Specification	Courtois *et al.* Test Unit	ALI Model 101102306
Freq. range, MHz	225–400	225–400
Input VSWR, max	1.4:1	1.5:1
Isolation, min	11 dB*	18 dB
Insertion loss, max		
225 MHz	0.9 dB	1 dB
400 MHz	2.2 dB	1.5 dB
Input power, max	40 W	150 W
Reverse power	10 W	50 W
Temperature range	−40 to +70°C	−10 to +60°C
Size	9 × 13 × 6.5 cm	8.2 × 8.2 × 2.55 cm
Weight	3.3 kg	285 g

* Over most of the frequency range the isolation was at least 15 dB.

The test results quoted above were confirmed by the USAF using both a computer-controlled network analyzer and a special high-power test setup. Detailed test results can be furnished to interested persons upon request.

Feasibility of the isolator described herein was demonstrated by D. Jeong and a unit designed to meet environmental and production requirements by R. Billings. We believe it to be significantly smaller and perform better than the one described by Courtois *et al.*

Comments on "Transmission-Line Transformation Between Arbitrary Impedances"

M. H. N. POTOK

The solution given by the author of the above letter,[1] for the characteristic impedance of the line transformer, has been given before (see H. Jasik, *Antenna Engineering Handbook*, McGraw-Hill, 1961, paragraph 31.3, p. 9). Jasik also gives the correct length of the transformer whereas Milligan and also apparently Day (*IEEE Trans. Microwave Theory Tech.*, vol. MTT-23, p. 772, 1975) give the distance between load and source impedance along the impedance circle, which is not the length of the desired transformer since the transformer should produce at the source the conjugate of the source impedance if matching, which presumably means power matching is desired. Thus in the expression given by Milligan for length, X_2 should be given as $-X_2$, which will now agree with Jasik's expression.

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The author is with the Department of Electrical and Electronic Engineering, Royal Military College of Science, Shrivenham, Swindon, England.
[1] T. A. Milligan, *IEEE Trans. Microwave Theory Tech.* (Lett.), vol. MTT-24, p. 159, Mar. 1976.

Computer Program Descriptions

CIA (*Ci*rculator *A*nalysis)

PURPOSE: Frequency analysis and optimization of three-port waveguide junction circulators.

LANGUAGE: Fortran IV for the CDC 3800 computer; with 960 cards.

AUTHORS: R. P. Meixner and J. P. Lawrence are with the U.S. Naval Research Laboratory, Washington, DC 20375.

AVAILABILITY: A punched deck is available from the authors upon written request.

DESCRIPTION: A computer optimization routine using sequential-random-search techniques is developed for use with an existing frequency analysis program [1] in the computer-aided design (CAD) of a three-port waveguide junction circulator shown in Fig. 1. A simple error function is defined using the scattering coefficients [S] of each port of the circulator. Since the theoretical properties of any lossless circulator are completely described if the three scattering parameters S_{11},S_{12},S_{13} are known, the energy flow from port 1 to 3 is maximized if S_{13} is maximum while S_{11} and S_{12} are minimum. The following error function, using the absolute values of each scattering coefficient, is used to optimize each initial design over the range of frequencies from f_1 to f_n:

$$\text{total error} = \sum_{f_1}^{f_n} (|S_{11}| + |S_{12}| + 1. - |S_{13}|).$$

The following constraints and/or boundary conditions are imposed on the CAD variables.

—The physical dimensions are $< 20/\sqrt{3}$ cm, the maximum radius of the radial line.

—The matching dielectric constant is $< 20/\sqrt{3}$, for ease of picking random numbers.

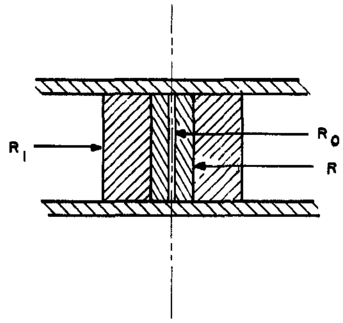

Fig. 1. Basic junction configuration.

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See NAPS document No. 02959 for 31 pages of supplementary material. Order from ASIS/NAPS c/o Microfiche Publications, P.O. Box 3513, Grand Central Station, New York, NY 10017. Remit in advance for each NAPS accession number. Institutions and organizations may use purchase orders when ordering; however, there is a billing charge for this service. Make checks payable to Microfiche Publications. Photocopies are $7.75. Microfiche are $3.00. Outside of the United States and Canada, postage is $3.00 for a photocopy or $1.50 for a fiche.

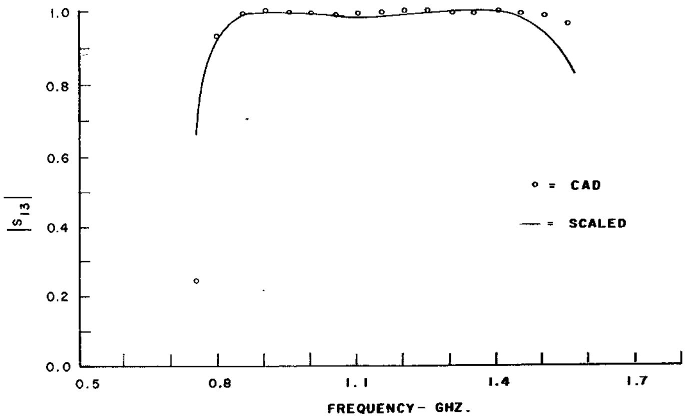

Fig. 2. Circulator scattering parameter.

TABLE I

Fortran name for input data	Dictionary definition	Scaled input data	CAD output data	Random numbers	Units
FMS	$4\pi M$ saturation magnetization	250	-	-	Gauss
ΔH	ΔH line width	45	-	-	
ER	Ferrite dielectric constant	13.8	-	-	
GM	g-factor	2.03	-	-	
RO	Conducting pin radius	.150	.105	.116	cm
R	Ferrite rod radius	2.400	2.289	2.290	cm
R1	Dielectric matching radius	6.390	6.178	6.360	cm
ER1	Dielectric constant	2.000	2.33	2.240	
A	½ waveguide width	10.0	-	-	cm
WF	Start frequency	.700	-	-	GHz
DW	Frequency increment	.025	-	-	GHz
W	Stop frequency	1.550	-	-	GHz
VAL	Value of error function	12.32	9.97	9.646	

—Only ordered statistics are allowed, i.e., $R_1 > R > R_0$.
—The CAD variables are $R0$, R, $R1$, and $ER1$.
—Negative numbers are not allowed.

To illustrate program usage, an example involving the design of a 0.850–1.550-GHz three-port circulator is included. The goal was to see if a scaled design from previous work [1]–[4] could be improved. The scaled input data in Table I for the configuration shown in Fig. 1 were run through CIA. Fig. 2 shows the frequency response of the initial (scaled) and the final (CAD) designs. Note the slight straightening out in the center and the increase of bandwidth at the high-frequency end.

Next, four sets of random numbers were run through the program. The best design had an error function value which was slightly lower than the optimized scaled run (see Table I). The scaled input data were obtained after scanning 120 designs from a global search technique. The optimization routine used here indicates that after 20 min of CPU time, and using four sets of random numbers, a better design was obtained without the laborious scanning of output data. The total dollar cost using the lowest computer priority was only $50.00.

At present, only this one geometric shape has been incorporated in the program. Other shapes [1], [2] can easily be written into the routine.

Dictionary for Input Data to CIA

Variable		Definition
ISETS		Number of circulator designs.
ICAD		CAD or frequency analysis.
M		Output data control.
MM		Controls printout.
IX		Seed for random number generator.
LIMIT		Sets number of CNBN evaluations.
RINT		Initial search radius.
R MIN		Minimum local search radius.
FMS	ferrite	$4\pi M_s$, saturation magnetization.
DH	ferrite	ΔH, line width.
ER	ferrite	Er, dielectric constant.
GM	ferrite	g, G, factor.
R	ferrite	R, outer radius.
HO	ferrite	H_0, internal biasing field.
A		½ waveguide width.
WF		Start frequency.
DW		Frequency increment.
W		End frequency.
AT		Controls graphic plot.
GT		Controls graphic plot.
DT		Controls graphic plot.
ER1		Matching dielectric constant.
R1		Outer radius of $ER1$.
RO		Pin radius.
KG		Error function weights.
KB		Error function weights.
KA		Error function weights.

References

[1] L. E. Davis and J. B. Castillo, "Computer-aided design of 3-port waveguide circulators," Final Report USAECOM Contract DAAB-07-67-C-0491, October 1968, Fort Monmouth, NJ, contains further details, including computer programs, automatic plotting of computed impedance, a brief discussion of optimization, more results, and analytical detail.
[2] J. B. Castillo, Jr., and L. E. Davis, "Computer-aided design of three-port waveguide junction circulators," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-18, pp. 25–34, Jan. 1970.
[3] J. B. Davies, "An analysis of the *m*-port symmetrical *H*-plane waveguide junction with central ferrite post," *IRE Trans. Microwave Theory Tech.*, vol. MTT-10, pp. 596–604, Nov. 1962.
[4] R. A. Stern, "High power *S*-band junction circulator," *IEEE MTT Int. Symp. Digest*, pp. 89–90, June 1973.