansoft[8] **HFSS** berechnet. Jedes der Hörner hatte gute achsensymmetrische Strahlungsdiagramme mit niedrigen Seiten- und rückwärtigen Zipfeln.

Figure 5 - 3D-Strahlungsdiagramm für ein optimales Dualmode-Horn mit 3λ Durchmesser

Ein Beispiel ist das 3D-Strahlungsdiagramm für das Horn mit 3λ Durchmesser, was in Abb. 5 gezeigt ist. Als Feedhorn ist die gerechnete Effektivität in Abb. 6 angegeben: 79% Effektivität für ein f/D von etwa 1.2, bei sehr niedrigen Seitenzipfeln und rückwärtigen Zipfeln. Das sieht nach einem exzellenten Feed aus, nur 1 dB unter dem theoretisch perfekten Wert. Ein Nahfeld-Plot, siehe Abb. 7, zeigt den Dual-Mode in Aktion: Die Intensität des E-Felds ist hoch in der Wand der H-Ebene des Horns (die obere Hälfte des Bildes), weil die Welle von der Stufe gestartet wird. Wenn die Welle die Öffnung des Horns erreicht, wird das elektrische Feld nahe der Wand durch den zweiten Mode ausgelöscht, was in einer niedrigen Intensität um den ganzen Rand der Öffnung resultiert. Das Ergebnis ist ein Diagramm mit sehr niedrigen Nebenzipfeln.

Abb. 6 - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn mit 3λ Durchmesser

Abb. 7 - E-feld in einem optimalen Dualmode-Horn mit 3λ Durchmesser

Die Spiegeleffektivität für diese Feedhörner wurde berechnet durch Integration der Diagramme mit dem Programm PHASEPAT[9]. Die Plots für die Spiegeleffektivität der Hörner sind in den Abb. 8 bis 11 für Öffnungsdurchmesser von 2, 4, 5 und 6λ gezeigt. Alle zeigen eine sehr hohe berechnete Effektivität mit einem optimalen f/D proportional zum Öffnungsdurchmesser, wobei ein f/D-Bereich von 0.8 bis etwa 2.0 abgedeckt wird. Die Diagramme sind sauber, mit sehr niedrigen Seiten- und rückwärtigen Zipfeln, typisch besser als 30 dB abgesenkt. Alle Ergebnisse sind in Tabelle 1 (oberhalb, am Ende des englischen Textes) zusammengefasst.

Ein Horn der größten Ausführung, 6λ im Durchmesser und 10λ lang, wurde von der AMSAT-DL für die Verwendung auf 10.4 GHz im 20-Meter-Cassegrain-Spiegel des Bochumer Radioteleskopes gebaut. Es basierte auf meinen Berechnungen, dass dieses die optimale Größe eines Feedhorns für diesen Spiegel ist. Dr. Karl Meinzer, DJ4ZC, berichtete dann von einer Verbesserung von 1.5 dB beim Gewinn und G/T im Vergleich zum vorherigen Feed. Seine Skizze des Feeds ist in Abb. 12 gezeigt. Abb. 13 zeigt das Feedhorn im Spiegel. Das 10.4-GHz-Feedhorn wurde im Jahr 2007 für EVE-(Erde-Venus-Erde)-Tests verwendet, die aber erfolglos blieben. Das Team der AMSAT-DL folgerte, dass eine niedrigere Frequenz bei 2.4 GHz, für gute Reflektionen benötigt würde. Das 6λ-Feedhorn ist physikalisch sehr groß bei dieser Frequenz, aber ich war nicht in der Lage ein kleineres Feed vorzuschlagen, das eine vergleichbare Leistung gehabt hätte. Das Team der AMSAT-DL hat dann das Feedhorn, das in Abb. 14 gezeigt ist, konstruiert und damit erfolgreich Echos von der Venus empfangen[10] – eine unglaublicher Erfolg im Amateurbereich. Die Ringe an der Außenseite des Horns dienen lediglich der mechanischen Versteifung.

Zwei zusätzliche Öffnungsdurchmesser sind in Tabelle 1 aufgelistet. Ich wurde von GW4DGU nach einem optimalen 10-GHz-Feedhorn mit f/D 0.935 für seinen Offset-Spiegel gefragt. Ich habe abgeschätzt, dass der benötigte Öffnungsdurchmesser 2.3λ sein würde, und das hat sich als sehr nah erwiesen. Dieses Horn hat eine extrem hohe Spiegeleffektivität von 80.2%, weniger als 1 dB unter der Perfektionsgrenze. Der Plot der Spiegeleffektivität ist in Abb. 15 gezeigt.

Sat-TV (DSS) Offset-Spiegel

Das kleinste optimale Dualmode-Horn von 2λ Durchmesser ist am besten für ein f/D von 0.83 geeignet und größere Hörner für größere f/D. Da die meisten gebräuchlichen offset-gespeisten Spiegel, wie die Sat-TV-Spiegel, ein Ausleuchtungswinkeläquivalent von f/D 0.7 benötigen, wollte ich auch eine kleinere Version machen. Unter Verwendung der Näherungsormel der geraden Linie für die Bestimmung der Länge der Aufweitung, habe ich verschiedene Größen von 1.5λ bis 1.9λ Durchmesser und verschiedene Aufweitungslängen ausprobiert. Die meisten waren sehr gut, wie in Tabelle 1 aufgelistet. Ein Öffnungsdurchmesser von 1.7λ mit einer Aufweitungslänge von 2.57λ war am günstigsten, die berechnete Effektivität war aber nicht ganz so gut wie bei den größeren Hörnern. Ich habe dann Aufweitungslängen von 10% mehr und 5%, 10%, und 20% kürzer probiert. Die 5% und 10% kürzeren Versionen mit 2.34λ bzw. 2.44λ Länge waren die Gewinner. Beide mit einer berechneten Spiegel-Effektivität von 79.6%. Die Plots für die Spiegeleffektivität sind in Abb. 16a und 16b zu sehen für die beiden Aufweitungslängen. Das kürzere Horn favorisiert ein leicht größeres f/D, während das längere Horn besser für ein etwas kleineres f/D ist. Ein 3D-Plot des sehr sauberen Strahlungsdiagramms der 2.44λ langen Version ist in Abb. 17 gezeigt.

Abb. 8 - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 2λ Durchmesser

Abb. 9 - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 4λ Durchmesser

Abb. 10 - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 10λDurchmesser

Abb. 11 - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 6λ Durchmesser

Abb. 12 - 10.4 GHz Feedhorn für das Radioteleskop in Bochum (Foto Dr. Karl Meinzer, DJ4ZC)

Abb. 13 - 10.4 GHz Feedhorn in Position im Bochumer Spiegel

Abb. 14 - Prof. Dr. Karl Meinzer, DJ4ZC, mit 2.4 GHz Feedhorn (Foto AMSAT-DL)

Abb. 15 - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 2.3λ Durchm.

Abb. 16a - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 1.7λ Durchmesser für DSS Offset-Spiegel, Länge 2.34λ

Abb. 16b - Berechnete Feedhorn-Effektivität für ein optimales Dualmode-Horn von 1.7λ Durchmesser für DSS Offset-Spiegel, Länge 2.44λ

Da die beiden Aufweitungslängen gleiche Leistung bringen, habe ich mich dafür entschieden, ein Horn mit einem Mittelmaß von 2.40λ herzustellen. Dann sollte eine angemessene Toleranz bei der Längen von ungefähr ± 1 mm bei 10 GHz und entsprechend weniger bei höheren Frequenzen die Leistung nicht beeinflussen. Ein Foto eines 47-GHz-Feedhorns mit einem Durchmesser von 1.7λ ist in Abb. 18 gezeigt. Es wurde aus einem ½-Zoll Aluminium-Stab gedreht. Einer spätere Version wurde aus einem Vierkant-¾-Zoll-Aluminiumstab gemacht, damit eine Verbindung mit einem rechtwinkligen Wellenleiter-Flansch möglich ist. Ein ähnliches Feedhorn für 10.368 GHz mit einer Anpassungssektion auf WR90 ist in Abb. 19

gezeigt. Ich habe auch ein ähnliches Feedhorn für 24 GHz hergestellt, das für EME von Al Ward, W5LUA verwendet wird. Er berichtet von 2.2 dB Mondrauschen mit einem 2.4m Offset-Spiegel.

Abb. 17 - 3D-Strahlungsdiagramm für ein optimales Dualmode-Horn mit 1.7λ Durchmesser

Abb. 18 - Optimales Dualmode-Horn mit 1.7λ Durchmesser für 47 GHz

Abb. 19 - Optimales Dualmode-Feed für 10.368 GHz mit 1.7λ Öffnungsdurchmesser und 2.4λ Aufweitungslänge

Die kleinen Hörner können relativ leicht mit einer kleinen Drehbank hergestellt werden. Die größere 10-GHz-Version und das niederfrequentere Horn der AMSAT-DL benötigen eine Kombination aus Dreh- und Blechnerarbeit.

Abb. 20 - Berechnete Feedhorn-Effektivität für ein 8.45λ Kittara "Pickett-Potter" Dualmode-Horn

Abb. 21 - Berechnete Feedhorn-Effektivität für ein Pickett Dualmode-Horn mit 6.4λ Durchmesser

Weitere Optimierung

Nachdem ich gesehen hatte, wie das Anpassen der Länge die Effektivität bei den kleinen Versionen verbessert hat, habe ich Variationen bei der Länge bei den größeren Durchmessern versucht. Erst in letzter Zeit wurde Speicherchips der Computer billig genug, um genaue Berechnungen der größten Hörner durchführen zu können – mehr als 6 GB RAM sind notwendig für das Programm HFSS. Bei den meisten zeigte sich eine Verbesserung und sehr hohe Effektivitäten wurden berechnet, einige davon über 80%. Die Dualmode-Hörner von Pickett und Kittara wurden ebenfalls analysiert und die Ergebnisse sind in Abb. 20 bzw. 21 zu sehen. Während die Leistung von beiden sehr gut ist, ist der beste Ausleuchtungswinkel für jedes der beiden vergleichbar mit dem des größten Skobelev-Horns, äquivalent einem f/D von etwa 2.2. Die Skobelev-Version ist kleiner als beide und hat eine etwas höhere berechnete Effektivität.

Alle Ergebnisse sind in Tabelle 1 aufgelistet, die berechneten Effektivitäten sind in Abb. 22 aufgetragen und die besten f/D in Abb. 23. Die besten Effektivitäten werden mit der nominalen oder leicht kürzeren Länge erreicht, wobei aber klar ist, dass die exakte Länge nicht kritisch ist. Bei einem gegebenen Durchmesser sind kürzere Hörner besser für größeres f/D – sie leuchten einen engeren Winkel aus. Folglich vergrößert man die Länge des Horns über die nominale Länge hinaus, wird der Öffnungswinkel größer und reduziert die Effektivität. Das ist Verschwendung von Metall. Die besten Resultate sind in den Design-Kurven in Abb. 24 zusammengefasst. Diese können dafür verwendet werden, die optimalen Abmessungen eines Feedhorns für ein jegliches benötigtes f/D zu finden.

Diese Hörner haben ebenfalls sehr saubere Diagramme mit niedrigen Nebenzipfeln. Die größeren Versionen können als Testantennen mit gutem Gewinn - von bis über 20 dB - verwendet werden, wie Tabelle 1 zeigt.

Abb. 22 – Optimale Effektivität eines Dualmode-Feeedhorns

Anpassung

Alle Größen des optimalen Dualmode-Horns verwenden die gleichen Stufen-Durchmesser von 1.016λ beim Eingang bis zu 1.3λ bei der Aufweitung, d.h. der Eingangsdurchmesser ist größer als der Single-Mode beim zirkularen Wellenleiter, der typisch nahe bei 0.7λ Durchmesser liegt. Der berechnete Returnloss für den Eingangswellenleiter von 1.016λ Durchmesser ist gut, so dass alles, was man braucht, ein angepasster Übergang ist. Eine leichte Aufweitung oder mehrfache Stufen werden bei zirkularem Wellenleiter funktionieren. Eine rechteckige Stufe kann als Übergang direkt auf normalen rechteckigen Wellenleiter verwendet werden.

Zusammenfassung

Eine Serie "optimaler" geometrischer Dualmode-Hörner, original beschrieben durch Skobolev und weiter optimiert mit der HFSS-Software, liefert außergewöhnlich hoch effektive Feeds für Offset- und Multiple-Reflektor-Spiegel. Bis dato sind die Ergebnisse verschiedener Größen bei Frequenzen von 10 bis 90 GHz ermutigend. Weitere Messwerte werden erwartet, da immer mehr dieser Hörner verwendet werden.

Die Design-Kurven in Abb. 24 sollten ausreichend sein, um die besten Abmessungen für die meisten Anwendungsfälle zu bestimmen. Simulationsergebnisse von verschiedenen Größen legen nahe, dass die Herstellung mit akzeptablen Toleranzen ausreichend ist.

Over-The-Horizon Optical Communication

Part 4: Reveivers

by Justin Giles-Clark, VK7TW and Rex Moncur, VK7MO

1. Receiver Options

In this fourth and final part we examine issues that influence the design of optical receivers for over-the-horizon optical communication and provide information and photographs that should be sufficient to allow the construction of the receivers and associated circuitry. Table 1 below list some receiver options and estimated performance.

Receiver	Size (mm)	Effective Area (mm^2)	Angular Field of View (degrees)	Lens Dimension & Focal Length (mm)	Relative Performance (dB)
36 BPW-34 PIN Photodiodes	50#	262	5	395 x395 550FL	0 *
S8664-50k Avalanche Photo-Diode (APD)	5	20	0.8	395 x 395 330FL	+15 **
S8664-50k Avalanche Photo-Diode	5	20	1.2	395 x 395 220FL	+20 ##
S8664-1010 Avalanche Photo-Diode	10	100	1.6	395 x 395 330FL	+22 *
S8664-1010 Avalanche Photo-Diode	10	100	2.4	395 x 395 220FL	+25 ##

Width of the array of photodiodes.

* These receivers have been constructed and used in our testing and are the basis of the construction information and circuits provided.

** This unit is identical to the 10 mm APD with 330 mm FL lens other than the APD.

Estimated performance only as these have not been constructed.

Table 1

2. Theoretical and Practical Considerations

In terms of the receiver the key issue is to maximise Signal to Noise ratio. In optical terms the signal is a function of the received power P_R as given by equation 12 in Part 2[1] of this series as below:

$$P_R = P_T - 65 - 20 \log (d) + G_s + 10 \log (A) - e.d - 10 \log (ML) \qquad \textbf{Equation 1}$$

Where:

- P_R = received power (dBWo[2])
- ***Pt*** = transmitter power (dBWo)
- ***d*** = distance (km)
- ***Gs*** = scatter gain

[1] Rex Moncur, VK7MO and Paul Edwards VK7ZAS, "Over the Horizon Optical Communications – Part 2: Theory: Physics & Engineering Analysis" DUBUS 1/2009

[2] Power nomenclature – "o" = optical power whereas "e" = electrical power

A = receiver aperture light collecting area (square metres)
e = the extinction loss (dB/km)
ML = the mismatch loss which for mid-path scattering is the square of the ratio of the RX beamwidth divided by the TX beamwidth.

The noise at the receiver is a function of three factors, sky noise, detector noise and pre-amp noise.

At the receiver end the key variables we can optimize are:

a. "A" receiver aperture light collecting area, which in our case is function of the size of the Fresnel lens used to collect the light. At present we use 395 x 395[3] mm square Fresnel lenses. A larger 1000 x 1000 mm square lens has been advertised but is not yet available. Potentially these would increase the area by a factor of 6.25 giving an optical gain of nearly 8 dBo and an improvement of 16 dBe in electrical S/N. However, these larger lenses have a focal length of 1000 mm which would for the same size APD increase the mismatch loss as discussed below and more than offset the increased capture area. However for other detector types the longer focal length lens may improve the mismatch loss (see table 2). The quantum efficiency of the detector also affects this parameters and this is discussed in section 4 below.

b. "ML" mismatch loss. To avoid mismatch loss we need to have a receiver Field of View (FOV) which matches that of the transmitter. Our present 100 mm square Avalanche Photo-Diode receiver is used with a 330 mm focal length 395 x 395 mm Fresnel lens giving an angular field of view of 1.6 degrees. This is somewhat less than the 2.2 degree beamwidth of our narrow beam transmitter producing a mismatch loss of around 3.5 dBe. We could in principle, reduce this mismatch loss by increasing the size of the APD although we are not aware of larger units and cost would be a factor. Also detector noise increases with area. In practical terms is seems that the only viable option is to reduce the focal length. There are 395 x 395 mm lenses available with 220 mm focal lengths[5] which would increase the FOV of our present system and eliminate the mismatch loss. A possible problem is that the rays from the outer edge of a very short focal length lens would arrive at the APD at a very steep angle and it has been suggested to us that this may result in a reduction in efficiency of the APD. At this stage all we can suggest is that the use of shorter focal length lenses is an avenue that is worth exploring. An associated issue is that the use of shorter focal length lenses allows the use of smaller and less noisy (as well as cheaper) APDs as discussed below in "e" (detector noise). We noted above that a 1000 x 1000mm square lens with 1000 mm focal length might become available and could increase the light capture and thus the electrical signal to noise ratio by around 16 dBe. However, with the existing 10 mm square APD the increase in focal length reduces the FOV from 1.6 degrees to around 0.5 degrees and the mismatch loss by around 19 dBe more than offsetting the gain from the increased capture area.

c. Detector Efficiency: Detectors such as PIN photo-diodes and APDs can be obtained with quantum efficiencies up to 0.85 at a specific wavelength representing a small loss of around 1.5 dB. While we have experimented with Photo Multiplier Tubes (PMT) these typically have a quantum efficiency of around 0.1 for red light representing an electrical loss of 20 dBe although we have not yet tested red/IR sensitive PMTs. While PMTs have the advantage of very high gain, large photocathode areas and very low internal noise which should help overcome such losses we have not yet compared them to large area APDs.

d. Sky noise: Sky noise arises primarily from "shot noise" from scattering of light from clouds. In city areas sky noise dominates over other sources with sensitive APD detectors, however away from city lights sky noise drops to a level comparable with other sources as discussed below. Even the light of the moon can be an issue if the cloud cover is thin or broken so it is best to operate at times when the moon is not above the horizon. Sky noise can be reduced by reducing the Field of View but this does require a corresponding reduction in TX beamwidth to avoid a mismatch loss and alignment becomes more difficult. Sky noise can also be decreased by narrow bandwidth optical filters as discussed in section 3.

e. Detector Noise: PMTs and PIN diodes have no significant detector noise, however APDs produce noise due to the avalanche process. For APDs detector noise may well be the limiting factor on a very dark night away from city lights with no moon. It is possible to reduce the APD detector noise by reducing the voltage and the gain, but at low gains pre-amp noise then becomes the limiting factor.

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3 http://www.3dlens.com/shop/largefresnellens.php

f. Pre-Amp Noise: PIN diodes have no gain and as a result pre-amp noise is the limiting factor. Low noise circuits have been developed by VK7MJ[4] and even lower by KA7OEI[5]. Even with APDs it is worth using as low a noise pre-amp as possible so the gain and thus the detector noise can be reduced to an acceptable level.

Cost is an important issue for amateurs. BPW34 PIN diodes cost only one to two US dollars and provide an inexpensive way of starting optical communications. Because of their low cost it is practical to construct a relatively large area detector as described in Section 5 using banks of 36 PIN diodes or more. At the time of printing a 5 mm square APD costs around $500 US and provides around 15 dB improvement over a bank of 36 PIN diodes and a 10 mm square APD costs around $1000 US and gives around 20 dB improvement over a bank of photo-diodes. The APDs require a low noise high voltage supply and these are available for about $50 US. PMTs are very expensive new but can be obtained surplus on EBay for $50 to $100 US and a 395 x 395 mm square Fresnel lens costs around $30 US.

In summary we are of the view that a 36 PIN photodiode array is a good introductory receiver for cloud bounce up to 100 km and while we have not constructed one yet we feel that a 5 mm APD is a good compromise between cost and performance for distances up to 200 km. The 395 x 395 mm Fresnel lenses with focal length of 220 mm is probably the optimum choice although we have not tested this combination yet.

3. Internal versus External Noise Limitations

In part 2[6] section 2.3 of this series three sources of noise in an optical receiver are identified. These sources can be further categorized to two types: 1). Internal noise due to the photodetector device and the amplifiers chain and 2). External noise which is noise contributed by the environment namely random photons scattered off the clouds or "shot" noise.

Figure 1: A good example of external shot noise – optical QRM in the form of Hobart (Tasmania, Australia) city lights scattered off the cloud base at night.

As mentioned above, noise reduction is the key strategy for improving the S:N and to achieve the best possible sensitivity we need to reduce the internal noise to below that of the external noise[7].

Preamp noise can be reduced by operating at very high input resistances such at Gohms. However, at such high input resistances the frequency response narrows considerably to a few hundred Hertz. Therefore, to widen the frequency response to provide the 1.5kHz required for WSJT[8] you need to decrease the load resistor with corresponding reduction in sensitivity. We have also found it necessary to

4 VK7MJ (http://modulatedlight.org/Modulated_Light_DX/modlightrx.html)

5 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

6 Rex Moncur, VK7MO and Paul Edwards VK7ZAS, "Over the Horizon Optical Communications – Part 2: Theory: Physics & Engineering Analysis" DUBUS 1/2009

7 Rogalski, A & Bielecki, Z – Detection of optical radiation – Bulletin of Polish Academy of Sciences – Technical Sciences Vol 52 No. 1 2004 (http://www.ippt.gov.pl/~bulletin/(52-1)43.pdf)

8 WSJT (http://www.physics.princeton.edu/pulsar/K1JT/)

operate above 800Hz due to the harmonics of AC line frequency from city lights. A happy medium needs to be found and for a good explanation take a look at the K3PGP[9] and KA7OEI[10] articles.

There also needs to be compromise between detector noise and pre-amp noise so one can further optimize S/N. To date we have found that running our APDs at high gains of 100 to 200 provides the best results. The detector noise of an APD is a function of the area of the detector and thus one should choose as small an APD as possible that will avoid a mismatch loss due to optical configuration.

Dependent on the environment the receivers are intended to be used in, it is good practice to mount all electronics in shielded boxes and feed signals to/from these boxes using RF feed through capacitors to prevent any unwanted RF energy from entering the circuitry. This is especially warranted if you will be operating the receiver on mountain tops with nearby high power TV and radio transmitters.

One optical method to reduce external noise is to filter the light before it enters the photodetector. In theory this would substantially reduce the amount of unwanted light. Most of the suburban lighting energy is down the blue-green end of the visible spectrum and therefore relatively inexpensive narrow band pass interference filters[11] (US$80-$140) could be used for exactly the wavelength of light being used i.e. 627nm. One issue with interference filters is they expect the rays of light to hit the filter perpendicular to the filter and with a narrow 220mm focal length Fresnel lenses the effectiveness of the filter will decrease due to the very steep angle of the rays entering the filter. Therefore, larger detectors with longer focal length lenses are more suited to filter utilization.

4. Photon Detectors, Field of View and Quantum Efficiency

As mentioned above the field of view is a function of the size of the detector and the focal length of the lens as demonstrated in figure 2.

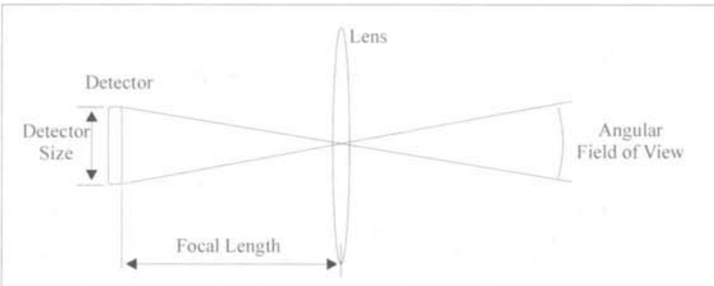

Figure 2: How receiver Angular Field of View is a function of Focal Length and the Size of the Detector

Table 2 compares the detectors and lens combinations we have been using and calculates the angular field of view that could be expected. The narrow transmitter beam width described in Part Three[12] of this series is currently 2.2 degrees and therefore to reduce the mismatch loss we are aiming for a similar field of view.

Quantum Efficiency (QE) is a percentage measure of photons entering the photodetector and producing an electron. While we used the standard BPW-34 which has a QE of around 50% at the wavelength used. There is a BPW-34B that has enhanced QE of 80% at 627nm. APDs are available with up to 85% QE at 627nm.

The photocathode material on the PMTs determine their quantum efficiency (see table 2 for S11, S20 and GaAs) and they are primarily made for the blue-green end of the visible spectrum and only have a QE of around 20%. Some PMTs have been produced for the IR end although the QE is still only 13% in the red spectrum. In equation 1 the receiver aperture or light collecting area (**A**) is the term reduced by the QE of photodetector.

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9 K3PGP (http://k3pgp.org/frontend1.htm)

10 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

11 Edmund Optics: (http://www.edmundoptics.com/)

12 Rex Moncur, VK7MO and Justin Giles-Clark VK7TW, "Over the Horizon Optical Communications – Part 3: Transmitters" DUBUS 2/2009

Type	Detector Size	Model	Detector Material	QE Blue	QE Red	Focal Length	Angular Field of View	Tested
	(mm)			%	%	(mm)	(degrees)	
APD	10	S8664 1010	Silicon	80	85	330	1.6	Tested
APD	10	S8664 1010	Silicon	80	85	220	2.6	Not Tested
APD	5	S8664 50k	Silicon	70	76	330	0.9	Tested
APD	5	S8664 50k	Silicon	70	76	220	1.3	Not Tested
36 Photo-diode	50	BPW34	Silicon	25	50	1000	2.9	Not Tested
36 Photo-diode	50	BPW34	Silicon	25	50	550	5.2	Tested
PMT	10	C31034A	PMT - GaAs	24	13	330	1.7	Not Tested
PMT	10	C31034A	PMT - GaAs	24	13	220	2.6	Not Tested
PMT	23	9524B	PMT S-11 Semi - transparent	15	1	550	2.4	Tested
PMT	44	9558B	PMT S-20 Semi-transparent	20	8	1000	2.5	Tested

Table 2: Detector and Focal Length Combination with resulting Angular Field of View.

5. Receiver Circuits

Circuit one presented here is the multi-photodiode receiver. The circuit is based on the KA7EOI receiver[13]. There is an array of 36 diodes which are organised into six rows of six photodiodes. Each photodiode has a dedicated FET with gate connected in free air to maintain a high input resistance and all FET drains paralleled together into a single cascode circuit with constant current source. This then feeds a unity gain opamp with each row output then being summed together into the differentiator and filter.

Circuit two is the APD receiver and again uses the KA7EOI circuit although it does not have a low pass filter. The APD has considerable gain due to avalanche multiplication from the process of impact ionization[14]. The avalanche is created by applying a high reverse bias voltage to bring the diode into the breakdown region. With the Hamamatsu S8664 APDs this is achieved with about 400VDC to achieve a gain of about 100. The power supply is a regulated low noise PSU that was sourced from Systems Development and Solutions[15].

Circuit 1 on the next page shows the schematic for the BPW-34 photodiode array receiver using the KA7EOI circuit[16].

The following Circuit 2 shows the schematic for the avalanche photodiode[17] receiver.

13 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

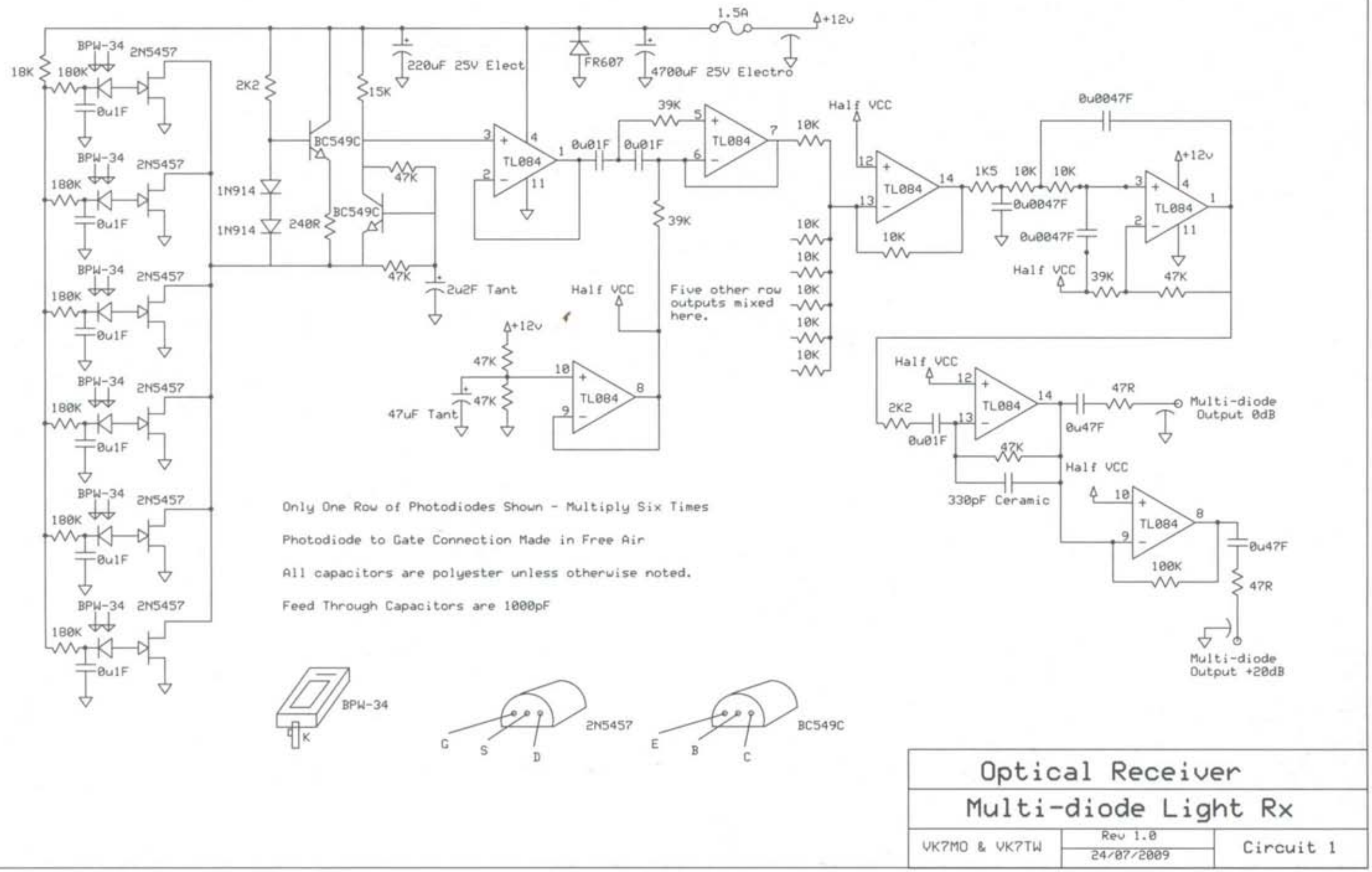
14 Donati, Silvano 2000 "Photodetectors Devices, Circuits and Applications" Prentice Hall PTR. NJ.

15 http://www.sdshv.com/PDF/produits/miniature-mountable-voltage-APDSeries.pdf

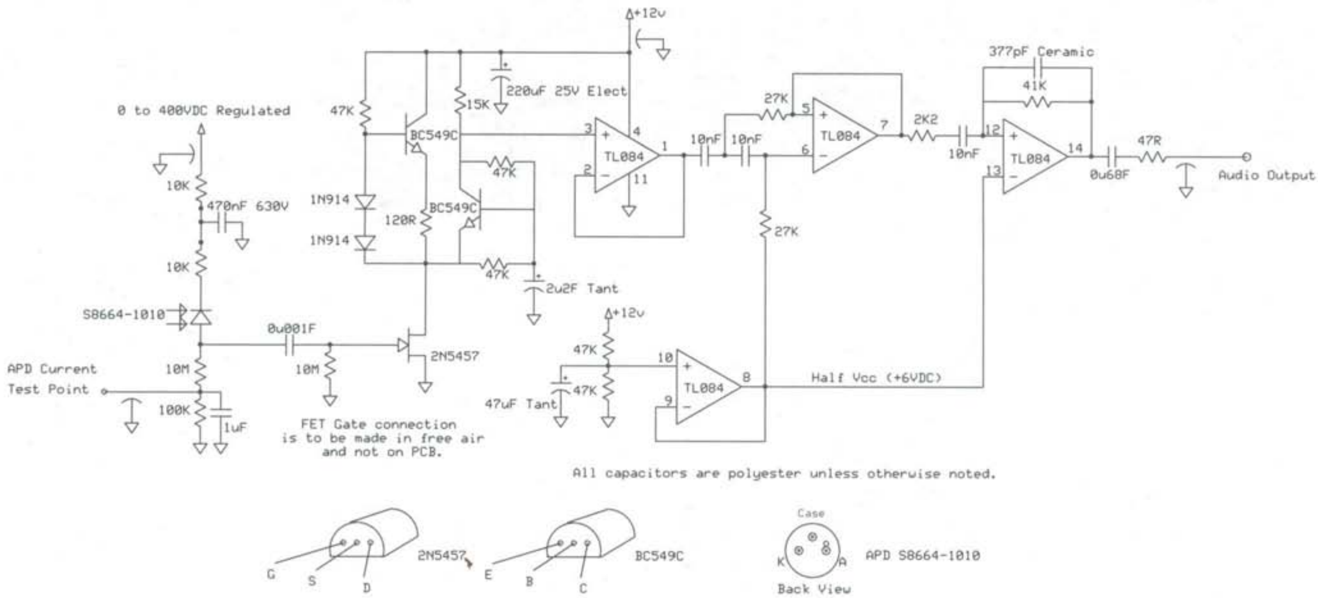
16 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

17 Hamamatsu data sheet S8664 series APDs http://sales.hamamatsu.com/assets/pdf/parts_S/S8664_series.pdf

Multi-photodiode light receiver based on KA7EOI circuit.



APD light receiver based on KA7EOI circuit.

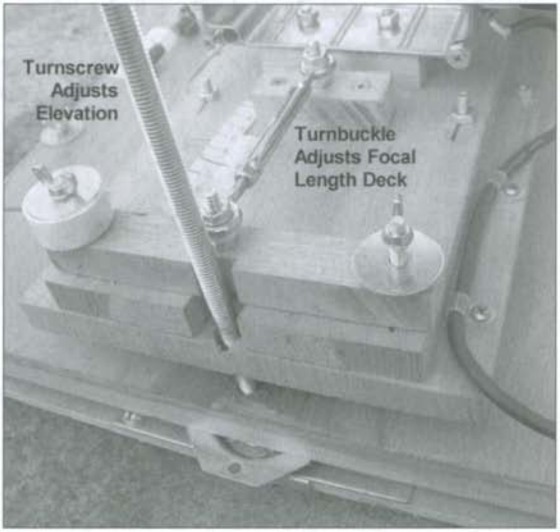


All capacitors are polyester unless otherwise noted.

Optical Receiver	
APD Light Rx	
VK7MO & VK7TW	Rev 1.0 04/07/2009	Circuit 2

7. Receiver Construction

We have split the receiver design pictures into three areas to provide a range of ideas about mechanical construction. The first area is what we will call the focal length deck. This area has the photodetector and receiver circuitry mounted on it and allows for the movement of the photodetector into the focal point of the Fresnel lens used.



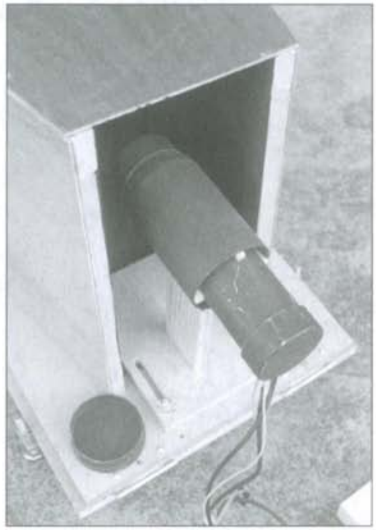


Figure 3: Precision Focal Length Deck Arrangement

Figure 4: Simplified Focal Length Deck Arrangement

The focal length deck in fig. 3 is styled much like the cross slide on a metalwork lathe and uses a chamfered slide which is adjusted by the turnbuckle for precise positioning and locking. For elevation adjustment the whole deck can be raised or lowered by a T-Nut and turn-screw to raise or lower the whole assembly. Figure 4 shows a simplified mounting and focal length adjustment for a PMT receiver. The larger capture area of the PMT allows for less critical focal length adjustment. A thick dark cloth is draped over the back of the box to prevent the entry of unwanted light into the back of the box. The PMT is mounted in a PVC tube that has been triple coated with black board paint which is then mounted in a larger PVC tube with a cap that can be used to protect the photocathode when not in use. The mounting of PMTs requires careful non-ferrous mounting techniques to prevent desensitizing the tube.

The second area shown is the actual surrounding box construction.

This box made from a pine frame and plywood for a short focal length (330mm) Fresnel lens. A rebate around the front surround holds the glass and Fresnel lens. The inclinometer allows direct reading of the elevation and the rifle scope is for sighting a distant landmark that aligns with the required path. The connection between the lens box and the electronics box is achieved by the use of speaker port tubes (see figure 6)[18] and this allows adjustment of focal length without ingress of stray light.

The Fresnel lenses are available from a range of manufacturers[19] [20] in a variety of configurations. Another cheap short focal length Fresnel lens source is from discarded overhead projectors which are being replaced these days with digital data projectors. The lens is secured to a piece of 3-4mm glass that is cut larger than the lens, with a very thin bead of neutral curing silicon adhesive all around the edge of the lens and a very small dot in the middle of the lens. Carefully place a heavy weight evenly on top of the glass/lens assembly until the silicon has cured. The lens can then be mounted into the box. Some boxes use a rebate and some have a slot that the glass slides into. Coat the inside of the box with black board or matte black paint to prevent internal reflections within the box.

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18 Eg. http://jaycar.com.au/productView.asp?ID=CX2684

19 http://www.bhlens.com/

20 http://www.3dlens.com/

Figure 5: Side View of 330mm APD Receiver

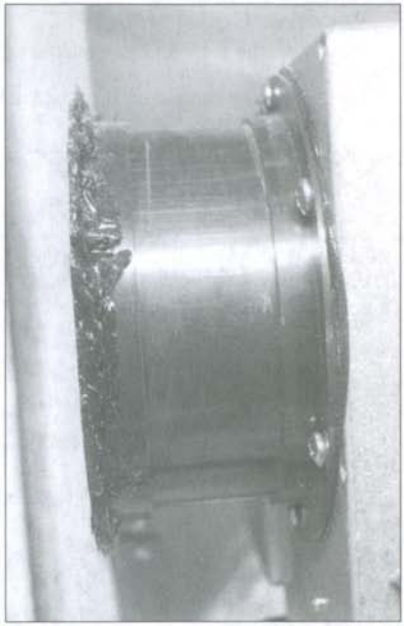

Figure 6: Speaker Tube Connector

Figure 7: Side view of the PMT 550mm FL box with sighting tube

Figure 7 is a quick build simplified box construction with pine frame, plywood and slotted frame for glass/lens mount. Elevation is a simple door hinge arrangement and leveling is undertaken with screw adjustable feet. Plywood could be replaced with thick cardboard to reduce weight and cost and taped together with heavy duty duct tape[21].

Another method for simple light weight enclosure could be made using minimal lens and photodetector mounts with stiff wire frames to support thick black cloth limiting extraneous light.
Azimuth adjustment is provided by a pivot point under each of these units that sit on a base board. The base board has angle measurements drawn on to it in the form of a large protractor.

[21] http://solutions.3m.com/wps/portal/3M/en_US/home_office/home/product_information/repair_maintenance/duct_tape/

The third area is the electronics. In Part 1 of this series in figure 1[22] it shows the matrix board construction of the 36 Multi-diode receiver circuit board. Dependent on the method of wiring we recommend the electronics is mounted in supporting metal boxes. These would provide shielding and mechanical stability for portable operation. RF feed through capacitors would reduce the ingress of RF when using the receivers in locations on mountain tops where high power TV and radio transmitters may also be located. The use of high power reverse polarity diode and fuses or circuit breakers will hopefully lessen disappointment.

8. Operation of Receivers

Google Earth can be used to determine the path and then look for any landmarks on the path to enable sighting to the landmark. If there are no landmarks on the path but there are landmarks close to the path then measure the angle between your location and the landmark and then sight with the rifle scope or sighting tube and using the protractor or arc scale base turn the receiver the required angle.
Cloud height measurements determine the elevation dependent on the distance of the contact and these can be obtained for many places throughout the world from the University of Wyoming[23].
It is useful to do a dark test to see how close we are to the external noise limit. We measure the noise level looking at the clouds and then cover the lens and note the difference using the Spectrum Laboratory application[24].

9. Discussion and Conclusions

The key areas of over the horizon optical communications receivers relate to matching the field of view to the transmitter and reducing the effects of internal and external noise to maximise the signal to noise ratio. The materials and construction methods are not beyond the average amateur constructor and we certainly encourage the development of more efficient and effective methods.
We hope the photographs, information and descriptions will be sufficient to guide potential constructors to try and make a receiver. In the last two parts we have attempted to provide the key elements of the theory and some practical examples of how these contribute and relate to building non-line-of-sight optical communications systems.

We would like to hear from anyone who attempts construction of the transmitters and receivers presented in these articles and our contact email addresses can be found on the first page of this part.

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22 Rex Moncur, VK7MO, Justin Giles-Clark, VK7TW and Ken Sulman, VK7DY, "Over the Horizon Optical Communications – Part 1: Overview and Practical Results" DUBUS 4/2008

23 http://weather.uwyo.edu

24 http://freenet-homepage.de/dl4yhf/spectra1.html

Überhorizont-Kommunikation im optischen Bereich
Teil 4: Empfänger

von Justin Giles-Clark, VK7TW and Rex Moncur, VK7MO

1. Empfänger-Optionen

In diesem vierten und letzten Teil des Artikels untersuchen wir Probleme, die das Design von optischen Empfängern für Überhorizont-Kommunikation beeinflussen und liefern Informationen und Fotos, die ausreichend sein sollten, um Empfänger und zugehörige Schaltungen nachzubauen. Tabelle 1 zeigt einige Optionen für Empfänger und deren Leistungsfähigkeit.

Empfänger	Größe (mm)	Effektive Fläche (mm^2)	Winkel-Sichtfeld (Grad)	Linsen-Maße & Fokus-Länge (mm)	Relative Leistung (dB)
36 BPW-34 PIN Photodioden	50#	262	5	395 x395 550FL	0 *
S8664-50k Avalanche Photo-Diode (APD)	5	20	0.8	395 x 395 330FL	+15 **
S8664-50k Avalanche Photo-Diode	5	20	1.2	395 x 395 220FL	+20 ##
S8664-1010 Avalanche Photo-Diode	10	100	1.6	395 x 395 330FL	+22 *
S8664-1010 Avalanche Photo-Diode	10	100	2.4	395 x 395 220FL	+25 ##

Breite des Systems der Photodioden.
* Diese Empfänger wurden aufgebaut und bei unseren Tests verwendet und sind die Basis für die Nachbau-Informationen und Schaltungen in diesem Artikel.
** Diese Einheit ist identisch mit der 10 mm APD mit 330 mm Fresnellinse mit Ausnahme der APD.
Nur geschätzte Leistung, da diese nicht aufgebaut wurden.

Tabelle 1

2. Theoretische und praktische Überlegungen

Beim Empfänger ist der Schlüssel das Signalrauschverhältnis zu verbessern. Optisch beschrieben ist das Signal eine Funktion der empfangenen Leistung P_R, wie in Gleichung 12 im Teil 2 dieser Serie[1] beschrieben:

$$P_R = P_T - 65 - 20 \log(d) + G_s + 10 \log(A) - e.d - 10 \log(ML) \qquad \textbf{Gleichung 1}$$

mit:

- P_R = Empfangene Leistung in dBW_o[2], d.h. bezogen auf 1W (optische Leistung)
- P_T = Effektivleistung des Senders in dBW_o
- d = Entfernung (km)
- G_s = Scattergewinn in dB_i, d.h. bezogen auf einen isotropen Scatter(punkt)

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[1] Rex Moncur, VK7MO and Paul Edwards VK7ZAS, "Over the Horizon Optical Communications – Part 2: Theory: Physics & Engineering Analysis" DUBUS 1/2009

[2] Nomenklatur der Leistung – "o" = optische Lesitung, "e" = elektrische Leistung

A = lichtsammelnde Öffnungsfläche des Empfängers in Quadratmetern
e = Extinktionsverlust in dB_o pro km
ML = Winkelmißverhältnis zwischen illuminierter und sichtbarer Wolke (Flächenverhältnis) bei Scattern im Streckenmittelpunkt; das Verhältnis von RX zu TX-Öffnungswinkel zum Quadrat

Das Rauschen im Empfänger ist eine Funktion von 3 Faktoren, dem Himmelsrauschen, dem Detektorrauschen und dem Rauschen des Vorverstärkers.

Beim Empfänger sind die Schlüsselvariablen, die man optimieren kann:

a. "A", die lichtsammelnde Öffnungsfläche des Empfängers, die in unserem Fall eine Funktion aus der Größe der Fresnel-Linse ist, die das Licht sammelt. Momentan verwenden wir quadratische 395 x 395mm Fresnel-Linsen[3]. Eine größere quadratische 1000 x 1000 mm Linse wurde angekündigt, ist aber noch nicht lieferbar. Potentiell würden diese die Fläche um den Faktor 6.25 vergrößern und einen optischen Gewinn von fast 8 dBo ergeben, was einer Verbesserung von 16 dBe beim elektrischen S/N entspricht. Diese größeren Linsen haben aber eine Fokallänge von 1000 mm, was für ein APD gleicher Größe den Anpasssungsverlust, wie weiter unten diskutiert, vergrößert und die vergößerte Fläche A mehr als aufhebt. Bei anderen Detektor-Typen jedoch kann die längere Fokallänge den Anpassungsverlust verbessern (siehe Tabelle 2). Die Quanten-Effektivität des Detektors hat auch Einfluß auf diese Parameter und wird unter Punkt 4 weiter unten diskutiert.

b. "ML" Anpassungsverlust. Um einen Anpassungsverlust zu vermeiden, benötigen wir einen Empfänger mit einem Sichtfeld (FOV), das zu dem des Senders passt. Unser jetziger quadratischer 100 mm Avalanche-Photodioden-Empfänger arbeitet mit einer 395 x 395 mm Fresnellinse mit 330 mm Fokallänge, die ein Winkelfeld von 1.6 Grad ergibt. Das ist etwas weniger als die 2.2 Grad Öffnungswinkel unseres Senders mit engem Öffnunswinkel, was einen Anpassungsverlust von etwa 3.5 dBe ausmacht. Prinzipiell könnten wir diesen Verlust durch Vergrößern der Größe des APD verringern, uns sind aber keine größeren Einheiten bekannt und Kosten würden dann sicher auch ein Faktor. Auch das Detektorrauschen steigt mit der Fläche an. Unter praktischen Gesichtspunkten scheint es, dass die einzige machbare Option ist, die Fokallänge zu reduzieren. Es gibt 395 x 395 mm Linsen mit 220 mm Fokallänge[5], die das FOV unseres jetzigen Systems vergößern würde und den Anpassungsverlust eliminieren würde. Ein mögliches Problem besteht darin, dass die Strahlen vom äußeren Bereich einer Linse mit sehr kurzer Fokallänge in einem sehr steilen Winkel auf den APD fallen und es wurde uns gesagt, dass dies in einer verringerten Effektivität des APD resultieren könnte. Mit jetzigem Stand können wir nur darauf hinweisen, dass die Verwendung von Linsen mit reduzierter Fokallänge eine Möglichkeit ist, die es Wert ist erforscht zu werden. Ein dazugehöriger Punkt ist, dass die Verwendung von Linsen mit kürzerer Fokallänge die Verwendung von kleineren und rauschärmeren (und auch billigeren) APDs ermöglicht, wie unten in e. diskutiert werden wird (Detektorrauschen). Wir haben oben darauf hingewiesen, dass quadratische Linsen von 1000 x 1000mm mit 1000 mm Fokallänge eventuell verfügbar werden und die Licht einfangende Fläche vergößern können und damit das elektrische Signalrauschverhältnis um etwa 16 dBe. Mit den vorhandenen quadratischen 10mm APDs reduziert die größere Fokallänge das Sichtfeld FOV von 1.6 auf etwa 0.5 Grad und den Anpassungsverlust um etwa 19 dBe, was mehr als der zusätzliche Gewinn durch die vergrößerte Fläche ist.

c. Detektor-Effektivität: Detektoren wie PIN-Photodioden und APDs können mit Quanteneffektivitäten von bis zu 0.85 bei spezifischen Wellenlängen erhalten werden, was einen kleinen Verlust von etwa 1.5 dB darstellt. Während wir mit Photo-Multiplier-Röhren (PMT) experimentierten, haben diese typisch eine Quanteneffektivität von 0.1 bei rotem Licht gezeigt, was einem elektrischen Verlust on 20 dBe entspricht. Wir haben aber noch keine speziell rot/IR-empfindlichen PMTs getestet. Obwohl PMTs den Vorteil von sehr hoher Verstärkung, einer großen Photokathodenfläche und sehr niedrigem internen Rauschen haben, was helfen sollte, solche Verluste zu vermeiden, haben wir sie noch nicht mit den großflächigen APDs verglichen.

d. Himmelsrauschen: Himmelsrauschen rührt primär from "Schrotrauschen" durch Streuung von Licht an Wolken. In Stadtgebieten überwiegt das Himmelsrauschen andere Rauschquellen bei Verwendung empfindlicher APD-Detektoren. Von den Lichtern der Stadt entfernt jedoch, fällt das Himmesrauschen auf ein Niveau ab, das mit anderen Quellen vergleichbar ist, wie weiter unten diskutiert wird. Sogar das Mondlicht kann ein Faktor werden, wenn die Wolkendecke dünn oder durchbrochen ist. So ist es am besten dann zu arbeiten, wenn der Mond unter dem Horizont ist.

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[3] http://www.3dlens.com/shop/largefresnellens.php

Himmelsrauschen kann reduziert werden, wenn das Sichtfeld (FOV) verkleinert wird, aber das erfordert eine entsprechende Reduzierung des TX-Öffnungswinkels, um einen Anpassungsverlust zu vermeiden und auch die Ausrichtung wird schwieriger. Himmelsrauschen kann auch durch schmalbandige optische Filter reduziert werden, wie in Abschnitt 3 diskutiert werden wird.

e. Detektorrauschen: PMTs und PIN-Dioden weisen kein signifikantes Detektorrauschen auf. APDs aber produzieren Rauschen durch den Avalanche-Prozess. Bei APDs kann das Detektorrauschen in einer sehr dunklen Nacht ohne Mond weit entfernt von der Stadt zum limitierenden Faktor werden. Es ist möglich, das APD-Detektorrauschen durch Reduzieren der Spannung und der Verstärkung zu verringern, bei kleiner Verstärkung wird dann aber das Vorverstärkerrauschen zum limitierenden Faktor..
f. Vorverstärkerrauschen: PIN-Dioden haben keine Verstärkung und damit wird das Vorverstärkerrauschen zum begrenzenden Faktor. Rauscharme Schaltungen wurden von VK7MJ[4] entwickelt und noch rauschärmere von KA7OEI[5]. Sogar bei APDs lohnt es sich, einen so rauscharmen Vorverstärker wie möglich zu verwenden, so dass Verstärkung und damit das Detektorrauschen auf eine akzeptables Niveau reduziert werden können.

Kosten sind ein wichtiger Aspekt für Funkamateure. Die BPW34 PIN-Diode kostet nur 1 bis 2 US Dollar und ermöglicht einen günstigen Weg mit optischer Kommunikation zu beginnen. Wegen der geringen Kosten ist es praktisch, einen relativ großflächigen Detektor zu bauen, wie in Abschnitt 5 beschrieben, der Bänke von 36 PIN-Dioden oder mehr verwendet. Zum Zeitpunkt der Erscheines dieses Artikels kostet ein quadratischer 5 mm APD etwa 500 USD und bringt etwa 15 dB Verbesserung gegenüber einer Bank mit 36 PIN-Dioden. Ein quadratischer 10 mm APD kostet etwa 1000 USD und bringt etwa 20 dB Verbesserung gegenüber der Bank von Photodioden. Die APDs benötigen ein rauscharmes Hochspannungsnetzteil, das für etwa 50 USD erhältlich ist. PMTs sind neu sehr teuer, können aber gebraucht bei Ebay für 50 bis 100 USD ersteigert werden. Eine Fresnellinse von 395 x 395mm kostet etwa 30 USD.

Zusammengefasst sind wir der Meinung, dass ein Array mit 36 PIN-Dioden einen guten Empfänger ergeben für Wolkenscatter bis zu 100 km Entfernung und, obwohl wir das bisher noch nicht konstruiert haben, glauben wir, dass ein 5mm APD ein guter Kompromiss zwischen Kosten und Leistung für Entfernungen bis zu 200 km darstellt. Die 395 x 395 mm Fresnellinse mit 220mm Fokallänge ist wahrscheinlich die optimale Lösung, aber auch diese haben wir in dieser Kombination noch nicht getestet.

3. Vergleich interner gegenüber externen Begrenzungen beim Rauschen

In Teil 2[6], Abschnitt 2.3, dieser Artikelserie haben wir drei Quellen von Rauschen in einem optischen Empfänger identifiziert. Diese Quellen können weiter in zwei Typen eingeteilt werden:
1). Internes Rauschen aufgrund des Photodetektor-Bauteils und der Verstärkerkette und 2). Externes Rauschen, das Rauschen ist, welches aus der Umgebung kommt in Form von zufälligen Photonen, die an Wolken reflektiert wurden bzw. in Form von „Schrotrauschen".

Abb. 1: Ein gutes Beispiel von externem Schrotrauschen – optisches QRM in Form von Licht aus der Stadt Hobart (Tasmanien, Australien), das an der Wolkenunterseite reflektiert wird.

Wie oben erwähnt, ist das Absenken des Rauschens die Schlüsselstrategie um das Signalrauschverhältnis zu verbessern. Um die bestmögliche Empfindlichkeit zu erreichen, müssen wir das interne Rauschen unter das externe Rauschen absenken[7].

Das Vorverstärkerrauschen kann reduziert werden, indem man mit sehr hohen Eingangswiderständen im Gigaohm-Bereich arbeitet. Allerdings wird die Bandbreite bei solch hohen Imdedanzen sehr schmal bis zu wenigen hundert Hertz. Desalb muss der Arbeitswiderstand abgesenkt werden, damit der Frequenzgang die 1.5 KHz ermöglicht, die für WSJT[8] benötigt werden, was wieder mit einer entsprechenden Verminderung der Empfindlichkeit einher geht.

4 VK7MJ (http://modulatedlight.org/Modulated_Light_DX/modlightrx.html)

5 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

6 Rex Moncur, VK7MO and Paul Edwards VK7ZAS, "Over the Horizon Optical Communications – Part 2: Theory: Physics & Engineering Analysis" DUBUS 1/2009

7 Rogalski, A & Bielecki, Z – Detection of optical radiation – Bulletin of Polish Academy of Sciences – Technical Sciences Vol 52 No. 1 2004 (http://www.ippt.gov.pl/~bulletin/(52-1)43.pdf)

8 WSJT (http://www.physics.princeton.edu/pulsar/K1JT/)

Wir haben auch herausgefunden, dass es nötig ist, oberhalb von 800 Hz zu arbeiten, aufgrund der Harmonischen der Wechselstromfrequenz der Straßenbeleuchtungen. Es muss ein glücklicher Mittelweg gefunden werden und gute Erklärungen sind in den Artikeln von K3PGP[9] und KA7OEI[10] zu finden.
Auch wird ein Ausgleich zwischen Detektorrauschen und Vorverstärkerrauschen benötigt, so dass man das S/N weiter optimieren kann. Bis jetzt haben wir herausgefunden, dass das Betreiben des APDs bei hohen Verstärkungen von 100 bis 200 die besten Resultate bringt. Das Detektorrauschen eines APD ist eine Funktion der Fläche des Detektors und deshalb sollte man ein APD wählen, der so klein wie möglich ist, bei der Vermeidung des Fehlanpassungsverlustes aufgrund der optischen Konfiguration.
Abhängig von der Umgebung des Empfängers, in der er betrieben werden soll, ist es eine gute Angewohnheit, die gesamte Eektronik in abgeschirmten Gehäusen einzubauen und die Signale in und aus diesen Geäusen mittels HF-Durchführungskondensatoren zu führen, um jegliche unerwünschte HF von der Elektronik fern zu halten. Das ist besonders gerechtfertigt, wenn man den Empfänger auf Berggipfeln betreiben will, wo eventuell auch andere (TV)-Sender hoher Leistung o.ä. stehen.
Eine optische Methode, um externes Rauschen zu reduzieren, ist das Filtern des Lichtes bevor es den Photodetektor erreicht. In der Theorie soll dies die Menge unerwünschten Lichtes substantiell reduzieren.
Das meiste der städtischen Lichtenergie liegt im unteren blau-grünen Ende des sichtbaren Spektrums und deshalb können relativ günstige, enge Passband-Interferenzfilter[11] (80 bis 140 USD) verwendet werden für exakt die Wellenlänge des Lichtes, die verwendet wird, d.h. 627nm. Ein Problem bei den Interferenzfiltern besteht darin, dass das Licht lotrecht auf das Filter auftreffen sollte. Mit einer Fresnellinse von 220mm Fokallänge wird die Effektivität des Filters sinken, aufgrund des sehr steilen Winkels, mit dem die Strahlen auf das Filter fallen. Deshalb sind größere Detektoren mit Linsen größerer Fokallänge besser geeignet für den Betrieb mit Filtern.

4. Photonen-Detektoren, Sichtfeld und Quanten-Effektivität

Wie oben erwähnt, ist das Sichtfeld eine Funktion aus der Größe des Detektors und der Fokallänge der Linse, wie in Abb. 2 gezeigt.

Abb. 2: Das Winkel-Sichtfeld ist eine Funktion von Fokallänge und Größe des Detektors

Tabelle 2 vergleicht die Detektoren und Linsen-Kombinationen, die wir verwendet haben und gibt berechnete Werte für das Sichtfeld an, die erwartet werden können. Der Sender mit schmalem Öffnungswinkel, den wir in Teil 3 dieser Serie[12] beschrieben haben, hat 2.2 Grad Öffnungswinkel und, um den Anpassungsverlust zu reduzieren, wollen wir ein ähnliches Sichtfeld erzielen.

Die Quenteneffektvität (QE) ist ein prozentualer Wert für die Photonen, die in den Photodetektor eindringen und dort eine Elektron produzieren. Wir haben hier die normale BPW-34 verwendet, die eine QE von etwa 50% bei der benutzten Wellenlänge hat. Es gibt die BPW-34B, die eine bessere QE von 80% bei 627nm hat. Es gibt APDs mit einer QE von bis zu 85% bei 627nm.

Das Photokathodenmaterial der PMTs bestimmt deren QE (siehe Tabelle 2 bei S11, S20 und GaAs) und sie sind primär ausgelegt für das blau-grüne Ende des sichtbaren Spektrums und haben eine QE von nur etwa 20%. Einige PMTs wurden für das IR-Ende hergestellt und dennoch ist die QE immer noch nur 13% im roten Spektralbereich. In Gleichung 1 ist die Empfänger-Öffnung oder Licht sammelnde Fläche (**A**) der Term, der durch die QE des Photodetektors reduziert wird.

Tabelle 2: Detektoren und Kombinationen verschiedener Fokallängen mit den resultierenden Sichtfeldern (Field of View). Siehe im engl. Text oben.

5. Empfängerschaltungen

Die hier vorgestellte Schaltung 1 ist der Multi-Photodioden-Empfänger. Sie basiert auf dem Empfänger von KA7EOI[13]. Es handelt sich um ein Array von 36 Dioden, das aus 6 Reihen von je 6 Dioden besteht. Jede Photodiode hat einen zugehörigen FET, der mit dem Gate in der Luft angeschlossen ist, um einen

9 K3PGP (http://k3pgp.org/frontend1.htm)

10 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

11 Edmund Optics: (http://www.edmundoptics.com/)

12 Rex Moncur, VK7MO and Justin Giles-Clark VK7TW, "Over the Horizon Optical Communications – Part 3: Transmitters" DUBUS 2/2009

13 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

hohen Eingangswiderstand zu gewährleisten. Alle Drains der FETs werden parallel zusammen geschlossen an einen einzigen Cascode-Verstärker mit Konstantstromquelle. Das Signal gelangt dann in einen OP-Amp mit der Verstärkung 1, für jeden Ausgang einer 6er-Reihe, der dann zusammenaddiert wird im Differenzierer und Filter.
Schaltung 2 ist der APD-Empfänger und hier wird wieder die Schaltung von KA7EOI verwendet, aber es gibt bei uns kein Tiefpassfilter. Der APD hat eine bemerkenswerte Verstärkung durch die Avalanche-Multiplizierung aufgrund des Prozesses der Einschlags-Ionisierung[14]. Die Lawine (avalanche) wird ermöglicht durch Anlegen einer hohen umgekehrten Vorspannung, die die Diode in die Durchbruchsregion bringt. Beim Hamamatsu S8664 APD geschieht dies bei etwa 400VDC, um einen Verstärkung von etwa 100 zu erreichen. Die Stromversorgung ist ein geregeltes rauscharmes Netzteil, das von Systems Development and Solutions[15] stammt.

Schaltung 1 zeigt das Schaltbild für das Array mit den BPW-34 Photodioden nach KA7EOI[16]

Schaltung 2 zeigt das Schaltbild für den Avalanche-Photodioden-Empfänger[17]

7. Bau des Empfängers

Wir haben die Bilder zum Empfänger-Design in drei Bereiche aufgeteilt, um einen Auswahl von Ideen für die mechanische Konstruktion abzudecken. Den ersten Bereich haben wir Fokallängen-Vorrichtung genannt. Auf dieser Vorrichtung wird der Photodetektor und die Empfängerschaltung montiert und sie ermöglicht die Bewegung des Photodetektors in den Fokalpunkt der verwendeten Fresnel-Linse.

Abb. 3: Präzisions-Vorrichtung für die Einstellung der Fokallänge
Abb. 4: Einfache Vorrichtung für die Einstellung der Fokallänge

Die Präzisions-Fokallängen-Vorrichtung in Abb. 3 sieht ähnlich aus wie der Querschlitten einer Drehbank und verwendet einen abgeschrägten Schlitten, der mittels Seilspanner für präzise Position und Einrastung justiert wird. Für die Einstellung der Elevation kann die komplette Vorrichtung mittels einer Gewindestange und Mutter angehoben und gesenkt werden. Abb. 4 zeigt eine einfache Vorrichtung für die Fokallängenjustierung eines PMT-Empfängers.

Die größere Fläche der PMT erlaubt eine weniger kritische Fokallängenjustierung. Ein dickes dunkles Stück Stoff wird über der Rückseite des Kastens drappiert, um den Eintritt unerwünschten Lichtes von hinten in den Kasten zu verhindern. Die PMT ist in ein PVC-Rohr montiert, das dreifach mit schwarzer Farbe gestrichen wurde und in ein weiteres größeres PVC-Rohr montiert wird, das eine Kappe hat und die Photokathode schützt, wenn sie nicht benutzt wird. Die Montage von PMTs erfordert sorgfältige Techniken ohne Verwendung eisenhaltiger Materialen, um ein Desensibilisieren der Röhre zu verhindern.

Der zweite gezeigte Bereich umfasst die umgebende Gehäuse-Konstruktion.

Der Kasten hier wurde aus einem Rahmen aus Kieferholz sowie aus Sperrholz für eine Fresnel-Linse mit kurzer Fokallänge (330mm) hergestellt. Ein Falz um die Frontumrandung hält das Glas und die Fresnellinse. Das Inklinometer erlaubt das direkte Ablesen der Elevation und das Zielfernrohr ist zum Anpeilen einer entfernten Geländemarke, die direkt in der betreffenden Strecke liegt.
Die Verbindung zwischen dem Linsen-Kasten und dem Kasten mit der Elektronik wird mittels Verbindungsrohren aus dem Lautsprecherbereich gemacht (siehe Abb. 6)[18] und dies erlaubt die Justierung der Fokallänge, ohne dass Streulicht einfällt.
Die Fresnel-Linsen gibt es von verschiedenen Herstellern[19] [20] in verschiedenen Ausführungen. Eine andere Quelle für billige Fresnel-Linsen sind ausgemusterte Overhead-Projektoren, die zur Zeit oft gegen digitale Datenprojektoren ausgetauscht werden. Die Linse wird durch ein Stück 3-4mm dickes Glas geschützt, das größer als die Linse ist, und mit neutralem Silikonkleber in dünner Schicht um den ganzen Rand der Linse und einem kleinen Punkt in der Mitte der Linse verklebt wird. Man stellt vorsichtig ein

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14 Donati, Silvano 2000 "Photodetectors Devices, Circuits and Applications" Prentice Hall PTR. NJ.

15 http://www.sdshv.com/PDF/produits/miniature-mountable-voltage-APDSeries.pdf

16 KA7OEI (http://modulatedlight.org/optical_comms/optical_rx1.html)

17 Hamamatsu data sheet S8664 series APDs http://sales.hamamatsu.com/assets/pdf/parts_S/S8664_series.pdf

18 Eg. http://jaycar.com.au/productView.asp?ID=CX2684

19 http://www.bhlens.com/

20 http://www.3dlens.com/

Gewicht gerade auf die Glas-Linsen-Kombination solange bis das Silikon ausgehärtet ist. Dann kann die Linse in den Kasen eingebaut werden. Einige Kästen haben einen Falz, andere eine Nut, in die das Glas eingeschoben werden kann. Die Innenseite des Kastens wird mit schwarzen Brettern verkleidet oder mattschwarz angestrichen, um Reflektionen im Kasten zu verhindern.

Abb. 5: Seitenansicht des 330mm APD-Empfängers ***Abb. 6: Lautsprecherrohr-Verbindung***

Abb. 7: Seitenansicht des PMT 550mm Gehäuses mit Sehrohr

Abb. 7 zeigt einen schnell zu bauenden einfachen Kasten aus einem Kieferholzrahmen und Sperrholzplatten und einem geschlitzten Rahmen für die Glas/Linsen-Montage. Die Elevation wird mittels eines einfachen Türscharniers gemacht und die Einstellung mittels höhenverstellbaren Füßen. Das Sperrholz könnte auch durch dicken Pappkarton ersetzt werden, um Gewicht und Geld zu sparen. Das ganze wird dann mit starkem Gewebeklebeband zusammengeklebt[21].

Eine andere Methode für eine einfache leichte Umhüllung mit minimalem Montageaufwand für Linse und Photodetektor wäre ein Drahtrahmengestell, um das dicker schwarzer Stoff angebracht wird, um Licht von außen abzuhalten. Die Azimut-Einstellung wird an einem Drehpunkt unter jeder dieser Einheiten vorgenommen, der auf der Basisplatte sitzt. Die Basisplatte hat einen Gradkreis aufgezeichnet in der Form eines großen Winkelmessers.

Der dritte Bereich ist der der Elektronik. Teil 1 dieses Artikels zeigt in Abb. 1[22] das Matrixboard für die Konstruktion des Empfängers mit den 36 Dioden. Abhängig von der Art der Verdrahtung empfehlen wir den Einbau in ein Metallgehäuse. Dieses gewährleistet elektrische Abschirmung und mechanische Stabilität bei Portabel-Einsatz. Durchführungskondensatoren sorgen für HF-Dichtigkeit, wichtig, wenn man sich in der Nähe starker Sender befindet. Verpolungsschutzdioden, Sicherungen und Schalter helfen Enttäuschungen zu begrenzen.

8. Betrieb des Empfängers

Google Earth kann benutzt werden, um den Pfad zu bestimmen und markante Orientierungspunkte zu finden, die gesehen werden können. Wenn solche Orientierungspunkte nicht direkt auf dem Pfad liegen, sucht man solche, die etwas daneben liegen und bestimmt den Winkel zwischen eigenem Standort und Punkt. Mit dem Zielfernrohr oder Sehrohr sucht man dann diesen Punkt und dreht den Empfänger um den entsprechenden Winkel mit Hilfe der Gradskala zurück auf den Pfad.
Messungen der Wolkenhöhe bestimmen die Elevation in Abhängigkeit von der Entfernung des Kontakts und diese können für viele Orte auf der Welt von der Universität von Wyoming erhalten werden[23].
Es ist nützlich einen Dunkel-Test zu machen, um zu sehen, wie nah man am Limit des externen Rauschens ist. Wir messen den Rauschpegel an den Wolken und bedecken dann die Linse und lesen die Differenz in der Software Spectrum Lab ab[24].

9. Diskussion und Fazit

Der Erfolgsschlüssel für Empfänger für Überhorizont-Kommunikation im optischen Bereich liegt in der Abstimmung des Sichtfeldes an den Sender und im Reduzieren von internem und externem Rauschen, um das SNR zu verbessern. Die Materialen und Baumethoden liegen nicht außerhalb des Bereiches, der für den Durchschnittsamateur möglich ist, und wir unterstützen mit Sicherheit die Entwicklung noch effektiverer Methoden. Wir hoffen, dass die Fotos, Informationen und Beschreibungen ausreichend sind, um potentielle Konstrukteure anzuleiten, den Bau eines Empfängers zu versuchen. In den beiden vorhergehenden Teilen haben wir versucht, die wichtigsten Elemente der Theorie zu vermitteln sowie einige praktische Beispiele gegeben, wie diese dazu beitragen Nicht-Sichtlinien-Kommunikationssysteme im optischen Bereich zu ermöglichen. Wir würden gerne von jedem hören, der versucht, die hier präsentierten Sender und Empfänger nachzubauen. Die Email-Adresse befindet sich oben am Anfang des Artikels.

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21 http://solutions.3m.com/wps/portal/3M/en_US/home_office/home/product_information/repair_maintenance/duct_tape/

22 Rex Moncur, VK7MO, Justin Giles-Clark, VK7TW and Ken Sulman, VK7DY, "Over the Horizon Optical Communications – Part 1: Overview and Practical Results" DUBUS 4/2008

23 http://weather.uwyo.edu

24 http://freenet-homepage.de/dl4yhf/spectra1.html

241 GHz Mixer Head for direct offset dish mount

by Jürgen Dahms, DCØDA, Vinklöther Mark 48, D-44265 Dortmund

Thanks to Philipp Prinz, DL2AM, the difficult techniques for constructing a 241 GHz station have been explained in DUBUS issue 1/2009. In the meantime I have built a RX mixer and a CW TX in separate cases for portable use according to the same frequency concept. Receiver sensitivity and TX output power are equal to the setup from Philipp. At the beginning many tests were made in the near field. As a first step for this, a 241 GHz signal source was necessary in order to be able to optimise the RX mixer. Starting from 24 GHz a simple x10 multiplier was built with the board Nr. 37 – "PCB 241 GHz Mixer" (DUBUS 2/1994) from DB6NT (1). As multipling diode a M/A COM 1317 was used.

The second step was to build the complete mixer head in a sandwich structure, that is described in this article. For the first field tests, this head was designed to be attached with its 241 GHz flange directly to the corrugated horn radiator of an offset dish.

Construction of the 241 GHz mixer head

Figures 1, 2 and 5 show views of the mixer head from three different directions. You will need to study all three views to understand how the major modules are assembled. I have described the details of this type of milled casing construction with integrated waveguides in DUBUS 1/2007, page 55.

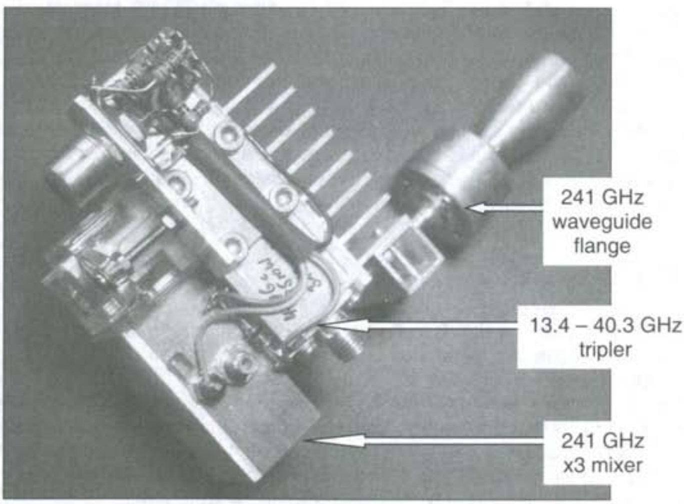


Fig. 1: 241 GHz mixer head with circular waveguide horn

Figure 1 is a view from the top with an experimentally attached circular waveguide horn. **Figure 2** is a view in the opposite direction from Figure 1, and can also be used to explain the frequency scheme of the mixer.

On the left top side one can see clearly the mechanical support for the thin circular waveguide, that comes from the casing at the very bottom. Beneath the heatsink is the doubler from 40.3 to 80.6 GHz. **Figure 3** shows the opened doubler casing. The input comes from the 13.4 to 40.3 GHz tripler module behind, which can be more clearly seen in Figure 1.

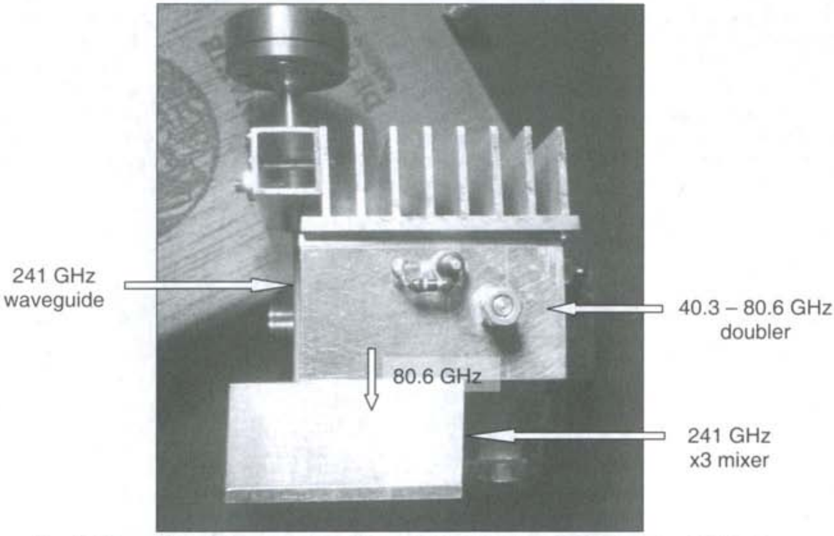


Fig. 2: Mixer head showing the 1.3mm OD circular waveguide for 241 GHz (thin vertical tube at left) which is given continuous mechanical support

The doubler casing is screwed directly to the mixer casing beneath the tripler, and the 40.3 GHz output from the tripler is supplied to the horizontally positioned input coupling pin of the doubler board by a laterally milled rectangular waveguide with internal short circuit slider (adjustment by M3 screw with lock nut).

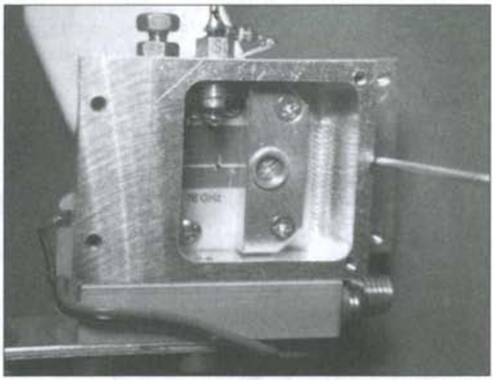


Fig. 3: View into the frequency doubler 40.3 to 80.6 GHz

The 13.4 GHz frequency source and OCXO are a separate unit, located outside the offset dish in a larger casing that is mounted on a stable support on the head of the tripod. Thus the feed support of the dish is stressed only by the mixer head itself. The connection to the tripler module is through an SMA cable.

The 9 V voltage for the tripler module is supplied from the side with a phono jack as shown in Figure 1. Beneath the bolted angle bracket a small selector switch is mounted (not visible in this picture), that allows to choose the working resistance of the mixer diode for mixing or transmitting. The operating status is indicated with a LED and a small µA meter allows to check the mixer current. The IF preamplifier is connected to the mixer separately via an SMC cable.

For better heat dissipation of the tripler module a small heatsink is attached to the casing beneath. As seen in Figures 1 and 2, a square tube attached to the heatsink provides additional support for the thin circular waveguide.

Now follow more details of the individual modules. For the 40.3 to 80.6 GHz frequency doubler I have used an existing board Nr. 29 – "PCB 76 GHz Mixer x 2" from DB6NT that was glued into the casing. The new PCB Nr. 41 – "PCB 40 – 80 GHz Multiplier" from DB6NT would be better. The doubling diode is a M/A COM 1317, that delivers 5.6 mW output on 80.6 GHz with a working resistance of 24 Ω and a DC current of 3.2 mA at about 85 mW input power from the module. These measurements were made by DL2AM with his measuring station. For adjustment in the short circuit block, in general I use only suitable tuning elements from TEKELEC. The 80.6 GHz output power is fed directly into the mixer by a circular WG that is drilled through the walls of both cases together.

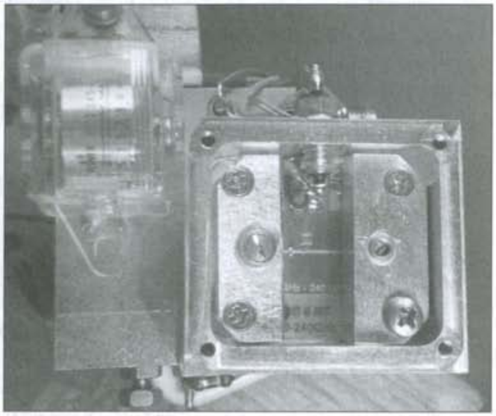


Fig. 4: View into the mixer from 80.6 to 241.9 GHz, also showing the DC meter

The 241 GHz mixer (**Figure 4**) uses the PCB Nr. 42 - "PCB 240 GHz, 80 GHz LO" from DB6NT. The mixer diode is a zero bias detector diode HSCH 9161 from HP. This works as a harmonic mixer from 80,6 to 241,9 GHz. Figure 4 shows the opened mixer casing with a small meter attached to the side to monitor the diode mixer current. The circular waveguide for the 241 GHz input section is a brass tube with an inner diameter of 0.9mm and an outer diameter of 1.3mm. This tube slides directly through the bottom of the casing up to the underside of the glued PCB. Thus transition losses are minimised. The SMC IF jack is positioned directly beneath the feed through capacitor and can be seen more clearly in Figure 1.
The best signal to noise ratio was obtained with a diode current of only 60 µA, which is equivalent to a working resistance of 1.2 kΩ. The highest output power of the tripled 241.9 GHz signal was achieved with a diode current of 370 µA and a working resistance of only 100 Ω. If now the LO frequency is altered accordingly, the mixer can be used as a mini CW TX for first tests in the near field.

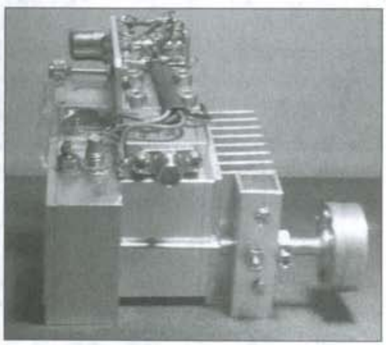


Fig. 5: Mixer head side view with support for the waveguide and flange for dish mount

Figure 5 is a final view of the complete mixer head with the support for the 241 GHz waveguide and the flange for the dish mount. Here one can also see the SMC IF output jack next to the feedthrough in the mixer casing. The tiny circular waveguide (1.3 mm OD, 0.9mm ID) can be clearly seen, and passes through the centre of the tube reinforcement for the waveguide flange, which can be adjusted exactly.

I hope that this article gives you motivation for constructing similar assemblies.
73 and 55 de DCØDA

Source

(1) DB6NT, www.kuhne-electronic.de, www.db6nt.de – search for PCB

241-GHz-Mischkopf für direkte Montage im Offset-Spiegel

by Jürgen Dahms, DCØDA, Vinklöther Mark 48, D-44265 Dortmund

Dankenswerterweise hat Philipp Prinz, DL2AM in DUBUS 1/2009 die Problematik der 241 GHz-Aufbautechnik veranschaulicht, wie sie sich z.Zt. in DL darstellt. Inzwischen habe ich nach dem gleichen Frequenzkonzept einen Empfangsmischer und einen CW-Sender jeweils in getrennten Schalengehäusen für den Portabelbetrieb aufgebaut. Empfängerempfindlichkeit und Senderausgangsleistung sind mit der Anlage von Philipp identisch. Im Vorfeld wurden umfangreiche Versuche im Nahfeld unternommen. Hierzu war im ersten Schritt eine Signalquelle auf 241 GHz erforderlich, um später damit Optimierungsarbeiten am Empfangsmischer vornehmen zukönnen.
Es wurde von 24 GHz ausgehend ein einfacher Verzehnfacher mit der Platine **Nr. 37- „PCB 241 GHz Mixer" (DUBUS 2/94)** aus dem Platinenangebot von DB6NT (1) aufgebaut. Als Vervielfacherdiode diente eine M/A COM 1317. Im zweiten Schritt entstand ein kompletter Mischkopf in Sandwichbauweise, der für erste Feldversuche mit seinem 241-GHz-Flansch direkt am Rillenhornstrahler eines Offset-Spiegels montiert werden sollte.

Konstruktion des 241 GHz- Mischerkopfes

In Bild 1 ist der Mischkopf mit einem versuchsweise anmontierten Rundhohlleiterhorn in der Draufsicht zu sehen.

Bild 1: 241 GHz Mischkopf mit Rundhohlleiterhorn

Die 9V-Versorgungsspannung für das kleine Verdreifachermodul S00-4079 wird seitlich über eine Cinchbuchse zugeführt. Unter dem aufgeschraubten Winkelblech ist ein kleiner Umschalter montiert (im Bild nicht zu sehen), der den Arbeitswiderstand der Mischdiode von Mischbetrieb auf Sendebetrieb umschaltet. Der jeweilige Betriebszustand wird über eine LED angezeigt, außerdem dient ein kleines µA-Messinstrument zur Überprüfung des Mischerstroms. Der ZF-Vorverstärker wird separat über ein SMC-Kabel am Mischer angeschlossen. Ebenfalls separat bekommt das Verdreifachermodul die Ansteuerleistung über ein SMA-Kabel von einem externen Oszillatorbaustein.
Der Oszillatorbaustein ist in einem größeren Gehäuse mit OCXO außerhalb des Offset-Spiegels auf einer stabilen Tragschiene am Stativkopf untergebracht. So wird der Tragarm für das Strahlersystem im Spiegel nur mit dem eigentlichen Mischkopf belastet.

Zur besseren Wärmeableitung des Verdreifachermoduls ist auf dem darunter liegenden Gehäuse ein kleiner Kühlkörper angebracht, an diesem wird auch die zusätzliche mechanische Versteifung mittels Führungsrohr für den dünnen Rundhohlleiter angeschraubt. Das Frequenzschema des Mischers lässt sich an Bild 2 erklären.

Bild 2: Rückseite des Mischkopfes mit Rohrführungsverstärkung für den 241 GHz Rundhohlleiter.

Hier sieht man im oberen Bildteil links die mechanische Führung für den dünnen Rundhohlleiter, der aus dem unteren Gehäuse austritt, sehr deutlich. Unter dem Kühlkörper sitzt das Gehäuse für den Verdoppler von 40,3 nach 80,6 GHz. Die Ausgangsleistung des dahinterliegenden Verdreifachermoduls (13,4 nach 40,3 GHz), von dem nur die hervorstehende SMA-Eingangsbuchse zu sehen ist, wird über einen seitlich eingefrästen Rechteckhohlleiter mit innen liegendem Kurzschlussschieber (Einjustierung über M3-Schraube mit Kontermutter) dem waagerecht liegenden Einkoppelstift der Verdopplerplatine zugeführt. Diese Gehäusekonstruktion wurde von mir bereits ausführlich in **DUBUS 1/2007 (S. 55, B. 8 u. 9)** beschrieben. Das Dopplergehäuse ist direkt mit dem darunter liegenden Mischergehäuse verschraubt.
Bild 3 zeigt das geöffnete Verdopplergehäuse.

Bild 3: Blick in den Frequenzdoppler von 40,3 nach 80,6 GHz

Hier ist nun auch das darunter liegende aufgeschraubte Verdreifachermodul zu sehen. Zur Frequenzverdopplung habe ich die noch vorhandene Platine **Nr. 29 - „PCB 76 GHz Mixer x 2"** von DB6NT eingeklebt, besser ist die Verwendung der neu im Programm aufgenommenen Platine **Nr. 41- „PCB 40 – 80 GHz Multiplier"**. Die Verdopplerdiode ist eine M/A COM 1317, die bei mir mit einem Arbeitswiderstand von 24 Ω und einem Querstrom von 3,2 mA bei einer Eingangsleistung von ca. 85 mW aus dem Modul 5,6 mW Output auf 80,6 GHz liefert. Die Messung wurde von DL2AM an seinem Messplatz durchgeführt. Als Abgleichelemente im Kurzschlussblock werden von mir nur noch grundsätzlich passende TEKELEC-Tuningelemente eingesetzt. Über eine Rundhohlleiterbohrung wird die Leistung direkt in das Mischergehäuse mit gleicher Bohrung eingespeist. Rechts seitlich ist noch zur Erklärung der Rundhohlleiter aus dem darunter liegendem Mischergehäuse zu erkennen. Bild 4 zeigt das geöffnete Mischergehäuse mit dem seitlichen Messinstrument für den Mischdiodenstrom.

Bild 4: Blick in den Mischer von 80,6 nach 241,9 GHz mit ZF- Auskopplung

Als Platine dient die **Nr. 42 - „PCB 240 GHz, 80 GHz LO"** von DB6NT. Die Mischdiode ist eine Detektor-Zero-Bias-Diode HSCH 9161 von HP. Es handelt sich hier um einen Oberwellenmischer von 80,6 nach 241,9 GHz. Der Rundhohlleiter für die 241-GHz-Eingangsseite ist ein Messingrohr mit 0,9 mm Innen Ø und 1,3 mm Außen Ø, dieses wird direkt bis unter die eingeklebte Platine durch den Gehäuseboden geschoben. So können Übergangsverluste minimiert werden. Die SMC-ZF-Buchse liegt direkt unter dem Durchführungskondensator und ist im Bild nicht zu sehen.
Das beste Signal-Rauschverhältnis wurde bei einem Diodenquerstrom von nur 60 µA erreicht, dies entsprach einem Arbeitswiderstand von 1,2 kΩ. Die meiste Ausgangsleistung des verdreifachten Signals auf 241,9 GHz wurde mit einem Querstrom von 370 µA bei einem Arbeitswiderstand von nur 100 Ω erzielt. Wird jetzt die LO-Frequenz entsprechend geändert, kann der Mischer als Mini-CW-Sender für erste Versuche im Nahfeld genutzt werden. Bild 5 zeigt die Seitenansicht des Mischkopfes mit der Rundhohlleiterführung und dem Spiegelmontageflansch.

Bild 5: Seitenansicht des Mischkopfes mit Rundhohlleiterführung und Spiegelanschlussflansch

Jetzt ist auch neben dem Durchführer im Mischergehäuse die SMC-ZF-Buchse zu erkennen. Die Rohrverstärkung mit Flansch, der eine 1,3 mm Bohrung für den kleinen Rundhohlleiter besitzt, kann genau einjustiert werden.

Ich hoffe, mit diesem Beitrag einige Anregungen für ähnliche Aufbauten vermittelt zu haben.

73 und 55 de DCØDA

Bezugsquelle

(1) Platinenangebot von DB6NT, www.kuhne-electronic.de, www.db6nt.de, Suchwort: Leiterplatten

A Broadband Preamplifier - construction and hints

by Philipp Prinz, DL2AM

Inspired by my experience with hot air soldering of microwave devices (see my article in DUBUS issue 2/2009, p. 78) I started to experiment with the tiny amplifier MMIC SGL 0163 from Sirenza. This device works from 30 to 1400 MHz and has 22 dB gain at the lower end of this frequency range. The NF is < 1 dB on 144 MHz. The is no indication of any oscillation and the gain falls smoothly with increasing frequency. The size of the chip is 2mm x 2 mm and there are 6 pins. The chip can be soldered easily with hot air to a 50 Ohm stripline on a PCB together with the other necessary parts. See figure 1.

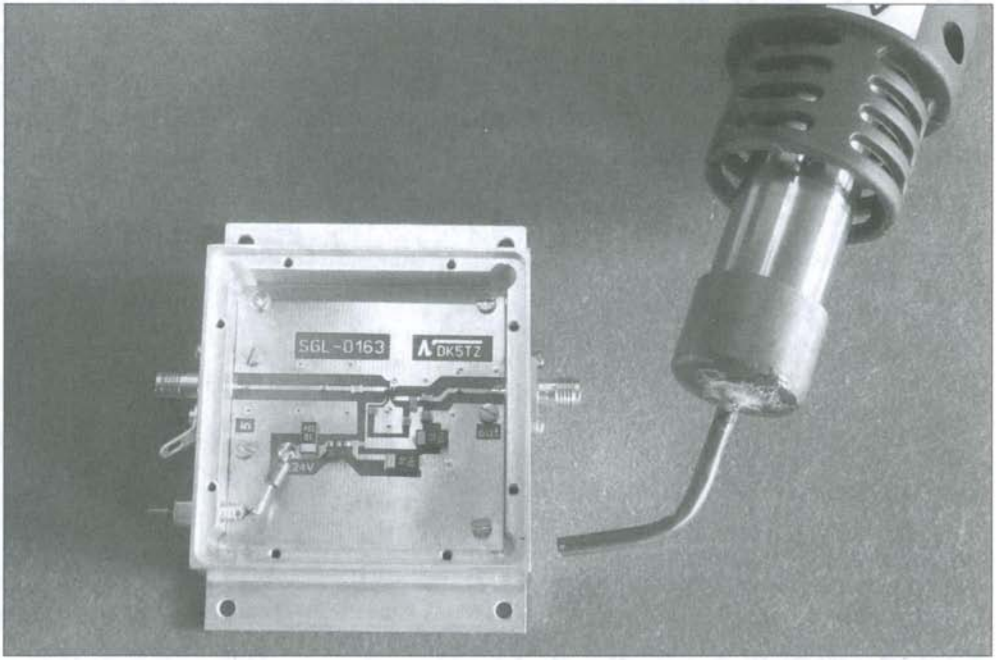


Fig. 1 SGL-0163 preamplifier with hot air soldering tool

I used an Ag-Sn-Bi solder paste (146° C). A head worn magnifying glass helped to make the soldering procedure easier. The PCB was made from 0.5mm FR 4 material by Werner, DK5TZ. See figure 2. The PCB and parts are the same as the evaluation board in the datasheet published by Sirenza. The 0.5mm thickness PCB is neccessary for getting the small 50 Ohm lines for the tiny chip. If one wants to use better PCB material, the new Rogers RO 3002 may be used. This is good up to 40 GHz.
If a 5 V DC regulator is used a 620 Ohm resistor must be put in series, as this amplifier needs 11mA @ 3 to 4 V DC. The best noise figure was obtained at 3 V DC. The claimed perfomance from the data sheet was almost reached. The data sheet can be found at www.sirenza.com
For narrow band applications it is possible to insert helical filters at the output and also at the input. The NF is lowered by the insertion loss of the helical filter, of course.
An amplier such as described here can be a usefull tool for measurements as well as a RX preamplfier.

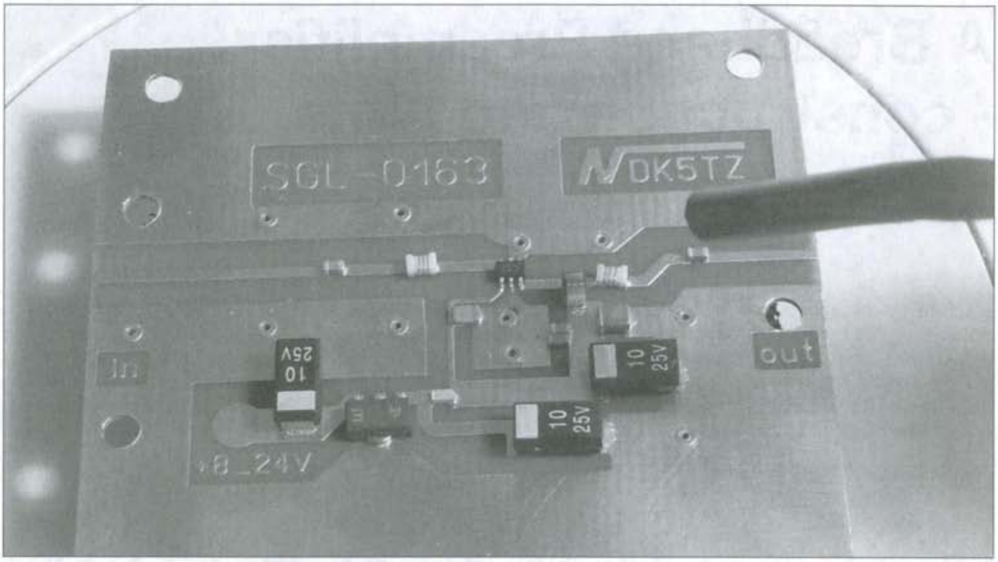


Fig. 2 PCB with tip of hot air soldering tool

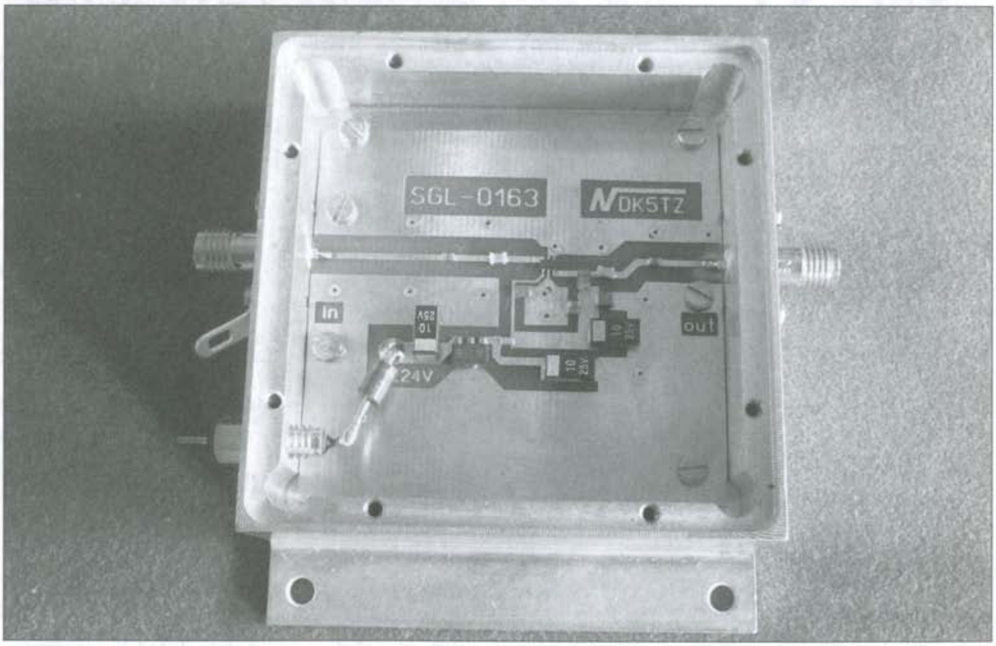
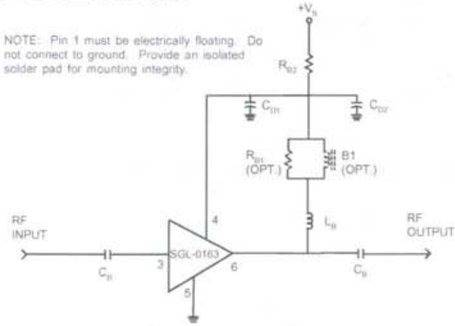


Fig. 3 Completed preamplifier – closeup view

Appendix
SGL 0163 MMIC Features

- Low NF = 1.2dB at 900MHz
- Gain = 21.5dB @ 433MHz, 15.5dB @ 900MHz
- Internally Matched to 50 Ohms from 800-1300 MHz
- Single Supply Operation (2.5 to 4 volts)
- High Input IP3 = 7.0 @ 900MHz
- Internal Temperature Compensation
- Low Power Consumption: 12mA @ 3V
- Small Package: SOT-363

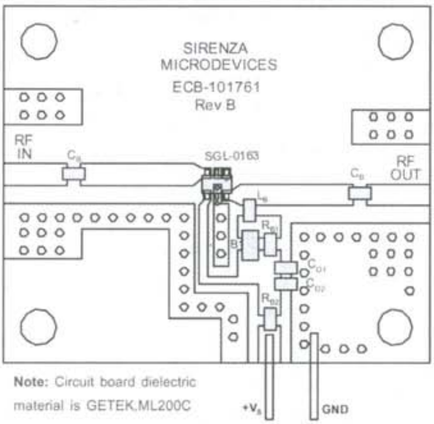
PCB and Part Info



Application Circuit Element Values		
Reference Designator	Value	Manufacturer & Part No.
L_B	33 nH	TOKO LL1608-FS27NJ
B1 [1]	1500 Ohms @100 MHz	FAIR-RITE 2508051527y0 Ferrite Bead
C_B, C_{D1}	0.1 uF	SAMSUNG CL10B103KBNC
C_{D2}	22 pF	ROHM MCH185AA220DJK
R_{B1} [1]	47 Ohms	PHILLIPS 9C06031A47R0 JL HFT
R_{B2} [2]	0 Ohms	PHILLIPS 9C06031A0R00 JL HFT

Notes:
1. B1 and R_{B1} provide improved K-factor but are optional.
2. R_{B2} may be introduced as a voltage dropping resistor for use with supply voltages greater than the desired device bias voltage.

800-1300 MHz Evaluation Circuit Board



Note: Circuit board dielectric material is GETEK ML200C

Device Pin Out Guide		
Pin #	Function	Description
1	N/C	No electrical connection. Provide an isolated (un-grounded) solder pad for mounting integrity
3	RF IN	RF input pin. This pin requires the use of an external DC blocking capacitor chosen for the frequency of operation.
4	DC BIAS	Voltage supply connection. Bypass with suitable capacitors.
2, 5	Ground	Connection to ground. Provide via holes as close to the device ground leads as possible to reduce ground inductance and achieve optimum RF performance.
6	RF OUT/ BIAS	RF output and voltage supply. DC voltage is present on this pin, therefore a DC blocking capacitor is necessary for proper operation.

Reliability & Qualification Information	
Parameter	Rating
ESD Rating - Human Body Model (HBM)	Class 1A
Moisture Sensitivity Level	MSL 1
The product qualification report may be downloaded at *www.sirenza.com*	

Part Identification Marking & Pin Out

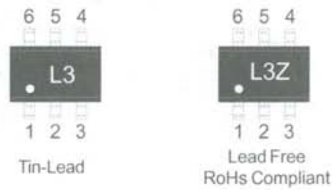


Fig. 4

Ein Breitband-Vorverstärker - Aufbau und praktische Hinweise

von Philipp Prinz, DL2AM

Durch die vielen Erfahrungen mit Heißluft Mikrobauteile einzulöten, konnte ich es nicht lassen, mit dem nachstehend beschriebenen Verstärker Versuche zu machen. Von Sirenza gibt es unter anderem einen kleinen Verstärker (MMIC) mit der Bezeichnung SGL 0163. Er ist zu betreiben von 30 MHz bis 1,4 GHz. Dabei hat er 22 dB Gain im unteren Bandsegment und eine Rauschzahl von < 1 dB bei 144 MHz.

100-800 MHz Operation

The useful range of the SGL-0163 may be extended down to 100Mhz using simple lumped element tuning. Following are two examples.

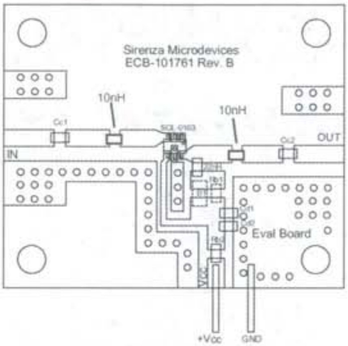
Option 1. A series inductor introduced at the input and output optimizes RF performance over 100MHz wide bands. Band center is selected by adjustment of the inductor values. The example presented is optimized for the 400-500 MHz band.

Option 2. An RC feedback network provides broadband RF performance from 100-800MHz. The resistor value may be adjusted to select a combination of gain/NF/return loss best suited to the particular application.

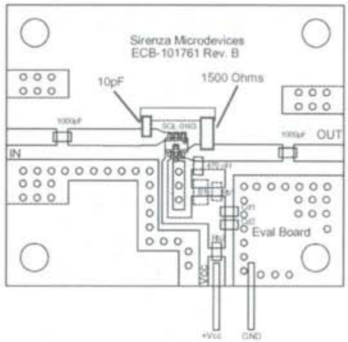
Data and schematics for these two options are presented below and on the following pages.

Contact Sirenza amplifier applications for further guidance.

Option 1. Series L Tune



Option 2. RC Feedback Tune



Application Circuit Parts List

Ref. Designator	Description	Value	Manufact. Part No.
B1 ²	Ferrite Bead	1500 Ohms @100 MHz	FAIR-RITE 2508051527y0
Cc1,Cc2,Cd1	Capacitor,SM,0603	0.1 uF	SAMSUNG CL10B103KBNC T/R
Cd2	Capacitor,SM,0603	22 pF	ROHM MCH185AA220DJK
Rb1 ²	Resistor,SM,0603	47 Ohms	PHILLIPS 9C06031A47R0 JL HFT
Rb2	Resistor,SM,0603	0 Ohms	PHILLIPS 9C06031A0R00 JL HFT
N/A ¹	Circuit Board	N/A	Sirenza Microdevices ECB101761 Rev B

Notes:

(1) Circuit board dielectric material is GETEK,ML200C

(2) B1 and Rb1 recommended for improved K-factor but are optional. Replace with 0 Ohm resistor if not used.

Fig. 5

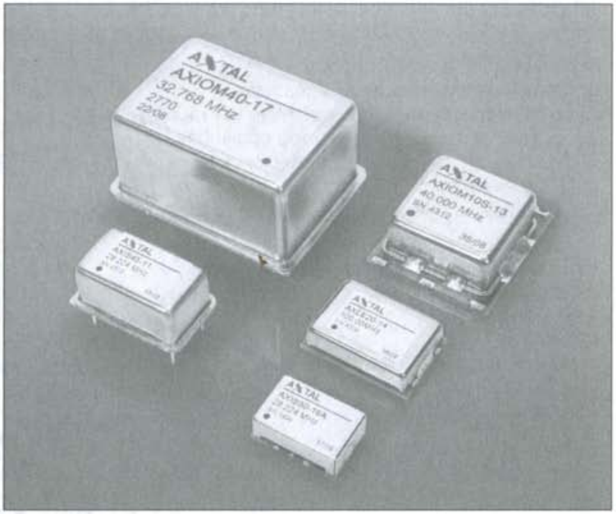
Er zeigt keinerlei Schwingneigung bei langsam abfallender Verstärkung bis 1,4 GHz. Der Chip hat ein Maß von 2 x 2 mm und 6 Beinchen. Dieser lässt sich hervorragend mit Heißluft auf eine 50-Ohm-Leitung (PCB) auflöten, so wie auch die anderen notwendigen Bauteile, siehe Dubus 2/09, Foto Nr. 1. Ich verwendete dafür auch die Lötpaste AG-SN-BI 146° C. Mit einer Kopflupe ist dies noch gut zu handeln. Die PCB ist aus FR-4 Material, 0,5 mm stark, angefertigt von Werner, DK5TZ, siehe Foto Nr. 2. Die 0,5 mm Stärke der PCB ist notwendig, um ein schmale 50-Ohm-Leitung zu bekommen für den kleinen Chip. Wenn besseres Material gewünscht wird, kann das neue Rogers Ro 3003 benutzt werden, was bis 40 GHz zu verwenden ist. Wenn ein 5 Volt DC-Regler benutzt wird, ist ein 620 Ohm-Widerstand in Serie zu schalten, da dieser Vorverstärker 3 – 4 Volt bei 11 mA benötigt. Bei 3 Volt Betriebsspannung erreicht man die beste Rauschzahl. Die angegebenen Werte sind annähernd zu erreichen und unter www.Sirenza.com sind die Daten mit viel Information herunter zu laden.

Für Schmalbandanwendungen ist es möglich, am Ausgang sowie auch am Eingang ein Helix-Filter anzubringen. Wenn so ein Helix-Filter am Eingang benutzt wird, verschlechtert sich der Rauschabstand um den Wert der Durchgangsdämpfung des Helix-Filters. So ein Verstärker kann ein nützliches Hilfsmittel für unterschiedliche Anwendungen z.B. Messverstärker, Vorverstärker an Antennen usw. sein.

73 Philipp, DL2AM

Microwave Parts

OCXOs from AXTAL



10 MHz OCXO - Referenzquelle für den anspruchsvollen Funkamateur

Mit seiner Serie AXIOM30-50 bietet AXTAL einen hochstabilen OCXO mit kleinsten Abmessungen von nur 20x20x12 mm an. Durch die Verwendung eines SC-Schnitt-Quarzes im 3. Oberton kann eine Stabilität von bis zu ±5 ppb erreicht werden. Das HCMOS-Ausgangssignal weist ein sehr geringes Phasenrauschen ist besser -90 dBc/Hz bei 1 Hz Offset bei einem Rauschflur von nur -150 dBc/Hz.
Als kostengünstiges Modell für Funkamateure wird das Modell AXIOM30-50-25 zu einem Einzelpreis von unter 100 € (zzgl. Versandkosten und MWSt.) mit kurzen Lieferzeiten angeboten. Das Datenblatt finden Sie auf der AXTAL – Webseite www.axtal.com. Anfragen per E-mail an info@axtal.com oder per Fax über 06261 9398-36.

Engl.: Axtal offers a highly stable **10 MHz OCXO** – reference source with a small size of just 20 x 20 x 12mm. The stability reaches ±5 ppb. The HCMOS output signal shows a very low phase noise of better -90dBc/Hz for 1 Hz Offset and a noise floor of -150 dBc/Hz. For radio amateurs there is a version AXIOM 30-50-25 available for 100 € + VAT in single units and with fast delivery. Datasheets are available on the AXTAL website for download. Contact: E-mail info@axtal.com or Fax ++49 6261 9398-36.

Low-Noise OCXO im 100 MHz-Bereich für Mikrowellen-Aufbereitung

Für die Aufbereitung von Mikrowellenfrequenzen werden sehr rauscharme und frequenzstabile OCXO (Ofenoszillatoren) benötigt. Für diese Anwendung bietet AXTAL die OCXO-Serie AXIOM75 an. Es können Ausgangsfrequenzen zwischen 90 MHz und 120 MHZ (Sonderausführungen bis 146 MHz) angefertigt werden. Das Gehäuse ist mit seinem Abmessungen von nur 25x25x14 mm äußerst kompakt. Das Ausgangssignal ist sinusförmig mit +7 dBm an 50 Ohm. Bei einer Betriebsspannung von 12 V werden im aufgewärmten Zustand nur 100 mA verbraucht. Das Phasenrauschen ist mit -140 dBc/Hz @ 100 Hz und -160 dBc/Hz Rauschflur einzigartig niedrig. Das Datenblatt finden Sie auf der AXTAL – Webseite www.axtal.com. Anfragen per E-mail an info@axtal.com oder per Fax über 06261 9398-36.

Engl.: Axtal offers a **low-noise OXCO** for microwave applications with frequencies from **90 to 120 MHz**. Special versions are available up tp 146 MHz. The series AXIOM75 has dimensions of 25x25x14mm. The sine output signal has +7dBm at 50 Ohm. Supply voltage is 12V at 100mA after warm up. Phase noise is -140 dBc/Hz @ 100 Hz and the noise floor is extremly low with -160 dBc/Hz. Datasheets are available on the AXTAL website for download. Contact: E-mail info@axtal.com or Fax ++49 6261 9398-36.

New Transverterkit for the 23 cm band from DB6NT

The new transverter-kit for 23 cm represents the current status of amateur radio in the field of microwave technology. Revised by DB6NT, this transverter features excellent technical data and is suited for portable or stationary activities due to its small mechanical dimensions. By the use of additional power amplifiers this transverter module can be upgrated to a high performance transmit / receive system for 23 cm. All well-tried functions and features of the previous transverters are included.

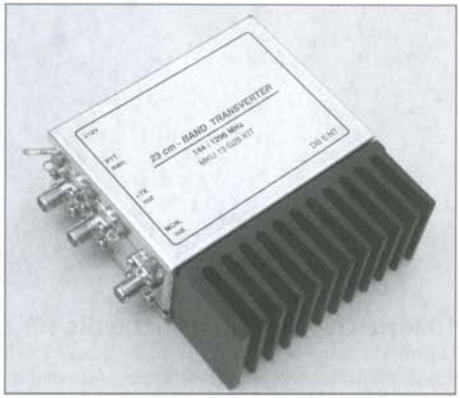
Features

- Super low noise converter in the receive path
- Transmit gain and receive gain separately adjustable
- Internal stabilized oscillator with precision crystal heater (40° C)
- Control output for additional amplifier stages or a coaxial relay
- PTT can be switched by voltage on the IF connector or by connecting the PTT pin to ground
- Detector output (DC voltage) for monitoring the output power
- Small mechanical dimensions due to the use of state-of-the-art SMD parts

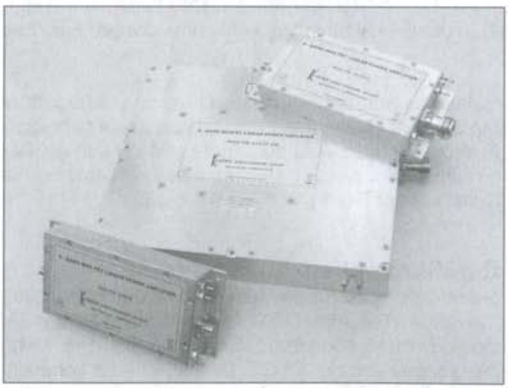
Data

Type	KIT 1,3 GHz 13G2B
Frequency range RF	1296 ... 1298 MHz
Frequency range IF	144 ... 146 MHz
Output power	min. 0.4 W
RFinput power	max. 3 W, adjustable
Noise figure @ 18 °C	typ. 0.8 dB
Receive gain	min. 20 dB, adjustable
Supply voltage	+12 ... 14 V
Current consumption	typ. 350 mA (at transmit)
PTT voltage (to the IF-connector)	+3 ... 14 V
Coaxial connectors	SMA-female
Case	Tinplate
Price	199,00 € incl. German VAT

For further information please visit: www.db6nt.de



New Power amplifiers for the 9cm band



DB6NT has developed a new series of three LDMOSFET power amplifiers for the 9cm band. These amps work very linear, show high efficiency and can be used for any mode, analogue or digital. The amps are also available as an option mounted on an heatsink with blowers.
All amps have a monitor output for the forward power.
The 350 W version has a thermal protection circuit and delivers the voltage for switching a coaxial relay.

Type	MKU PA 3440 A	MKU PA 34100 A	MKU PA 34350 CU
Frequency range	3400...3460 MHz	3400...3460 MHz	3400...3460 MHz
Input	2 W	8 W	1 W
Gain	min. 13 dB	min. 10 dB	min. 28 dB
Output	typ. 40 W	min. 100 W	min. 350 W
Efficiency	typ. 31 %	typ. 40 %	typ. 34 %
Ub	+28 V	+28 V	+28 V
Current	max. 5 A	max. 10 A	max. 42 A
Casing	milled aluminium	milled aluminium	silvered copper

Microwave Europe

Editor: Guy Gervais, F2CT
F2CT@wanadoo.fr

Welcome to Microwave UK,
the UK input to Microwaves Europe.

In my contribution on microwave UK I have tried to keep the focus on microwave activities specific to the UK, but also of interest to amateur microwave enthusiasts elsewhere.

By the time this is published the summer 2009 rain scatter season will have passed its peak. It may be useful to analyse how rain scatter propagation affects radio amateurs in and close to the UK.

From about early May ground temperatures are often high enough to trigger large thunderstorms. Over mainland Europe these storms occur almost daily at their peak in early to mid June. The storms are often so vigorous that super cooled liquid water may exist in the core of the updraft to the top of the storm. Rain drops, which would normally turn to ice crystals above about 2km height, are borne upwards so fast that they can reach as much as 14 or 15km before either freezing or reaching the top of the thunder cell and then falling back towards the ground. It should be noted that ice crystals do not scatter signals as well as liquid rain drops in the 3 to 10GHz frequency range.

From a height of 15km the distance to the (sea level) horizon is around 400km, line of sight. It is probably not appropriate to use k=1.33 as much of the path is through the upper atmosphere. A microwave signal radiated from a station at sea level can still be scattered from the liquid rain at the top of a big thunder cell 400km away. The forward scattered signal can then travel another 400km to a QSO partner, giving a theoretical range of around 800 km. Obviously, if one or both stations are located on a high mountain then the theoretical range can be a bit further. Few UK radio amateurs live or regularly operate from much above about 500m, so that range extension with rain scatter is, perhaps, a few km. What does this mean for UK operators in terms of range towards mainland Europe?

For a station located in, say, Birmingham, a suitable scatterer would need to be no further away than a radial distance equivalent to Brussels (467km) to be useable if the k=1.33. If the refractive index were only 1 then the scatterer would need to be above the Belgian coast at about Brugge. It does appear to be difficult to access storms that are beyond about 400km from the average UK location. Since the bigger European storms usually track further inland than along the coast this makes it difficult for many UK microwave operators to participate in the bigger rain scatter events as they are located just beyond the maximum range to the storm.

I was discussing this with Jim, G3YLA, who is a well-known UK weather broadcaster on the BBC. I asked Jim about the height of storms over the UK and about those that occasionally cross the Channel from the French direction (there have been several of these in 2009). He was of the opinion that the storms that originate over the continent and cross the channel are probably of mid altitude (7.5-10km) and would therefore give a range to the storm of about 300km. This would certainly allow operators up to around Manchester to access the scatterer when it was just south of London and the onward scatter would allow signals to reach to Brussels. This takes in a lot of the more active microwavers in the north of France and the Low countries. Figure 1 shows the coverage (300km) of such a mid altitude storm centered south of London (inner dark circle) It should be clear from this that rain scatter coverage into the nearer parts of mainland Europe are possible from much of central and southern England.

Our own 'home grown' supercell storms can occasionally reach within a few km of the bigger European mainland storms, but these are rare. As Jim says "However, our bigger storms of comparable size are very much less common than in Europe...it's a temperature thing...hot places bigger storms." The lighter outer ring of figure 1 shows that it should be possible for stations in parts of south Wales and further north in England, to work parts of mainland Europe in one of these bigger events, centered south of London.

A very good example of a strong UK storm occurred on Monday 15th June. Around mid day (UTC) a big storm passed through the Manchester area. From the Ipswich area it was possible to receive a strong, minimally distorted, signal from the Manchester beacon GB3XGH, (10368.810 MHz) and a back scattered signal from the Wolverhampton beacon GB3CEM, (10368.880 MHz). The storm centre was about 290km from Ipswich and therefore well above the horizon if the top of the storm was at 14km height.

Although this storm produced few QSOs (perhaps because of the mid day timing?), it was capable of supporting 10GHz QSOs across much of the UK. Maybe global warming may bring more such storms?

Up until now it has been presumed that only stations located in the south and east of the UK could work into the continent using this mode. It is clear from the information available that UK microwave enthusiasts located further north and west should be able to take advantage of some of the bigger storms to enhance their operating range by using rain scatter on 5.7 and 10GHz Maybe our friends in continental Europe could also beam towards these more westerly storms?

Figure 1 Possible coverage area for a mid altitude storm (dark inner circle) and a rare high altitude storm (lighter outer circle) centered south of London.

Signal level reporting - Part 2

Since part 1 was published I have received some feedback on the discussion as to whether we should change the signal level reporting to dBm rather than the badly abused S unit system currently used.

One comment was that the proposed system adds an extra character to the signal report whereas it might be preferable to reduce the number of characters from the existing 3 (in CW reports) to 2. Although this would be possible by truncating the 3 characters e.g. (-)120 to just two, by assuming that the range required is no more than 99dB, so that (-)120 becomes (-)20 and (-)140 becomes (-)40 and that signals never reach above about -40dBm (it would be obvious if they did as they would be so strong) this could be extremely confusing and looks complicated.

A less confusing system might be to retain 'S' units but make them just 3dB/S and reset the reference for S9 to -113dBm. Unofficially, this is what happens in many cases anyway. There are not many who use a genuine 6dB/S. Above -113dBm the dB over S9 would continue to be used.

As far as the R and T part of the existing reporting system are concerned. The R is almost totally redundant. It is rare to receive a readability of less than a 4. A report of 5 is so much more common.

The T part of the report was never, I am told, officially adopted by IARU R1 and may be of ARRL origin. Whilst it was probably important when unstable, non crystal controlled, transmitters were in use, it is completely meaningless today. It has already been largely superseded by the more meaningful propagation reports such as 'A' for aurora, 'S' for scatter and 'M' for multi-path. These tell the transmitting station far more about how his/her signal is received than a 1 to 5 R report. Reporting by propagation could be usefully extended to account for many other modes.

A very meaningful report could now be '3S'. This indicates to the sending operator that his signal is in the range -134 to -131dBm and is being received by scattering (rain maybe?).

Character	**Designated Meaning**
A	Aurora
B	
C	
D	Ducting or Doppler
E	
F	Flutter
G	
H	
I	Interference? QRM
J	
K	Avoid - Used to indicate *over*. May cause confusion.
L	
M	Reserved for EME TMO Change from IARU recommendadtion as Multipath
N	Normal - delimiter
O	Reserved for EME TMO
P	
Q	QSB (deep?)
R	Reflection
S	Scatter
T	Reserved for EME TMO
U	Random contest exchange
V	Random contest exchange
W	Random contest exchange
X	Random contest exchange
Y	Random contest exchange
Z	Random contest exchange
Other characters	To be decided if required

Table 1 - Possible character set for the P report. Note the change of use for 'M' from the IARU recommendation.

This reduced character **S**IGNAL LEVEL / **P**ROPAGATION (SP) report is likely to be more accurate than the existing system as it lines up better with the S meter calibration on many rigs and seems to more accurately reflect given reports. With a resolution of +/- 3dB it is calibrated to a more meaningful reference level (-113dBm) and therefore potentially more accurate (and useful) than at present and includes a far more useful second character in that propagation mode or other characteristic e.g. Interference, is given.

For the CW traditionalist the second character could be just an 'N' (for normal?). With weak signals the 'N' or '9' (N is shorter to send) acts as a very good 'frame delimiter' character and this may be more important than perceived propagation or it could indicate a signal with **N**o indications of propagation mode.

Finally, there has always been a great deal of disquiet about contest exchanges and some unwieldy systems employed to add some degree of authenticity to reports, such as postal (zip) codes. If the characters 'U' through 'Z', say, were reserved as random characters then appending one of these to the S report could at least introduce an extra level of non-guessing into the exchange. Probably during contests the importance of a propagation character is much lower anyway and so can be dispensed with in favour of the random single letter.

Table 1 shows a possible extended range of P characters to be used with the S report character.

I am not deluded enough to think that 100 years of amateur radio traditional signal reporting is about to change overnight. However, as a new system is needed, this may help us to achieve something better than the outdated, inaccurate and abused system used today! 73 de Sam, G4DDK, JO02pa

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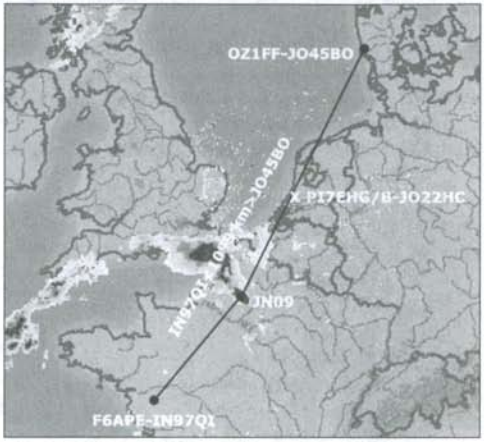
F2CT: Many and very interesting RS qsos since April with some Dx and records up to 1093 km on 6 and 3 cm. On 24 GHz some unilateral tests up to 600 km let us to think that long distance qsos are possible with very strong storms and very high clouds of ice.

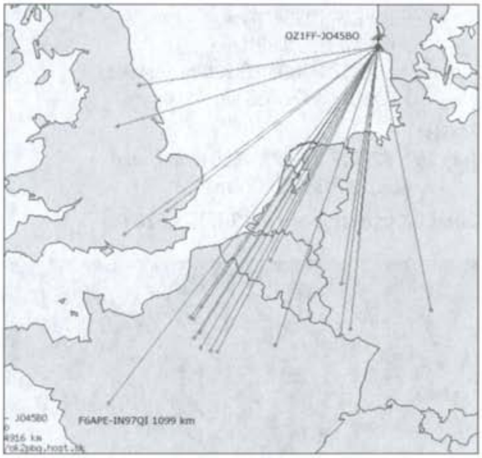
Here is the report from Kjeld OZ1FF:

Hello Guy, your prediction in DUBUS 2/2009 that RS QSOs in the 1000 km range would be reached was right. On May 25 2009 at 07:43z **I worked F6APE on 10 GHz RS, IN97QI over 1099 km from JO45BO for a new RS world record.** The old RS WR was 1008 km and held by AF1T/W4DEX. The scatter point was located over JN09 about 800 km away and could be reached with the help of super refraction over the North Sea indicated by the reception of PI7EHG/B in JO22HC. Exchanged reports was 51S in both directions. A sound clip is at: www.oz1ff.dk/Pages/News/News.htm.

F6APE rig: DB6NT xverter, 60 cm dish/6 W and here: DB6NT xverter, 65 cm offset dish 25 m ASL/3,5W. The RS/TR lasted until the early evening making 10 GHz RS QSOs with 10 different F-stations possible (F6APE, F6DKW, F6DWG, F5DQK, F4BUC/P, F6ACA, F1ISM, F1PYR/P, F1NXP/P, F5PEJ/P). Before ending I worked F6DWG also on 5,7 GHz RS, 804 km and 1. F to OZ on this band. 20 TR/RS QSOs with an average of 750 km and 6 new squares. Really an exciting day. Now off for the record on 24 GHz! :-)
Vy 73 de OZ1FF - Kjeld



Path of the 1099km Rainscatter QSO on 3cm



RS QSOs on 3cm by OZ1FF

<u>**Reports from F2CT:**</u>

5,7 GHz > 600 km, Tropo

May 31st, F2CT/P IN92PX 1600 m asl, wkd:
- F9ZG/P/JN36/652 km

June 20th, F2CT/P IN93HG 930 m asl, wkd:
- F6DWG/P/JN19/729 km

July 16th, F2CT/P IN93HG 930 m asl, wkd:
- F4CKC/P/JN26/653 km

July 26th F2CT/P F6AJW/P F6CBC/P IN92PX 1600m:
- F5LWX/P/IN78/644 km
- F6DWG/P/JN19/744km
- F5IGK/JN09/727km
- F4CKC/P/JN19/715km
- F1JGP/JN17/600km
- F6KPL/IN99/738km

August 1st F2CT/P IN93HG 930 m asl, wkd:
- F4CKC/P/JN27/635 km

10 GHz > 600 km, Tropo:

May 31st, F2CT/P IN92PX 1600 m asl, wkd:

- F9ZG/P/JN36/652 km

June 17th, F2CT/P JN13IO 1100 m asl, wkd:

- F6DWG/P/JN19/646 km

June 20th, F2CT/P IN93HG 930 m asl, wkd:

- F6DWG/P/JN19/729 km

July 16th, F2CT/P IN93HG 930 m asl, wkd:

- F4CKC/P/JN26/653 km

July 26th, F2CT/P F6AJW/P F6CBC/P IN92PX 1600 m:

- F5LWX/P/IN78/644 km
- F6DWG/P/JN19/744km
- F5IGK/JN09/727km
- F4CKC/P/JN19/715
- F1JGP/JN17/600km
- F6KPL/IN99/738km
- F9OE/P/IN78/644
- F6DKW/JN18/682km
- F5AYE/P/JN35/627km
- F1NPX/P/JN29/801km

August 1st F2CT/P IN93HG 930 m asl wkd:

- F4CKC/P/JN27/635 km

24 GHz

July 26th F2CT/P IN92PX 1600 m asl, wkd:

- F5BUU/P/JN03/142 km

Good DX to everybody on SHF! 73 F2CT

F6CBC and F2CT/p in IN92PX on July 26th 2009

VHF News
Australia & New Zealand

GippsTech 2009

Australia's annual VHF and above Conference, GippsTech, was held on the weekend 11 and 12 July. Over 100 enthusiasts attended and were treated to a range of excellent presentation as set out below. Special thanks to Peter, VK3KAI, and his team who have now run this very successful conference for 11 years. Here the 2009 lectures:

• Direct conversion, phasing type transceiver for 2 m SSB - Dale Hughes VK1DSH

• Sporadic E and VHF Propagation: New Observations and Advances in Understanding - Roger Harrison VK2ZRH

• Assessing and Modifying Commercial Microwave Equipment for AR use - Alan Devlin VK3XPD

• Fires.. being in the middle of it .. and surviving many may wonder how and why and what were the comms etc - Doug McArthur VK3UM

• Experiences with the Qualcom boards as the basis of a 10 GHz transverter A - Russell Lemke VK3ZQB

• Towers, Some of what you need to know plus what you don't want to know - Andrew Martin VK3OE

• Are we there yet? Solar cycle minimum and emerging prospects for long-haul VHF DX - Roger Harrison VK2ZRH

• Experiences with the Qualcom boards as the basis of a 10 GHz transverter B - Russell Lemke VK3ZQB

• Square-Section Parallel Transmission Lines: Theory, Practice and Applications - Roger Harrison VK2ZRH and Andy Sayers VK2AES

• A Simple USB Rig Interface - David Smith VK3HZ

• Latest software updates - Doug McArthur VK3UM

VK3UM reporting about the fires in February

- A building block approach to transverter design: an example for 2.4 GHz - Andrew Davis VK1DA
- Home Brew Dishes - Chris Skeer VK5MC
- Simple Coax Band Pass Filters - Neil Sandford VK2EI
- High Level Wideband Noise Source - Neil Sandford VK2EI

Gipps Tech 2009 door prize winners, from left to right Nick VK3VFO, George VK3HV, David VK3VL, Roger VK3ADE. (photo by Chris VK3CJK)

Echoes of Apollo

During the Echo's of Apollo weekend Doug VK3UM, Chris VK5MC and Dave VK2DJS were all active from their home stations on 1296 MHz. Doug VK3UM provided the voice from the moon allowing school children in Tasmania to hear their names from the moon. Rex VK7MO took advantage of the Tasmanian University 26 meter dish to try some QRPP with JT65c, working HB9Q (15 metre dish) at 10 milli-watts and PI9CAM (25 metre dish) with 3 milli-watts. Signal levels were within 2 dB of that predicted with the VK3UM software with its recent amendment that takes account of moon noise.

10 GHz Troposcatter

David VK3HZ and Rex VK7MO have extended their 10 GHz VK terrestrial digital record to 325 km using JT65a on a purely tropospheric scatter path. Both systems are GPS locked and used 7 and 10 watts output to 45 cm and 65 cm dishes. Signal levels averaged around -8 dB on the WSJT scale so there are opportunities to extend this distance. The signal levels are within a few dB of those calculated for tropospheric scatter.

TNX to VK7MO for the all the above information and to VK3UM for the photos from Gipps Tech!

Microwave Japan

Seiji Fukushima, Ph.D, JH6RTO
jh6rto@m.ieice.org

23 and 13-cm domestic DX records updates, Masanao Furugen, JR6RMZ

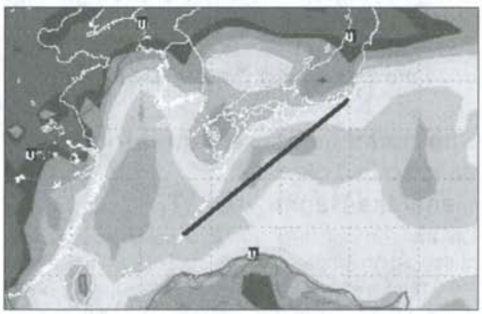
On the 10th of May 2009, we made several domestic DX records between Okinawa Island (JR6, PL36XP) and Kanto Land (JA1, PM94WV) on 23 and 13cm bands. The distance is 1460km and my log is as follows:

JST	Callsign	MHz	Mode
0555	7K1FTE	1294	2xCW
1434	7K1FTE	2424	2xCW
1620	7K1FTE	2427	2xFM
1650	7K1FTE	2424	2xSSB
1738	7K1FTE	1295	2xFM

Note that JST is UTC + 9 hours. All the signal reports were 59 or 599. The propagation looked like oceanic tropo.

My QTH is Aza Izumi 2380, Motobu Cho, Kunigami Gun, Okinawa Prefecture or N26-38-46, E127-56-59. The equipment was an IC-910D and a transverter with 2W on 13cm and 10W on 23cm, where the output power is legal maximum in Japan. I used a 29el quagi and a 40el Yagi on 13 and 23cm, respectively. 7K1FTE's QTH was Takiguchi 5580-113, Shirahama Cho, Minamibousou City, Chiba Prefecture or N34-54-11, E139-51-45.

Here are some hints for trope prediction. For initial prediction I use 'William Hepburn's Worldwide Tropospheric Ducting Forecasts' on the web at http://www.dxinfocentre.com/tropo_eas.html



Hepburn map from May 10th 2009 indicating very good Tropo chances for JR6 to JA – the black line is the 1460km path from JR6RMZ to 7K1FTE

In addition, visible observation has been experimentally confirmed to be very effective. Photos 1 and 2 are Motobu Peninsula near my shack. When there is a haze in front of the Peninsula and visibility is low, as shown in Photo

1, the chance of tropo is very high. The chance, in contrast, becomes low when we see the scenery clearly such as Photo 2. These photos show that the propagation occurred was the oceanic tropo.

My email address is jr6rmz@jarl.com.

Reference: www.jarl.or.jp/Japanese/A_Shiryo/A-8_Kiroku/distance.htm

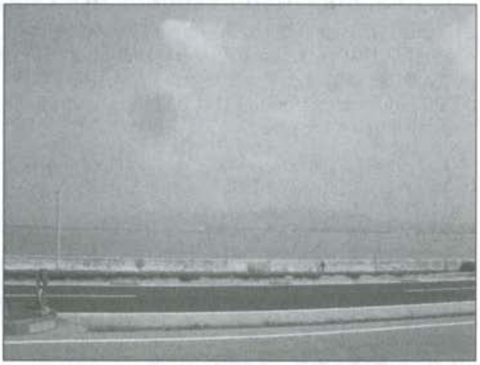


Photo 1 Poor visibility showing a chance of tropo DX

Photo 2 Good visibility - no DX expected

Sun noise measurement during solar eclipse in Tokyo
Masatake Henmi, JA1ATI

On the 22nd of July 2009, a solar eclipse was observed in Japan. Here, in Tokyo, the phase maximum was reported to be about 0.749 although we could not see the eclipse directly because of the weather condition. I measured the sun noise on 47GHz instead.

My measurement setups include a Kuhne LNA, MKU472B, a homebrew receiver, and a 40cm offset dish antenna. Details of my receiver were reported in DUBUS 4/2005. As shown in Fig. 1, the sun noise power changes like a valley shape. The minimum power was observed exactly at the maximum phase at 1113 of JST. During the observation, the temperature and humidity was 25-30C and 55-77%, respectively. Since the weather and humidity changed at the beginning of and the end of eclipse, the sun noises were not the same before and after the eclipse.

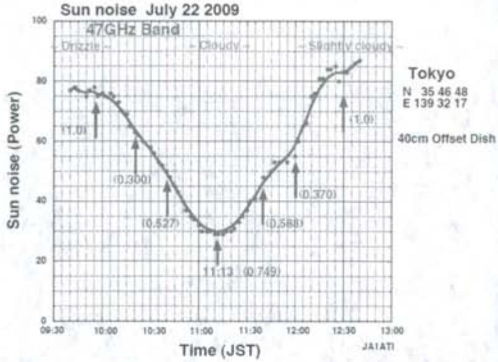


Fig. 1 Result of sun noise power measurement. (Ed.: Phases are written near the curve but the two (1.0)'s should read (0.0)'s.

Reference

JA1ATI, 'Celestial direction finding based on sun noise measurement', pp. 59-61, DUBUS 4/2005.

Microwave USA

Editor: Kent Britain, WA5VJB
WA5VJB@flash.net

WA1ZMS 2m Transatlantic beacon

The WA1ZMS Trans-Atlantic beacon/transmitter project has had a recent upgrade to its operation.

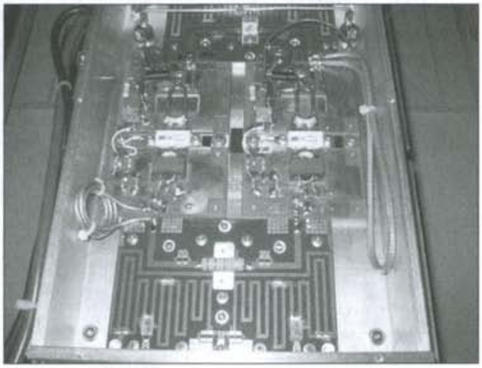
Technical description: A land mobile grade base station VHF exciter is used and the 25w driver PA is keyed for CW modulation. The exciter utilizes a 10MHz frequency reference with is derived from an HP-Z3801A GPS frequency standard. The TX frequency is 144.285MHz and is stable to within 1E-10Hz, although propagation effects will likely cause much more observed frequency error than the GPS standard can provide.

A new higher power PA has been added as well as an upgrade to the physical rack cabinet and requisite power supply, etc.

RF power out of the transmitter is now 500w and is driving a new pair of Sinclair 6-element yagis. After LPF, circulator, bandpass cavity filter, and feed line losses the ERP is now at the 7kw level. This is likely the highest power 2m beacon currently on the air worldwide. The new PA is a home brew design using a pair of MRF151G push-pull devices operating with PCB Wilkinson splitters and coax delay lines to allow for true quadrature operation of the pair of 300w amplifier pallets.

All QSL reports are welcome and can be sent to: wa1zms@arrl.net, although trans-Atlantic QSL reports will be given the highest priority! More info: www.directivesystems.com/WA1ZMS.htm

WA1ZMS 2m beacon rack



WA1ZMS 2m beacon 500W PA

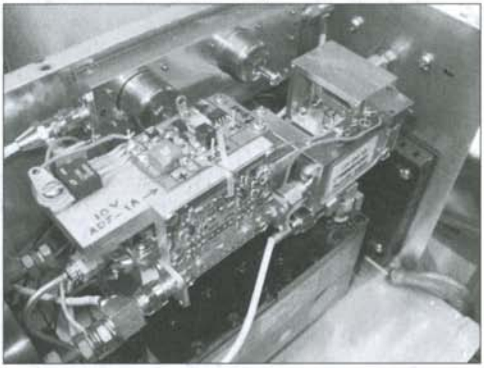
WA1ZMS 2m beacon antenna – FM07FM

4 Meters in the USA

Currently there is no 70 MHz band in the US, but with the change from Analog to Digital Television, this frequency is only used in a few areas of the US. The Central States VHF Society is petitioning the FCC for a new amateur assignment that will be in the EU 4 Meter band. This may only be a few kHz and when the stations are more than 200 km from an active TV CH 4 transmitter but this would permit transatlantic 4 Meter QSO's. Also on 4 Meters, WA1ZMS has applied for a 70 MHz Experimenters license to put up a 70 MHz transatlantic beacon. The beacon will be licensed as a scientific experiment rather than a amateur transmitter. So look for a transatlantic 70 MHz beacon during the next E Season. More details to follow. (WA5VJB)

122 GHz

On the 11th of July N1JEZ and W1RIL had their first long range 122 GHz QSO. While the current record is not in danger, longer QSOs are in work. They used 40.7 GHz Local Oscillators tripling to 122.112 with 30 cm dishes. As I turn in this column they are in the field extending their personal records. (WA5VJB)



W1RIL 122 GHz transverter – close view

W1RIL on 122 GHz

VHF South America

by Flávio Archangelo, PY2ZX

AIRCRAFT SCATTER

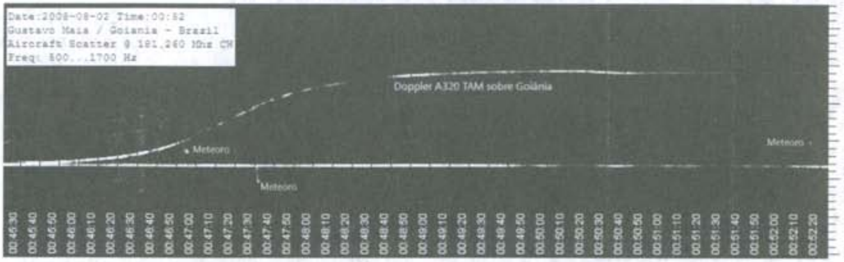


Image 1: Brazilian TV Broadcasting carriers by Tropo and single Aircraft Scatter.

Image 1 is a presentation of a TV Broadcasting signal on *Spectrum Lab Software* as copied by Gustavo Maia (ZZ2FGM) in Central Brazil. It covers the TV carrier at 181,260 MHz (long trace below) and the according Doppler effect (long derivative upper trace) produced by reflections on A320 airplane over Goiania, GH53ih. Since Gustavo is an active monitor of utility frequencies, he can identify the aircrafts and their locations when they produce the lines. The most curious were the multi reflections across the band as show in the image 2. Aircraft Scatter is an interesting field of experiments for amateur radio and is also related to spacecrafts as already covered by DUBUS (04/2007) for old MIR.
G0ISW produced the following table for different heights of the aircrafts and maximum link range If both stations could "see" the same aircraft on their radio horizons:

Link Distance	Minimum aircraft altitude
1000km	20 km
750km	11 km
500km	5 km
250km	1.2 km
125km	0.3 km

Table 1: Aircraft height for link distance by G0ISW http://tinyurl.com/g0isw-air

Lionel Sear, G3PPT, produced specialized software for Aircraft Scatter contacts called *SlowFeld* available at: *http://tinyurl.com/slowfeld*

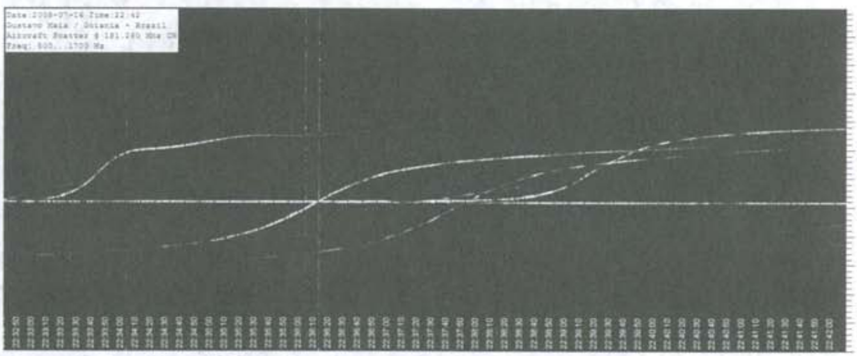


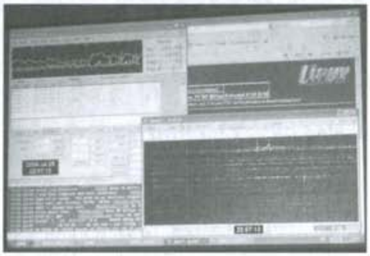
Image 2: Brazilian TV Broadcasting carriers by Tropo and multiple Aircrafts Scatters.

Ingolf Larsson, SM6FHZ, also produced an interesting article and software for prognosis: "*The first time I used ACS intentionally was in 1993 when working SM5BEI (JP81) on 23 cm over a path length of 521 km (...) In 1996 SM5CTV/4M in JP71 was worked on 70 cm over a path length of 452 km. The equipment for* *these QSOs was not extremely sophisticated at neither ends (…) From my winter QTH in JO67aq I can at a daily basis use ACS to hear both SK1UHF [365 km away] and OZ7IGY [241 km away] on 70 cm. I use very modest equipments: IC-706MkIIG with no external pre-amp, 6 element yagi in a fixed direction only 4 m above the ground (…) ACS can be heard on SK7MHL (229 km, 165 deg) and SK7MHH (295 km, 111 deg) as well*". He stated that "*Today ACS is used on an regularly basis from 23 cm to 3 cm to work at least 500 km in the monthly Scandinavian microwave activity contests by several stations*". More information at: *http://tinyurl.com/aircraft-scatter*

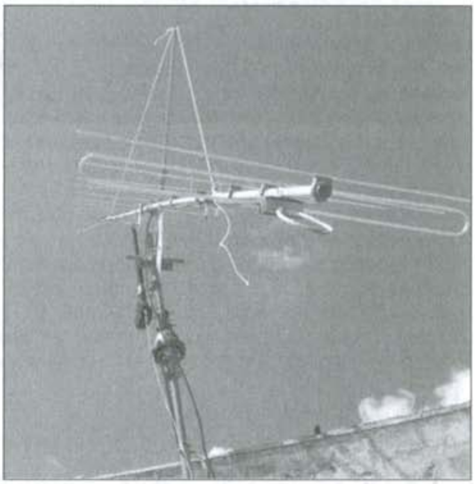
MOONBOUNCE FROM NORTHEAST BRAZIL

A new EME station made their first contacts from Northeast Brazil lead by the post-graduation researcher and engineer Renner Pedrosa (PY7RP). They mounted a simple and well workable EME station on the top of the *Centro de Ciências e Tecnologia´s* building (CTG) where is located the engineering courses of *Universidade Federal de Pernambuco* (UFPE) in Recife, locator HI21nx. The QSOs were made with KB8RQ (EM79su) and W5UN (EM23md) during the *144 MHz Digital EME Championship (DUBUS/REF)*. They used a single EF0213M YU7EF beam with 13 elements, 4 WL (16 dBi), horizontal polarization, PA 160 Watts, IC-7000 and WSJT (JT65B).

PR7CP (l) and PY7RP (r). UFPE ready for Moonbounce!



EME happening on WSJT over Linux



YU7EF beam looking to the tropical sky with 50 degrees of elevation at PY7RP

The azimuth was driven by rotator. Mechanical home made artefacts worked on the elevation system and traditional good paper geometry was used to determine the correct positions. Heavy winds didn't allow raising the mast as planned, limiting the maximum elevation. They also operated on the noisy machine elevator's house in order to minimise loss in the lines considering the usual station's room several floors below. Around 60 meters of network cable were installed to carry Internet to this higher operating position. They are planning to add one more Yagi and a low NF pre-amplifier for new EME QSOs. For skeds and support: py7rp@yahoo.com.br

Elevation system at PY7RP, CTG/UFPE.

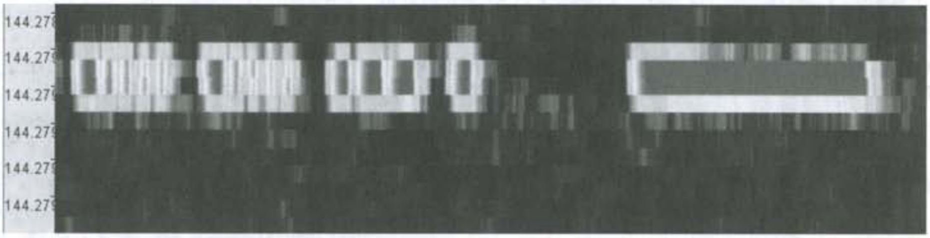
NEWS

Sporadic E: Raul, CE3SOC, identified in March, 2009 several openings to PP2 and PY2 areas on 6 m. and 46/47 MHz UTY services with just a halo. Videos at: *http://www.youtube.com/user/ce3soc*

Europa watching America: In July 02, 2009; Hugh Cocks made recent history again watching in Algarve, Portugal, the TV Recife Channel A2 of Northeast Brazil at 55,250 MHz around 1600 Z. Days before he monitored the TVES Network of Venezuela also on ChA2, while Paul Logan break it's own record of Transatlantic FM DXing via multi-hop Es hearing WVAS 90,7 MHz of Montgomery, Alabama, USA, 6456 km far from his QTH in Ireland.

DX Videos of Paul Logan: http://www.youtube.com/user/yogi540
DX Videos of Hugh Cocks: http://www.youtube.com/user/HughTVDX

Beacon update: PP2SIX and PR8ZIX are well active on 50,073 and 50,018 MHz from GH53 and GI64 respectively. The first was reported in Chile. PR8ZIX was heard on north side of America and central Brazil. PY0FF 50,006 and PU3SIX 50,050 MHz are under repairs. Japy DX Group made in July 2009 2 meters modified equipment frequency stability tests with good results. They received the callsign from ANATEL and expected build a new beacon soon.



Signal of PY2OC test beacon for Japy DX as copied by PY2ZX on SDR.
Each vertical pixel shows 100 Hz, tuned on CWr with tiny bandwidth.

Araucaria VHF Contest: AVHFC became one of the most competitive VHF 50/144 MHz contests in South America with 294 logs received, more than 600 stations contacted, embraced over 6.000 QSOs on 6 meters and 2 meters from 12 countries and 15 PY states! Following some of the top scores. The next edition will take place on October 17 and 18, 2009. The rules are almost the same of CQWW VHF Contest. Popular Cabrillo contest softwares are usable for log. More information, including rules in English, Spanish or Portuguese are at http://www.avhfc.com.

MULTIOPERATOR

STATION	QSO	GRID	POINTS
ZV2K	173	27	7965
PY5ARP	117	31	6572
PT1R	121	19	4123
PY2OC	93	21	3066
PY4BQS	75	21	2730

SINGLE OPERATOR ALL BAND

STATION	QSO	GRID	POINTS
PY2RJ	150	30	7470
PW2P	122	23	4807
PU2TIO	75	11	1419
PY2PE	73	11	1386

SINGLE OPERATOR 144MHZ

STATION	QSO	GRID	POINTS
PU2PJA	70	15	2100
PY2UDX	81	11	1782
PY1MNC	79	06	948

SINGLE OPERATOR 50MHZ

STATION	QSO	GRID	POINTS
PR8ZX	75	68	5100
PU8TEP	36	28	1008
PY2NF	59	12	708

Araucária DX Group
ARAUCÁRIA VHF CONTEST

2-m-EME News

Heinz Borde, DM2BHG
e-mail: H.Borde@t-online.de

DUBUS ACTIVITY 04/09

-DK3EE (Thomas) I was qrv in the first part at beginning, and only 20min in the end of the second part. I worked: IT9CJC, SM2CEW, OZ1HNE, LA8YB (strongest sigs), YO2AMU, K9DX, OK1MS.

-K9DX (John) I am sorry I missed so many stations due to rain static. Missed the first 1 1/2 hours and then the static would be quiet for a time, build to s9 ... and snap back down. So if you were there during the quiet times we probably worked. Anyway I was pleased with the results in such a short time and with some stations I worked for the first time. Worked: F0FXO, IT9CJC FIRST QSO, DL5MAE, YO2AMU, DF1CF FIRST QSO, OZ1HNE, SM2CEW, DK3EE FIRST CW. No USA, no I, no SV, no SP. Very unusual.

-OZ1HNE (Jorgen) I was QRV most of the time in both parts of the April Event and found conditions OK with the sun so close. I had some problems with my RX side on 28 MHz IF, so sorry for the stations calling me without my reply. I worked the following stations on random: IT9CJC, VK2KU, SM2CEW, DK3EE, F0CXO, LA8YB, DL5MAE, K5PF, OK1MS, YO2AMU, K9DX. Thanks to all for the QSO's. It was all great fun as always, and I look forward to the next event.

-VK2KU (Guy) Only a short window in eastern VK this time: 0530 - 0730 UTC in the first time slot. Conditions difficult with gale force winds and occasional horizontal showers. Worked: OZ1HNE and SM2CEW. Called LA8YB many times without any reply. Also heard good signals from DK3EE.

-YO2AMU (Doru) Here is my log-extract for the April Event: OZ1HNE, OK1MS, F0CXO, DL5MAE K9DX, DK3EE. Sorry for missing the first time slot. I was at job until 19.30 LT(16.30 UTC).I found condition fair and all came with nice signals. A very unpleasant noise was wobbling from 144.048 to 144.056 "walking" slowly up and down without any time rule. I was "forced" to jump between free frequency slots , walking with my signals where I found free of QRM place! Heard with good signals IT9CJC but no answer! Also heard SM2CEW.

DUBUS ACTIVITY 05/09

-IK1FJI (Valter) I was qrv in the last event for some time in first and second leg. Found average coditions with some qsb, but i had really fun for the first time try to receive with my new ts 2000, with 5khz bw (i need to modified it for 12khz when find the time). The partecipation quite good i was able to work 13 stations: IK2DDR, SM2CEW, LZ1DP, LA8YB, IT9CJC, RX1AS, K5QE, K9DX, K9MRI, OZ1HNE, OK1MS, DF1CF, SM7GVF.

-K9DX (John) I was active Saturday. The first two hours were pretty good ... the third hour had very deep and long fades. Anyway it was fun and I worked the following 10 stations ...and heard DL1CF but no qso: OK1MS, IK1FJI, OZ1HNE (big consistant signal), LA8YB, K3MRI, SM2CEW K5QE, F0CXO, W5UN, W3TWX.

-OK1MS (Stan) I worked in the second part: K9DX, I3EVK , K5QE, IT9CJC, IK1FJI, SM2CEW OZ1HNE, F0CXO, LA8YB, SM7GVF, K9MRI W5UN, W3TWX

DUBUS ACTIVITY 06/09

-K9DX (John) I am sorry that I was only able to operate for 1 1/2 hours. Signals peaked very strong but had extreme fading. Worked: OZ1HNE, IK2DDR, UA3PTW, SM2CEW, F1FLA IK1FJI, F0CXO, OK1VVP, OK1MS. SV1BTR was booming in but had so many callers that I decided to wait .... and then he was gone! Thanks for the fun. Will try for full time in the next event.

-OZ1HNE (Jorgen) I was QRV most of the time in both parts of the June Event and found good conditions, nice activity and great signals. I came home from a barbecue just in time before the first part, so sorry if my key control was a little unstable. I worked the following stations: SV1BTR, LZ1DP, IT9CJC, F1FLA, SP7DCS, YO2AMU, SM2CEW, OK1VVP, IK1FJI, F0CXO K9DX, UA3PTW, I3EVK, OK1MS, DK3EE. Thanks to all for the QSO's. It was great fun as always.

-YO2AMU (Doru) I found conditions poor and without echoes or very weak most of the time. Low participation due the vacation,maybe. Testing here a new array but, as Joergen-OZ1HNE said,it takes more time to observe if it is performing better than the old array!Especially when conditions are so strange. Good signals from Jimmy-SV1BTR and Joergen-OZ1HNE. Of course, double polarity has to tell us that they are performing excellent in hard condition. No "lock-out" time! Wkd: F1FLA, SP7DCS, IK2DDR, SM2CEW, OZ1HNE, SV1BTR, RX1AS, K9DX, LZ1DP, I3EVK, F0CXO, IT9CJC, OK1MS, OK1VVP. Hrd: IK1FJI, UA3PTW.

-IK2DDR (Francesco) Last Sunday, June 21, I was active on both windows during Dubus 2m cw eme activity event, until 16:05 UTC. I found good conditions in the morning, with strong own echoes and strong signal from all the worked stations. I was really happy to hear the beacon eme signal of my good friend Jimmy, SV1BTR, active after lot of months of QRX, due work commitments. At least I worked 11 stations on 1st and 3 on second leg. Here the list of worked stations: SV1BTR, OZ1HNE, F1FLA, SP7DCS, SM2CEW YO2AMU,

IT9CJC, LZ1DP, IK1FJI, UA3PTW F0CXO, K9DX, OK1MS, I3EVK. Heard:SM3AKW. Many thanks to all and particularly to the Dubus crew for supporting these events.

DUBUS ACTIVITY 07/09

-SP7DCS (Chris) Thanks a lot for good fun on 2m band. I had to quit 1h earlier because of very strong wind. Many thanks for E77DX team for 2m CW sked and new dxcc for me in 10min qso. Congratulations for them for fabulous multi band eme expedition. During the event I worked: SV1BTR, IK2DDR, SM2CEW, LA8YB, PE1LWT OZ1HNE, YO2AMU, F0CXO, I3EVK, KB9RQ K9DX, DK3EE.

-OK1MS (Stan) I worked: IK2DDR, PE1LWT, LA8YB, SV1BTR, OZ1HNE, I3EVK, K9DX, SV3AAF, KB8RQ, F0CXO, SM2CEW, YO2AMU, IT9CJC. Hrd: DK3EE, SP7DCS and UA3PTW.

-IK1FJI (Valter) First leg due oversleep was qrv about one hour, found great conditions with strong signal, in the second leg seems conditions were not good. Saw some weak traces of stations answering my cq but I didn't hear the calls. Wkd: LZ1DP, F1FLA, IK2DDR, F0CXO, IT9CJC SM2CEW, OZ1HNE, SV1BTR, OK1MS, K9DX, I3EVK.

-K9DX (JOHN) Wow. The first 90 minutes were great .... strong signals and lots of them. Then it went dead for the last 90 minutes. From time to time some of the big signals would pop out and then go away again. Here is the log: SV1BTR, SM2CEW, LA8YB, SP7DCS, YO2AMU OK1MS, IK2DDR, DK3EE, F0CXO, UA3PTW, OZ1HNE, KB8RQ, I3EVK, 1239---1400 CQ NIL.

-YO2AMU (Doru) Expecting more from my new array. I was a little disappointed with the results in the last 2 events! I am afraid to think that my old array of 4 x 15 el. BVO was performing better! Let's the time and random activity decide! A lot of regular HAM's were missing. Much noise and a hot summer with more than 37 degrees in the shack. A lot of stations came with surprising good signals moving the S-meter up to S-6. Here is my list of stations worked , all random: OZ1HNE, SV1BTR SM2CEW, IK2DDR, SP7DCS, F0CXO, LA8YB, I3EVK, SV3AAF, K9DX, KB8RQ, IT9CJC,OK1MS.

-OZ1HNE: I was QRV full time in the first part of the July Event and second part was very difficult because of heavy rain with strong static noise (thanks for patience and sorry for all my QRZ). I found very good activity with deep QSB on the signals. I worked the following 17 QSO' on random: SV1BTR, IK2DDR, YO2AMU, UA3PTW, SM2CEW, SP7DCS, DL7HR, F0CXO, SV3AAF, OK1MS, LY8YB, KB8RQ, I3EVK, K9DX, IT9CJC, CT1HZE, DL5MAE. Thanks to all for the QSO's. It was great fun as always meeting friends this way in our hobby. I look forward to the next DUBUS CW EME Event in August.

Next Periods DUBUS CW EME Activity:

Frequency 144.040 - 144.060 CW

22 August	**0830 - 1130 GMT**
22 August	**1530 - 1830 GMT**
5 December	**0400 - 0700 GMT**
5 December	**2100 - 2400 GMT**

Dates are a mixture of high declination, perigee, and lower declination with low background noise. High declination in the summer means that the sun is fairly close to the moon, but the proposed times should not present any problems.
We have to compromise as we are trying not to collide with other activitiy events, on other bands.
More info: **www.sm2cew.com/dubus-aw.html**

DXpeditions

-IS0/DH7FB & IS0/DF2ZC

Completed with 162 different stations in 36 DXCC entities. Country firsts were established with BX1AD, XE2AT, PJ4NX and probably also with OY4TN and maybe more.

-4O3A Dxpedition

The current 2m 4O3A DXpedition to Montenegro suffered from a severe lightning hit during the night from 29 to 30 May 2009. A thunderstorm was getting closer and closer to their QTH and (without any corresponding lightning noticed before) all of a sudden there was a huge bang – most of the equipment was broken. Only later at daylight the full extent of the damage became obvious. A lot of equipment was broken: TS850, Microham usb interface, one laptop, network router, rotor, Transco H/V coax relais and the "Lidl" elevation readout. Even from the commercial broadcasting station at the same QTH, about 50 m away, some equipment had died. Some 10 m away from their shack they discovered a hole in the concrete, just the size of a hand. So the boys were very very lucky that no-one got injured. Those who now might think this would be the end of the dxpedition are of course wrong: Chris, Jurgen and Johan quickly did what was possible to bring 4O3A on the air again, now with spare equipment and on generator since there was no mains supply anymore. And with manual aiming of the 4 yagi group on the moon. 186 are initials. Not surprisingly a lot of people are very happy with the new DXCC and also PA2CHR, PA3FPQ and PE1LWT are happy – that they could help with this new one.

5H1HP & 5H1MS activated Tanzania

Hermann DL2NUD and Joe DL9MS successfully activated the two grids KI93 and KI94 in Tanzania. They completed in excess of 330 QSO altogether from both QTHs. Sadly their linear amp broke on 30 May 2009 so they lost the final three days of activity.

ZA Albania

OK1DFC plans after his successfull Expedtion to E7 in July already his next destination for 2010. He will try to be qrv as ZA1EME on 2m EME and up.

Thaiand on 2m EME in Ocober

Karsten, DL2LAH, will be back in Thailand from October 9 to 24 nd try to be qrv as HS0ZIL from OK16BQ on 2m EME in JT65 with 2 x 10 el Yagis. For 2010 he is planning an upgrade to 4x 10 el.

Once there was a chat about

(Chats of common interest in INTERNET)

- PARAMETER SETTINGS IN MAP-IQ

(DG0OPK, Michael): I am looking for a description of parameter settings in MAP IQ which can be found in:
SETUP-> OPTIONS-> MISCELLANEUS -> Dphi(deg), Fcal(Hz), Fadd(MHz), Csmin, Rxt1 maybe anyone can help for better understanding..

K1JT (Joe) Your questions are very reasonable. This information should of course be covered in the "MAP65 User's Guide and Reference Manual" ... but unfortunately, this document has not yet been written. Very briefly:

1. Dphi (deg) is relevant only for a dualpolarization (MAP65) system. It is the phase shift required to match the Rx systems (H/V, or 45/135 deg) and thus prevent "leakage" of linear polarization components into circular. Dphi is not used by MAP65-IQ.
2. Fcal (Hz) is a frequency correction to correct MAP65's frequency readouts. My WSE converters lead produce a 630 Hz frequency error at centre frequency 144.125 MHz, so I enter 630 here. You can experiment with a known signal in order to get the right magnitude and sign.
3. Fadd (MHz) is the number to be added to your SDR-IQ frequency setting in order to get your on-the-air received frequency. For example, if you use a 144 to 28 MHz down-converter, enter 166.0 here.
4. CSmin is the minimum length of a "word" considered to be a callsign for entry in the Band Map. The second "word" in a decoded message is normally taken to be the transmitting station's callsign. With CSmin=4 (the default value), the # message "TNX JOE 73 GL" will not put "JOE" in your Band Map, because JOE has only 3 characters. (Obviously a better algorithm could be implemented here; this was a quick-and-dirty solution.)
5. Rxt1 is the time (in seconds, since the start of an Rx minute) at which the decoder will start to compute FFTs as part of the JT65 synchronising procedure. Full decoding begins at about t=52 or t=53 s. Decoding speed is improved somewhat if Rxt1 is set somewhat earlier, say t=48 s (the default value). The optimum value depends somewhat on the details of individual computers (CPU speed, cache size, etc.), but you will probably not notice much difference. tems 4 and 5 were put there mainly for my own use during program development. There is probably no need for you to change them. Let me take this opportunity to call attention to the new WSJT page, http://physics.princeton.edu/pulsar/K1JT/ . I have tried to simplify it and make things easier to find, while at the same time bringing a number of links up to date. This has also been an excuse for me to spend some time learning HTML and a little bit about web design, of which previously knew only the barest essentials. I will appreciate any feedback on the new layout -- of course, including suggestions for how it could be further improved!

- Antenna hight (KB2FCV, James): I am working on the tower and mounts for my antennas. I built 4 9el Yu7EF design yagis. They will be on an H frame. I have a question, if the antenna is pointed straight up, how high should the reflectors be off the ground? Is there a minimum and optimum height?

W7GJ *(Lance):* In order for ground not to interfere with the antenna pattern, antenna guru VE7BQH recommends that a good rule of thumb is to keep the lowest projection of the array be half the stacking distance above ground as the antenna is elevated. In other words, if the vertical stacking distance between your yagis is 10', they should always clear the ground by at least 5'. You can use my free SPACE spreadsheet to see the clearance figures all around any sized array as it is elevated.

-Chattering elements (OZ1PIF, Peter): I have the above antenna sitting at approx. 13m agl. It has the annoying habit of chattering the elements in certain wind conditions. I've tried once to tighten the locking washers, but that only helped for a short time. Next time I take it down for fixin' it better be a long-term solution or it stays down. Any advice fellows?

John: I have to hang one of these on each of my 2M5WL yagis. They work great and look good. http://www.chichesterinc.com/images/RaccoonTailsNaturalLg.jpg

AA6EG (Pat): You need to install some lossy mechanical dampers on the elements. Some sort of dielectric material weights, or "sails" or frizzy material on the elements. Maybe a wrap or tie or two of yarn, or some electrical tape, with a bit hanging in the wind, on each element, to move the mechanical resonance frequency away, or "Q" from the element when excited by the winds. If the elements are hollow, a bit of sand in the end of the element, with a plug... At the same time you have to watch that the material used, does not affect the RF properties of the element.

VK5PJ (Peter): I have a six metre M2 yagi (40' boom) that has a similar problem. It would appear that if the delron insulators are not a tight fit in the boom hole, then they will start to vibrate. Mine have gotten to the stage where the boom holes are getting to be oval in shape from all of the movement. I would suggest that you check the fit of the insulators and if any are loose either replace them or like I have done, carefully use a centre punch near the loose hole and force the boom to expand to tighten up the hole / insulator fit. I have also considered using an epoxy glue to help but have not tried this. My m2 is now over 20 years old and I think its time for some new element insulators as they have worn away from the vibrating. My advice would be that if you have a yagi that sings, do not ignore it as it will only get worse. Attend to it as early as you can, with some form of dampening and or check the mechanical fit of the elements. The Dacron overhead support ropes can also resonate at low wind speeds which then will cause slow speed ripple along the boom, this is very scary to watch a 40' long boom ripple like a worm crawling along the ground, so dampening these ropes is a good idea too.

-Spacing between 2-m-antennas (AB1UI, Adam): Quick question for you all. I have a pair of 2mxp20's from m2. Currently I have them spaced at 144 inches. (Which is what m2 suggests although the cross boom they sell is only 10ft long). I am getting a lot of sag in my fibreglass cross boom and was thinking of spacing them at 120 inches (10ft) to remove some of the sag. Will this really effect their performance badly? Can I get away with them spaced at 10ft?

OZ5IQ (Kim): Regarding the spacing of the antennas in general. The spacing given from different analysis programs is : The POINT OF OPTIMUM GAIN. And THIS is absolutely NOT an advantage always! WHY? It will give a pair of long boomers a "nasty" pattern, in the way, that you will get at least two sidelobes, rather close type. 10-20 besides the mainlobe. Its my experience, to compress the stacking distance a bit, and you will get a much more clean pattern! The cost in gain, is only few tenth of a dB, but absolutely an advantage, in the matter when listening at the moon with ONE MAIN lobe. I have only noticed this with antennas with length more than i.e. 6M.

I have been compressing beam with booms of 4,5 mtrs down to as low as 2mtrs! So I will never again use the "optimal stacking distance" again. This is the results of min 20 Y of experience with stacked yagis.

-N type connector instead of PL259? (PY7RP, Renner): I commonly see that many people use N type connector instead of the common used PL259 for VHF and upper frequencies... Is there any reason for this? I found on a quick research in google.com that these type of connectors (the N one) can handle up to frequencies in GHZ scale. But in VHF range is this the most indicated or the PL259 could be used without big problems?

OZ5IQ (Kim): N-connectors are watertight - and do keep the impedance up to several GHz thus handle several kW. At least on 144 MHz.

KL7UW (Ed): My personal preference is the N connector >50MHz. I find their assembly in the field is easier and more reliable. The amount of heat required to solder the shield on PL-259s can often melt centre insulation leading to bigger impedance issues or even shorts. Once used the PL-259 is virtually unusable for installation on other coax. N connectors may be disassembled and reassembled with the centre pin the only item being soldered.

K1JT (Joe): For a very good essay by Dick Kindle, K2RIW, entitled "Coax Impedance's, Losses, and the Maligning of UHF Connectors". See links below.

http://www.vhfsouth.org/tutorials/50-Ohms.htm

http://www.k5rmg.org/UHF-con.html

-FIBER GLASS CROSS BOOM (AB2UI, Adam): I am still dealing with an issue of too much sag in the Fiberglas cross boom on my array and I am forced to reduce the amount of Fiberglas and increase the amount of aluminium. Obviously the less the antennas see of the metal cross boom the less it will affect the performance but does anyone have any documentation I can look at that shows at what distance the antennas start to "see" the aluminium cross boom and what kind of impact it has on their performance?

OZ1LPR (Peter): Hello I am running 4 2mXP20 and instead of Fiber glass I use solid Oak tree poles of 50mm thickness (round). They do not sag at all. I only use 1 guying wire in each side to compensate for the T bracing and the cables weight. The Oak I soaked in Lindoil for 3 days and then covered with heatshrink tubing with glue inside to water tighten it. The bright sides are: The wood is so hard it will not collapse when tightening antennas hard. And It has sit for 3 years now with no problems even though we had high winds. Only draw backs are I had to tighten the antenna clamps a few times because the wood shrinks a little when it dries out. My vertical risers consist of a 4 Foot Oak top and bottom. Rest is Aluminium tubing that can be put together with the Wood with a tight fit. Of course other types of Hard wood can be used also.

K0GU (Jay): I modelled on NEC-2 2x 17B2s stacked horizontally 14 feet apart and then the same two antennas with an 8 foot three inch metal cross boom in the middle. That leaves three feet from the end of the cross boom to the antennas. The plot of just the 2x 17B2s gave 17.50 dBd gain and 28.15 dB front-to-back. The model with the cross boom gave 17.45 dBd gain and 25.59 dBd front to back. So at least on the computer there is some slight interaction. I then modelled a 6 foot cross boom that put the 17B2 four feet from the cross boom. That resulted in 17.46 dBd gain and 27.42 dB F/B. I then changed the cross boom to 2 inch OD. With an 8 ft cross boom the results were 17.45 dBd gain and 27.83 dB F/B. With a 6 foot 2 inch cross boom the results were 17.47 dBd and 24.40 dB F/B (yes the F/B went down).
Modelling is a bit of a conundrum. It I add some mast to the middle of the cross boom it becomes part of the "interacting structure" and changes the results a little. From what I can tell about three feet separation from the cross boom should generally cost you less than 0.1 dBd gain and will have some minor affect on the pattern.
KL7UW (Ed): Another approach is to install the antennas in the "X" position rather than with vertical and horizontal elements. This decouples the antennas a little more from your crossboom. To achieve V-pol and H-pol is a little more complicated in switching, though. See Leif Asbrink's, SM5BSZ, website for how that is done.

NEWS AND INFORMATION

-Linrad setup (PE1LWT, Jurgen) We are still getting requests about our Linrad setup and how to.. On my homepage I put some file together with some screen dumps as a start Just follow the appropriate link on:
http://www.xs4all.nl/~pe1lwt/html/newsetup.htm

-ARRL rules changes (KX9X, Sean) The VUAC has released a White Paper, explaining their reasoning on their recommendations for rules changes in the upcoming 2009 ARRL International EME Competition. The PDF file can be found under the Rules and Forms area of the main contesting page (www.arrl.org/contests), or you can view it directly here:
http://www.arrl.org/contests/emerules.pdf

Dates for the ARRL 2009 EME Contest 50 MHz to 1296 MHz are October 10/11 and December 5/6.

-SM5CUI (Rune) Today is a happy day for me, when I received the 144 MHz DXCC # 37 from ARRL. It has been a dream for a long time, but now it's real. Got my licence 1961 and have been an active grid square hunter on VHF. In middle of the 1970 I used 2x10 el.1,6 wl. Wisi yagis and QQE 06/40. Later I got a home-made PA with 2x4cx250B in push-pull. I use the same today. Most of the "DX" was worked on Aurora and HSCW with tape recorder. Never heard an ES opening until a few years ago, up here in the north. At that time skeds were made up with letters or 14 MHz radio. 1982-2002, 20 years QRT.
Had enough of radio in my new job at the local FM/TV broadcast station. Got experience and instruments to measure to see what I was dealing with. 2002 I decided to start up again and now try, for the first time EME on 2m. My two old small yagis was not enough, so I had to search for more of them. Not easy to find, but I was lucky to get four, but in a bad shape. The first station I heard off moon was I2FAK, and I was able to work him. hat was with the small 4x10 el.1,6 wl, they look like TV-antennas. Later I got the remaining 2 up and 6x10 el. were working good. The first digital JT44 qso was in January 2003 with S52LM. A few years later I found another two yagis, with 8x10 it was easier to work a lot of EME. Two years ago I got four old 15 el.3wl CueDee antennas. I now use them horizontal pol. 15m. up in tower. Four of the 10 el. yagis are now down at ground level beside the garage for vertical pol. The LNA's are down in shack as I only have 0.25 dB loss in the 1 5/8" cables. My rig is like the other old stuff, FT225RD and as 2nd rx, TS700S. I will end this story with a big THANK to all of you in different country's. You helped me to get this fine award. All operators of the xpeditions who make so many DXCC's possible to get. K1JT Joe for the new mode FSK441 who made I could continue with meteor scatter. The rubber belt in tape recorder was to dry to turn the wheel after 20 years stop. Hi At last: I wish you all good health. Have fun and enjoy one of the finest hobbies we have.

TREASURY INTERNET

-VK3UM EMECalc Ver 6.01
The software in a zip format may be obtained from
http://sm2cew.com/download.htm
http://www.ve1alq.com/vk3um/
http://www.vk3bez.org/vk3um_software.htm

REF / DUBUS EUROPEAN EME Contest 2009 - CW Results *by DL8HCZ*

MULTIBAND

Place	Call	Points	PWR	Bands
1	OZ4MM	2.128.000	QRO	2/70/23/13
2	G3LTF	1.956.000	QRO	70/23/13/9
3	F2TU	1.830.400	QRO	23/13/3
4	OK1KIR	1.623.600	QRO	23/13/9/6/3
5	ES5PC	1.456.000	QRO	23/13/6/3
6	SD3F	1.280.000	QRO	2/70/23/13
7	K1RQG	1.162.800	QRO	70/23
8	OK1DFC	955.800	QRO	23/13
9	SP7DCS	772.800	QRO	2/70/23
10	OH2DG	721.000	QRO	70/23/13
11	VK3UM	720.900	QRO	70/23
12	SP6JLW	695.200	QRO	70/23
13	WA6PY	693.000	QRO	2/70/23/13/3
14	SV3AAF	655.500	QRO	2/70/23/13
15	SM2CEW	593.400	QRO	2/20/23/13
16	DF3RU	475.200	QRO	70/23
17	OK1CA	395.600	-	13/9
18	DL1YMK	369.600	QRP	70/13/9
19	W5LUA	369.000	-	13/9/6/3
20	UA3PTW	348.000	QRO	2/70
21	DL4MEA	338.400	QRO	23/13/9
22	JA6AHB	296.800	QRO	70/23
23	JA4BLC	262.400	QRO	23/13/9
24	F5JWF	258.400	QRP	23/13/3
25	K2UYH	237.900	QRO	23/13
26.	G3LQR	150.500	QRP	70/23/13
27	OE5JFL	129.500	QRO	70/23
28	OZ6OL	117.000	QRO	70/9
29	LZ1DX	113.100	QRP	70/23/13
30	JA6CZD	85.800	QRP	23/13
31	SM3JQU	46.200	QRP	70/23
32	CT1DMK	22.000	-	6/3
33	JA8IAD	16.800	QRO	23/13

144 MHz

Place	Call	Points	QSO (+Sked)	Multi	Pwr	OP
1	SP7DCS	119000	35	33	QRO	SIN
2	LA8YB	87000	30	29	QRO	SIN
3	YO2AMU	78300	29	27	QRO	SIN
4	OZ1HNE	75600	28	27	QRO	SIN
5	OK1MS	52900	23	23	QRO	SIN
6	IK2DDR	48400	22	22	QRO	SIN
7	OZ4MM	44100	21	21	QRO	SIN
8	I3EVK	38000	20	19	QRO	SIN
8	SM2CEW	38000	20	19	QRO	SIN
10	K9MRI	36100	19	19	QRO	SIN
11	LZ1DP	34200	19	18	QRO	SIN
12	RA6DA	32400	18	18	QRO	SIN
12	UA3PTW	32400	18	18	QRO	SIN
14	SD3F	25600	16	16	QRO	SIN
15	F0CXO	22500	15	15	QRO	SIN
16	W3TWX	16900	13	13	QRO	SIN
17	DF1CF	3600	6	6	QRP	SIN
17	WA6PY	3600	6	6	QRO	SIN
19	9A9B	1600	4	4	QRP	SIN
20	RV9UV	900	3	3	QRP	SIN
20	YU7XL	900	3	3	QRP	SIN
22	VK2KU	400	2	2	QRP	SIN
22	SV3AAF	400	2	2	QRP	SIN
24	F6DRO	100	1	1	QRP	SIN

432 MHz

1	OZ4MM	197800	46	43	QRO	SIN
2	K1RQG	172000	43	40	QRO	SIN
3	UA3PTW	168000	42	40	QRO	SIN
4	G3LTF	160000	40	40	QRO	SIN
5	I1NDP	152000	40	38	QRO	SIN
6	VK3UM	115500	35	33	QRO	SIN
7	SP6JLW	78400	28	28	QRO	SIN
8	SD3F	75600	28	27	QRO	SIN
9	DL1YMK	72900	27	27	QRP	SIN
10	DF3RU	65000	26	25	QRO	SIN
11	SM2CEW	62500	25	25	QRO	SIN
12	N4GJV	55200	24	23	QRP	SIN
13	OZ6OL	52900	23	23	QRO	SIN
14	JA6AHB	48400	22	22	QRO	SIN
15	OE5JFL	42000	21	20	QRO	SIN
16	JJ1NNJ	28900	17	17	QRO	SIN
17	DL9KR	25600	16	16	QRO	SIN
18	OH2DG	23400	18	13	QRO	SIN
19	SP7DCS	22500	15	15	QRP	MULTI
19	SV3AAF	22500	15	15	QRP	SIN
19	WA6PY	22500	15	15	QRP	SIN
19	DL7APV	22500	15	15	QRO	SIN
23	JA9BOH	16900	13	13	QRP	SIN
23	SM3JQU	16900	13	13	QRP	SIN
25	NC1I	14400	12	12	QRO	MULTI
26	G3LQR	10000	10	10	QRP	SIN
27	LZ1DX	4900	7	7	QRP	SIN
28	S51ZO	3600	6	6	QRO	SIN
29	YO2IS	2500	5	5	QRP	SIN

1296 MHz

1	K1RQG	440200	71	62	QRO	SIN
2	F2TU	406000	70	58	QRO	SIN
3	OZ4MM	381900	67	57	QRO	SIN
4	OK1DFC	324000	60	54	QRO	SIN
5	SP6JLW	306000	60	51	QRO	SIN
6	G3LTF	285000	57	50	QRO	SIN
7	LZ2US	275000	55	50	QRO	SIN
8	VK3UM	259200	54	48	QRO	SIN
9	OK1KIR	234000	52	45	QRO	MULTI
10	ES5PC	215000	50	43	QRO	SIN
10	ON4BCB	215000	50	43	QRO	SIN
12	DF3RU	188600	46	41	QRO	SIN
13	MI/DL1YMK	184000	46	40	QRP	SIN

14	OH2DG	175500	45	39	QRO	SIN
15	K0YW	155800	41	38	QRO	SIN
16	SP7DCS	151200	42	36	QRP	MULTI
17	SD3F	148000	40	37	QRO	SIN
18	SV3AAF	140000	40	35	QRO	SIN
19	SM6FHZ	125400	38	33	QRO	SIN
19	HB9MOON	125400	38	33	QRO	MULTI
21	RK3WWF	108500	35	31	QRO	MULTI
22	JA6AHB	105400	34	31	QRO	SIN
23	IK3COJ	102000	34	30	QRP	SIN
24	UT5JCW	95700	33	29	QRP	SIN
25	PI9CAM	89900	31	29	QRO	MULTI
26	DL4MEA	87000	30	29	QRO	SIN
27	OK3RM	81000	30	27	QRP	SIN
27	WA6PY	81000	30	27	QRO	SIN
29	K2UYH	72500	29	25	QRO	SIN
30	IW2FZR	70000	28	25	QRP	SIN
30	JA4BLC	70000	28	25	QRO	SIN
32	K2DH	62400	26	24	QRO	SIN
33	DL3EBJ	59800	26	23	QRP	SIN
34	JA6CZD	55000	25	22	QRP	SIN
34	ON5UN	55000	25	22	QRO	SIN
36	LZ1DX	37400	22	17	QRP	SIN
37	LA9NEA	36000	20	18	QRP	SIN
38	G3LQR	34200	19	18	QRP	SIN
39	F5JWF	34000	20	17	QRP	SIN
40	K5SO	32400	18	18	QRO	SIN
41	OE5JFL	24000	16	15	QRP	SIN
42	SM2CEW	16900	13	13	QRO	SIN
43	VA7MM	14300	13	11	QRP	MULTI
44	JA8IAD	10000	10	10	QRP	SIN
45	SM3JQU	7200	9	8	QRP	SIN
45	W9IIX	7200	9	8	QRP	SIN
47	PA3FXB	4200	7	6	QRP	SIN
48	N9JIM	3600	6	6	QRP	SIN
49	AL7RT	1600	4	4	QRP	SIN
49	DL1HYZ	1600	4	4	QRP	SIN
49	VA3TO	1600	4	4	QRP	SIN

2300 MHz

1	OK1CA	133000	38	35	SIN
2	F2TU	125400	38	33	SIN
3	ES5PC	111600	36	31	SIN
4	OK1DFC	78300	29	27	SIN
5	OK1KIR	58200	24	22	MULTI
6	G3LTF	57500	25	23	SIN
7	SD3F	44000	22	20	SIN
8	OH2DG	36000	20	18	SIN
9	G4CCH	34200	19	18	SIN
10	SV3AAF	32300	19	17	SIN
10	W5LUA	32300	19	17	SIN
12	WA6PY	28800	18	16	SIN
13	DL1YMK	27000	18	15	SIN
14	K2UYH	22400	16	14	SIN
15	DL4MEA	19500	15	13	SIN
16	HB0/DF1SR	18000	15	12	MULTI
17	F5JWF	16800	14	12	SIN
17	SM2CEW	16800	14	12	SIN
19	OZ4MM	15600	13	12	SIN
20	JA4BLC	11000	11	10	SIN
21	VE6TA	10000	10	10	SIN
22	SP6GWN	9450	10+1	9	SIN
23	WG5AGO	9000	10	9	SIN
24	G4DDK	5400	9	8	SIN
25	G3LQR	4900	7	7	SIN
26	DF9QX	2500	5	5	SIN
26	JA8ERE	2500	5	5	SIN
26	LZ1DX	2500	5	5	SIN
29	JA6CZD	1600	4	4	SIN
30	JA8IAD	400	2	2	SIN

3400 MHz

1	OK1CA	6400	8	8	SIN
1	OK1KIR	6400	8	8	MULTI
3	G3LTF	5600	8	7	SIN
3	OZ6OL	5600	8	7	SIN
5	DL1YMK	4200	7	6	SIN
5	W5LUA	4200	7	6	SIN
7	DL4MEA	3000	6	5	SIN
7	G4NNS	3000	6	5	SIN

5700 MHz

1	OK1KIR	16900	13	13	MUL
2	ES5PC	9000	10	9	SIN
2	IK2RTI	9000	10	9	SIN
4	CT1DMK	5400	9	8	SIN
4	W5LUA	5400	9	8	SIN
6	G4NNS	5250	7+1	7	SIN
7	JA4BLC	4200	7	6	SIN
8	WD5AGO	1600	4	4	SIN

10 GHz

1	IQ4DF	19600	14	14	SIN
2	F2TU	19500	15	13	SIN
3	OK1KIR	12100	11	11	MULTI
4	W5LUA	10000	10	10	SIN
5	F5JWF	9000	10	9	SIN
5	G4NNS	9000	10	9	SIN
7	ES5PC	7200	9	8	SIN
8	GW4DGU	4900	7	7	SIN
9	WA6PY	3600	6	6	SIN
9	LX1DB	3600	6	6	SIN
11	SP7JSG	900	3	3	SIN
12	CT1DMK	400	2	2	SIN
13	DF9QX	100	1	1	SIN

Note for Multiband:
If one or more of the bands of 2m / 70cm / 23cm was QRO category then on Multiband also QRO is listed. This is just for information. On 13cm and up there is no QRP/QRO indication.

Congratulations to all winners:
OZ4MM on Multiband, SP7DCS on 2m, OZ4MM on 70cm, K1RQG on 23cm, OK1CA on 13cm, OK1CA and OK1KIR on 9cm, OK1KIR on 9cm and IQ4DF on 3cm. Again more activity and entries on all bands from 23cm and up. Especially 3.4 + 5.7 +10 GHz activity was up this time! Allthough some regular big guns were absent on 2m this time, we got same number of entries. 70cm activity also good. In total again more contest entries in 2009 vs. 2008. QRP winners are DF1CF on 2m, DL1YMK on 70cm and Multiband and MI/DL1YMK on 23cm who gets a also special award for the best 23cm EME expedition of the contest.
Certificates will be sent out in September.
73 Joe, DL8HCZ/CT1HZE

Soapbox

YO2AMU, 2m: Glad to see again old friends and new ones! Vertical polarization for long time! Low activity at the second Moon-pass. Calling CQ for hours and no answers. At 1500 UTC/29.03.2009 - decide to stop the contest. Low partici-ation of USA and JA and no participation of SA and AF. Glad to hear VK2KU, VE2JWH, W3TWX, G4ZFJ, UA3PTW, DF1CF in our contests! Sorry for those I did not copy the calls. Several times I heard only my call followed by a deep QSB when was sending the caller callsign! Sending "YYYYYYY" has no effect...again only my call! Hi! Thank you very much for the fun in "human mode"!

LZ1DP, 2m: I tookpart in EU EME contest and found that the conditions were very changeble on the first day. Most of the time I used vertical polarization, but then there was much noise from an electricity line 2 km away from my place. On second day conditions were better, but low activity especially from USA stations. I made only 19 QSOs.

GW4DGU 10GHz: I finally managed to get back on the band. Our weather didn't allow operation on Saturday (high winds - F8 Beaufort), and I had a problem with a shaft encoder which seems not to be what is marked on the case ;-) This weekend wasn't optimum for microwave EME. Perhaps in the future EME contest organisers could choose weekends where the Moon is closer to perigee for the higher freqency band sections. A dB and a bit makes a lot of difference. Something which was reflected in a greater proportion of TMO reports than usual. Despite that, I worked everybody I heard in the few hours I was able to be qrv: F2TU, G4NNS, F5JWF, ES5PC (1st ES-GW QSO on 10GHz), OK1KIR, IQ4DF, and W5LUA. Vy 73, Chris, GW4DGU

OZ4MM, 2m: I was able to be QRV some hours during this weekend on 144MHz, in the DUBUS CW contest. Conditions here was found OK, but many hours with vertical polarisation. Activity was as expected, but for those who were QRV 10-20 years ago on 144MHz, very little activity nowadays on CW. Newerless it was very nice to work some of the old stations, I worked more than 25 years ago on 144 EME.

SV3AAF, 70cm: Activity was relatively good on MHz. Mostly good signals with Faraday spread during eastern window and to the west vertical conditions with one way propagation to central and northern Europe, had to alternate polarity between RX/TX. Single & non-adjustable polarity stations would have a hard time. On Sunday I only had the chance to operate later when the traffic was disappointing with only the usuals calling CQ; no stations responded my calls.
Libration was terrible at times. I think it will help a lot to account for libration when arranging activity weekends and contests for 432 and 1296 where it is the most disturbing.
I have put together a low libration table on http://users.otenet.gr/~pgiogk/sv3aaf/page4.html and expect it to reflect conditions better for the northern temperate latitudes while moon at high positive declination.
If anyone gets the chance to check it out over time, please email me with a feedback. So far this year table's lows were clearly observed here (KM17) in January and March while February was not that clear. Libration highs don't show on the table and they are assumed at 4 days before the start date and 5 days after the end date of the low periods. It is all based on lunar ephemeris and takes geometric libration as the root cause of the effect on signals although phenomenon seems more complex, possibly relating to magnetic field distribution and disturbances. 73, Petros

OZ6OL, 70cm: First thanks for all the CW QSOs! I was using a new loop feed, but only with horizontal pol. The feed shows very good performance on my 5m dish. Sun noise (flux 71) is 12.4 dB to cold sky and ground to cs (leo) is 4.6dB. I will now build a 180 deg pol. rotator system for the loop feed. 73 Hans

I1NDP, 70cm: Unfortunately I could not be on air during the first moon pass on Saturday morning, I have also lost several hours for bad weather and suffering a lot for an unusual high level of noise left behind by the windy & stormy conditions.
Conditions, moon wise, have been good in average with some fast signal level change. Even so, I'm satisfied of the result and good participation so thanks a lot to the organisation and to the emers community.

SP7DCS, 2m & 70cm. At first I would like to thank all for nice qsos and good fun. Conditions on 2m week ago and on 70cm this weekend were difficult for H pol only stations like me. Most of time Faraday was not coperative and only stations that can change polarization were audiable. There were also deep signal fadings. Of course there were also some good moments in both weekends on both bands. In 2m leg activity was quite low, but I worked 35 stations that is the same as last year. 70cm was a good surprise with 15 stations that was able to read my small signal. My station is 4 x 25el H pol and 400W at shack. Activity was quite good and I hope to be more active on 70cm in future.

SM2CEW: Mixed weather (strong winds) resulted in plenty of off times during the contest. Highlight for me was to hear the activity on 13cm, I am new to this band and the amount of stations QRV on this band was truly a surprise. Also, super signals from all. Really nice contest format, thank you to the organizers of this fine event! 73 Peter

EME News

70cm & up

Editor: Bernd Wilde, DL7APV

Intro

We had several nice events in the last 3 month.

Apollo SSB Fun event on 23cm brought high activity. See VK3UM report later on.

3 Expeditions made good activity. Back in June **MI/DL1YMK** Michael & Monika made a successful 5 band trip to GI. See his report.
Be careful, they will be on **tour** in **october** again!

OK1DFC made also a 5 Band activity, but from E7. They made 109 QSO on 144, 22 on 432, 46 on 23cm, 20 on 13cm and 7 on 9cm. Zdenek writres: "I was last week traveling in Albania - ZA and looks that it can be target for next EME pedition in 2010 if everything will go o.k. I had meeting with people in Albania telecommunication authority and they confirmed possibility to have license from 144 MHz up to 10 GHz including 9cm. Call ZA1EME or so possible."
And also the **8J1AXA** big Dish events made a lot of public. See JH1KRCs report.

The **C37DXU** Andorra expedition was also successful on 2m and 70cm. See for details:
http://www.eme2008.org/c37dxu/index.html
They wkd on 432 I1NDP, OH2DG, UA3PTW, DL7APV, OK1DFC, G4RGK, DL7UDA, DL9KR*, HB9Q, ZS6WAB, K2UYH, SV1BTR*, DG1KJG*, OZ4MM*, LZ1DX, K2UYH, K7XQ, I1NDP, OH2DG, UA4AQL, UA4API, OK1KIR, OK1KIR* G3LTF*. (*=cw)

ARRL contest 2009 comes with new rules which are very welcome. Internet loggers are not allowed so we hope all parties are satisfied and participation will increase. Dates: **Oct. 10/11 & Dec. 5/6 50-1296** and **Nov. 7/8 2320 &up**. More at: www.arrl.org/contests/rules/2009/eme.html

HAM Radio 2008: We had a little meting of some 70cm & up EME ops, like SM4IVE, SM7GVF, DL1YMK, HB9BBD, HB9JAW, OE9ERC, DL7YC, DL2NUD, ON4BCB and many more EMEers joint the meeting.

432

Due to summer time, the activity on 432 was down. But we had highlights, the expeditions. 5N0EME, Bodo is again qrv from in Nigeria until October.

UA3PTW wkd CX5IC in JT65
RV9UV made his first 70cm EME QSO with HB9Q, JT65B congrats.

1296

PY2BS & JA6AHB made a new 23cm record long path over 18.853km on May first in JT65 and added a CW qso on June 26th. Congrats to both stations, max el. on both sides was 3,5°!!
http://www15.plala.or.jp/ja6ahb/page026.html

Dubus 23cm contest May 30&/31:
VK3UM was about an hour late getting on for my Moon rise on Saturday and may have missed a few NA stations. Conditions were excellent both days except at low elevation when considerable Libration was evident. Unfortunately the low GHA made it harder for some in the Northern Hemisphere and reflected back on me when my greatest activity then occurred in the last few degrees of my moon. (with added ground noise). As it happened I worked PI9CAM starting at 0.2 degrees of moon on the Saturday but left some one in my 'moon shadow' on the Sunday! (who was it? a DL2?). For me it was a rare event to actually work some one at 48 degrees elevation when given the high DEC weekends it rarely gets above 28 degrees. Score 54x48= 259200 points Thanks to all that came on, great operating skills and a lot of fun (hard work). A special thank you to David VK2JDS who came on CW unannounced and to Chris VK5MC who was running flea power to his new 10 meter dish. Very pleasant surprises.
73 Doug VK3UM

Technical

In this issue we will have a closer look to the **preamp** needed for EME. In all cases sensivity is needed to hear better. This is more valid on 432 & up due to colder background in the sky. The best preamps I know are around 0,25dB. BUT when talking about absolute values of noise figures we have to remember that the measurement error is nearly in the same range!!! You need a good noise figure meter and you have to know what you are doing. If no expensive noise figure meter is available there is only the chance to measure the performance in the antenna with sun noise or other galactical sources.

I will give some **examples** from the VK3UM simulation software with a single 21el. F9FT yagi. Sun flux =70, Tsky = 30K, gain preamp 20dB.

RX	Noise figure	Sun noise	Difference
Trx+10m RG213	3,5dB	1,9dB	0
Trx+5m Aircom	2,3dB	2,7dB	+0,8dB
Trx+preamp 1dB	1dB	4,1dB	+2,2dB
Trx+preamp 0,5dB	0,5dB	4,8dB	+2,9dB
Trx+preamp 0,25dB	**0,25dB**	**5,3dB**	**+3,4dB**
Trx+preamp 0,35dB	0,35dB	5,1dB	+3,2dB
Trx+preamp 0,45dB	0,45dB	4,9dB	+3,0dB

We can see that a low loss cable + preamp in front of an antenna can improve signal like doubling the antennas. If all other parts are optimal a tenth of a dB at the preamp makes not the big difference. But 10m **RG213 will kill** all possiblilities of a EME qso where small signals are expected.

Which preamp is best?? This question has no answer which will fit every case. It depends on loacation and your wallet. In an urban area you need all selectivity that is possible and IP3 must be good, NF is secondary. On a lonely island only NF is interesting. And if you are able to use a soldering iron it can cost 20.- Eur, but you can pay up to several hundred Euros for a comercial one. The one I use today is from Hubert, DJ3FI a very fine cavity with <0,3dB NF. Bandwith is small and IP3 fair. Better IP3 have for example the DB6NT preamps with ATF54.. series transistors, but they have wideband input. OZ2OE published in Weinheim some years ago a preamp with ATF54143 which will cost only <20 €. He used only a serial C input to Gate and no tune. Simple and good, a bit difficult to handle self oscillation. The production charges of the ATF are not always the same, so dependend on the individual transistor you have NF will be 0,3 to 0,5.

There are of course many other preamps available. Google for preamp 432 and there will be much info. Or look here :

http://www.g0mrf.com/432LNA.htm
http://www.ssbusa.com/db6ntvhfuhf.html
http://www.qsl.net/dl5lf/432_preamp.html
http://www.downeastmicrowave.com/PDF/70ulna.PDF
http://www.rfham.com/ preamps
http://www.kuhne-electronic.de/de/shop/143_Vorverstaerker

Next important point is the **matching** from the antenna to the preamp. If you buy a preamp or the homebrew preamp is optimized at a noise figure meter the best NF at the antenna can be achieved only if the antenna has the same impedance as the noise source, typically 50 Ohms. So in order to not loose sensivity, the return loss of the antenna has to be 16dB or better (SWR <1,4).

Enough **gain** of the preamp is recommend. Based on the example before, we change gain and cable length.

RX Trx+preamp 0,25dB	Cable loss	Preamp Gain	Sun noise	Differ-ence
	1dB	20dB	5,3dB	**0 dB**
	1dB	15dB	5,2dB	-0,1dB
	1dB	13dB	4,6 dB	-0,7
	1dB	10dB	4,4 dB	-0,9
	2,5dB	20dB	5,2dB	-0,1dB
	3 dB	20dB	4,8 dB	-0,5dB
	5 dB	20dB	4,7 dB	-0,6dB
	10 dB	20dB	4,1 dB	-1,2dB
	10 dB	10dB	1,7 dB	-3,6dB

The NF of the TRX 2dB, the gain of preamp is 20dB, cable preamp-TRX has a loss of 1dB. Now we change the values and see that with a 1 dB cable loss the gain can be as low as 16dB to effect the noise figure. See table above.

Tuning. All who have a noise figure meter I hope know how to use it, but for all other I have a very simle trick from OE3JPC. All you need is your station with a FM RX an analog ac-voltmeter and a very small signal in band. The voltmeter is connected to the audio out of the tranceiver. Use long wires so that you can read the voltmeter while tuning the preamp in the antenna. Tune the RX on a very small signal. Turn the antenna into the "cold" sky and tune the preamp until the reading of the voltmeter is minimum. (In german a better description is here:
http://www.qsl.net/oe3jpc/eme/UHFTECH3.pdf

It is very simple to optimize the preamp in the used antenna, all problems due to mismatch (bad SWR) are solved this way. The only disadvantage is, you optimize relatively, so no idea about the absolute noise figure. This can be solved by measuring the sun noise or other noise sources compared to the cold sky.

Checking **absolute noise figure** of the preamp with the sun. If there is no noise figure meter, we can use easily the antenna and TRX as measuring system. We need two things to measure, a good S-meter (or a chance to get the voltage from the S-Meter) and a step attenuator. The measuring function of the WSJT software fits not, because the demodulators of the receivers are often not linear. The preamp must have enough gain so that the step attenuator does not decrease the system noise figure. As we can see in the table above we need more than 20dB gain when a 10dB attenuator is needed (depends on estimated sun noise).

With the **VK3UM EME planer** (or other software) we can calculate where are the cold sources and the sun are at a given time.

Procedure is to point the antenna first to cold sky (Aquarius, Leo or Pictor) and read the S-meter (or better a voltmeter parallel to the S-meter). Then we point to the sun and now we switch the step attenuator to the postion that we get the same S-meter reading as before. Now we see our sun noise on the step attenuator. Because of local noise and (at high sun activity) various flux values this should be repeated 3-5 times a day. With the mean value of this values we should get close to reality.

The same procedure can be made with the **ground noise**, but there are several problems to solve. First is to have a dry non conductive ground in your garden. It took me 3 years to find out that my garden is wet and has a good conductivty.

Good for 80m verticals, but gives not the estimated ground noise values. Second is man made noise, modern plasma TVs switching power supplies make some more or less noise. So I found out, that my housewall is the best "ground noise" when all PC & TVs are off. So instead pointing to the sun the antenna is pointing into the ground or housewall with the full beam and we get the ground noise.
With this values measured carefully and some more times to get a feeling for this we can calculate the RX parameters.

Getting own NF by two measurements
The VK3UM EMEcalc helps us to find out if the station is ready for EME. For our example we take a single 21el. yagi which is very popular in Europe.

Gain	18,2 dBi = 16dBD
Flux today	75
Cold sky	20K (Aquarius) or 25K (Leo)
Loss ant-preamp	0,2dB (2m aircom+2N-connectors)
Preamp NF	0,5dB (start value)
Preamp Gain	19dB
Loss preamp to RX	0,4dB (5m aircom+connectors)
NF of RX	3dB (I hope worst case)
sidelobes	15K
backlobes	5K

These values we put in the VK3UM calculator. The last two needed values are a bit difficult, spillover and feedthru. These names come from dishes and mean at yagis sidelobes and backlobes. The lobes give some extra noise to the dipol and the system. We go into the datasheet of the antenna and see first sidelobe is 13dB down and the front/back ratio is >20dB. So we have up to 15K from the sidelobe and about 5K from the back. These values can be much higher in a noisy urban area!!
Now we can calculate the noise figure and gain of the system. For a 0,5dB preamp we have to measure 5,6dB sun and 4,7dB ground. If not:

Sun	Gnd	what is wrong
4,6	3,2dB	preamp has 1dB NF
4,6	4,7	antenna gain is 1,5dB low
4,0	3,2	NF is 1dB & 1db low Gain

For the two measured values we can calculate exactly gain & NF of the system when all other parameters are fixed and known. So this way shows how to find out the own parameters. With one yagi the gain should be as it was taken from the datasheet, otherwise the antenna has a problem. At bigger groups as 4 or more yagi also the gain can be wrong by error in phasing lines. This should be found out also by the method above. See other station data at:
http://www.do9bc.de/index.php?page=806688781&f=1&i=1179997641&s=806688781

1296 & up

by DL1YMK Michael

Which dish would you like?

If you want to get started on 23 cm & up moonbounce with a dish of reasonable size (the fun really begins at 3 m dia), you first will have to spend a few thoughts on a suitable ratio of the focal length to its diameter (f/D), in order to be able to illuminate it effectively. This applies for building your own prime focus dish from scrap (offset dishes is another story), as well as if you are lucky enough to have spotted a surplus one.
So let's take a look at the pro's and con's of differently shaped dishes with respect to their efficiency for moonbounce. The focal length f of a prime focus parabolic dish can be easily calculated as f = diameter^2 / (16 x c), where c is the depth of the dish in the centre up to its rim level. In other words this means that with an increasing f/d ratio the dish simply gets more shallow. For a home brew dish this implicates an easier way of constructing the struts by a template with only little deviation from the ideal parabolic curvature, which has a significant impact on its maximum working frequency. A huge majority of big hb dishes (7 - 15 m dia) have an f/d range of 0.5 – 0,6. BUT you have to be aware that for such kind of dish the focal length is significantly longer than that of a deeper dish.

E77DX 9cm - opposite of dish TRV and SSPA connected by hard line to the feed

For example a 6 m dia dish at f/D = 0.5 has a focal length of 3 m – this means a 3 m long lever arm, that carries all the weight of your feed system, transverter etc. The same dish at f/D = 0.375 possesses a reduced focal length of only 2.25 m. This has to be thoroughly observed in the mechanical layout of your dish's struts structure, as it will contribute to the (elevation dependent!!) distortion. Most probably this will not be noticed on 23 cm, but you will suffer from it on 9 cm already, where the beam width comes into the lower one digit degrees range. It is said a certain MI/DL1YMK had to deal with this kind of squint problems on 9 cm recently...

A very nice mechanical solution to overcome any distortion problems has been realized by Geert, PA3CSG, which can be seen on his web page (www.pa3csg.hoeplakee.nl): his feed support structure is completely decoupled from the parabolic reflector, which then stays in perfect parabolic shape.

Generally, a deeper dish, if properly illuminated, exhibits lower side lobes, hence it will pick up less ground noise. Therefore EMEers with a more shallow dish of F/D @ 0.5 tend to feed the dish in a way that the -10 db power level is located on the rim. This implicates a feeder of relatively narrow beam width and the W2IMU dual mode waveguide feeders proved to be best choice in this case. Recently N2UO has described a no-tune version of this CP feeder using a septum instead of the delay line screws of the original layout.

Most surplus so called **T**ele**V**ision **R**eceception **O**nly (to err is human...the reciprocity theorem does apply to this antennas also!) dishes are typically in a f/D range of 0.33 to 0.45, originally designed to sort out TV satellites mainly in the C-band, which are positioned in a stationary orbit rather close to each other. These deeper dishes at low side lobe properties are easily turned into effective moonbounce antennas, but they need primary feeds with a beam width beyond 100° in order to effectively illuminate them. State-of-the-art designs are the Kumar-type feeds with corrugation rings to neutralize parasitic RF currents at the outer WG aperture, which have been adopted for amateur use by VE4MA, OK1DFC, OM6AA and more recently RA3AQ. All these WG-feeds produce circular polarisation (RHCP / LHCP separate ports for RX/TX) at low cross-polarisation levels, thus providing a very 'round' and effective illumination for deeper dishes, and more than 65 % effectiveness can be reached in optimised set-ups. These feeders can be used down to an f/D of 0.3 also, if the single corrugation ring is replaced by a multiple ring construction (mostly three rings of tapered diameter spaced at lambda/4), known as Chapperal feeds.

Actually dishes below an f/D of 0.3 down to so-called focal plane dishes (the focal plane is coincident with the aperture plane) are very hard to illuminate effectively, especially in CP, so these are of little use for moonbounce operation.

For those interested in more details, the online Microwave Antenna Handbook of P. Wade, W1GHZ is highly recommended (www.w1ghz.org). It contains numerous simulations for different feeder types in a particular f/D dish scenario, thus giving a valuable start-up orientation for designing a suitable feed horn for a given dish type. Have lots of fun in squeezing the ultimate performance out of YOUR dish!

Supplementary activity Echo's of Apollo the "SSB Fun event"

by Doug McArthur VK3UM

There was considerable excitement in the early stages of the planning of the 40th anniversary of the landing on the Moon with the possible activation of Honey Suckle Creek, Parks and other notable installations. The weekend of 26/28 June was originally chosen (it was a month earlier than the Apollo 11 landing) to allow the Honey Suckle dish to acquire the Moon. It is mechanically limited to elevations above 25 degrees and thus a weekend of low declination (high Moon in the Southern sky) was chosen.

As time approached it appeared that a lot of the plans were not going to happen so, as a supplementary activity, I put it to the EME fraternity that we stage a *SSB Fun Net* to concentrate as much activity as we could muster and to support the event. It was hoped that children and other interested parties would be attracted to several of the larger stations and foster science and technology.

23cm was chosen where there is the most activity of SSB stations capable of communicating via EME. It was agreed that we use 1296.025 MHz as our net frequency and windows to suit North America (NA) to Oceania (OC), Oceania to Europe (EU) and Europe to North America were chosen to maximize the available Moon for each of the respective windows. It was also agreed that I (VK3UM) would act as net control for the NA > OC and OC > EU windows and Joe (K1RQG) would handle the EU > NA window. The main mode was to be SSB but smaller stations were encouraged to call on CW.

The activity was conducted on June 26, 27 and 28th and provided the 3 daily windows on each day. The times worked out quite favourable and nobody needed to get up in the middle of the night as they fell in the late morning and early evenings.

Well it was a resounding success! I had over **60 SSB QSO's** alone via the Moon during the activity periods, something even 10 years ago would have been just a dream. The smallest station I worked (all totally random and only 2 were 'CW support' calls) was a 2½ meter dish and 50 watts. I am running a 8.6 meter dish and 500 watts at the feed. I have deliberately under illuminated my dish providing a 15dB edge taper to gain a lower noise temperature.

The individual stations worked (most with relative ease at Q5 up to S8) are as follows. The ARRL issued special call signs for the event as can be seen below.

W5HN, W5LUA, N6NB, AA6EG, K2DH, W1O, (K6MYC was first heard operating the Stanford dish before handing to over to other members of the team).

F2TU, OZ4MM, OZ6OL, JA4BLC, VK2JDS, G3LTF, VK5MC and SV3AAF SP6JLW, HB9MOON, OH4DG, SM6FHZ, HB9US, HB9RJG, F2TU, LX1DB, G3LTF (again through his trees) and G4CCH, SV3AAF, W1O, N0O, JA8ERE, W7BBM, VE3KRP, W5J, SP6JLW, OH2DG, SM6FHZ, HB9US, HB9RJG, LX1DB, G4CCH, W1M, VE6TA, KD5FDX, K0C, RK3WWF, ES5PC and DF9QX.

Many of the above stations were worked each day and multiple way QSO's were had, which in itself was challenge to net and track the Doppler shift.

I had a ¾ hour chat with HB9MOON where there were many school children and hams present including the youngest YL in HB.

No we don't have any crocodiles at VK3UM, only Koalas, kangaroos, wombats (free to a good home) echidna and snakes (though I did not tell them that!). It was a fascinating chat and you could tell how very excited the children were and how obsessed they are with our 'snappy handbags'. They also had TV coverage and all manner of dignitaries on site we learnt later.

Rex VK7MO kept up our side of the promotion by using the University of Tasmania 26 meter dish as reported elsewhere in AR and I greeted all the children present by their names (he told me via the phone, I'm not that good !!). Rex tells me they were *'over the Moon'* in hearing their names called off the Moon over path of 750,000 kms at the time. Later we did similar with a TV crew at the site.

I did not get the chance to chat with the Apollo 8 astronaut (Bill Anders) as the Stanford dish only came on the once (Friday) and did not appear in our other common windows.

It really was a fun weekend and provided the promotional opportunity for one unique facet of our hobby. It also served as a reminder to the brave pioneers that set foot on the Moon that is so far away where 98% of the power leaving your antennae that actually hits the Moon only 6.5% of that power is reflected and then 98% of that is lost getting back. And it's a moving target 0.5 degrees wide where the dish gain achievable at high micro wave frequencies makes tracking a challenge in its self, but that's all another story…

'HELLO MOON EVENT' by KDES, 8J1AXA

35 elementary school children, parents, and teachers met at Katsuura Space Communication Center, JAXA, June 27, 2009. KDES (Katsuura Dish Experimental Station) group had planed an EME exhibition, titled 'Hello Moon Event' on June 27, inviting elementary school children from Aoyama Gakuin, a famous private school in Shibuya, Tokyo. Before their visit, JO1LDY, Hiro made a proceeding lecture on EME in their school hour a few days back.

At the moon elevation of 12 deg. at 10 a.m., 8J1AXA contacted with Joe, K1RQG, CW 559/579. Then Al, K2UYH followed 559/559. Then Joe came in SSB, but signal was hardly audible in the cosmic noise. Masa, JE1BNZ, conducted the tour guide, and then children which came into the operation room, got stacked around the EME desk in a big pile-up, listening to these QSOs for half an hour. Great thanks to Joe and Al for the presentation!!

Mike, JH1KRC with the kids listening to a qso

Before the lunch hour in the operation room, children climbed up to the pedestal of the 18m dish antenna in the backyard to take photos. Special permission was given to their parents and the teachers so that they had a lucky chance to climb up onto the main reflector of the antenna.

In the afternoon, Mike, JH1KRC, made an easy, but joyful EME simulation using a bubber moon, on which the latest moon mapping drawned by KAGUYA exploiter satellite of JAXA, that was covered by shrunk alminium foil, then illuminated by two razar pointers and a LED tourch by children. It makes marvellous glistening in the dark room, and another pile-up occured again around the simulation set-up.

Yasu, JH2COZ performed an informative slide lecture on EME, using many photos and sounds. Perhaps some of the DUBUS subscribers appeared in the slides.

Both EME teachers, who made these lectures, got their first amateur license at the age of 5th-grade of their elementary school some forty years back.

Before they left the EME site the children enjoyed a good pile-ups again on 40m SSB for a while. Aki, JE1LIB, a high-school boy, instructed this operation.

8J1AXA, reported by Mike, JH1KRC

8J1AXA with visiting children

73 Bernd DL7APV

MI/DL1YMK - Moonbounce DXpedition May 2009

From May 24th to June 2nd 2009 MI/DL1YMK was operational via moon from the peninsula of Islandmagee, grid IO74du. After 10 days of intense moonbounce operation we are happy to say that we successfully performed the world's first ever moonbounce DXpedition on 5 bands: 2m, 70 cm, 23cm, 13cm and 9 cm – but this was quite an effort, not to say a hard piece of work, the CX-activation in 2008 was a kind of BBQ-party against this year's event....

The holiday home we rented as our operating site was merely chosen from descriptions and photos in the internet, which implicitly meant an extremely high risk in terms of feasable moon access, not to mention the most likely adverse weather conditions (the holiday home was called Seabreeze, oh boy...), which we already experienced during our 2005 EI/DL1YMK operation. Some location scouting, which was done by Sam, G4DDK, when he was on a visit to Northern Ireland, did not really make us optimistic about the moon window.

When we arrived in the late afternoon of Saturday, 23rd of May after 2 days of journey with our SUV literally packed up to the roof top with the rig and the dish parts, actually we were somehow prepared to face difficulties, but when we climbed down that 24% slope of a steep narrow winding road for about 100m of height difference on less than 400m distance, we both were really kind of shocked. We stepped out the car and very little was spoken – and it was not because Monika and myself were tired from the 1,5 day's trip via Ijmuiden-Newcastle-Cairnryan and finally Larne...

Quickly a compass and an elevation level was sorted out and we went around the house, long before we spent an idea to fiddle our cases out of the vehicle, only to find out that our Western window was confined to an optimistic (!) 20° of minimum elevation by the hilltop we just had climbed down by car. To the East we had a broad ridge, which was between us, VK3UM and the rest of the Eastern world, not less than 10° of elevation were feasable – the first OP was absolutely thrilled with that kind of mess.... To make things even worse, dense shrubs were growing all around the house (.."probably to keep the seabreeze away from the house", I grunted), which confined a possible location for the stressed dish to just one specific spot on the south-eastern corner of the house. To be honest, at that point in time the chief operator had it up to the eyeballs...to say the least.

The second OP and logistics manager Monika urged me, though, to set up the tripod and the skeleton of the dish on late Saturday evening in the light of a powerful lamp, we had brought along, in order to put the meshes into the dish on early (and believe me: Monika definitely means, what she says...) Sunday morning. Just before noon we actually were ready to listen for the first echoes on 23cm and Dominique, HB9BBD, acted as a beacon for us and made the first QSO with MI/DL1YMK at 1215UT with 579/569 reports, yepp, that's the way we like it. When we lost the moon at around 1800UT in the West, already 20 stations had found their way in the log, including our friends K1RQG and OE9ERC, who we easily worked in sideband and had a little chat off the rock again. Well, at least, we hadn't dumped it completely so far, things began to look slightly more positive, due to the high declination of the moon we had a window also to the US, although being far from ideal....The diner, some kind of spaghetti we had brought along from DL - as we absolutely had no time for completely unimportant things like shopping, when the moon was up – was a convenient end point of the first moonbounce day.

The next days were extremely busy with the subsequent activation of all bands, the gale force winds during the first days forced us to tie down the dish several times in order to prevent a premature QRT.

The good thing was that none of the cables was missing this time, thanks to a sophisticated check list procedure set up for the TF DXpedition, and all rig worked flawlessly.

The 27th of May was the scheduled activity day on 9cm, our moon window was supposed to begin early afternoon. When we had breakfast at 1100 local - smile, moonbouncer's nights can be pretty long – we looked out on the North Channel from the living room to direction Scotland and noticed that the surf was getting rougher with every minute while the waves got white crowns – nice to look at, but promising big trouble for the dish!

MI/DL1YMK: Changing feeds

Before we started on 9 cm, we calibrated the heading of the dish with sun noise. The sun noise was good, when I finally found the sun, as it was overcast. To find a maximum was extremely complicated because of the rocking and rolling dish and the surprisingly narrow beam of the antenna on 3.4 GHz. Monika tried to stabilise the dish the whole day. We owe a big TNX to Willi, LX1DB, and Peter, G3LTF, who both served as a beacon for us with great patience, helping us to trace back the moon after another wind attack – and to find back frequencywise, what we thought was 3400.100 MHz – a new OCXO for my old 9 cm tropo rig is a must for the next DXpedition in October.

The specific confinements of the location really needed quite a bit of a Midas touch to turn a 'close to failure' situation into gold. An absolute highlight were the QSO's with VK3UM on 70 and 23cm and JA4BLC on 23 cm, when at least one third of the dish was still obstructed by the corner of the house (see the pics on the website, Zdenek, OK1DFC has set up and updated for us during the DXpedition – to transfer reports by mail we had to drive up a hill some 3 km away from our holiday home, where we had a slight touch of a UMTS signal, whenever there was a tropo lift).

In the end we succeeded to make a total of 174 QSO's on 5 bands, resulting in 132 initial contacts from 35 DXCC's, presenting a rough counting still, will have to transfer the handwritten log into the computer at home, but you can find a list of all initials per band, which was compiled for K2UYH's Newsletter 07/09 issue . On 23 cm alone 67 initials were worked during our operation and during the European WW EME contest a score of 46 QSO's was achieved, which is a very respectable result for a rather basic portable set-up. There were no DSP units used, no waterfall-display, no digital filters, just an old AF-OP-filter and two ears, one of them with -6dB built-in attenuation...as still I think EME is a pure radio event.

The performance of the dish on 23 and 13cm was noticeably improved by adding a small choke ring for the 23 cm square septum (I made the 32 cm dia corrugation ring only one week before we left for GI, being initiated by G4DDK's 'pie in the sky') and a flare for the 13 cm square septum feed, in order to obtain a better illumination efficiency for the f/D=0.43 stressed dish. Especially on 13cm the new CDMA-derived SSPA (2 strips at 200W, combined with a homebrew specially designed high power hybrid) was loafing along comfortably at a 400W level, which gave significantly better echoes than the 140 W in the feed we had in CX in 2008. Thus, on both 23 cm and 13cm we heard good echoes and very enjoyable sideband-QSO's were performed, which in itself is remarkable for a portable moonbounce station. The 13 cm band provided 27 QSO's at 24 initials.

Some weak points have been discovered with the 9cm station, mainly frequency stability, which will be improved easily before the next moonbounce trip, but still about 100W in the RA3AQ-dual mode feed guaranteed for not less than 10 initials on that band, despite the pointing problems. On 70 cm it was again an advantage to be able to switch the polarisation from horizontal to vertical with the flip of a switch, because the Faraday rotation was very strong at times, shifting even inner-European signals by 90°. Only due to this feature of the loop feed we were able to work another 20 initials.

On June 3rd we knocked down the dish and used the tripod and the Az/El-rotator head of the dish for a single 2.3 wl yagi for 2m. With that antenna and a SSPA, loaned by courtesy of Bernhard Korte, we completed actually moonbounce contacts on our 5th band with DL9MS being our first contact on 2m.
A warm 'thank you' goes to all our fellow-EMEers for the contacts made and to Joe, K1RQG, for the invaluable work arranging the skeds for us. And if you could not catch us this time, there is more portable moonbounce to come on **the first 2 October weekends and the week in between**, so look out for XXX/DL1YMK....CU off the rock, guys! Michael, DL1YMK

9cm EME shack in Northern Ireland

Monika & Michael

Tropo Reports

2m, 70cm and up

Editor: Michael M. Dienel, DG7SFL

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2m

DL0TTM in JN49VJ wkd on 144 MHz with QRB > 600 km

Date: 02 May 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
15:21	SN9D	JN99MQ	668km	SSB
17:54	OM8A	JN87WV	617km	SSB
19:37	OL9W	JN99GR	632km	SSB

Date: 05 Jul 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
07:52	IK5ZWU/6	JN63GN	682km	SSB
09:31	OL9W	JN99CL	609km	SSB
09:40	OK2KYC	JN99BM	603km	SSB
10:03	OM6A	JN99JC	654km	SSB
10:22	9A5Y	JN85PO	704km	SSB
10:26	SN9D	JN99MQ	668km	SSB
10:36	SP2WDW	JO94BF	785km	SSB
11:34	OM8A	JN87WV	617km	SSB
11:46	OZ9EDR	JO55KR	709km	SSB
11:53	SK7MW	JO65MJ	703km	SSB

OPs: DL4AAS, DL4SJ, DK3SML, DJ4WG, DG7SFL
RIG: 300W, ATF-58143, 3x12 Ele.

F/LA0BY/P in JN24PE wkd on 144 MHz with QRB > 700 km

Date: 02 May 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
	DR2X	JO40QL		
	DL0GTH	JO50JP		
	S57C	JN65XM		
	S59DEM	JN75DS		
	DR1H	JN59OP		
	DF7ZS	JO50DO		
	DL0HG	JO40IG		
	DK0CG	JN59RJ		

Date: 03 May 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
	OQ4U	JO20KV		
	DB5KN	JO31NB		
	F5SGT/P	IN88KD		
	DF0CI	JO51CH	873km	ODX
	DL0LB	JN49QA		
	ON4WY	JO11LC		

QTH: Mont Ventoux 1850m asl
RIG: IC706 + PA 120W, 9 El. F9FT
CONDX: flat band but good weather
TNX FOR REPORT STEFAN!

23cm + up

DG7SFL/P in JN49VJ wkd on 1296 MHz > 300 km

Date: 02 May 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
18:17	PA6NL	JO21BX	492km	SSB

RIG: 100W, XVTR DB6NT, 1m Dish.

DG7SFL/P in JN49VJ during May-Contest 02/03 May 2009. QSO with PA6NL on 23cm through the trees in the back.

DK7QX in JO42KH wkd on 1296 MHz > 500 km:

Date: 03 Apr 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
17:50	F5DQK	JN18GR	599km	

Date: 19 Apr 2009

10:07	F5DQK	JN18GR	599km	

Date: 21 Apr 2009

08:53	G0EWN	IO93FK	710km	
17:54	SM6AFV	JO67GQ	642km	AR
18:17	SM7GEP	JO77IP	700km	AR
19:25	G3XDY	JO02OB	523km	SSB
20:20	G4DDK	JO02PA	518km	

Date: 02 May 2009

15:32	G3XDY	JO02OB	523km	
17:10	OK1KJB	JN79IO	507km	
21:29	SM7GEP	JO77IP	700km	AR

Date: 03 May 2009

04:32	OK1KPA	JN79US	555km	
06:03	F6DKW	JN18CS	614km	
08:30	F5DQK	JN18GR	599km	
08:54	OK2STV	JN89DO	600km	
09:08	OK2DGB	JN79RL	559km	
09:29	OK1KUO	JO80FF	576km	
12:20	SP6GWB	JO80JG	595km	
12:33	SM6AFV	JO67GQ	642km	AR

Date: 10 May 2009

15:23	F5DQK	JN18GR	599km	

Date: 17 May 2009

09:18	OE5VRL/5	JN78DK	577km	SSB
09:38	OK2KJT	JN99AJ	720km	
15:54	F5DQK	JN18GR	599km	

Date: 19 May 2009

17:13	SM7GEP	JO77IP	700km	AR
17:20	SM6AFV	JO67GQ	642km	AR+TR
19:44	G3XDY	JO02OB	523km	SSB
19:54	G4DDK	JO02PA	518km	
19:57	G4EAT	JO01HR	568km	

Date: 24 May 2009

20:47	G4KIY	IO92WN	610km	SSB
20:57	G0DJA	IO93IF	691km	
21:20	G0EWN	IO93FK	710km	
21:29	G0JJG	JO02LE	539km	SSB

Date: 25 May 2009

07:00	G4KIY	IO92WN	610km	SSB

07:28	G3RED	IO92UO	622km	SSB

Date: 01 Jun 2009

20:54	GM4LBV	IO86RQ	882km	SSB
22:22	GM3UAG	IO87XJ	897km	

Date: 02 Jun 2009

06:19	SM6HYG	JO58RG	682km	SSB
06:33	G4EAT	JO01HR	568km	SSB
06:45	G6CQC	IO94DT	751km	SSB

Date: 06 Jun 2009

18:58	OK2STV	JN89DO	600km	
22:12	OK5Z	JN89AK	595km	

Date: 07 Jun 2009

06:12	OE5VRL/5	JN78DK	577km	
07:11	OL4K	JO70TQ	501km	
11:05	OK2DGB	JN79RL	559km	SSB
11:36	G3XDY	JO02OB	523km	
11:48	G4DDK	JO02PA	518km	

Date: 16 Jun 2009

17:29	SM6AFV	JO67GQ	642km	
18:50	SM7GEP	JO77IP	700km	AR
19:48	G3XDY	JO02OB	523km	SSB
20:09	G4DDK	JO02PA	518km	
20:52	SM7DTE	JO75CN	503km	

Date: 04 Jul 2009

15:08	G5LK/P	JO01OC	545km	
16:10	OM3KII	JN88UU	732km	
23:17	G3XDY	JO02OB	523km	
23:49	OK5Z	JN89AK	595km	

Date: 05 Jul 2009

00:29	OE3A	JN77XX	697km	
06:10	OK1KPA	JN79US	555km	
06:38	OK1KJB	JN79IO	507km	
09:35	OK2KYC	JN99BM	718km	
10:16	G3OHM/P	IO82XJ	741km	
12:19	SM7DTE	JO75CN	502km	

Date: 21 Jul 2009

17:53	SM7GEP	JO77IP	700km	AR
17:59	SM6AFV	JO67GQ	642km	AR
19:21	SM7DTE	JO75CN	503km	

TR: Tropo
AR: Airplane Reflection
RIG: 180W, MGF1302, 44 Ele Yagi
TNX FOR REPORT ECKHARD!

F6DKW, JN18CS, wkd on 10 GHz:

02/05/09	GD0EMG	IO74 Tr
25/05/09	OK1JKT/P	JO60 Rs
25/05/09	OZ1FF	JO45 Rs
25/05/09	DB0GHZ/B	JO34 Rs 1st time hrd
26/05/09	OE5VRL/5	JN78 Rs 888 Km
02/06/06	OZ2LD	JO54 Tr
03/07/09	OK1VAM	JO60 Rs
04/07/09	HB0/DL7URH	JN47 Rs
21/07/09	DH7OT	JO52 Rs 200mW !
21/07/09	DK1ZD	JO44 Rs
21/07/09	OZ1FF	JO45 Rs
21/07/09	DB0VC/B	JO54 Rs 1st time hrd 844 Km

F6DKW, JN18CS, wkd on 24 GHz:

15/04/09:	ON4IY	JO20 Rs
16/07/09:	F6DRO	JN03 Rs Hrd 599 Km!

TNX FOR REPORT MAURICE

OZ1FF in JO45BO wkd on 1296 MHz > 600 km

Date: 20 Apr 2009

19:41	G0ILO	JO01NI	661km	SSB
19:52	G0JJG	JO02LE	603km	SSB

Date: 21 Apr 2009

18:16	DF9IC	JN48IW	742km	CW
19:23	DM2AFN	JO61WB	632km	CW
20:07	DB6NT	JO50VJ	629km	CW
20:27	G3XDY	JO02OB	600km	SSB
20:46	G0ILO	JO01NI	661km	CW

Date: 13 May 2009

10:09	GM3SBC	IO85IX	714km	SSB
11:15	GM4LBV	IO86RQ	671km	SSB

Date: 19 May 2009

17:31	OK3RM	JN69MS	728km	CW
18:14	DF9IC	JN48IW	742km	CW
18:32	DB6NT	JO50TI	629km	CW

Date: 16 Jun 2009

17:04	SM0FZH	JO99HI	752km	CW
17:32	DF9IC	JN48IW	742km	CW
17:47	DL9GK	JO50TI	629km	CW
18:00	DL6NAA	JO50VF	646km	CW
19:55	G3XDY	JO02OB	600km	CW

Date: 21 Jul 2009

17:38	DF9IC	JN48IW	742km	CW

RIG: 1,5 m dish, 145 W
TNX FOR REPORT KJELD!

OZ1FF in JO45BO wkd on 2320 MHz > 500 km

Date: 21 Apr 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
20:29	G3XDY	JO02OB	600km	SSB
20:30	G4FSG	JO02PC	593km	SSB
20:37	PE1EWR	JO11SL	549km	CW

Date: 28 Apr 2009

18:43	DF9IC	JN48IW	742km	CW
20:21	SA4Z	JO79OF	584km	CW

Date: 26 May 2009

17:57	DB6NT	JO50TI	629km	CW
18:01	DF9IC	JN48IW	742km	CW
19:33	DL6NAA	JO50VF	646km	CW
19:43	SA4Z	JO79OF	584km	CW

Date: 28 Jul 2009

17:21	SA4Z	JO79OF	584km	CW
17:41	DB6NT	JO50TI	629km	CW
18:37	DF9IC	JN48IW	742km	CW

RIG: 1,5 m dish, 200 W
TNX FOR REPORT KJELD!

OZ1FF in JO45BO wkd on 5760 MHz > 400 km

Date: 24 Mar 2009

Time	*Call*	*Loc*	*QRB*	*Mode/Remark*
20:19	SM7GEP	JO77IP	462km	CW

Date: 28 Apr 2009

20:41	SM7GEP	JO77IP	462km	CW

Date: 25 May 2009

07:27	G8KQW	IO91OC	774km	SSB
18:32	F6DWG/P	JN19AJ	803km	CW **1. F – OZ**

Date: 26 May 2009

20:14	SM7GEP	JO77IP	462km	CW

Date: 28 Jul 2009

19:49	SM7GEP	JO77IP	462km	CW

RIG: 1,5 m dish, 7 W
TNX FOR REPORT KJELD!

OZ1FF in JO45BO wkd on 10368 MHz > 300 km

Date: 28 Apr 2009

Time Call Loc QRB Mode/Remark

18:13 SM6AFV JO67GQ 356km CW
18:25 DJ1LP JO64CC 310km CW
20:45 SM7GEP JO77IP 462km CW
Date: 25 May 2009
06:53 G0EWN IO93FK 668km CW
07:04 G8KQW IO91OC 774km SSB
07:18 G4EAT JO01HR 655km SSB
17:43 M0DTS/P IO94MJ 594km SSB
Date: 26 May 2009
20:16 SM7GEP JO77IP 462km CW
20:33 SM7ECM JO65NQ 314km CW
Date: 01 Jul 2009
15:33 G3XDY JO02OB 600km SSB
21:45 G0EWN IO93FK 668km SSB
Date: 28 Jul 2009
17:36 SM6AFV JO67GQ 356km CW
18:45 DJ1LP JO64CB 313km CW
19:51 SM7GEP JO77IP 462km CW
RIG: 0,65 m dish, 4 W
TNX FOR REPORT KJELD!

OZ1FF in JO45BO wkd on 24048 MHz> 300 km
Date: 01 May 2009
Time Call Loc QRB Mode/Remark
08:58 DC6UW JO44VJ 171km SSB
Date: 21 May 2009
14:21 DC6UW JO44VJ 171km SSB
Date: 28 Jul 2009
18:59 DC6UW JO44VJ 171km SSB
RIG: 0,65 m dish, 2 W
TNX FOR REPORT KJELD!

"Transatlantic" Tropo on 2m from D4 to PY0F

Ony July 4th 2009 at 1915 UTC D44TD from HK86NO received the 2m beacon PY0FF/B from Fernando de Noronha for several minutes via Tropo on 144.298 MHz. Signals not strong, about 319 to 519. D44TD phoned to PY0FF, but he was not home, unfortunately. The distance is "only" about 2503km, but it is a difficult path as the turbulent almost always unstable equatorial zone is blocking this path most of the time for Tropo ducting. At the time of the observation there was a very high probability for Tropo ducting on the southern half of the path. See map on the right side.

D44TD is using a 10 element yagi and the PY0FF beacon is transmitting with 30w and a 6 ele Yagi.

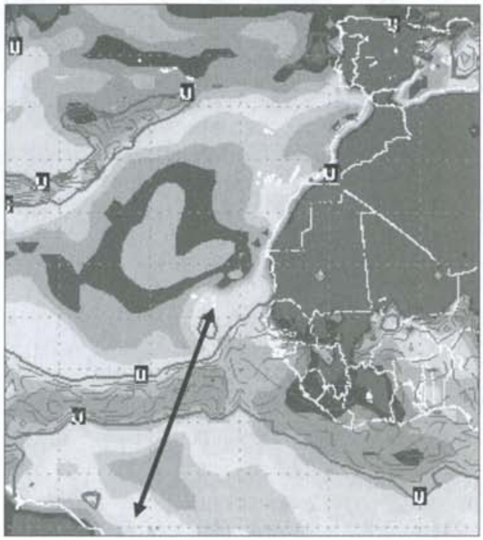
Later the same evening at 21:00z D44TD wkd CT1HZE with only 51 / 51 reports on 2m. So it was no surprise that CT1HZE did not hear anything from PY0 this time.

D44TD is conducting daily Tropo tests on 2m with CT1HZE in IM57NH over 2681km since July first.

The tests will run untill the end of August and the results will be published in next DUBUS issue.

We can report already now that the path from CT to D4 in July/August is probably one of the most reliable paths for Tropo ducting on 2m and up.

When signals were good on 2m also 70cm was tested with QRP rigs (30w 8 ele and 10 ele yagis, respectively and no preamps) and several times QSOs were made. When signals were extremly strong on 2m also some tests were made on 50 MHz and D44TD was wkd with on Tropo on 6m over 2681km. This is believed to be a new Tropo world record on 6m.



PY0FF/B to D44TD on 2m

A detailed report from the Swiss group around HB9RXV, HB9TOI etc. that visited D44TD in June 2009 and made QSOs on 3cm with EA8 will follow in next DUBUS issue 4/2009.

For a short summary of the results see the News & Comments section.

Microwave secrets..... note the feed!

CN2GHZ DX-pedition to Dar Bouazza Morocco, IM63BM

June 23 to 28, 2009

Participitians: F6AYK/CN2YK Elyane, F6AJW/CN2JW Jack, F2CT/CN2CT Guy, Corine YL F2CT for logistic

After a very long trip by utility car from Anglet / north Pays Basque / IN93, through Spain, we arrived 24 h later in Morocco / IM63, 1570 km southern! Andrés, HB9HLM family in law, Mohamed CN8PA, his brother Nouredine CN8QG and Saïd CN8LI were waiting and immediately took care of us. All equipement was taken off the car and put into the flat wich was at the second level! Tuesday early morning June 23rd all VHF, UHF and SHF antennas were on the roof top.

CN2CT wkg CT7/F6DPH on 5.7GHz

Firstly we listened to beacons on 144 MHz:

- CS5BALG/IM67 from Portugal is extremely loud with strong splatters over 422 km !!!
- CS3BRM/IM12 from Madeira over 835 km is 529
- From time to time we heard CU2VHF/HM49 over 1700 km.

We thought that tropo conditions to the south over the Atlantic Ocean should be quite good.
We tried with Philippe CT7/F6DPH/P and David CT7/F1URI/P from Cap Saint Vincent IM57 on 6 and 3 cm. The distance is around 402km with only sea path! But the signals are "only" 58 to 59 with strong qsb. We tried also on 24 GHz with Philippe CT7/F6DPH/P but unfortunatly the test was negative!
On Tuesday June 23rd we made fantastic qsos on 144, 432 and 1296 into EA8. Average distance between 900 and 1100km with outstanding signals even on 1296 with low power on 144 antennas!
From Wednesday June 24th to Saturday June 27th Tropo conditions were down and we got some difficulties to make successful qsos with Joe CT1HZE on 1296MHz.
The tropo conditions were much better into the south and we continued to test on 3 cm every day with Peter EA8BFK (DJ9PC) from IL38BO over 800 km with signals up to 59 even at 11h utc under hot sun! We heard absolutly no signal on 3 cm from D44TXV, HK86MU over 2400 km.

CN2GHZ shack in IM63BM

On Sunday June 28th tropo conditions became much better into the north and we made successful qsos on 3 cm with CT7/F5BUU from IM57NH near Joes, CT1HZE qth.
Looking at the Hepburn forecast we thought that tropo conditions will be fantastic next week but unfortunatly we must come back to France!

CN8QG, CN2JW, CN8P and CN2CT

Summary:
- on 144, 432, 1296 regular qsos with:
- CT1HZE/IM57, 432 km
- EA8AVI/IL28, 948 km
- EA8TJ/IL18, 1007 km
- EA8TX/IL18, 1013km
- EB8CDX/IL18, 1033km
- EB8BRZ/IL27, 945km
- EA8CCG/IL18, 1013km
- EA8BFK/IL38, 800km
- EB7DBX/IM67, 452km
- DX on 144 MHz: G4LOH/IO70/1857 km on MS but with tropo signals 519 during our test !!!
- some fine tests also in MS/tropo with :
- F6DRO/JN03/1373km
- F5ODA/JN13/1429km
- F6HTJ/JN12/1385km

- 5,7 GHz > 400 km, tropo
- CT7/F6DPH/P/IM57 First qso on 6 cm between Portugal and Morocco

- 10 GHz > 400 km, tropo

- CT7/F1URI/P/IM57 First qso on 3 cm between Portugal and Morocco
- CT7/F6DPH/P/IM57
- CT7/F5BUU/P/IM57
- EA8BFK/IL38 first qso on 3 cm between Canary Islands and Morocco

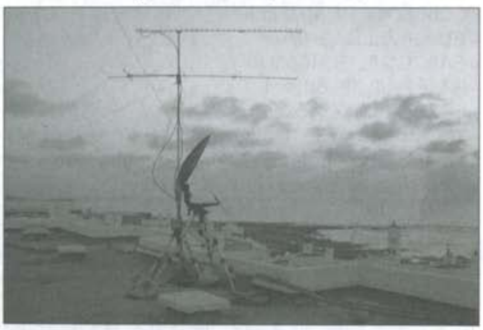
CN2GHZ (F2CT) wkg EA8BFK on 10 GHz

We are extremely satisfied with our results during this first expedition. Oo 50 MHz Elyane, CN2YK and Jack, CN2JW made a lot of DX qsos with a FT857 on a vertical antenna! 6m was open all day long via E-sporadic or sea tropo ducting to south. The only successful qso with D44TOI/HK86 was on 50 MHz! So we hope to come back in July 2010 and stay 2 weeks or more! We think that the best way is to have two teams: One in Dar Bouazza, IM63BM and the second in Essaouira, IM51 270 km southern. We hope that some guys will be interested to come back to D44, CU2, CT, EA8.

We are sure now that new tropo world records are possible on V/U/SHF upper 2000 km range over the Atlantic Oceac. Tests on 144 must be also organized with Brazil and Carribean areas.

Special thanks and regards to:

André, HB9HLM and his "in law family"; Mister Khadiri and Misses Malainine from ANRT; Kacem, CN8LR; Mohamed, CN8PA, Nouredine CN8QG and their family; Saïd CN8LI; ARRAM; PY2ZX.



CN2GHZ antennas and take off

EA8BFK in his shack, IL38BO, from where he hrd the 3cm beacon from CT7/F5BUU in June. Later in the beginning of July he wkd CT1HZE on 3cm who was running only a 30cm dish and 200mW over 1074km although this path is blocked by Lanzarote Island. EA8BFK using 10W and 48cm dish. From here he wkd also CN2GHZ on 23 and 3cm

EA8BFK/p, IL28XR working CT7/F5BUU on 3cm

Roof terrace at CT1HZE with 3cm stations and beacon from F1AAM, F5BUU and F1URI

CT7/F6DPH/p in IM57NH on 1.2, 10 & 24 GHz

6m News

Reports, Expeditions, Infos

Editor: Joachim Kraft, DL8HCZ

Summer Multihop Es season

Thanks to the still sleeping sun and an extremely quiet geomagnetic field the northern hemisphere got another summer with extended multihop Es openings. On several days there were openings from Europe into Japan and even China, Taiwan and Malaysia were worked, from some EU countries for the first time ever on Es. CT1HZE worked some 50 QSOs to Japan this season, all in the range from about 10.000 to 11.000 km for his best JA short path season ever. Remarkable were also the openings from OA4TT into Europe over distances up 12.000 km. On many days EU wkd into the Caribbean and South America. Goodies like 8R1DB, 5J0BV, J79PAK, V29JKV, XE2WWW, A7/M0FGA are in many logs now. From the US there were again many openings to JA, may be more or less the same level like in 2008. On several occasions even the US eastcoast stations worked into JA and HI3TEJ did it again: After 2008 he worked again into JA and **set new Es world record on July 8th: At 23:46 UT HI3TEJ worked JR2HCB from PM85NC over a fantastic distance of 13288km** on Es. Ted worked also VE5UF from DO61 who is on the path at that time. And WK3N from EN91 hrd both ends, the JA and HI3. Some other highlights:

On June 30th at 08z 6m was still open from JA too VE7 (JE1BMJ to VE7DAY) and at the same time JL8GFB worked into Europe to SV1DH. Quite remarabble.

On July 2nd for the first time ever AFAIK EA8 worked into JA on 6m via multihop Es: At 0849z EA8BLL (IL38BP) wkd JL8GFB (QN03RH) over 11.627 km. CT1HZE could hear both ends of this exciting QSO.

On July 3 at 0610z DK1MAX wkd BA3AG, BD7NWF and BA7AO from Chine and got another new DXCC. The chinese stations were worked from several EU's and peaked 599 at times!

KG6DX from Guam wkd at the same time into the Ukraine. On the same day at about 17z KE7V, VE7SL, VE7XF, W7CW, VE6TA and others were wkd from DL, ON and PA. This is really rare as the path is realy a northern one.

On July 4th EA8CQS wkd JH0RNN over 12200km and at 0919 DK1MAX wkd 9M6XRO over 10562km.

On July 14th CT1HZE hrd the TI2NA beacon for the first time and wkd TI7/N5BEK from EK70 and HP3TA from EJ88, QRB some 8100km. Also DK1MAX was able to work the TI7 over 9670km.

On July 17 PU8TEP from FJ92 wkd into DL&PA.

4m News

Reports, Expeditions, Infos

Editor: Joachim Kraft, DL8HCZ

Spain on 4m also 2009/2010

The Spanish 4m experiment on 70.150 and 70.200 MHz (+/- 6 kHz each) was continued in June 2009 and EA amateurs can use these QRGs now untill June 22nd 2010. Many new first ever QSOs took place already in June and July 2009. EA8BPX is quite active on 4m now from IL18SK. No activity on 4m from EA9 has been reported yet.

4m in Slovakia

A nice surprise – but now totally unexpected as OK has a 4m experiment also – was the news that 4m licences were available for slovakian amateurs since May 2009. The permissions are valid for 1 year and the QRG range is 70.250 to 70.350 MHz with max. 10 W ERP in CW/SSB/FM. On air are already OM5KM, OM3CLS and OM3RM.

Macedonia on 4m

Z35Z, Dime, reports that he has a special experimental licence for 4m. He is qrv on 70.200 with 5 W and a short yagi from KN11 and has heard several EU's on Es already.

Cabo Verde on 4m

D44TD, Antonio, is qrv from HK86NO, on 4m with FT847 and a 4 el Yagi. Obviously his RX is not really sensitive. However, on June 12th at 1812 UTC he made his first QSO with SV2DCD KN00NF over an **amazing distance of 4970km for a new 2 way Es world record on 4m.**

Norway on 4m

The release of the 4m allocation in LA from 70.0 to 70.5 MHz has been delayed again. The release is now expected to come in autumn 2009.

4m beacon from OE in summer 2009

The 4m beacon OE5QL is qrv from Austria on 70,045 MHz since June 1th untill August 31st. It transmits for 2 mins every quarter of the hour. The beacon has been spotted from several EU countries via Es. However, the keeper OE5MPL is dissappointed about the low number of spots and will not apply for a new beacon licence he said.

4m allocation for Finland

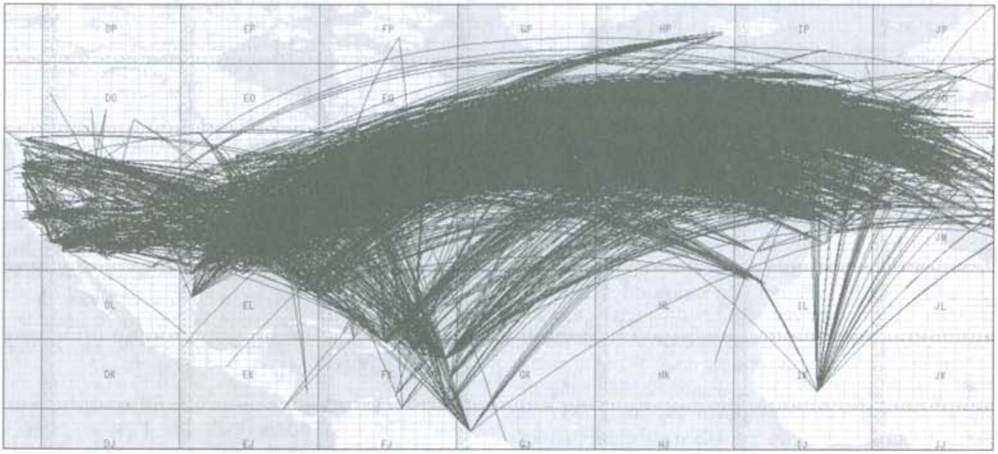
Finland will get a 4m allocation for amateur radio! The planned range is 70.000 - 70.050 (max. 1 kHz modes) / 70.050 - 70.175 (max. 18 kHz modes) / 70.225 - 70.300 (max. 18 kHz modes). A release is not expected before October 2009.

OX4MB beacon heard in Finland

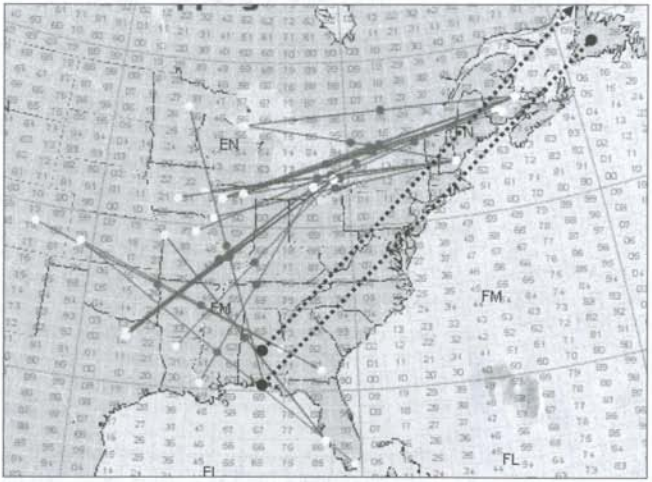
OH1ZAA from KP01RO hrd the OX4MB beacon on 70012 from GP47TA On June 4th 2009 from about 2105 to 2200 with max. 559 on Es. QRB 3326km. This is the first ever report of the beacon.

June 26th 2009 – with a Wordrecord!

June 26th 2009 was a remarkable day on 6m. See the map below (tnx ON4KST!) Thousands of QSOs took place between NA and Europe. F6KHM wkd 350 NA, G4DEZ wkd > 100 NA and CT1HZE wkd 260 NA. The band was open from 14z until after midnight UTC. Best DX wkd from CT1HZE were W6 and W7 from CN87, DM62, DM65, DM03, DM14, DM26, DM33, DM43.



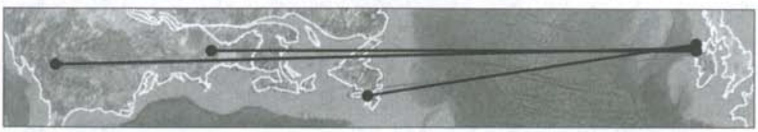
June 26th 2009 – the day with the most 6m transatlantic QSOs in 2009



From 2217 to 0043 UTC on June 26/27 there was a nice 2m sporadic E-opening in USA and Canada. The QSOs are plotted on the map on the left side as continous lines (tnx to G7RAU for the map!). The MUF peaked to 162 MHz over FN05 at about 00:30 UTC.

Unfortunately the EU 4m DXers from EI and the U.K. did not make any serious tests with NA during this opening....

However BC DXer Paul Logan from Ireland (IO64GF) was active during this opening and he received many stations from NA on the 3m FM BC band from 21 to 22 UTC! Beside stations from Newfoundland (3165km), New Jersey, Philadelphia, Massachusets and Maryland in the range from 4711 to 5260 km he received the station WVAS on 90.7 MHz from Montgomery, Alabama (EM62UI) over a distance of a fantastic **6456** km. This is a new WORLD RECORD on 3m FM BC DX. Mr. Logan classifies this propagation clearly as multihop-Es and from his observation experience he assumes a 4 hop scenario (4 x 1614km). The highest observed QRG on this day was 98 MHz. BTW Mr. Logan was also the holder of the former 3m BC DX world record that was set with stations from W1 – believe it or not – exactly 6 years ago on June 26th 2003 at 19:30 UTC!!! At the same time on June 26th 2009 FM DX DXer KW4RZ from EM60QK, reported double hop FM BC DX on 92.2 MHz from Newfoundland (GN18) for his first time. QRB is 3165km. This path is the lower dotted line on the map. The westerly half of the path from EI to EM62 is the upper dotted line. Impressive is the fact that Mr. Logan was able to trace 3 touch downs of the 4 hops:



The 2nd touch down in VO1 after 3165km, the 3rd touch down after about 4800 km and the final 4th touch down after 6456 km.

News & Comments
Editor: Joachim Kraft, DL8HCZ
info@DUBUS.de

Expeditions and DX

Microwave activity on Atlantic Ocean or Grande Bleue goes West

From June 19th to 28th there took place a major Microwave activity event on the Atlantic coasts of Portugal (CT), Canary Islands (EA8), Cape Verde (D4), Spain (EA7) and Marokko (CN). There was activity from 23cm to 24 GHz.

The following first ever QSOs were achieved:

1st CT to CN on 23cm by CN2GHZ and CT1HZE
1st CT to CN on 5.7 GHz by CN2GHZ and CT7/F6DPH
1st CT to CN on 10 GHz by CN2GHZ and CT7/F1URI
1st CT to EA8 on 10 GHz by EA8BFK/p and CT7/F5BUU
1st D4 to EA8 on 10 GHz by EA8BFK/p and D44TD

CN2GHZ was located in IM63BM in the QTH from CN2DX.

The dream QSO from CT to D4 on 10 GHz over a >2600 km path did not take place due to bad luck with the WX conditions. The end of June was exceptionally unstable in the area of southern Portugal this year and the record was missed probably just by a few days as D44TD was very strong on 2m and 70cm ust a few days after the French groups went back home. On 23cm D44TD was able to hear CT1HZE on CW with 319 on one occasion but no QSO was made. May be in the future there will be another attempt for the 10 GHz world record from D4 to CT.

Peter, DJ9PC, operating as EA8BFK/p in IL28XR working on 10 GHz to D44TD (HK86NU) over 1600km and to CT7/F5BUU & F6DPH (IM57NH) over 1068km in June 2009

8Q – Maledives on EME in 2010

HB9QQ, HB9CRQ etc. will be qrv on EME from 8Q from March 20 to April 3 2010 on 6m, 2m, 70cm and 23cm with good equipment. Loc. MJ64.

Azores on 2m EME

CU2JX from HM77ES will be qrv on 2m EME in JT65 from September permanently with 200W and 2 x 10 ele will full elevation.

Bolivia on 6m

CP6UA is a new station on 6m with 100w and 4 el yagi from FH82JF. CP is a rare DXCC on 6m.

Microwave EME from Japan

JH1KRC reports that he will be qrv from the 8J1AXA 18m JAXA dish on 1.2 GHz & 5.7 GHz in September/October. and 10 GHz EME. He plans also to come on 10 GHz EME with a 300 W TWT that will be used at 100 W.

JO34 DG7TG etc. will be qrv again on September 5./6. from JO34we in the 2m contest as DR3M.

JO98 OZ8ZS has changed plans and will try to be qrv from JO98 on 6m and on 2m via FSK-MS in summer 2010.

Beacons

2m Beacons from Madeira

The ex CS3DUB 2m beacon is qrv again as CS3BRM on 144.421 MHz from IM12OR with 10w in A1A and 6 ele to EU. Another group on the island has established another 2m beacon there with the call CS3BTM on 144.481 MHz. This beacon runs in FSK and has just 1 W to a 3 ele beaming EU. As the QTH is 739m a.s.l. and very clear to EU this beacon is usually mich stronger than the CS3BRM beacon.

2m Beacon from OX on air!

Thanks to DF7KF for the hardware and OZ1DJJ for transport and installation since the end of July the 2m beacon OX3VHF is on air from Greenland. QRG 144417.6 MHz (CW) running 30 w to a 4 ele Yagi beaming 105 deg. from GP80KB. The beacon should be audible via MS pings from Scotland.

OX3VHF/B on 2m – 4 el. Yagi and take off to Europe

OX3VHF/B beacon rack in GP80KB on 144.4176 MHz

6m beacon from 8R on air

The 8R1DB/B beacon went on air in mid July from GJ06WT. It is running with 30w and H loop.

New 2m Beacon on the air from Turkey

The first 2m beacon went on air from Turkey on July 19th 2009. The call is YM7VHF/B and grid is KN91RB. QRG: 144.450 MHz. The beacon runs 5 w to a 4 ele Yagi beaming EU from 573m a.s.l. Keeper is TA7OM.

News

Ken Willis G8VR - SK

Ken Willis, G8VR, became a silent key in June in the age of 90. He was active on 6m for decades and well known for his propagation studies.

JT4 on the Microwave Bands

A growing number of Radio Amateurs are using the JT4 mode on the microwave bands with excellent results. JT4 is part of the WSJT weak signal software developed by Joe Taylor, K1JT. It uses 4-tone FSK, so it can also also include both a sync bit and a data bit in each symbol. Again the keying rate is 4.375 baud, and a number of different tone spacings are offered.
Reports on the UK Microwave reflector indicates it very tolerant of radar, aircraft scatter, fading, and rig drift and tests on 10GHz with heavy rainscatter worked 100% over a very obstructed 70km path. Further information on JT2 and JT4:
http://physics.princeton.edu/pulsar/K1JT/JT2_JT4.TXT

UNITEC-1 Satellite

A group called UNITEC, of Japanese universities have a plan to launch a small satellite as a payload of JAXA mission to Venus. They plan to use 5.84GHz downlink (9.6W) and to ask moon-bouncers to receive the CW telemetry, 1-bps. The satellite has no position-keeping system, so it would be spinning all the time until it reaches to Venus. Uplink is planned to be on 145 MHz. The launch is currently planned in May or June 2010, with the target arrival date of Venus in December 2010. A PDF with more info is on the web at www.k1rqg.com under UNITEC-1. (Info via JH1KRC from UNITEC and JK1KOE & JH0TOG/JAMSAT)

Dates

French Journees d`Activite (JA)

The next French Microwave Activity days on 23cm and up take place from Saturday 17z to Sunday 17z on Aug. 29 to 30, Sept, 26 to 27 & Oct. 24 to 25.

UKW-Tagung Weinheim 2008

The next 54th Weinheim VHF-Meeting will take place in Bensheim/Weinheim on **September 12/13 2009**. For more info see www.UKW-Tagung.com

Martlesham Roundtable

The Martlesham Microwave Round Table will take place on November 7/8 2009. http://mmrt.homedns.org/

Reference

WB2AMU, Ken Neubeck, writes on June 1st 2009 on eham.net about DUBUS Magazine: Rating: 5/5 - Exception magazine that covers VHF/UHF topics. I recently received the last three issues of this fine magazine. The articles are thoughtful and well-presented. I appreciate that fact that both English and German translations appear for each article that appears in each issue. This magazine is a level above the US-based CQ VHF because of the high technical and scientific content. I especially like the editor's articles on Sporadic-E, a field that I am involved in.

Deadline for reports etc. for DUBUS 4/2009 is Nov. 1st 2009