SEMINAR SUBJECTS

AN ELEMENTARY INTRODUCTION TO FERRITE ISOLATORS, CIRCULATORS AND RF LOADS

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by

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C2003H92

Introduction

Ferrite circulators, isolators and ***RF loads*** are fundamental components of the transmitter multicouplers (combiners) that allow crowded radio sites to operate reasonably free of interference. Without them, communication technologies such as trunking repeaters, IMTS radiotelephone and cellular radio would not be possible in their present form. Surprisingly, isolators and loads remain among the least understood RF system components. In both cases, a lack of uniform test and specification standards makes product comparisons very difficult.

Isolators are theoretically complex. They do not lend themselves to easy quantitative analysis, as evidenced by the body of esoteric literature on the subject. They are difficult to design, manufacture and tune. Designing a practical circulator is a formidable task. In the past 30 years, few companies in the world have been able to design manufacturable, commercially successful circulators for radio communication applications. **TX RX Systems Inc.** has been among those few for a decade.

Loads, on the other hand, are deceptively simple in function and appearance. They are available from many sources, and there is a general misconception that all loads are suitable for isolator and transmitter combiner duty. This is definitely not the case. Again, **TX RX Systems** has been manufacturing RF loads specifically for isolator and combiner service for more than ten years.

This **Seminar Subjects** draws upon **TX RX Systems'** own experience as a designer and manufacturer of a large variety of systems that incorporate ferrite isolators and RF loads, and provides practical information about their design, characteristics, operation and application in systems.

Ferrite Circulators

A ferrite ***circulator*** is a three-terminal, non-reciprocal device that permits RF energy to flow between two adjacent ports in only one direction. In the circulator shown in **Figure 1,** RF can flow from port 1 to 2, 2 to 3 and 3 to 1, but not from 1 to 3, 3 to 2 or 2 to 1.

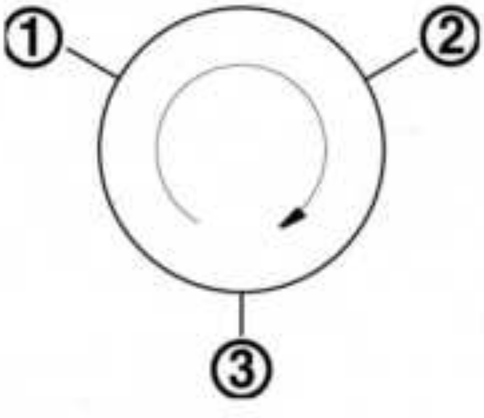

Figure 1 - Basic Circulator

Ferrite Circulator Operation

The heart of a circulator is an assembly consisting of three intersecting transmission lines, spaced 120° apart and positioned between two disk-shaped pieces of ferrite material.

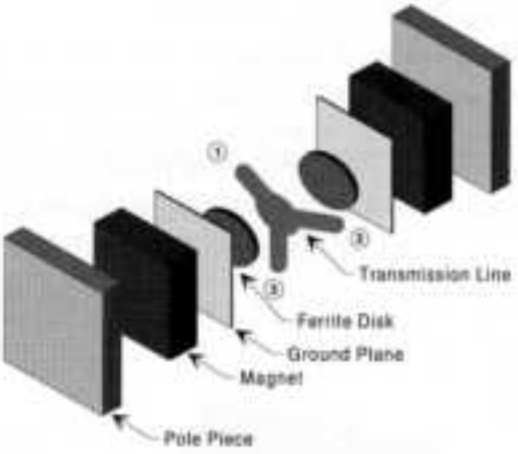

Figure 2 - Y-Junction, Distributed-Parameter Circulator Construction

When RF is applied to one of the transmission lines, two equal, counter-rotating electromagnetic fields are induced in the ferrites. By applying an external, axial magnetic field of the correct intensity to the ferrite disks, the counter-rotating fields can be made to cancel over one of the adjacent transmission lines and reinforce over the other. As a result, RF flows with little attenuation into one of the adjacent transmission lines but not into the other, and ***circulation*** is thus achieved.

Circulator Construction

Figure 2 illustrates the basic construction of a ***Y-junction, distributed-parameter circulator*** of the type described in the previous paragraph. The structure consists of a Y-shaped stripline transmission line assembly, two ferrite disks, two non-ferrous metal ground planes, two permanent magnets, and two ferrous-metal pole pieces which close the magnetic circuit and provide magnetic shielding.

Coaxial connectors, usually type N in low- and medium-power circulators, are provided for connection to external 50-ohm devices and systems. Tuning components, typically variable capacitors, are provided to optimize isolation and insertion loss at specified center frequencies.

A metal housing provides RF shielding, a low-resistance thermal path for efficient heat dissipation, a rigid support for all elements, and protection from the environment.

Circulators of the above construction are suitable for use at frequencies above 400 MHz because of their small size, efficiency and low manufacturing cost. **Figure 3** shows one of **TX RX Systems'** distributed-parameter circulators for the 400-512 MHz range.

At VHF frequencies from 66 to 300 MHz, however, distributed-parameter circulator junctions would require large ferrites, magnets and transmission line assemblies, all of which are costly.

Figure 3 - 450-470 MHz Distributed-Parameter Circulator, Model 81-70-15-00

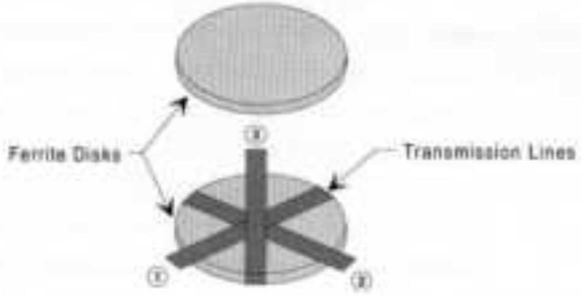

Figure 4 - Stripline Arrangement in Lumped-Constant Circulator

The ***lumped-constant circulator*** utilizes the transmission line arrangement shown in **Figure 4** to achieve better electromagnetic coupling into the ferrites. The three stripline transmission lines are wrapped radially over one of the ferrite disks and connected to a ground plane underneath. Thin insulating disks between overlapping transmission lines prevent shorting. A second ferrite disk and ground plane are then placed over the first assembly and soldered in place. Magnets, pole pieces, matching and tuning components, a housing and connectors are essentially the same as in the case of distributed-parameter circulators.

The physical appearance and external size of a lumped-constant circulator are similar to those of a distributed-parameter circulator.

Circulator Design Objectives

A practical circulator must provide low forward insertion loss and high reverse isolation between adjacent terminals, as well as high return loss (low VSWR) at all ports. To be suitable for practical applications, the circulator junction must be designed to operate reliably at power levels typical of communication transmitters.

Achieving those design objectives under all operating conditions is extremely difficult in a practical circulator design, since they are a function of complex interactions that include, among others:

- Temperature- and RF-dependent ferrimagnetic material properties.
- Transmission line geometry.
- Temperature-dependent mechanical dimensions and clearances.
- Matching circuit design and temperature-dependent characteristics of matching elements.
- Magnetic field intensity, which is a function of initial magnetization and temperature-dependent magnet material properties.

Achieving stable circulator operation requires an intelligent choice of materials and geometries, sound mechanical design and the correct choice of compensation elements to offset component and material variations. Furthermore, it is necessary that the design be manufacturable, in the sense that mass produced circulator assemblies should exhibit uniform, predictable characteristics. This imposes an additional requirement of precision manufacturing and quality control techniques.

It is not surprising, in view of the above, that there are relatively few successful circulator manufacturers, and that circulator designs have tended to survive for decades after their introduction.

Ferrite Isolators

A ***ferrite isolator*** is a two-terminal, nonreciprocal device that passes RF from input to output with little attenuation, and blocks RF in the opposite direction.

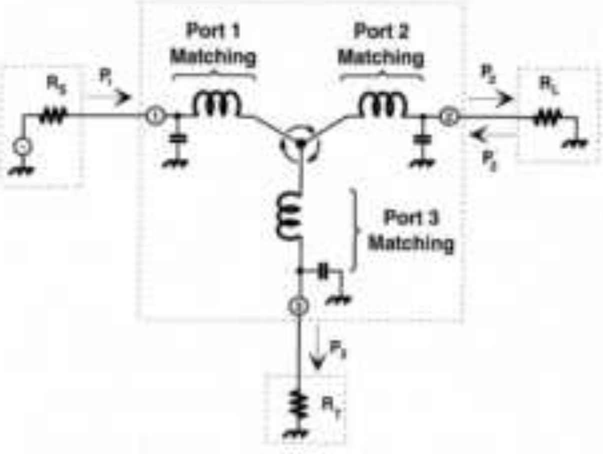

Figure 5 - Isolator = Circulator + Termination

A ferrite isolator is easily constructed by terminating one port of a circulator with a matched RF load resistor. In **Figure 5,** power P_1 entering port 1 circulates through the junction, undergoes a small amount of attenuation and appears at port 2 as P_2. Power P'_2 entering port 2 cannot circulate into port 1 and passes to port 3, where it is dissipated by R_T. Thus, port 2 is effectively isolated from port 1.

Reverse isolation is a function of circulator properties *and* impedance matching between port 3 and its associated termination, since any power reflected by the termination is circulated back to port 1. State-of-the-art junction circulators provide in the order of 30 dB peak reverse isolation at a specified center frequency, and no less than 25 dB reverse isolation over a specified bandwidth and temperature range. However, achieving maximum isolation requires an excellent impedance match at port 3. RF loads for isolator service are therefore designed to have a return loss of at least 30 to 40 dB over a broad frequency range.

Peak vs. Minimum Reverse Isolation

When carefully tuned to a specified center frequency, at room temperature and with high-quality resistive terminations, bench measurements of peak reverse isolation between 35 and 40 dB are not difficult to achieve with single-junction ferrite isolators.

The situation changes radically as soon as transmitter power is applied to the isolator: junction temperature rises substantially, thermal gradients develop that change element properties in different directions, and ferrimagnetic materials may be pushed close to their operating limits. Under such conditions state-of-the-art, single-junction isolators provide in the order of 25 dB minimum reverse isolation, over a bandwidth commensurate with the application and over a temperature range appropriate for the commercial operating environment.

Dual and Triple Isolators

When greater isolation is required, two or more isolators may be connected in series. Total forward insertion loss and reverse isolation are the sum of individual isolator losses and isolations.

Dual- and triple-junction isolators can be built into a single chassis which is generally more compact and less costly than two or three individual isolators. There are good reasons, however, to use series-connected single isolators. The first is that a larger surface area is available for heat dissipation, and operating circulator junctions at lower temperatures improves reliability in applications where isolators are operated at maximum rated power. The second is that complete control of impedance matching between stages is achieved by having access to all circulator ports. Finally, the resulting modularity has functional and cost-of-repair advantages.

Contrary to popular belief, there are no reliability penalties, because good-quality coaxial connections between stages are at least as reliable and free of intermodulation as the stripline or lumped-constant matching sections used in multiple-junction designs.

TX RX Systems' circulator and isolator product family includes both multiple-junction and multiple-stage designs.

Isolator Power Ratings

Isolators have ***two*** distinct power ratings:

1. Maximum input power, which is primarily determined by circulator junction design and thermal dissipation limits, and
2. Maximum reverse power, which is primarily a function of isolator load power rating.

TX RX Systems publishes circulator power ratings that state the true capability of its devices to handle input power under matched, 100% duty cycle conditions. Recognizing that isolators are often required to protect transmitters under specified output mismatch conditions, **TX RX** also publishes data that enable the system designer to intelligently derate isolator maximum input power as a function of output load mismatch. In this fashion, the system designer is assured that the correct product has been chosen for the application. See **Tech-Aid No. 92001,** literature number D3003, "Isolator Power Derating". The data provided there are applicable to isolators of any power rating and manufacture.

RF Load Power Ratings

Since all RF power present at the isolator output is circulated into its load, the isolator load must be capable of dissipating the sum of power reflected by the isolator output load and total power from external sources, such as other system transmitters.

It is not uncommon to see commercial isolators that are outfitted with loads whose true power rating is far below published isolator ratings. The rationale behind the practice seems to be that, depending on the application, a "60-watt" isolator load may be required to dissipate only a fraction of 60 watts transmitter power. For example, in a hybrid combiner that is connected to an antenna via a lossy feedline, it would be rare to see a worst-case return loss of less than 5 or 6 dB. Additionally, circulator internal losses cause a further reduction of power dissipated by the isolator load. Thus, only one quarter of transmitter power may be reflected into the isolator termination, and a 10- or 15-watt load may be perfectly satisfactory for a "60-watt" application.

In order to avoid misunderstandings, **TX RX Systems** prefers to state the true, continuous power rating of its RF loads, and to separately publish data which enable the system designer to calculate the amount of power dissipated in the load, as a function of isolator output mismatch and isolator forward insertion loss. This gives the system designer the ability to intelligently select the correct isolator and RF load combination for each application. See

Tech-Aid No. 92001, literature number D3003, "Isolator RF Load Power". The data provided there are general and applicable to isolators and loads of any manufacture.

If an application requires that loads operate in very high ambient temperatures, **TX RX** recommends choosing loads of a higher power rating. If that is not possible or economical, forced-air cooling can decrease the thermal resistance of a heatsink by a factor of two to four relative to natural convection cooling.

Other RF Load Design Parameters

TX RX Systems specifies load design parameters that facilitate load selection and objective product comparisons:

- **Resistor Element Power Rating** is the manufacturer's specification of maximum power that can be safely dissipated by the element. **TX RX Systems'** 5- and 25-watt loads are built with 60-watt resistors; 60- to 250-watt loads utilize 250-watt resistors.
- **Heatsink Surface Area** is the total surface area of the load in contact with air. **TX RX Systems'** loads have sufficient heatsink area to keep resistor element surface temperature well below the manufacturer's recommended maximum.
- **Heatsink Power Density** is the ratio of load rated power to heatsink surface area. This parameter provides an unequivocal means to compare the true power-handling capability of loads of similar power rating. **TX RX Systems'** loads are conservatively designed to operate at power density factors of 0.54 to 0.28 watts/in^2.

For example, a 60-watt load that has a 20-watt resistor, a surface area of 23 square inches and a power density of 3 watts per square inch is ***not*** equal to another 60-watt load that has a 250-watt element, 172.7 square inches of surface area and a heatsink power density of only 0.35 watts per square inch. It does not make sense to compare the cost of two loads of such obviously dissimilar designs, nor the cost of two isolators outfitted with those loads.

Furthermore, in the absence of complete data of the type published by **TX RX Systems**, it is only possible to guess the true power rating of the first load and its suitability for a particular application.

Harmonic Filters

Due to the non-linear behavior of ferrite materials utilized in circulator junctions, isolators may generate spurious outputs at harmonic frequencies of the transmitter carrier applied to it. These harmonics may mix with other signals to cause intermodulation products, or may interfere by themselves with higher-frequency receivers.

For that reason, a bandpass cavity filter or a lumped-constant harmonic filter should always be provided at the output of ferrite isolators. Bandpass cavity filters are preferred because they attenuate transmitter broadband noise, in- and out-of-band signals that may intermodulate in the transmitter output stage, and intermodulation products. Lumped constant harmonic filters are less expensive than cavity filters and have a broad passband and rejection bandwidth. They are typically used in hybrid combiners, intermodulation suppression panels and other applications where cavities are not used, or where cavities are of the notch or pseudo-bandpass type.

Ferrite Isolator Applications

Isolators are used in intermodulation suppression panels, ferrite/hybrid combiners and ferrite/cavity combiners, for the primary purpose of suppressing intermodulation in transmitter power output stages. They accomplish this by providing isolation between antennas and their associated transmitters, as well as between transmitters that share the same antenna. In all cases, ferrite isolators provide the inherent benefit of isolating transmitters from reactive or mismatched loads which may cause destructive instability or spurious outputs. This causes a net improvement in system reliability and performance.

A few representative applications are described below to illustrate the proper application of isolators and loads in system designs.

Intermodulation Suppression Panel

Figure 6 shows a diagram of a 900-MHz intermodulation suppression panel, **TX RX** Model 81-90-92223, consisting of a dual ferrite isolator, a 100-watt load and three four-inch, onequarterwave bandpass cavity filters. The panel has a total insertion loss of 1 dB and provides more than 80 dB reverse isolation at its center frequency. It also provides 50 dB of noise suppression at frequencies 35 MHz above and below the transmitter. The transmitter can operate on any frequency within the 5-MHz filter passband.

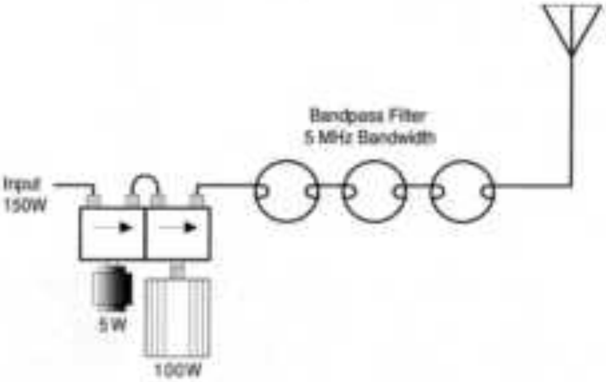

Figure 6 - Intermodulation Suppression Panel Model 81-90-92223

T-Pass ® Multicoupler

Figure 7 is a diagram of a 5-channel VHF multicoupler that utilizes dual ferrite isolators and 10" T-Pass ® cavities.

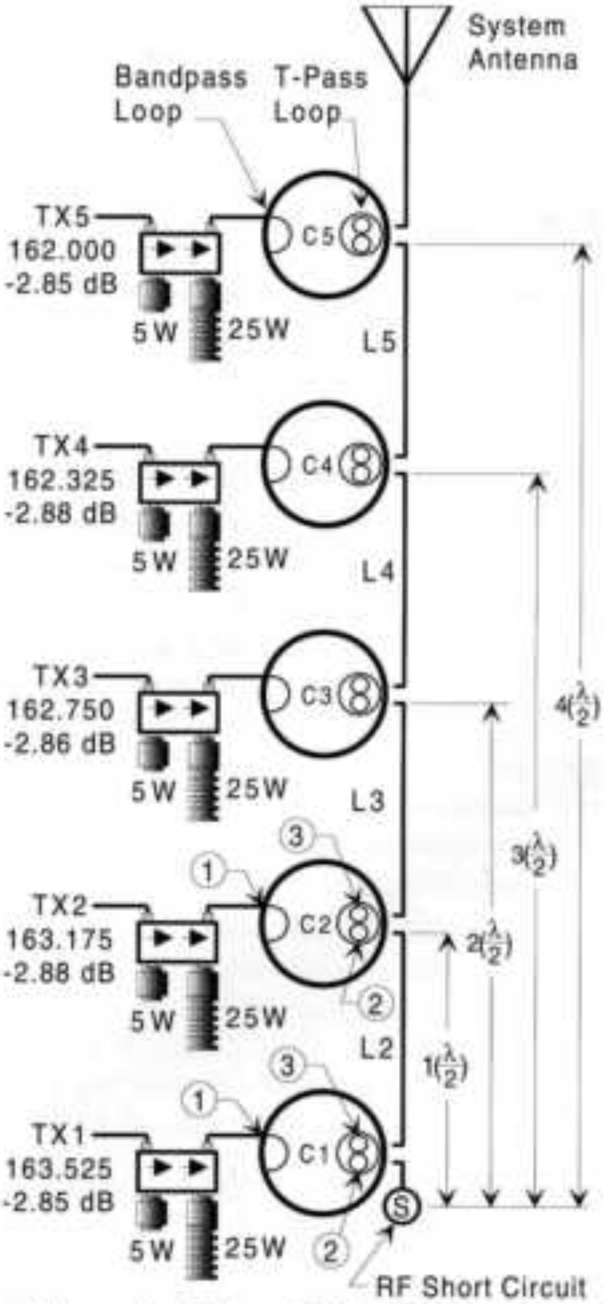

Figure 7 - 5-Channel T-Pass Multicoupler Model 73-37-01-05

T-Pass cavities are patented, three-port bandpass filters of unique construction and characteristics. Each T-Pass filter consists of a bandpass cavity, C1 to C5 in **Figure 7**, which has a conventional bandpass coupling loop on its input (port 1, on the left of each cavity) and a two-port, T-Pass coupling loop on its output (ports 2 and 3, on the right of each cavity). Each cavity is tuned to resonate at the frequency of its associated transmitter. The input loop simply injects RF into the cavity at its resonant frequency.

Port 2 of the T-Pass loop on the output of C1 is terminated with an RF short circuit that grounds the loop at that point. The loop therefore behaves as a conventional bandpass loop that couples RF power from the cavity into port 3. Power from TX1 therefore appears at the output of the cavity, less the normal attenuation of the isolator and cavity insertion loss.

Port 3 of C1 is connected to port 2 of C2 via a specified length L_1 of 50-ohm coaxial cable. If the resonant frequencies of C1 and C2 are sufficiently far apart, the T-Pass loop on the output of C2 behaves as a low-loss, 50-ohm transmission line at the frequency of TX1, and power from TX1 passes to port 3 of C2 with negligible attenuation.

The length of thruline cable L_1 is chosen so that the transmission line between port 2 of C2 and the RF short circuit on C1 is exactly one-half wavelength at the frequency of TX2. This causes the RF short circuit to be reflected onto port 2 of C2. Port 2 of the T-Pass loop on the output of C2 is therefore at RF ground at the frequency of TX2 and the loop behaves as a conventional bandpass loop that couples power from TX2 into port 3 of cavity C2, together with power from TX1.

The process is repeated with C3, C4 and C5. Each cavity is tuned to the frequency of its associated transmitter, and each thruline is cut to a length such that port 2 of each cavity "sees" an RF short circuit at its resonant frequency. The net result is that all transmitters are in effect coupled to a common, tuned output transmission line.

Insertion loss of a T-Pass system is small and equal to the sum of isolator, cavity and cable insertion loss, plus a small "bridging loss" due to RF leakage into the cavities of close-spaced channels.

High transmitter-to-transmitter isolation results from the sum of cavity selectivity, thruline mismatch loss, cavity and cable insertion loss, and isolator reverse isolator. Excellent transmitter protection results from the sum of reverse isolation provided by the isolators and bandpass filter selectivity. Bandpass filter selectivity provides additional intermodulation suppression and transmitter broadband noise suppression.

The system can be easily expanded by adding an expansion channel consisting of a T-Pass cavity, a ferrite isolator and a thruline cable. Unless the new channel is very close to an existing one, there is normally no need to retune the system after expansion. Compact T-Pass systems can be assembled on **TX RX Systems'** patented "Peg Rack" ®.

Minimum channel-to-channel separation varies from 75 KHz with one-quarterwave, 10-inch VHF cavities, to 250 KHz with six-inch, three-quarterwave cavities at 900 MHz.

2-Channel Hybrid Combiner

Figure 8 is a diagram of a conventional 2-channel transmitter combiner. It utilizes a tunable, balanced 3-dB hybrid coupler and dual ferrite isolators to provide 80 dB minimum transmitter-to-transmitter isolation and 55 dB antenna-to-transmitter isolation. This type of combiner is particularly attractive for close-spaced applications where ferrite/cavity systems cannot be used. Second harmonic filters are used at the output of each isolator to provide harmonic rejection in excess of -80 dBc.

The hybrid load should have a continuous power rating of at least 50% of the sum of transmitter output power, or 100 W in this case. The 60-watt isolator loads can safely dissipate worst-case reflected power (50 W with an open or shorted output) in a system of this type.

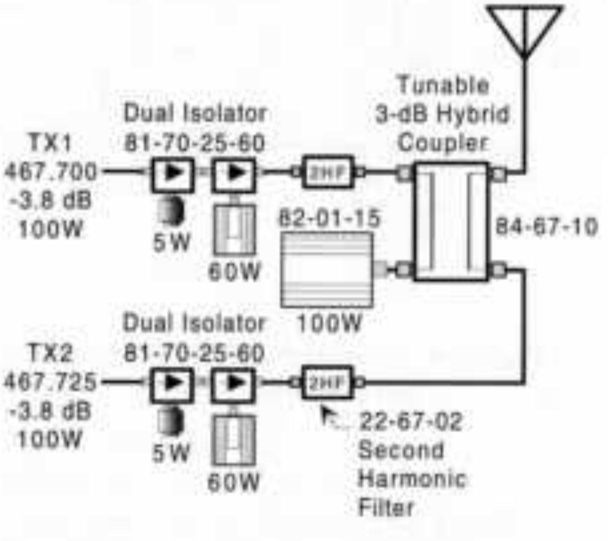

Figure 8 - 2-Channel Hybrid Combiner

5-Channel Hybrid Combiner

Figure 9 is a diagram of an 800-MHz, five-channel combiner that utilizes ferrite isolators and series-connected, untuned hybrid couplers to provide minimum-loss combining of an odd or even number of transmitters, with equal insertion loss on all channels. The system can be easily expanded and maintains equal insertion loss after expansion.

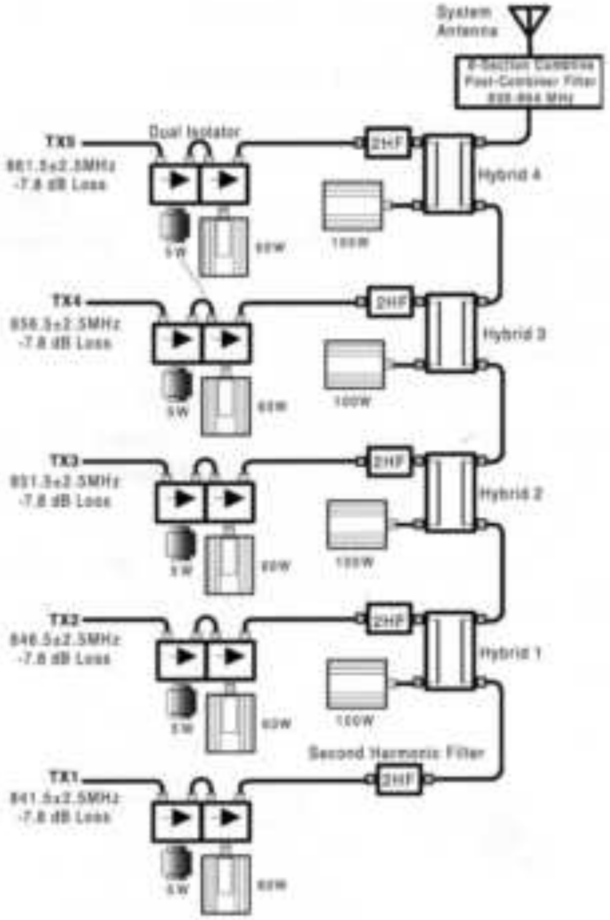

Figure 9 - 5-Channel Hybrid Combiner
Model 431-90-92307

The system shown has an eight-section, low-loss combline filter at the output, to provide a 25-MHz passband from 839 to 864 MHz, at an insertion loss of only 0.5 dB. Frequency-agile transmitters could operate on any frequency within the bandwidth of the isolators and output filter, without the potential unreliability of motor-tuned cavity systems.

Back-to-Back Repeater Multicoupler

Figure 10 shows a back-to-back, 4 frequency repeater system of the type used to extend the coverage of duplex base stations or repeaters in radiotelephone and telemetry applications. It illustrates one of the most economical solutions to a practical duplex multicoupling problem.

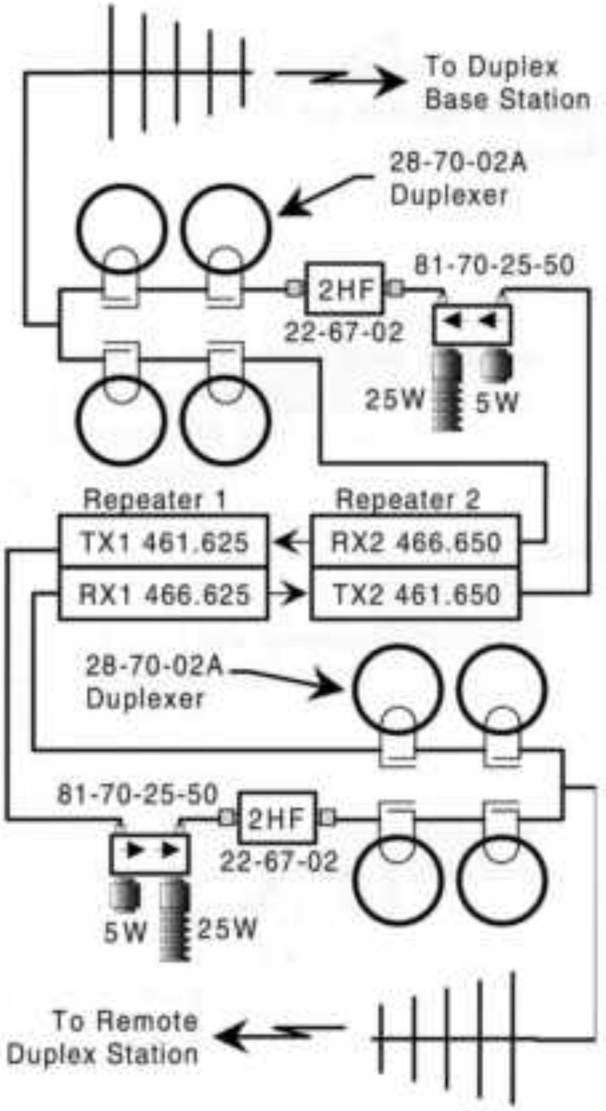

Figure 10 - Back-to-Back Repeater Multicoupler System

The first repeater operates on 461.625 MHz Tx and 466.625 MHz Rx. It is connected through a four-inch, four-cavity Vari-Notch ® duplexer to a directional antenna aimed at the remote duplex station. The second repeater operates on a pair of frequencies 25 KHz higher than the first, 461.650 MHz Tx and 466.650 MHz Rx. It is connected through a duplexer identical to the first to a second directional antenna aimed at the duplex base station.

The two dual ferrite isolators provide ample isolation between transmitters to permit operation of the transmitters with only 10 to 20 dB of antenna isolation. Second harmonic filters are used to increase harmonic suppression. The arrangement provides more than 90 dB transmitter-to-receiver isolation.

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"Eliminación de las Salidas Espúreas y de la Sobrecarga con Cavidades de Filtro", TX RX Systems Inc., 1980. Literature No. 400 KD.

TX RX Tech-Aids

No. 92001: Ferrite Isolator Power Derating and Isolator Load Power Requirements.

No. 76002: Power In/Out vs. Insertion Loss; Forward/Reverse Power vs. VSWR.

No. 77001: Isolation Curves for VHF and UHF Transmitters and Receivers.

Other References

Kaegebein, Daniel P., "Testing for Intermod", Communications Magazine, July 1984.

Hohman, Dennis G., "Are All Multicouplers and Multicoupling Systems Created Equal?, Communications Magazine, December 1982. Literature No. E(H)503M2.

"I.M. Master - Intermodulation Analysis & Data File Programs", Coden Enterprises, Inc., 195 Burmon Dr., Orchard Park, NY 14127.

FOR ADDITIONAL INFORMATION

TX RX Systems Inc. provides an unusually broad range of technical support services to its customers, including extensive assistance in the selection of products for specific customer applications and/or system design services.

Contact **TX RX Systems Inc.** at the address, fax and telephone numbers given below, for additional information on ferrite circulators, isolators, RF loads and an extensive line of RF system products, transmitter and receiver multicouplers, and signal boosters (repeater amplifiers).

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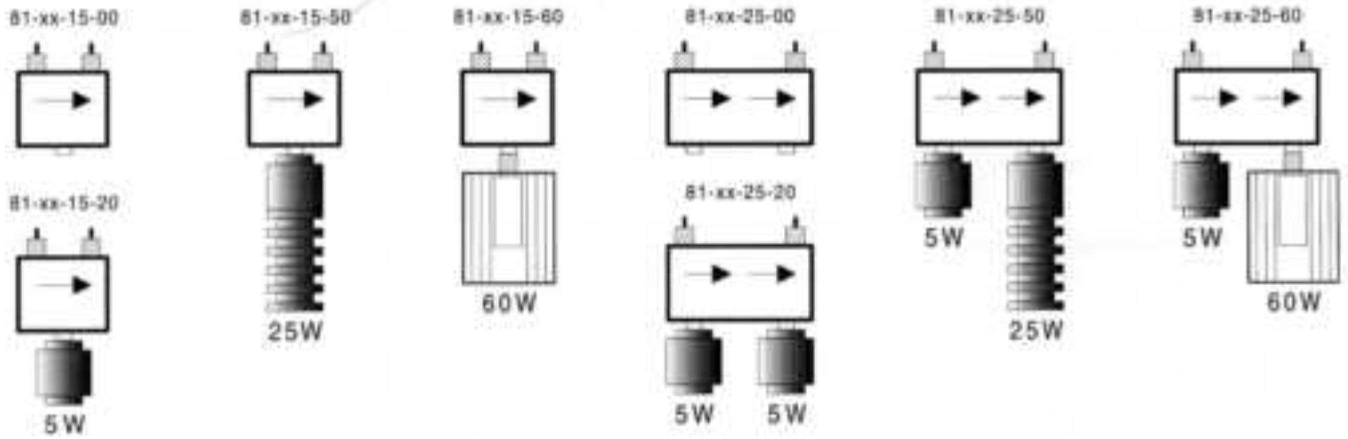
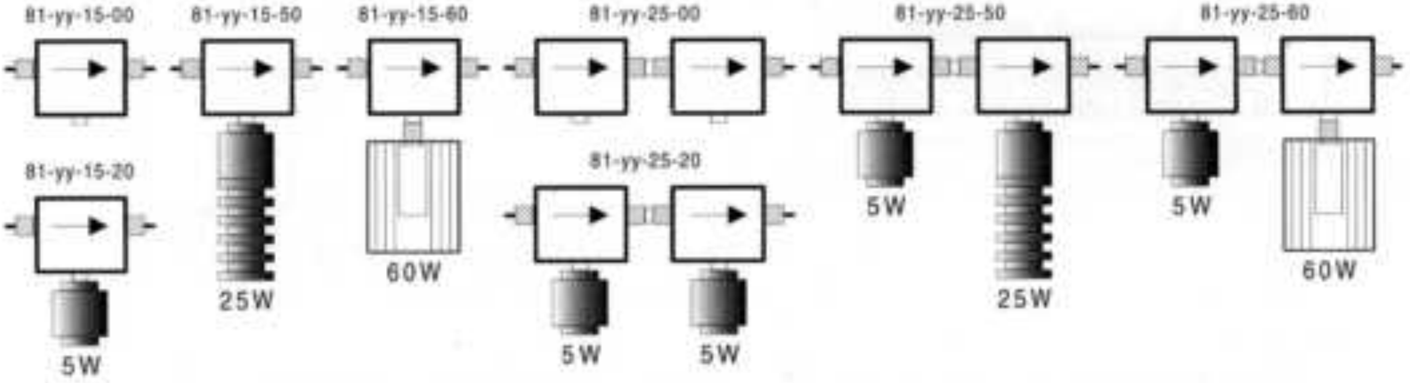
CIRCULATORS, ISOLATORS AND LOADS

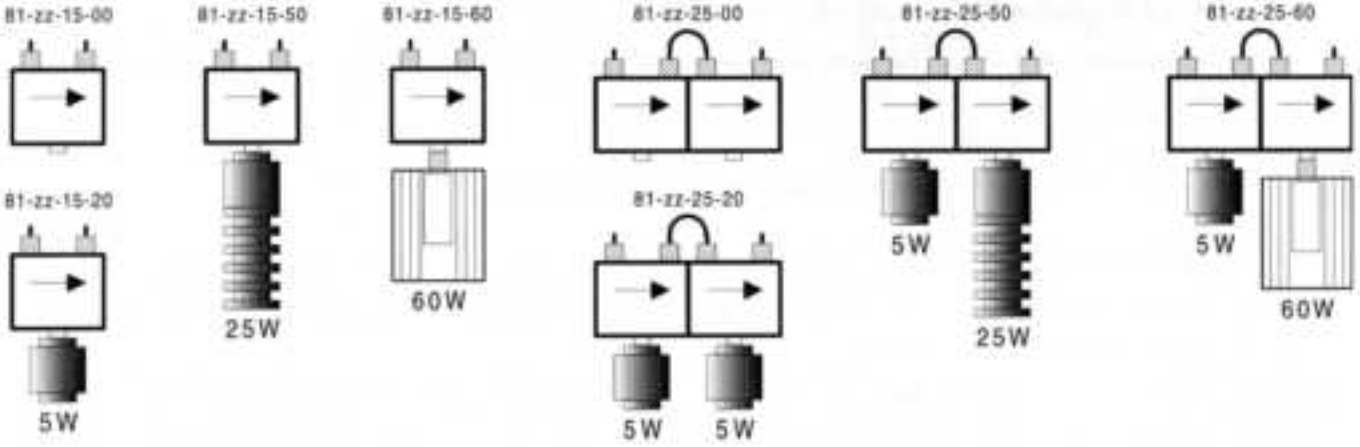
VHF CIRCULATORS & ISOLATORS



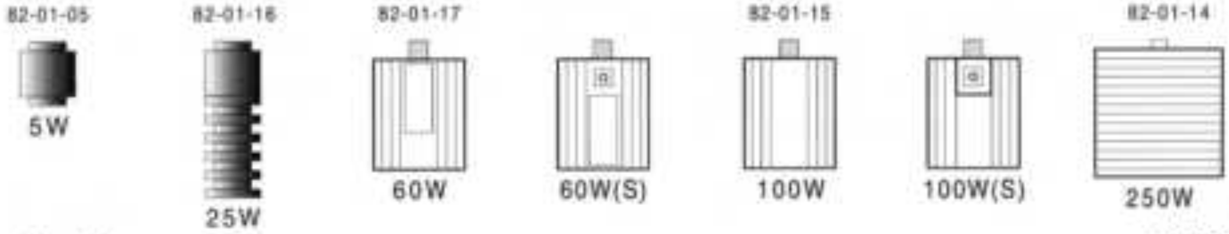
UHF CIRCULATORS AND ISOLATORS



800/900 MHz CIRCULATORS & ISOLATORS



RF LOADS



TECH-AID

No. 92001

Ferrite Isolator Power Derating

When an isolator operates into a mismatched output load, power reflected by the load circulates through the junction before it reaches the isolator termination. Power dissipated in the isolator increases by an amount which is a function of isolator insertion loss and output load return loss or VSWR. The table below provides a power derating factor which can be easily applied to ensure that isolators are operated well within their power ratings.

The derating factor is calculated on the basis of thermal dissipation limits only. Voltage effects are not a practical consideration as long as the isolator is operated within its power rating.

OUTPUT CONDITIONS			SINGLE ISOLATOR IL (dB)				DUAL ISOLATOR IL (dB)			
RL (dB)	**VSWR**	**P_R/P_O**	**0.35**	**0.40**	**0.45**	**0.50**	**0.70**	**0.80**	**0.90**	**1.00**
0.00	INFINITE	1.00	0.52	0.52	0.53	0.53	0.69	0.70	0.70	0.70
1.00	17.39	0.79	0.58	0.58	0.58	0.59	0.74	0.74	0.75	0.75
2.00	8.72	0.63	0.63	0.63	0.64	0.64	0.78	0.78	0.79	0.79
3.00	5.85	0.50	0.68	0.69	0.69	0.69	0.82	0.82	0.82	0.82
4.00	4.42	0.40	0.73	0.73	0.74	0.74	0.85	0.85	0.85	0.85
5.00	3.57	0.32	0.77	0.78	0.78	0.78	0.88	0.88	0.88	0.88
6.00	3.01	0.25	0.81	0.81	0.82	0.82	0.90	0.90	0.90	0.90
7.00	2.61	0.20	0.84	0.85	0.85	0.85	0.92	0.92	0.92	0.92
8.00	2.32	0.16	0.87	0.87	0.88	0.88	0.93	0.94	0.94	0.94
9.00	2.10	0.13	0.90	0.90	0.90	0.90	0.95	0.95	0.95	0.95
10.00	1.92	0.10	0.92	0.92	0.92	0.92	0.96	0.96	0.96	0.96
11.00	1.78	0.08	0.93	0.93	0.93	0.93	0.97	0.97	0.97	0.97
12.00	1.67	0.06	0.95	0.95	0.95	0.95	0.97	0.97	0.97	0.97
13.00	1.58	0.05	0.96	0.96	0.96	0.96	0.98	0.98	0.98	0.98
14.00	1.50	0.04	0.96	0.96	0.97	0.97	0.98	0.98	0.98	0.98
15.00	1.43	0.03	0.97	0.97	0.97	0.97	0.99	0.99	0.99	0.99
16.00	1.38	0.03	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99
17.00	1.33	0.02	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99
18.00	1.29	0.02	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
19.00	1.25	0.01	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
20.00	1.22	0.01	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00
21.00	1.20	0.01	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00
22.00	1.17	0.01	0.99	0.99	0.99	0.99	1.00	1.00	1.00	1.00
23.00	1.15	0.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

RL (dB) = Return loss (dB) of isolator output load.
VSWR = VSWR of isolator output load.
P_R/P_O = Fraction of isolator output power reflected by isolator output load.

Example 1

Find the maximum input power that can be applied to a single 250-watt isolator operating into an open or shorted output terminal. Isolator insertion loss is 0.45 dB.

Return loss is 0 dB and VSWR is infinite. 100% of isolator output power is reflected by the load. Enter the table with 0.00 dB RL and 0.45 dB single isolator loss. At the intersection find a power derating factor of 0.53. Isolator input power should not exceed 0.53 x 250 W = 132.5 W.

Example 2

Find the maximum input power that can be applied to a 150-watt dual isolator operating into an output load that reflects 50% of incident power. Isolator insertion loss is 0.9 dB.

For $P_R/P_O = 0.50$, VSWR = 5.85:1 and RL = -3.01 dB, a derating factor of 0.82 is found for dual isolator RL = 0.90 dB. Maximum isolator input power is 0.82 x 150 W = 123.0 W.

Isolator Load Power Requirements

In addition to providing a matched resistive termination to the circulator junction, isolator load resistors must dissipate RF power from external sources or reflected by the isolator output load. The isolator load resistors must have a power rating at least equal to maximum reverse power expected at the isolator output terminal, minus internal isolator losses.

The table below provides a factor that is simply multiplied by maximum isolator input power to determine isolator load power under specified isolator output conditions.

OUTPUT CONDITIONS			SINGLE ISOLATOR IL (dB)				DUAL ISOLATOR IL (dB)			
RL (dB)	**VSWR**	**P_R/P_O**	**0.35**	**0.40**	**0.45**	**0.50**	**0.70**	**0.80**	**0.90**	**1.00**
0.00	INFINITE	1.00	0.85	0.83	0.81	0.79	0.79	0.76	0.73	0.71
1.00	17.39	0.79	0.68	0.66	0.65	0.63	0.63	0.60	0.58	0.56
2.00	8.72	0.63	0.54	0.52	0.51	0.50	0.50	0.48	0.46	0.45
3.00	5.85	0.50	0.43	0.42	0.41	0.40	0.40	0.38	0.37	0.35
4.00	4.42	0.40	0.34	0.33	0.32	0.32	0.32	0.30	0.29	0.28
5.00	3.57	0.32	0.27	0.26	0.26	0.25	0.25	0.24	0.23	0.22
6.00	3.01	0.25	0.21	0.21	0.20	0.20	0.20	0.19	0.18	0.18
7.00	2.61	0.20	0.17	0.17	0.16	0.16	0.16	0.15	0.15	0.14
8.00	2.32	0.16	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.11
9.00	2.10	0.13	0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.09
10.00	1.92	0.10	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07
11.00	1.78	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06
12.00	1.67	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
13.00	1.58	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
14.00	1.50	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
15.00	1.43	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
16.00	1.38	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
17.00	1.33	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
18.00	1.29	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
19.00	1.25	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
20.00	1.22	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
21.00	1.20	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
22.00	1.17	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
23.00	1.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

RL (dB) = Return loss (dB) of isolator output load.

VSWR = VSWR of isolator output load.

P_R/P_O = Fraction of isolator output power reflected by isolator output load.

Example 1

A 100-watt transmitter operates through a single isolator, insertion loss 0.45 dB, into an open or shorted output terminal. How much power is dissipated in the isolator load?

An open or shorted output reflects 100% of isolator output power. Therefore P_R/P_O is 1.00, return loss is 0.00 dB and VSWR is infinite. Enter the table at the row for RL = 0.00 dB. At the column for single isolator IL = 0.45 dB find a load power factor of 0.81. The isolator load will disspipate 0.81 x 100 W = 81.0 watts.

Example 2

A 150-watt transmitter operates through a dual isolator, insertion loss 0.90 dB, into a mismatched output load that reflects 25% of isolator output power. How much power is dissipated in the isolator load?

Enter the table with $P_R/P_O = 0.25$ (RL = -6.02 dB, VSWR = 3.01:1) and dual isolator insertion loss = 0.90 dB, to find a load power factor of 0.18. The isolator load will dissipate 0.18 x 150 W = 27 watts.