BIRD®

TECHNOLOGIES GROUP

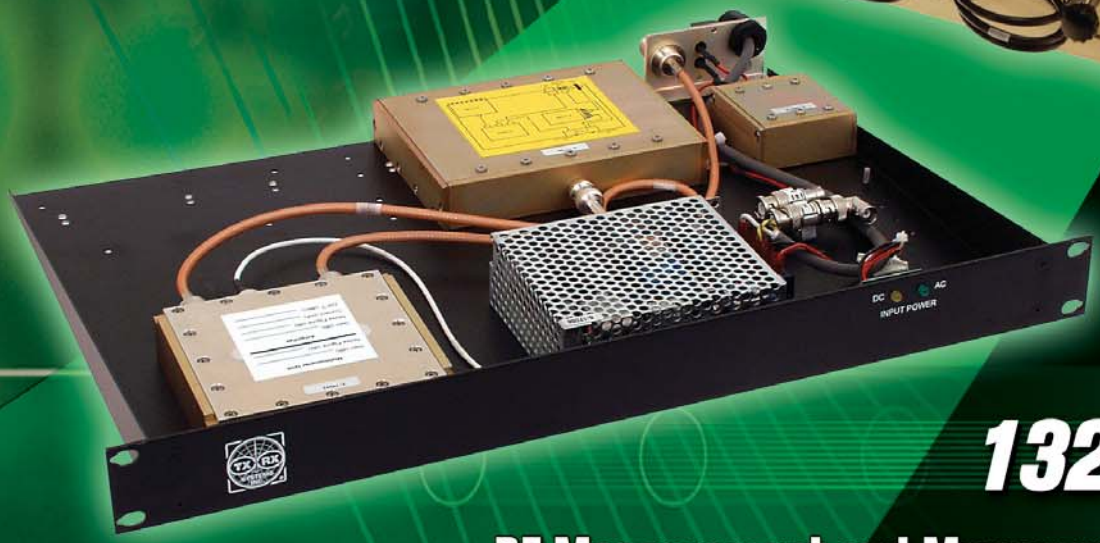
TX RX SYSTEMS

RF Site Management Equipment









TX RX SYSTEMS INC.®

132-300 MHz

RF Measurement and Management in Your World™

TX RX SYSTEMS INC

TX RX Systems is the right choice…

Choosing the supplier of your multicoupling, combining, or signal booster system is a vital part of the engineering process. The proper application, as well as performance and reliability of the equipment can make or break a communications system. With businesses, communities, and lives dependent on these networks, getting it right is serious business.

TX RX Systems, Inc. has established itself as the leader in the design and manufacture of transmitter combiner and receiver multicoupler systems, duplexers, cavity filters, signal boosters, and a vast range of RF components.

This success is the result of numerous industry experiences, including:

- Innovative product design, manufacturing skills and quality control.
- Extensive experience in RF systems analysis and design.
- An unparalleled dedication to customer service.

TX RX Systems is committed to providing effective, reliable solutions for RF applications that serve the Wireless, Public Safety, Government and Military markets. With close to 30 years of experience in serving critical Public Safety needs, TX RX Systems has earned an unrivaled reputation for delivering high quality, reliable systems that enable efficient base station management and extend the range of radio communications to basements, subways, high-rise buildings and other locations where obstacles challenge life-saving communications.

We are the supplier of choice to major radio system OEM's in North America as well as to private system managers and end-users for RF infrastructure equipment that includes transmitter combiners, tower-top amplifiers, receiver multicouplers and receive preselectors. Our equipment serves as the fundamental conduit to efficiency and high-performance in many small, medium and large enterprise communication systems as well as mission-critical, agency-wide, county, city and statewide communication systems. Our resume of projects includes the State of Pennsylvania, Washington MTA, Los Angeles MTA, Disney, Lawrence Livermore, Kern County, City of Glendale, Cook County, Coors Brewery, and many more.

Our core capabilities include:

- Innovative Product Design
- Class A Planning & Manufacturing
- Problem Analysis and Resolution
- Comprehensive System Design
- Hardware and Software Configurability
- Installation Support
- Acceptance Testing
- Customer Service Philosophy

Our team can offer off-the-shelf or configured solutions to suit your requirements. In a single catalog we cannot possibly cover the broad range of components, sub-systems and systems available to address the degree of design customization we can provide.

Rather, this catalog is intended as an introductory guide to our individual multicoupling products and related engineering services and capabilities. We have included comprehensive, accurate technical information - whether it is suited for use as a stand-alone item or as a building block that may be integrated into more complex application solutions. This information is presented for engineers, technicians, and purchasing staff alike.

As our product offering continues to grow, we encourage you to review our web site at www.txrx.com for updated information as you need it, or contact our sales office for any further information on our products and services.

We look forward to the opportunity to serve you.

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SOLUTIONS...

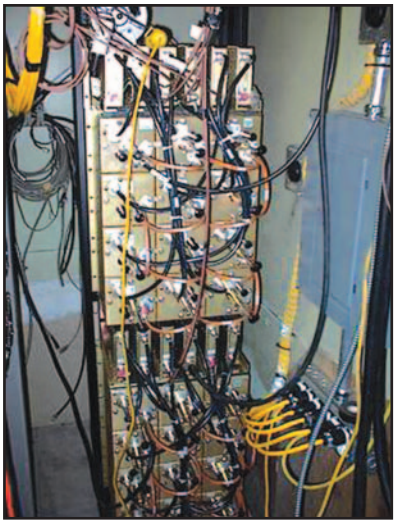
From 30 MHz to 1 GHz, TX RX Systems has provided a multitude of components and systems to the LMR (Land Mobile Radio) market. Whether you require a standard product or a highly configured solution, WE DELIVER …

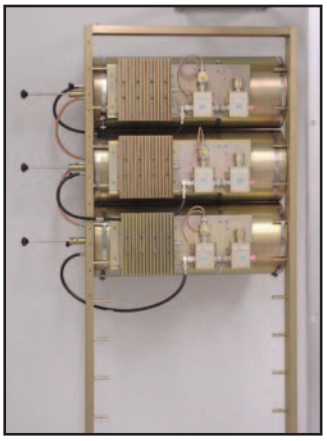
- Custom mechanical solutions where space is at a premium
- High Performance Filter solutions when channel planning is sub-optimum
- Compact packaging for complex systems
- Superior system design guidance for busy sites

OBSOLESCENCE AVOIDANCE…

With the current uncertainty in spectrum policy, TX RX Systems is a natural choice for RF management products that help mitigate product obsolescence. The broadband architecture of critical components means existing systems can be economically upgraded in the field to protect your infrastructure investments.







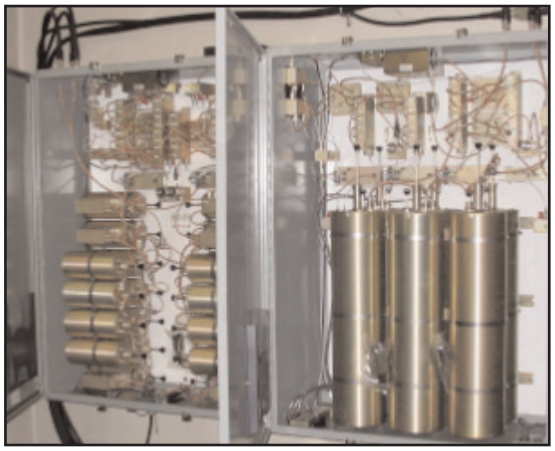


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TRANSMITTER COMBINERS

118-174/215-300 MHz



73-FFF-05-2C-NN



73-FFF-01-2D-NN

- Each system configured for optimum performance
- Ideal for interleaved VHF Transmit and Receive Frequencies
- Electrically and mechanically designed for easy expansion

T-Pass® Multicouplers

Spectrum Issues

High-band VHF spectrum (150 - 174 MHz) was originally allocated in the early 1950's for single frequency simplex operation. Repeaters did not start to be used until the mid to late 1960's, and trunking has just very recently been authorized in this band. Due to the lack of a band-plan such as exists in UHF and higher frequency allocations, multicoupling at VHF can be quite difficult. Receive and transmit frequencies are often interleaved with only narrow guard-bands between them. TX RX designed the T-Pass® multicoupler system as the solution to this environment. A T-Pass® multicoupler can be configured to be used as a transmitter combiner or as a complex receive preselector. T-Pass® is a cost-effective way to "tame" complex VHF High-Band systems.

T-Pass® Solution

TX RX's time-proven T-Pass® multicoupler provides design security for any multi-channel radio system. From the most complex multi-site Homeland Security system to the simplest 2-channel private system, T-Pass® allows unsurpassed flexibility to accommodate the most challenging frequency plans now so common at VHF, as well as future expandability. The same architecture used for transmitter combining can also be used as a preselector in receive systems where receive and transmit frequencies are interleaved. Proven low-loss and low PIM construction techniques are used such as welded cavity construction; silver- plated loops, Alballoy®- plated integrated loop plates and connectors; as well as a unique fingerstock-free high-conductivity silver- plated tuning probe. Our patented internal temperature compensation insures that transmitter cavities remain in tune even when connected to high duty cycle transmitters. Coupled with the space-efficient Peg Rack® packaging system and TX RX's own high-isolation transmitter isolators, the T-Pass system continues to hold its position as the gold standard in the demanding private and Public Safety market. And all TX RX products are designed and manufactured in the USA.

Design Methodology

TX RX provides multicoupling systems, not "one-size-tries-to-fit-all" products. Each T-Pass® system is designed and configured for the specific site at which it is to be used. Intermodulation studies as well as transmitter noise and receiver desense estimates are used to design the unit with the required isolation characteristics for the environment where it will be used. The system documentation is kept on-file to aid in future expansions or modifications of the site.

System Expansion

Unlike "star-junction" combiners, expanding a T-Pass® system is a breeze. Just add the new cavity (with its isolator attached, if required) and the cable provided to the top of the "stack". No re-tuning is required and the added frequency entails no changes in other cable lengths, even if the added frequency is far-removed from the existing frequencies. Since the first channel in the T-Pass® system has no cable associated with it, it may be tuned to any frequency in the band. Some customers with known expansion to unknown frequencies on the horizon keep this first channel open. When it is required to add the new channel, they tune this first channel cavity to the new frequency and then order the expansion hardware. After the expansion channel hardware is installed and tuned, the first channel is detuned and ready for the next expansion.

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Specifications [Note 1]	73-35A-01-2B-nn	73-35A-01-2D-nn	73-35A-05-2B-nn	73-35A-05-2D-nn
Frequency Range [Note 2]	118-136 MHz			
Cavity Type and Diameter	Quarterwave, 6.625" (168 mm)		Quarterwave, 10" (254 mm)	
Maximum Continuous Transmit Power	See tables below			
Isolator Load Pwr (Continuous) [Note 3]	5W/25W	5W/100W	5W/25W	5W/100W
Min Tx-Tx Separation @ Cavity Loss	100 kHz @ -1.5 dB; 60 kHz @ -2.5 dB		80 kHz @ -1.5 dB; 45 kHz @ -2.5 dB	
Typical Tx-Tx Isolation @ Min Separation	-70 dB			
Typical Antenna-Tx Isolation	-60 dB			
Typical Tx Noise Suppression	Depends on cavity loss (See curves below)			
Nominal Input Impedance	50 ohms			
Maximum Input Return Loss (VSWR)	-20 dB (1.22:1)			
Temperature Range	-30 to +60 Celsius			
Connectors, Input & Antenna	N			
Mechanical Mounting	Peg Rack®			
Mounting Options [Notes 4,5]	**MC:**19" rackmount adapter plates, 17.5" high		**LR:** System supplied without Peg Rack	
Maximum Channels Per Rack [Note 4]	15		12	
Dimensions [Note 6]	65.25"Hx24"Wx40.25"D (1659x610x1022 mm)		79.5"Hx24"Wx42.5"D (2019x610x1080 mm)	
Weight, lb (Kg) - Basic Single-Channel	38 (17.2)	39 (17.7)	44 (19.9)	45 (20.4)
Weight, lb (Kg) - Expansion Channel Assy	16 (7.2)	17 (7.7)	21 (9.5)	22 (10.0)

Notes:
1. **-nn** in model number represents the number of channels.
2. Consult factory on T-Pass multicouplers for frequencies below 118 MHz.
3. Models available with 5W/60W loads. Same specifications as 25W and 100W models, except load power.
4. **-MC** option reduces maximum number of channels to ten 10-inch or twelve 6.625-inch channels per rack.
5. **-LR** systems are tuned and tested on customer frequencies, then disassembled for shipping.
6. Rack depth with cavity tuning rods at maximum frequency. Rod travel is approximately 3.3" (84 mm).

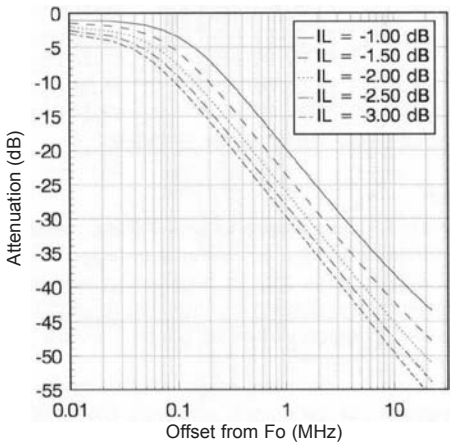
Typical Insertion Loss and Maximum Input Power

73-35A-01-Series Systems (6.625" Cavity Diameter)						
Tx-Tx Separation	Cavity Loss	Maximum Power	Loss (dB) vs. No. of channels 2	4	8	12
1 MHz	-1.5 dB	150 W	-2.6	-2.7	-3.0	-3.3
250 kHz	-1.5 dB	150 W	-2.7	-3.0	-3.3	-3.6
100 kHz	-1.5 dB	150 W	-3.2	-4.0	-4.7	-5.1
75 kHz	-2.0 dB	135 W	-3.6	-4.5	-5.2	-5.6
50 kHz	Use 10" cavities at this separation					

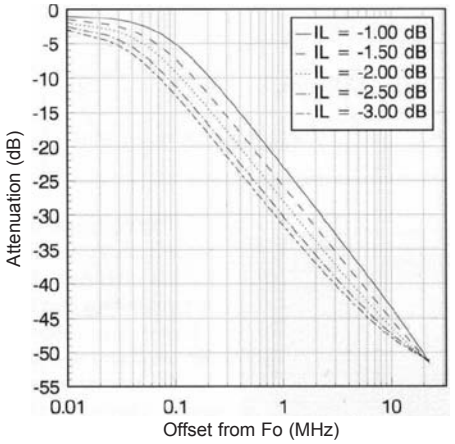
73-35A-05-Series Systems (10" Cavity Diameter)						
Tx-Tx Separation	Cavity Loss	Maximum Power	Loss (dB) vs. No. of channels 2	4	8	12
1 MHz	-1.5 dB	150 W	-2.6	-2.7	-3.0	-3.2
250 kHz	-1.5 dB	150 W	-2.6	-2.9	-3.1	-3.4
100 kHz	-1.5 dB	150 W	-2.9	-3.6	-4.0	-4.4
75 kHz	-2.0 dB	150 W	-3.5	-4.1	-4.6	-4.9
50 kHz	-2.5 dB	130 W	-4.1	-4.8	-5.4	-5.7

Typical Transmitter Noise Suppression

73-35A-01-Series Systems
6.625" Diameter Quarterwave, Fo=124 MHz



73-35A-05-Series Systems
10" Diameter Quarterwave, Fo=124 MHz



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TRANSMITTER COMBINERS

Technical Specifications

Specifications [Note 1]	73-38-01-2B-nn	73-38-01-2D-nn	73-38-05-2B-nn	73-38-05-2D-nn
Frequency Range [Note 2]	132-174 MHz			
Cavity Type and Diameter	Quarterwave, 6.625" (168 mm)		Quarterwave, 10" (254 mm)	
Maximum Continuous Transmit Power	See tables below			
Isolator Load Pwr (Continuous) [Note 3]	5W/25W	5W/100W	5W/25W	5W/100W
Min Tx-Tx Separation @ Cavity Loss	125 kHz @ -1.5 dB; 75 kHz @ -2.5 dB		95 kHz @ -1.5 dB; 50 kHz @ -2.5 dB	
Typical Tx-Tx Isolation @ Min Separation	-70 dB			
Typical Antenna-Tx Isolation	-60 dB			
Typical Tx Noise Suppression	Depends on cavity loss (See curves below)			
Nominal Input Impedance	50 ohms			
Maximum Input Return Loss (VSWR)	-20 dB (1.22:1)			
Temperature Range	-30 to +60 Celsius			
Connectors, Input & Antenna	N			
Mechanical Mounting	Peg Rack®			
Mounting Options [Notes 4,5]	**MC:**19" rackmount adapter plates, 17.5" high		**LR:** System supplied without Peg Rack	
Maximum Channels Per Rack [Note 4]	15		12	
Dimensions [Note 6]	79.5"Hx24"Wx36.9"D (1659x610x937 mm)		79.5"Hx24"Wx26.9"D (2019x610x937 mm)	
Weight, lb (Kg) - Basic Single-Channel	33 (17.5)	37 (17.7)	41 (18.6)	42 (19)
Weight, lb (Kg) - Expansion Channel Assy	15 (6.8)	16 (7.2)	19 (8.6)	20 (9.1)

Notes:
1. **-nn** in model number represents the number of channels.
2. Consult factory on T-Pass multicouplers for frequencies above 174 MHz.
3. Models available with 5W/60W loads. Same specifications as 25W and 100W models, except load power.
4. **-MC** option reduces maximum number of channels to ten 10-inch or twelve 6.625-inch channels per rack.
5. **-LR** systems are tuned and tested on customer frequencies, then disassembled for shipping.
6. Rack depth with cavity tuning rods at maximum frequency. Rod travel is approximately 5.4" (137 mm).

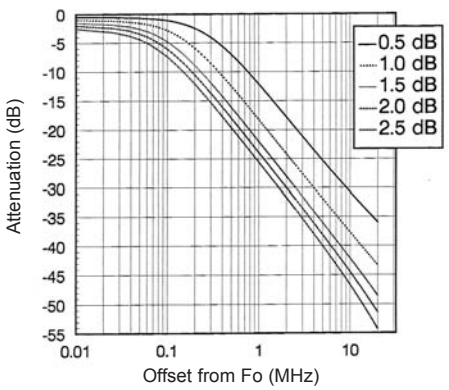
Typical Insertion Loss and Maximum Input Power

73-38-01-Series Systems (6.625" Cavity Diameter)						
Tx-Tx Separation	Cavity Loss	Maximum Power	Loss (dB) vs. No. of channels 2	4	8	12
1 MHz	-1.5 dB	150 W	-2.6	-2.7	-3.0	-3.3
250 kHz	-1.5 dB	150 W	-3.3	-4.5	-5.3	-5.7
100 kHz	-2.0 dB	135 W	-3.6	-4.5	-5.2	-5.5
75 kHz	-2.5 dB	115 W	-4.3	-5.4	-6.2	-6.7
50 kHz	Use 10" cavities at this separation					

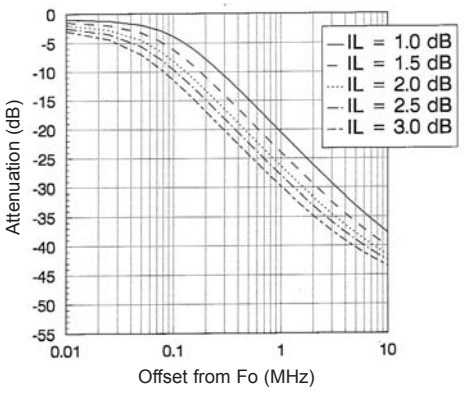
73-38-05-Series Systems (10" Cavity Diameter)						
Tx-Tx Separation	Cavity Loss	Maximum Power	Loss (dB) vs. No. of channels 2	4	8	12
1 MHz	-1.5 dB	150 W	-2.6	-2.7	-2.9	-3.1
250 kHz	-1.5 dB	150 W	-2.9	-3.4	-3.8	-4.0
100 kHz	-1.5 dB	150 W	-3.0	-3.7	-4.2	-4.5
75 kHz	-2.0 dB	150 W	-3.5	-4.2	-4.7	-5.0
50 kHz	-2.5 dB	130 W	-4.1	-5.0	-5.7	-6.1

Typical Transmitter Noise Suppression

73-38-01 Series Systems
6.625" Diameter Quarterwave, Fo=160 MHz



73-38-05 Series Systems
10" Diameter Quarterwave, Fo=160 MHz



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Specifications [Note 1]	73-54A-01-2B-nn	73-54A-01-2D-nn	73-54A-05-2B-nn	73-54A-05-2D-nn
Frequency Range [Note 2]	215-300 MHz			
Cavity Type and Diameter	Quarterwave, 6.625" (168 mm)		Quarterwave, 10" (254 mm)	
Maximum Continuous Transmit Power	See tables below			
Isolator Load Pwr (Continuous) [Note 3]	5W/25W	5W/100W	5W/25W	5W/100W
Min Tx-Tx Separation @ Cavity Loss	170 kHz @ -1.5 dB; 95 kHz @ -2.5 dB		140 kHz @ -1.5 dB; 75 kHz @ -2.5 dB	
Typical Tx-Tx Isolation @ Min Separation	-70 dB			
Typical Antenna-Tx Isolation	-60 dB			
Typical Tx Noise Suppression	Depends on cavity loss (See curves below)			
Nominal Input Impedance	50 ohms			
Maximum Input Return Loss (VSWR)	-20 dB (1.22:1)			
Temperature Range	-30 to +60 Celsius			
Connectors, Input & Antenna	N			
Mechanical Mounting	Peg Rack®			
Mounting Options [Notes 4,5]	**MC:**19" rackmount adapter plates, 17.5" high		**LR:** System supplied without Peg Rack	
Maximum Channels Per Rack [Note 4]	15		12	
Dimensions [Note 6]	65.25"Hx24"Wx26.4"D (1659x610x671 mm)		79.5"Hx24"Wx28.4"D (2019x610x721 mm)	
Weight, lb (Kg) - Basic Single-Channel	34 (17.2)	35 (17.7)	39 (19.9)	40 (20.4)
Weight, lb (Kg) - Expansion Channel Assy	14 (7.2)	15 (7.7)	18 (9.5)	19 (10)

Notes:
1. **-nn** in model number represents the number of channels.
2. Consult factory on T-Pass multicouplers for frequencies below 215 or above 300 MHz.
3. Models available with 5W/60W loads. Same specifications as 25W and 100W models, except load power.
4. **-MC** option reduces maximum number of channels to ten 10-inch or twelve 6.625-inch channels per rack.
5. **-LR** systems are tuned and tested on customer frequencies, then disassembled for shipping.
6. Rack depth with cavity tuning rods at maximum frequency. Rod travel is approximately 3.9” (99 mm).

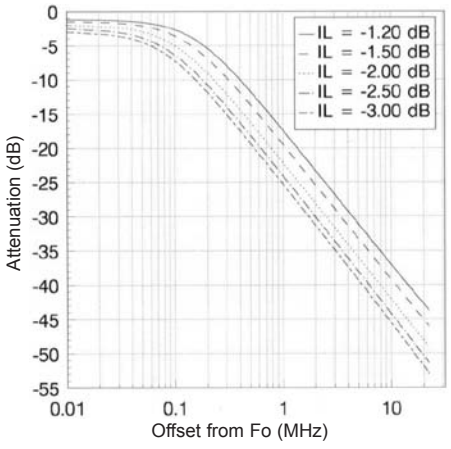
Typical Insertion Loss and Maximum Input Power

73-54A-01-Series Systems (6.625" Cavity Diameter)						
Tx-Tx Separation	Cavity Loss	Maximum Power	Loss (dB) vs. No. of channels 2	4	8	12
1 MHz	-1.5 dB	150 W	-2.6	-2.7	-3.0	-3.3
250 kHz	-1.5 dB	150 W	-2.9	-3.4	-3.8	-4.1
175 kHz	-1.5 dB	150 W	-3.1	-3.9	-4.5	-4.9
125 kHz	-2.0 dB	135 W	-3.6	-4.4	-4.9	-5.3
100 kHz	-2.5 dB	115 W	-4.1	-4.5	-5.4	-5.8

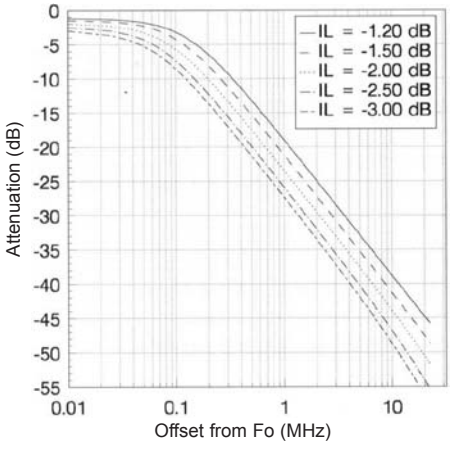
73-54A-05-Series Systems (10" Cavity Diameter)						
Tx-Tx Separation	Cavity Loss	Maximum Power	Loss (dB) vs. No. of channels 2	4	8	12
1 MHz	-1.5 dB	150 W	-2.6	-2.7	-2.9	-3.1
250 kHz	-1.5 dB	150 W	-2.8	-3.1	-3.4	-3.7
150 kHz	-1.5 dB	150 W	-3.4	-3.8	-4.3	-4.6
100 kHz	-2.0 dB	150 W	-3.6	-4.5	-5.1	-5.5
75 kHz	-2.5 dB	130 W	-4.2	-5.1	-5.8	-6.2

Typical Transmitter Noise Suppression

73-54A-01-Series Systems
6.625” Diameter Quarterwave, Fo=124 MHz



73-54A-05-Series Systems
10” Diameter Quarterwave, Fo=124 MHz

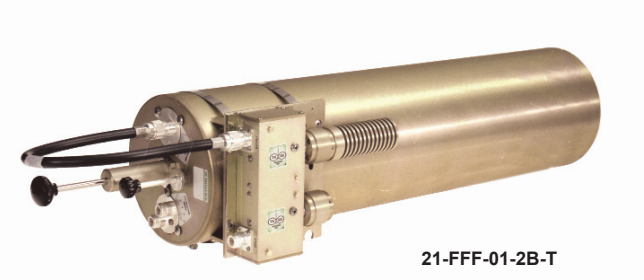


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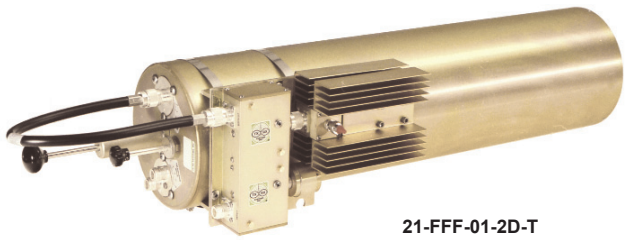
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e: sales@txrx.com **www.txrx.com**

TRANSMITTER COMBINERS

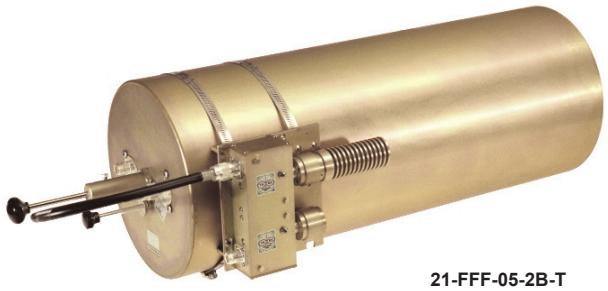
Expansion Channels



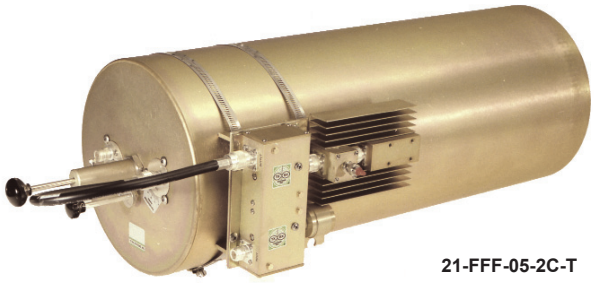
21-FFF-01-2B-T



21-FFF-01-2D-T



21-FFF-05-2B-T



21-FFF-05-2C-T

Expansion Channel Description

T-Pass® transmitter multicoupler expansion channel assemblies consist of the following items:

- A 6.625" or 10" quarterwave **T-Pass®** cavity filter;
- A dual ferrite isolator, with RF loads and coaxial cable for connection to the cavity;
- An RF sampler to measure RF power reflected into the isolator output load;
- Isolator and channel mounting hardware.

Expansion assemblies for channel 2 and higher are supplied with a thruline of the correct length for the new channel frequency. Starter channels (channel 1, bottom) are supplied with a short circuit on the T-Pass loop.

Ordering Information

To order an expansion channel, specify the following:

- frequency and position of all channels in the system to be expanded;
- New channel frequencies;
- Transmitter output power on all new channels.

T-Pass® Expansion Channel Guide

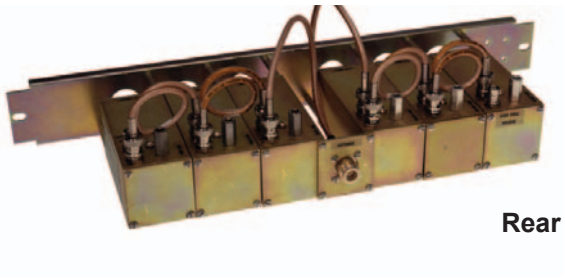
Tech-Aid No. 93002 (Lit. No. D3011F93) provides a listing of expansion channels by frequency range and isolator load power, as well as diagrams to facilitate selection of the correct channel configuration. Expansion channels are also available with 60-watt loads. Consult with factory.

T-Pass Multicoupler Model Number	Cavity Diameter	Isolator Power	Isolator Loads	Frequency Range (MHz)	Expansion Channel Model Number	Starter Channel Model Number
73-52-01-2B-Series	6.625"	150 W	5W/25W	220-250	21-52-01-2B-T	21-52-01-2B-TS
73-52-01-2D-Series	6.625"	150 W	5W/100W	220-250	21-52-01-2D-T	21-52-01-2D-TS
73-52-05-2B-Series	10"	150 W	5W/25W	220-250	21-52-05-2B-T	21-52-05-2B-TS
73-52-05-2D-Series	10"	150 W	5W/100W	220-250	21-52-05-2D-T	21-52-05-2D-TS
Contact factory on expansion channels for frequencies below 220 or above 250 MHz.						

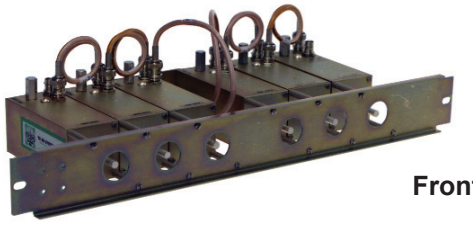
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28-37-02A



Rear



Front

30-36-01A 30-37-01A
30-36-02A 30-37-02A
30-36-03A 30-37-03A



28-36-11E
28-37-11E

- TX RX Systems offers a wide variety of Duplexer options to suit your application, including Vari-Notch®, Bandpass, and notch type circuits.
- Vari-Notch® design provides low loss and high isolation in a compact package.
- All high RF-current components silver-plated for highest performance.
- Various models to choose from to match your application.

Duplexers

A Duplexer (or diplexer as they are sometimes called) is a 3-port device most commonly used to allow a transmitter and receiver, operating on different frequencies, to share a common antenna while operating simultaneously. The filters that make up the duplexer isolate the transmitter from the receiver by doing two important functions - the most important is filtering out any transmitter noise sidebands that are being generated on the receive frequency. The second function is protecting the receiver from transmitter carrier overload. The amount of isolation necessary is dependent upon the TX to RX frequency spacing. As the frequencies get closer, a higher value of isolation is required.

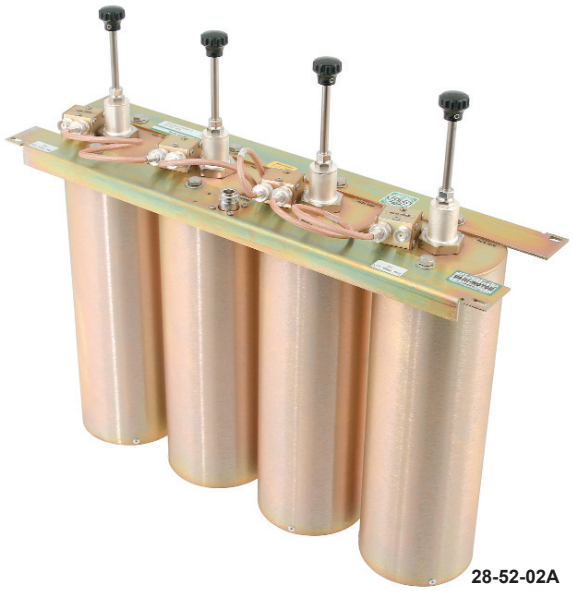
At high-band VHF, the TX RX Vari-Notch® design is the most commonly used. Vari-Notch® provides a low-loss pseudo-bandpass characteristic that can exist very close to a deep notch. Proven low-loss and low-noise construction techniques are used such as welded cavity construction; silver- plated loops, Alballoy®- plated integrated loop plates and connectors; as well as a unique fingerstock-free high-conductivity silver- plated tuning probe. Our 4" and 6.625" diameter cavities are constructed of hardened aluminum which, unlike most copper cavities, resists denting and associated detuning.

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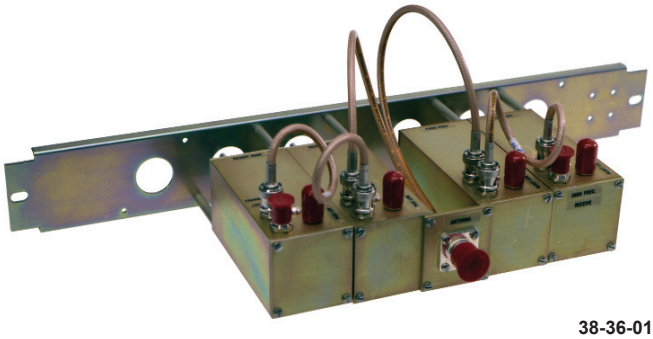
TX RX Systems Inc.
8625 Industrial Parkway, Angola, NY 14006
tel: 716.549.4700 fax: 716.549.4772
e: sales@txrx.com www.txrx.com

DUPLEXERS

Technical Specifications



28-52-02A



38-36-01A
38-37-01A

Electrical: Temperature Range: -30° to + 60° C
Impedance: 50 ohms
VSWR: 1.3:1 max.

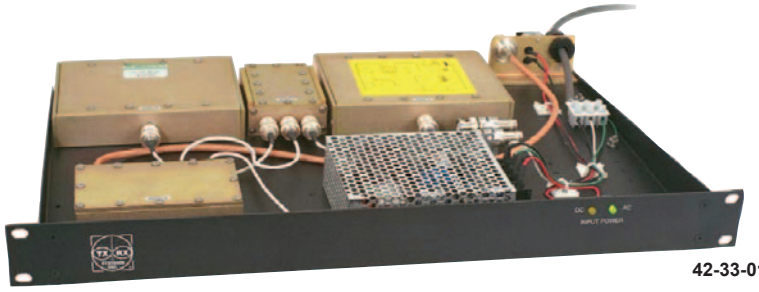
ELECTRICAL								MECHANICAL					
Frequency Range (MHz)	Model Number	Minimum Freq. Separation (MHz)	Power Rating (W)	Isolation (dB)*	Insertion Loss (dB)*	No. of Cavities	Cavity Size	H (in)	W (in)	D (in)	Tx & Rx Port Connectors	Antenna Connectors	Shipping Weight (lbs)
	38-36-01A	4.5	100	70	0.9	4	2" SQ.	5.25	19	7.25	BNC	N	10
Tx High	30-36-01A	3.0	100	100	1.4/1.5	6	2" SQ.	5.25	19	7.25	BNC	N	14
Tx Low	30-36-02A	3.0	100	100	1.4/1.5	6	2" SQ.	5.25	19	7.25	BNC	N	14
132-150	74-36-02A	3.0	400	57	1.35	4	6.625" DIA.	33	19	±7.5	N	N	50
Tx High	30-36-03A	1.5	100	80/90	1.4/2.2	6	2" SQ.	5.25	19	7.25	BNC	N	14
Tx Low	30-36-04A	1.5	100	80/90	1.4/2.2	6	2" SQ.	5.25	19	7.25	BNC	N	14
	28-36-02A	0.5	400	85	1.5	4	6.625" DIA.	33	19	±7.5	N	N	50
	28-36-11E	0.3	400	100	2.2	6	6.625" DIA.	33	24	±7.5	N	N	75
	38-37-01A	4.5	100	70	0.9	4	2" SQ.	5.25	19	7.25	BNC	N	10
Tx High	30-37-01A	3.0	100	100	1.4/1.5	6	2" SQ.	5.25	19	7.25	BNC	N	14
Tx Low	30-37-02A	3.0	100	100	1.4/1.5	6	2" SQ.	5.25	19	7.25	BNC	N	14
	28-37-07A	3.0	400	85	0.7	4	4" DIA.	5.25	19	+4.5/-15.5	N	N	22
	28-37-07C	3.0	400	85	0.7	4	4" DIA.	9.5	19	10.50	N	N	24
144-174	74-37-02A	3.0	400	57	1.35	4	6.625" DIA.	33	19	±7.5	N	N	50
Tx High	30-37-03A	1.5	100	80/90	1.4/2.2	6	2" SQ.	5.25	19	7.25	BNC	N	14
Tx Low	30-37-04A	1.5	100	80/90	1.4/2.2	6	2" SQ.	5.25	19	7.25	BNC	N	14
	28-37-06A	1.0	125	75	1.2	4	4" DIA.	5.25	19	+4.5/-15.5	N	N	22
	28-37-06C	1.0	125	75	1.2	4	4" DIA.	9.5	19	10.5	N	N	24
	28-37-04A	0.5	125	65	1.8	4	4" DIA.	5.25	19	+4.5/-15.5	N	N	22
	28-37-04C	0.5	125	65	1.8	4	4" DIA.	9.5	19	10.5	N	N	24
	28-37-02A	0.5	400	85	1.5	4	6.625" DIA.	33	19	±7.5	N	N	50
	28-37-11E	0.3	400	100	2.2	6	6.625" DIA.	33	24	±7.5	N	N	75
215-250	28-52-02A	1.6	250	90	1.2	4	4" DIA.	5.25	19	+3/-15	N	N	19

*Specifications for duplexers of unsymmetrical construction or response are listed as follows:
Isolation: Noise Suppression/Carrier Suppression
Insertion Loss: Tx Loss/Rx Loss

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RECEIVER MULTICOUPLERS

118-174 MHz



42-33-01

- Space-saving 19", 1 RU rack-mount design.
- TX RX-designed and manufactured high-performance LNA.
- Auto-Ranging AC and DC power:
  - 85 - 264 VAC 50/60 Hz
  - 12 - 24 VDC

Compact Receiver Multicouplers

TX RX's new generation of broadband receiver multicouplers provide unequalled performance in a 1-rack unit (1-3/4 inch) space-saving package. The high-performance LNA's exhibit a very low noise figure while providing a (100% measured) 3rd order output intercept point in excess of +40 dBm. The multicouplers are designed with a minimum excess gain of 10 dB which gives maximum sensitivity in rural applications. All the units are designed for ease of expansion, with no change in system gain in most cases. Three basic models cover the most popular applications from 118 - 901 MHz.

Consult our comprehensive RF component and accessories catalog for receiver multicoupler systems components such as LNA's and power dividers for special needs you may have.

All TX RX Receiver multicouplers are easily expandable by either adding additional power dividers to the existing chassis or by addition of a 1-rack unit deck. The 16-channel BNC models have 2 terminated BNC connectors for non-invasive expansion of up to 16 additional outputs in 8-output blocks, with no change in performance or specifications. All necessary cables with attached connectors are included in each kit.

MODEL NUMBER	NUMBER OF CHANNELS	BANDWIDTH	SYSTEM GAIN (MAX)*	PREAMP NOISE FIGURE	PREAMP 3RD ORDER OUTPUT INTERCEPT POINT	POWER REQUIREMENT	DC BACKUP	CONNECTORS (IN/OUT)	DIMENSIONS	TEMP RANGE
42-33-01-04N	4	118-174 MHz	12 dB	2.0 dB	+41 dBm	85-264 VAC, 47-63 Hz	12-26 V	N / N	1.75"H x 19"W x 14"D	0 - 50 C
42-33-01-08N	8	118-174 MHz	15 dB	2.0 dB	+41 dBm	85-264 VAC, 47-63 Hz	12-26 V	N / N	1.75"H x 19"W x 14"D	0 - 50 C
42-33-01-12N	12	118-174 MHz	15 dB	2.0 dB	+41 dBm	85-264 VAC, 47-63 Hz	12-26 V	N / N	1.75"H x 19"W x 14"D	0 - 50 C
42-33-01-08	8	118-174 MHz	13 dB	2.0 dB	+41 dBm	85-264 VAC, 47-63 Hz	12-26 V	N /BNC	1.75"H x 19"W x 14"D	0 - 50 C
42-33-01	16	118-174 MHz	12 dB	2.0 dB	+41 dBm	85-264 VAC, 47-63 Hz	12-26 V	N /BNC	1.75"H x 19"W x 14"D	0 - 50 C

***Attenuator pads are provided to reduce system gain for performance optimization**

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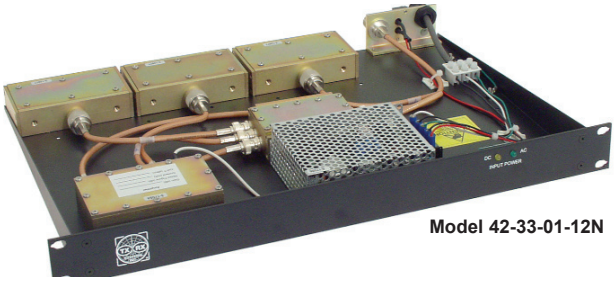
TX RX Systems Inc.
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tel: 716.549.4700 fax: 716.549.4772
e: sales@txrx.com **www.txrx.com**

RECEIVER MULTICOUPLERS

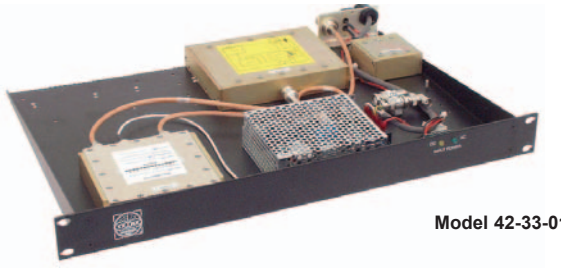
Expansion Kits

Second Generation Receiver Multicoupler Expansion Kits

TX RX Systems Inc. line of Compact Receiver Multicoupler products are easily expanded via the following system expansion kits. This second generation of products can be recognized by the form factor exhibited in the photos below.



Model 42-33-01-12N

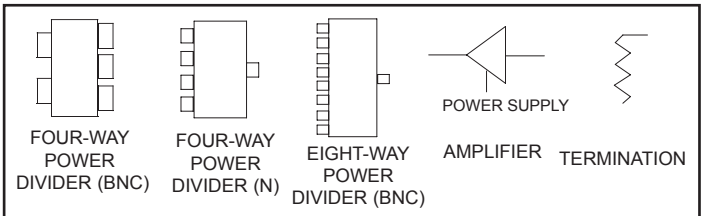


Model 42-33-01-08

EXPANSION KIT MODELS

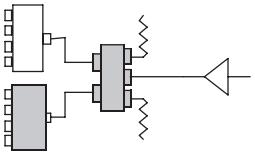
Frequency (MHz)	Model No.	Expansion		Shipping Weight (lbs)	Figure No.
		From	To		
100-512	75-01-14	4	8	3	1
100-512	75-01-15	8	12	3	2
100-512	75-01-16	12	16	3	3
100-512	75-05-02	8	16	3	4
100-512	75-05-01	16	32	7	5

SYMBOL KEY



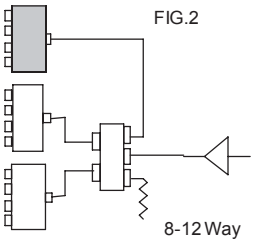
SHADED COMPONENTS INCLUDED WITH KIT

FIG.1



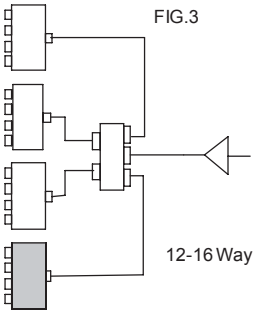
4-8 Way

FIG.2



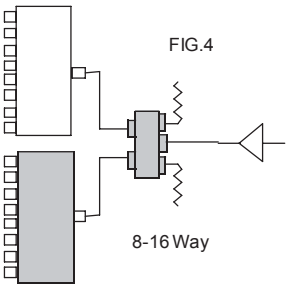
8-12 Way

FIG.3



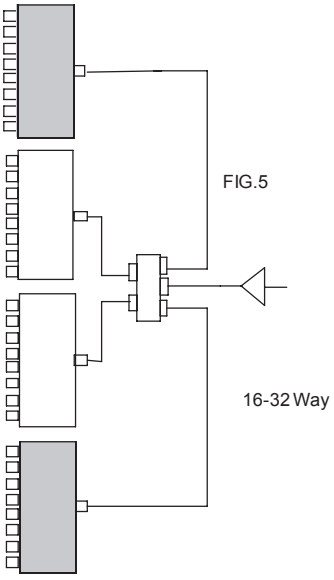
12-16 Way

FIG.4



8-16 Way

FIG.5



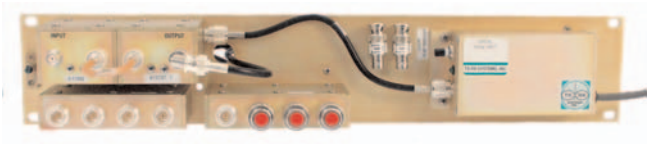
16-32 Way

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Legacy Models - Receiver Multicoupler Expansion Kits

TX RX Systems Inc. continues to support its first generation of Receiver Multicoupler products with system expansion kits. These models employ single and dual stage preamplifiers with two and four channel power dividers in pyramid interconnection systems allowing us to support expansion from four to sixty-four channel capacity in four-channel increments.

The first generation of products can be recognized by the form factor exhibited in the photo below.

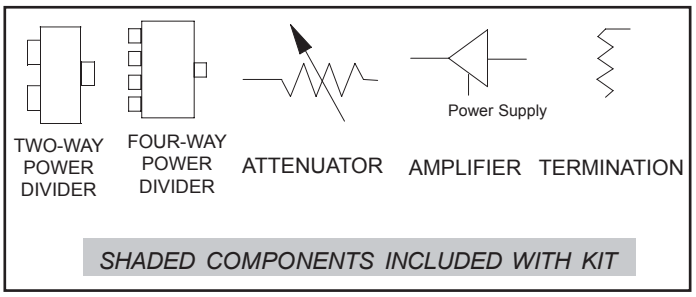


Model 42-38-22

EXPANSION KIT MODELS

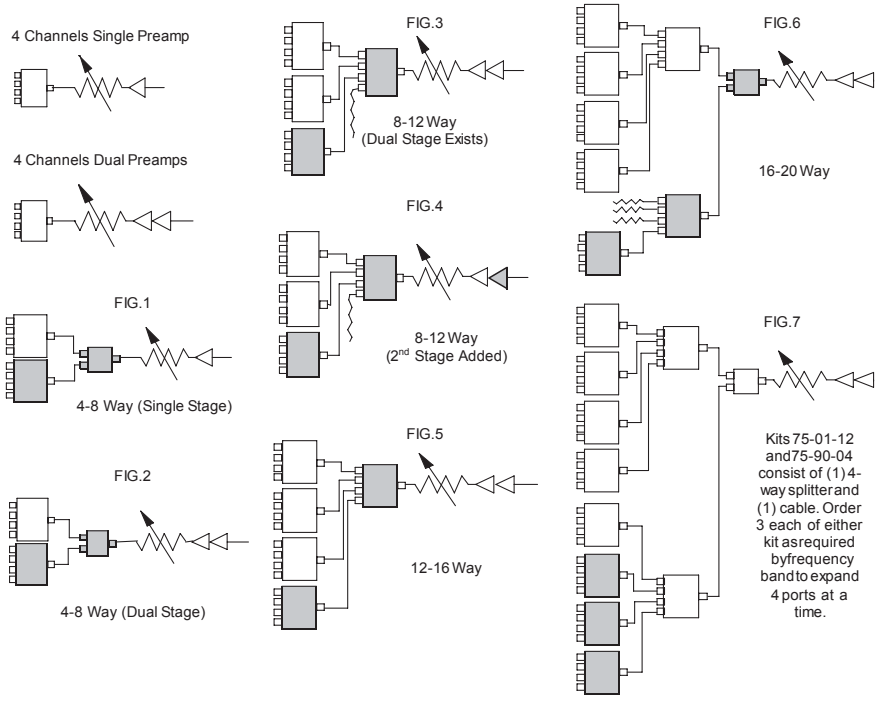
Frequency (MHz)	Model No.	Expansion From	Expansion To	Shipping Weight (lbs)	Figure No.
132-512	75-01-10	4	8	3	1 or 2
132-512	75-01-11	8	12	5	3
132-512	75-01-12	12	16	3	5
132-512	75-01-13	16	20	6	6
132-512	75-01-12	20-28	+4	3	7
406-512	75-67-01*	8	12	5	4
800-1000	75-90-01	4	8	3	1 or 2
800-1000	75-90-02*	8	12	6	4
800-1000	75-90-03	8	12	5	3
800-1000	75-90-04	12	16	3	5
800-1000	75-90-05	16	20	6	6
800-1000	75-90-04	20-28	+4	3	7

SYMBOL KEY



Range	Model No.	Tuned Sub-band
132-174	86-38-12-E	20 MHz
406-512	86-67-12-E	60 MHz
800-1000	86-85-11-E	800-900 or 900-1000 MHz

Notes: *Receiver multicouplers may be ordered with single stage or dual stage amplifiers. Expansion kit model number with asterisk indicates second preamplifier stage is included. As per table below, second stage preamplifiers may be ordered separately.



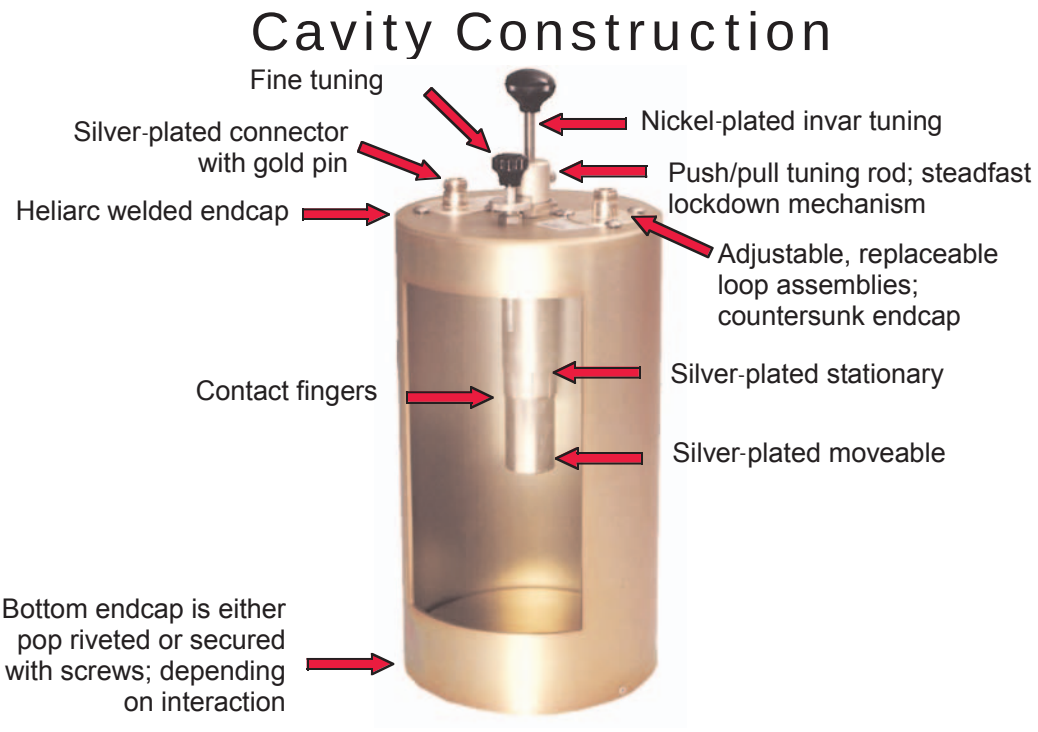
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Cavity Filters

Resonant cavity filters are the primary building blocks of VHF duplexers, multicouplers and preselectors. However, their use is not limited to these specific applications. Individual or cascaded cavities may be used for a variety of interference fighting chores, such as cleaning up the performance of existing filter systems that have inadequate isolation or off-channel interference rejection. At crowded antenna sites, cavity filters are ideal for quieting noisy transmitters or for preventing transmitter IM mixing. Receiver front-end selectivity can be greatly enhanced by the use of additional filtering, thus eliminating many desensitization, IM, and overload problems.

When used in conjunction with a spectrum analyzer or service monitor, cavity filters can allow a detailed analysis of lower-level transmitter noise. This lower-level noise is one of the major sources of interference at multi-transmitter sites. Cavity filters can stand alone as pieces of test equipment for analyzing many receiver IM problems and can also help determine the best type of filter to use for a permanent fix.

TX RX has designed and manufactures 4 primary types of cavity filters: Bandpass, T-Pass®, Vari-Notch® and Series-Notch®. Each uses a specific type of loop assembly which provides the desired characteristic. The Vari-Notch® and Series-Notch® filters use one loop assembly per cavity and incorporates a tuning capacitor. The Bandpass and T-Pass® designs utilize 2 loop assemblies per cavity.



- Silver plated connectors with gold pins reduce the risk of intermod; especially at higher frequencies
- Silver plated probes insure conductivity even if corrosion occurs
- Nickel plated invar has high temperature coefficient and resists rust.
- Push/pull tuning (not threaded) mechanism stays on frequency when locked down.
- Temperature compensation stem keeps cavity on frequency
- Slotted probe fingers insure excellent contact between stationary and moveable probes
- Heliarc welded end cap = one piece construction which maximizes 'Q'
- Field adjustable loops allow changes in selectivity as well as circuit style
- Fine tuning rod provides an easy way to optimize tuning

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- Various Low-Loss High-Rejection Models to Choose From.
- All Loop Plate/connector assemblies are silver- or Alballoy®-plated for low IM.
- Welded cavity construction and silver-plated tunable probe and loops give superior pass and reject characteristics.

BANDPASS





The Bandpass cavity passes one narrow band of frequencies and attenuates all others with increasing attenuation above and below the pass frequency. It is equivalent to a parallel-tuned circuit and is most often used for general transmitter spurious clean-up or a sharpening of a single receiver front end selectivity with or without amplification. TX RX bandpass cavities (4", 6", and 10") have adjustable selectivity characteristics (rotatable loops) to allow a trade-off between insertion loss (0.5--3.0 dB) and selectivity. Maximum power handling is generally determined by insertion loss setting.

T-PASS®





T-Pass® is a variation of the Bandpass cavity used for our expandable multicoupler applications. Its general characteristics are nearly identical to a bandpass cavity but the output loop has a pair of N-connectors so it can easily be coupled to other channels.

SERIES NOTCH®





The Series-Notch® passes a relatively wide band of frequencies while rejecting a very narrow band of frequencies. It is equivalent to a series-tuned circuit. Notch depth is variable from 15 - 25 dB. Both pass and notch frequencies must be known so that the optimum loop assembly can be used. This is the best filter for very close separations (70 KHz to 200 KHz) in VHF applications.

VARI-NOTCH®





The Vari-Notch® design passes a relatively narrow band of frequencies and rejects (notches out) a relatively wide frequency band. Equivalent to a combination series-tuned and parallel-tuned circuit, this filter has a greater notch depth than the Series-Notch® design. The notch depth is adjustable but varies with passband insertion loss (0.3dB or 0.6dB typical) and the difference between pass and notch frequencies. Vari-Notch® is ideal for moderately close to wide separations (200 KHz and greater) in VHF applications.

CASCADING FILTERS

All cavity types mentioned above may be cascaded to achieve an arithmetic sum of individual filter attenuation. Up to 6 dB of additional attenuation can be achieved if the proper length of cable is used to interconnect the cavities. (This additional 6 dB does not occur in the filter passband but only at frequencies where moderate to high attenuation occurs.) A TX RX system specialist can assist you in ordering the proper length of interconnecting cable for your frequencies.

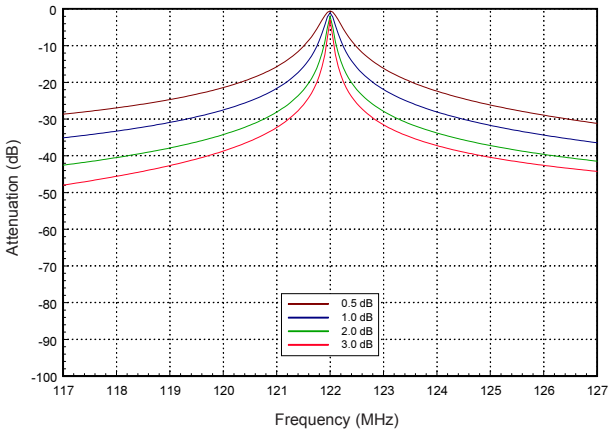
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e: sales@txrx.com **www.txrx.com**

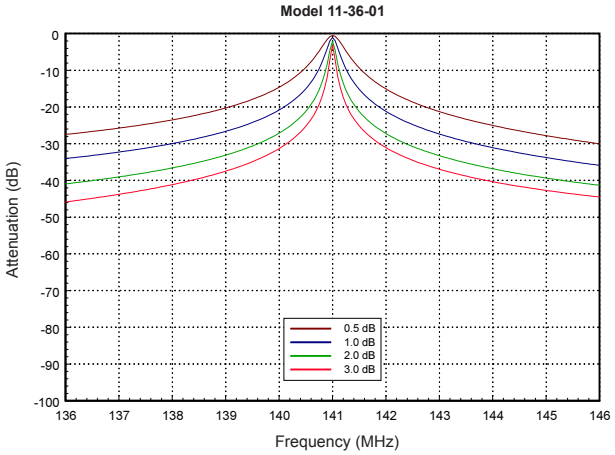
CAVITY FILTERS

Bandpass

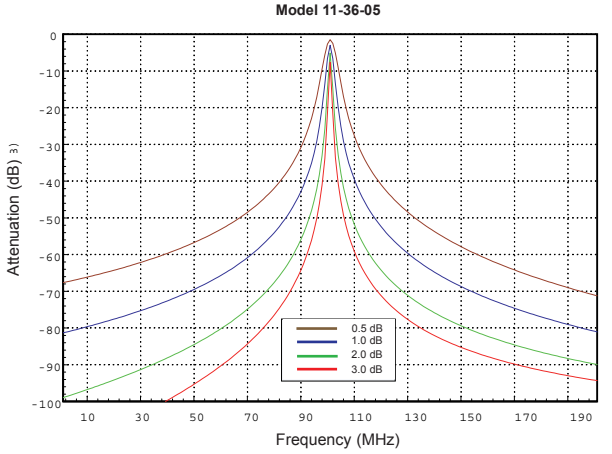
Model 11-35-01



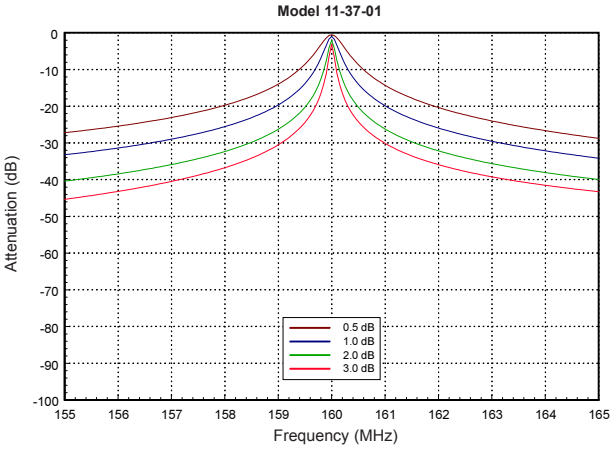
Model 11-36-01



Model 11-36-05



Model 11-37-01

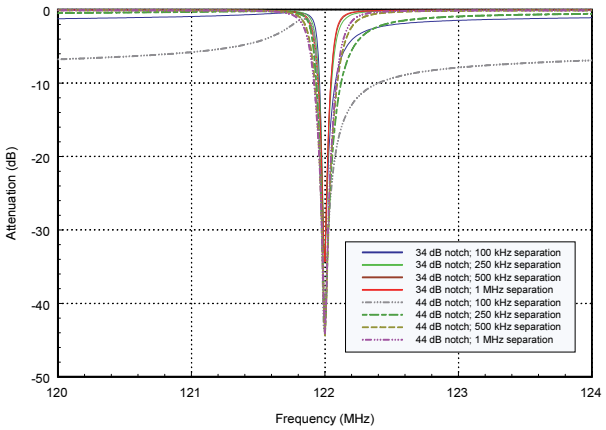


Model Number	11-35-01	11-35-02	11-35-05	11-35-06	11-36-01	11-36-02
Frequency Range (MHz)	108-136	108-136	108-136	108-136	132-150	132-150
Max. pwr., per cavity, @ 0.5 dB IL	270 Watts	270 Watts	270 Watts	270 Watts	270 Watts	270 Watts
Max. pwr., per cavity, @ 0.3 dB IL	60 Watts	60 Watts	60 Watts	60 Watts	60 Watts	60 Watts
Impedance	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms
VSWR	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.
Cavity Length (electrical)	1/4 λ	1/4 λ	1/4 λ	1/4 λ	1/4 λ	1/4 λ
Temperature Range, ° C	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60
Cavity Size, diameter (inches)	6.625	6.625	10	10	6.625	6.625
Number of Cavities	1	2	1	2	1	2
Connectors	N	N	N	N	N	N
Dimensions, HxWxD (inches)	31.5 x 6.625 x 6.625	31.5 x 6.625 x 6.625	33.5 x 10 x 10	33.5 x 10 x 10	26 x 6.625 x 6.625	26 x 6.625 x 6.625
Shipping Weight, lbs.	20	42	27	56	15	30

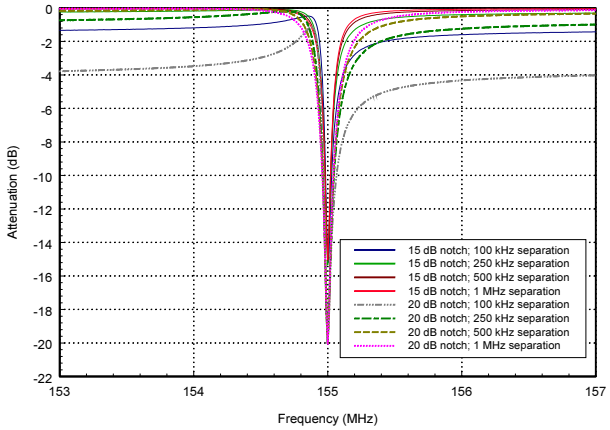
Model Number	11-36-05	11-36-06	11-37-01	11-37-02	11-37-05	11-37-06	11-37-09
Frequency Range (MHz)	132-150	132-150	144-174	144-174	144-174	144-174	144-174
Max. pwr., per cavity, @ 0.5 dB IL	270 Watts	270 Watts	270 Watts	270 Watts	270 Watts	270 Watts	100 Watts
Max. pwr., per cavity, @ 0.3 dB IL	60 Watts	60 Watts	60 Watts	60 Watts	60 Watts	60 Watts	N/A
Impedance	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms
VSWR	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.	1.25:1 max.
Cavity Length (electrical)	1/4 λ	1/4 λ	1/4 λ	1/4 λ	1/4 λ	1/4 λ	1/4 λ
Temperature Range, ° C	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60	-30 to + 60
Cavity Size, diameter (inches)	10	10	6.625	6.625	10	10	4
Number of Cavities	1	2	1	2	1	2	1
Connectors	N	N	N	N	N	N	N
Dimensions, HxWxD (inches)	26 x 10 x 10	26 x 10 x 10	26 x 6.625 x 6.625	26 x 6.625 x 6.625	26 x 10 x 10	26 x 10 x 10	15 x 4 x 4
Shipping Weight, lbs.	21	44	15	30	21	44	5

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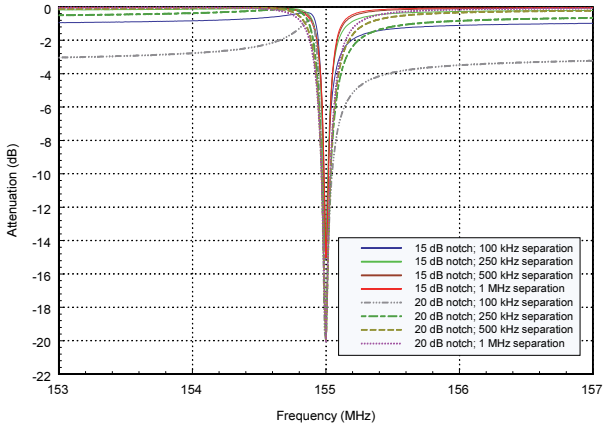
Model 20-35-02



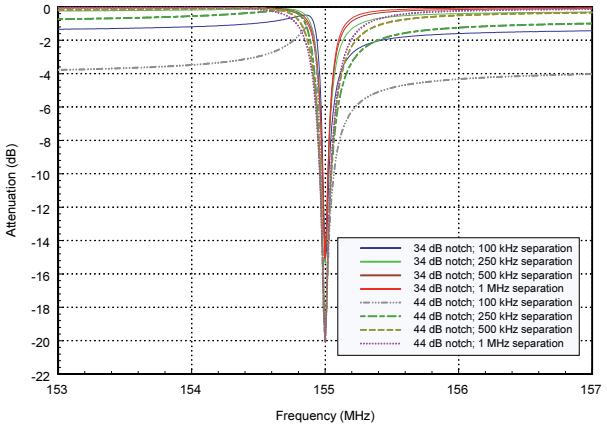
Model 20-37-01



Model 20-37-05



Model 20-37-06



Model Number	20-35-01				20-36-01				20-37-01				20-37-05				
Frequency Range (MHz)	108-136				132-150				144-174				144-174				
Insertion Loss vs. Frequency Separations	100 kHz	250 kHz	500 kHz	1 MHz	100 kHz	250 kHz	500 kHz	1 MHz	100 kHz	250 kHz	500 kHz	1 MHz	50 kHz	100 kHz	250 kHz	500 kHz	1 MHz
with single cavity, notch depth @ 15 dB	<1.0 dB	<0.2 dB	<0.2 dB	<0.2 dB	<1.0 dB	<0.2 dB	<0.2 dB	<0.2 dB	<1.0 dB	<0.2 dB	<0.2 dB	<0.2 dB	<2.0 dB	-	<0.2 dB	<0.2 dB	<0.2 dB
with single cavity, notch depth @ 20 dB	<1.5 dB	<0.3 dB	<0.2 dB	<0.2 dB	<1.5 dB	<0.3 dB	<0.2 dB	<0.2 dB	<1.8 dB	<0.3 dB	<0.2 dB	<0.2 dB	-	<1.0 dB	<0.2 dB	<0.2 dB	<0.2 dB
Impedance	50 ohms				50 ohms				50 ohms				50 ohms				
VSWR	1.5:1 max.				1.5:1 max.				1.5:1 max.				1.5:1 max.				
Max. Pwr. (Watts) @ stated separation	60	250	350	350	60	250	350	350	60	250	350	350	80	150	350	350	350
Cavity Length (electrical)	1/4 λ				1/4 λ				1/4 λ				1/4 λ				
Temperature Range, ° C	-30 to +60				-30 to +60				-30 to +60				-30 to +60				
Cavity Size, diameter (inches)	6.625				6.625				6.625				10				
Number of Cavities	1				1				1				1				
Cavity Height (inches)	31.5; w/tuning rod extended, 43 max.				26, w/tuning rod extended, 38 max.				26, w/tuning rod extended, 38 max.				26, w/tuning rod extended, 38 max.				
Width (inches)	6.625				6.625				6.625				10				
Depth (inches)	6.625				6.625				6.625				10				
Connectors	N				N				N				N				
Weight, lbs.	18				17				17				22				

Model Number	20-35-02				20-36-02				20-37-02				20-37-06				
Frequency Range (MHz)	108-136				132-150				144-174				144-174				
Insertion Loss vs. Frequency Separations	100 kHz	250 kHz	500 kHz	1 MHz	100 kHz	250 kHz	500 kHz	1 MHz	100 kHz	250 kHz	500 kHz	1 MHz	50 kHz	100 kHz	250 kHz	500 kHz	1 MHz
with dual cavity, notch depth @ 34 dB	<2.0 dB	<0.6 dB	<0.5 dB	<0.4 dB	<2.0 dB	<0.6 dB	<0.5 dB	<0.4 dB	<2.0 dB	<0.6 dB	<0.5 dB	<0.4 dB	<3.5 dB	-	<0.5 dB	<0.5 dB	<0.4 dB
with dual cavity, notch depth @ 44 dB	<3.0 dB	<0.8 dB	<0.5 dB	<0.4 dB	<3.0 dB	<0.8 dB	<0.5 dB	<0.4 dB	<3.6 dB	<0.8 dB	<0.5 dB	<0.4 dB	-	<2.0 dB	<0.6 dB	<0.5 dB	<0.4 dB
Impedance	50 ohms				50 ohms				50 ohms				50 ohms				
VSWR	1.5:1 max.				1.5:1 max.				1.5:1 max.				1.5:1 max.				
Max. Pwr. (Watts) @ stated separation	60	250	350	350	60	250	350	350	60	250	350	350	80	150	350	350	350
Cavity Length (electrical)	1/4 λ				1/4 λ				1/4 λ				1/4 λ				
Temperature Range, ° C	-30 to +60				-30 to +60				-30 to +60				-30 to +60				
Cavity Size, diameter (inches)	6.625				6.625				6.625				10				
Number of Cavities	2				2				2				2				
Cavity Height (inches)	31.5; w/tuning rod extended, 43 max.				26, w/tuning rod extended, 38 max.				26, w/tuning rod extended, 38 max.				26, w/tuning rod extended, 38 max.				
Width (inches)	6.625				6.625				6.625				10				
Depth (inches)	6.625				6.625				6.625				10				
Connectors	N				N				N				N				
Weight, lbs.	36				34				34				45				

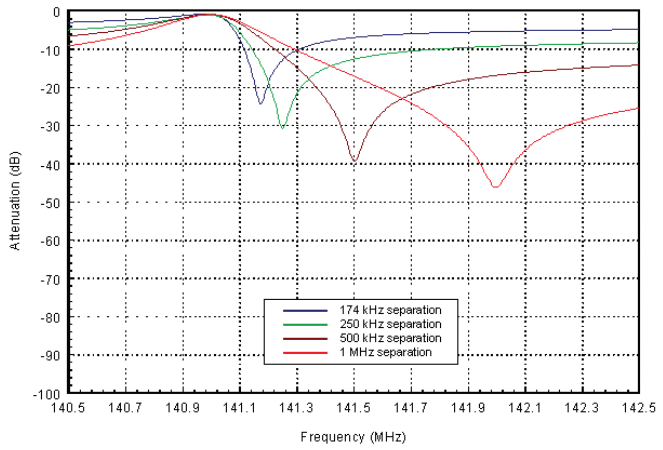
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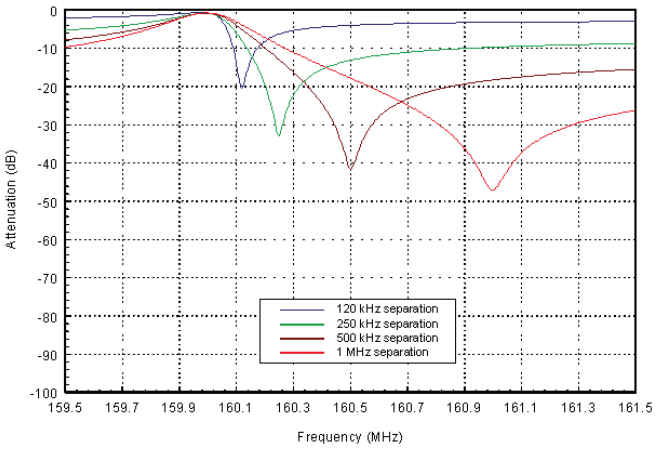
CAVITY FILTERS

Vari-Notch

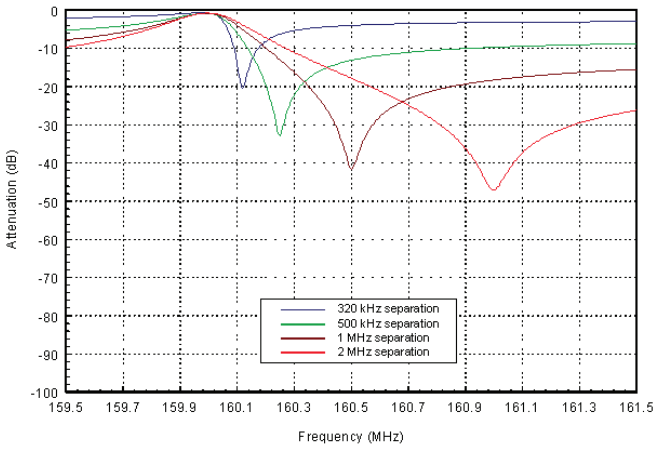
Model 15-36-01



Model 15-37-05



Model 15-37-09

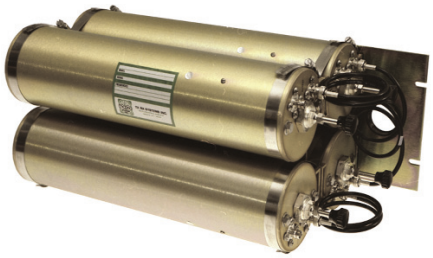


Model Number	15-35-01				15-35-05				15-36-01			
Frequency Range (MHz)	108-136				108-136				132-150			
Minimum Separation (Pass-to-Notch):	174 kHz				130 kHz				140 kHz			
Frequency Separation	174 kHz	250 kHz	500 kHz	1 MHz	130 kHz	250 kHz	500 kHz	1 MHz	140 kHz	250 kHz	500 kHz	1 MHz
Attenuation vs. Pass-to-Notch	24 dB	30 dB	39 dB	46 dB	24 dB	34 dB	43 dB	47 dB	19 dB	27 dB	37 dB	45 dB
Power Rating	300 Watts				300 Watts				300 Watts			
Impedance	50 ohms				50 ohms				50 ohms			
VSWR	1.25:1 max.				1.25:1 max.				1.25:1 max.			
Cavity Length (electrical):	1/4 λ				1/4 λ				1/4 λ			
Temperature Range, ° C	-30 to +60				-30 to +60				-30 to +60			
Cavity Size, (diameter) inches	6.625				10				6.625			
Number of Cavities	1				1				1			
Connectors	N				N				N			
Cavity Height (inches)	31.5, w/tuning rod extended, 44 max.				33.5, w/tuning rod extended, 48 max.				26, w/tuning rod extended, 38 max.			
Width (inches)	6.625				10				6.625			
Depth (inches)	6.625				10				6.625			
Shipping Weight, lbs.	20				27				17			

Model Number	15-36-05				15-37-01				15-37-05				15-37-09			
Frequency Range (MHz)	132-150				144-174				144-174				144-174			
Minimum Separation (Pass-to-Notch):	100 kHz				170 kHz				120 kHz				320 kHz			
Frequency Separation	100 kHz	250 kHz	500 kHz	1 MHz	170 kHz	250 kHz	500 kHz	1 MHz	120 kHz	250 kHz	500 kHz	1 MHz	320 kHz	500 kHz	1 MHz	2 MHz
Attenuation vs. Pass-to-Notch	19 dB	33 dB	42 dB	47 dB	22 dB	27 dB	37 dB	45 dB	20 dB	32 dB	41 dB	47 dB	18 dB	24 dB	35 dB	44 dB
Power Rating	300 Watts				300 Watts				300 Watts				150 Watts			
Impedance	50 ohms				50 ohms				50 ohms				50 ohms			
VSWR	1.25:1 max.				1.25:1 max.				1.25:1 max.				1.25:1 max.			
Cavity Length (electrical):	1/4 λ				1/4 λ				1/4 λ				1/4 λ Low Pass			
Temperature Range, ° C	-30 to +60				-30 to +60				-30 to +60				-30 to +60			
Cavity Size, (diameter) inches	10				6.625				10				4			
Number of Cavities	1				1				1				1			
Connectors	N				N				N				N			
Cavity Height (inches)	26, w/tuning rod extended, 38 max.				26, w/tuning rod extended, 38 max.				26, w/tuning rod extended, 38 max.				15, w/tuning rod extended, 20 max			
Width (inches)	10				6.625				10				4			
Depth (inches)	10				6.625				10				4			
Shipping Weight, lbs.	23				17				23				5			

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89-37-13A


89-37-06C


89-37-06A

- Several models available to match your specific application.
- All filters are factory tuned to meet specific frequency channel requirements.
- Temperature compensation keeps product tuned to specification from -30 to +60 C.

Preselectors/Post Filters

TX RX has designed application-specific multi-cavity filter products for use in limiting the bandwidth in front of a multiple-receiver system (Preselector) or after a multiple-transmitter system (Post Selector). Size and complexity range from a model built from three helically-loaded 1.3-inch rectangular resonators for relatively low-selectivity receive-only applications, where 2 dB of loss can be tolerated, to four 6.625-inch cavities that can handle 400 watts with high selectivity and loss of 1 dB or less. The most popular models are built from four 4-inch cavities, exhibit medium to high selectivity, depending upon the center frequency, and can handle 125 watts of power with 1.2 to 1.8 dB of loss.

The 4 and 6-inch cavity models can be ordered with pass bandwidths ranging from 0.5 to 2 MHz. The typical curves show how different bandwidths affect isolation and insertion loss. Generally, a narrower bandwidth results in a higher insertion loss and selectivity than a wider bandwidth.

Model Number	89-36-03A	89-37-01K	89-37-06A	89-37-06C	89-37-13A
Frequency Range (MHz)	132-150	144-174	144-174	144-174	144-174
No. of Cavities/Resonators	4 x 4"	3 x LC	4 x 4"	4 x 4"	4 x 6.625"
Pass Bandwidth (MHz)	0.5 to 2.0	4-10	0.5 to 2.0	0.5 to 2.0	0.5 to 2.0
Specification Bandwidth (MHz)	1.0	1.0	1.0	1.0	1.0
Insertion Loss (dB) @ F_o (MHz)	1.2 @ 140	1.5 @ 155	1.4 @ 160	1.4 @ 160	0.7 @ 160
Passband Insertion Loss (dB)	1.6	2.0	1.8	1.8	1.0
Typical Selectivity (dB @ MHz)	58 @ 135	30 @ 140	65 @ 155	65 @ 155	73 @ 155
Typical Selectivity (dB @ MHz)	78 @ 145	20 @ 170	78 @ 165	78 @ 165	76 @ 165
Return Loss, dB (VSWR)	20 (1.22:1)	14 (1.5:1)	20 (1.22:1)	20 (1.22:1)	20 (1.22:1)
RF Power (Watts)	125	Rx only	125	125	400
Temperature Range, °C	-30 to +60	-30 to +60	-30 to +60	-30 to +60	-30 to +60
Connectors, Antenna/Output	BNC	N / BNC	BNC	BNC	N / N
Dimensions, HxWxD (inches)	5.25x19x22	1.5x4.5x2.5	5.25x19x20	9.5x19x10.5	33x19x15
Dimensions, HxWxD (mm)	133x483x559	38x115x64	133x483x508	241x483x267	838x483x381
Mounting	19"**	Surface	19"**	19"^^	19"**
Shipping Weight, lb (kg)	21 (9.5)	3 (1.4)	19 (8.6)	23 (10.4)	50 (22.6)

*** EIA rack mount*

^^ Cross Mount

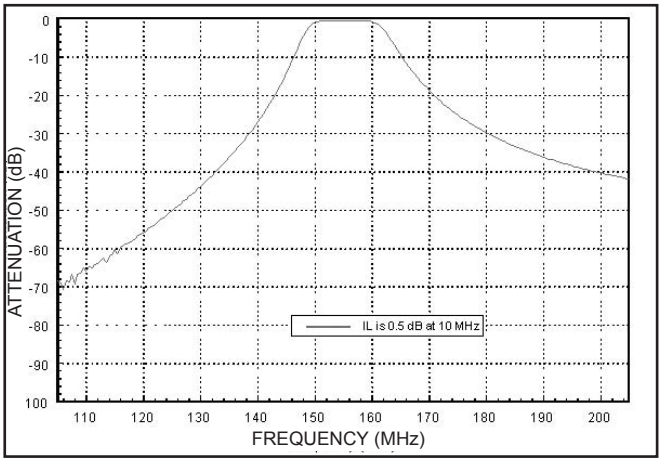
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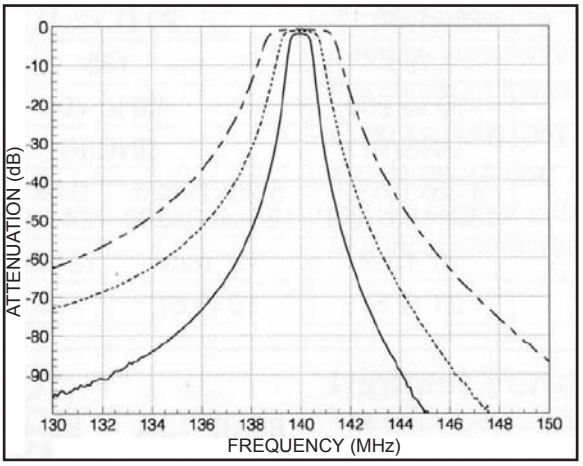
PRESELECTORS

Typical Curves

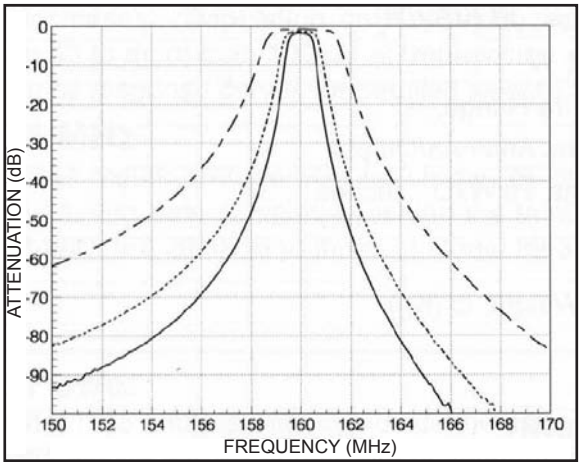
Models 89-37-01K



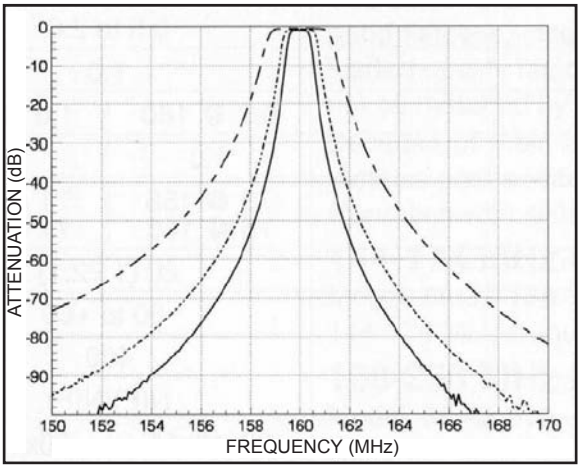
Models 89-36-03A (0.5, 1.0, 2.0 MHz BW)



Models 89-37-06A, -06C (0.5, 1.0, 2.0 MHz BW)



Models 89-37-13A (0.5, 1.0, 2.0 MHz BW)



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81-FFF-15-20



81-FFF-25-100T



81-FFF-25-50



81-FFF-25-60T

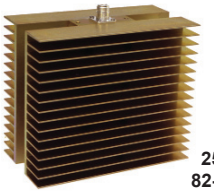
- Provides rated isolation at rated continuous power.
- Standard isolator loads rated to protect against antenna system failure.
- Most versions include a reverse-power RF probe for combiner cavity fine-tuning.

ISOLATORS

A ferrite isolator is actually a specific application of a ferrite circulator with a 50-ohm load or termination included on one port. If we label the circulator's ports Input, Output and Load and connect a transmitter to Input, the transmitter power will appear at the Output port (minus the insertion loss of the device.) This output is connected to a load, such as a cavity combining system or antenna. Any power coming back from that load, such as reflected power from a mismatched antenna or residual power from an adjacent transmitter channel in the combiner or coupled from another antenna enters the output port and over 99% of it is routed to the Load port. Less than 1% of the reflected power appears back at the Input port. Thus the transmitter is isolated from the load by at least 25 dB per isolator (or isolator junction if there is more than one in a particular model.) Most multicoupler systems are designed with dual-junction isolators (two single junctions in tandem) which allow less than .01% of any power appearing at the output junction to find its way back to the transmitter.

Isolators perform two important functions. Their primary function is to keep other RF frequencies out of the transmitter so that intermodulation products cannot be generated. They also insure that the transmitter never sees any significant reflected power so it will always operate with maximum stability at full-power output.

TX RX isolators are designed to provide the specified isolation under continuous duty at maximum power. Their conservative, rugged design and construction have a record of excellent reliability and high performance established through over 20 years of service in critical systems.



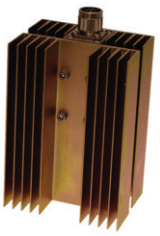
250 W
82-01-19
82-90-20



25 W
82-01-16



5 W
82-01-05



100 W
82-01-15

- Precision 50-ohm loads for all termination applications.
- High heatsink surface area for lower heatsink surface temperatures.
- >30 dB return loss up to 1000 MHz.

LOADS

TX RX natural convection, air-cooled dry RF loads are designed as precision, heavy-duty 50-ohm terminations for isolators and specialized hybrid combining applications operating up to 1000 MHz. These loads have power density factors (ratio of rated power to heatsink surface area) that are among the lowest in the industry which means lower heatsink surface temperatures for a particular power dissipation. They also have excellent return loss characteristics over their entire operating range, making them ideal for use in test as well as operational applications.

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Technical Specifications

118-300 MHz

Single-Junction Circulators and Isolators

Frequency	118-136	81-35A-15-00	81-35A-15-20	81-35A-15-50	81-35A-15-60	81-35A-15-100
Range (MHz)	132-150	81-36-15-00	81-36-15-20	81-36-15-50	81-36-15-60	81-36-15-100
	144-174	81-37-15-00	81-37-15-20	81-37-15-50	81-37-15-60	81-37-15-100
	220-250	81-52-15-00	81-52-15-20	81-52-15-50	81-52-15-60	81-52-15-100
Number of Junctions		1				
Junction Type		Lumped constant				
Max Continuous Input Power		81-35A-15-xx: 100 W; all others: 150 W				
RF Load Model Number		None	82-01-05	82-01-16	82-01-17	82-01-15
Continuous RF Load Power		None	5 W	25 W	60 W	100 W
Isolation Bandwidth		2.5% of center frequency				
Typical Insertion Loss		0.45 dB				
Max Insertion Loss		0.5 dB				
Peak Reverse Isolation		>30 dB				
Min Reverse Isolation		>25 dB				
Nominal Impedance		50 ohm				
Min Return Loss (VSWR)		20 dB (1:22: 1)				
Temperature Range		-30 to +60 Celsius				
Connectors, Input/Output/Load		N				
Dimensions, HxWxD, inches		3.94x3.75x1.78	5.0x3.75x1.78	8.81x3.75x1.78	9.91x3.9x1.78	9.91x3.9x2.9
Dimensions, HxWxD, mm		100x95x45	127x95x45	223x95x45	252x99x45	252x99x74
Weight, lb (Kg)		1.40 (0.64)	1.58 (0.72)	2.04 (0.93)	2.68 (1.21)	3.41 (1.54)

Dual-Junction Circulators and Isolators

Frequency	118-136	81-35A-25-00	81-35A-25-20	81-35A-25-50	81-35A-25-60	81-35A-25-100
Range (MHz)	132-150	81-36-25-00	81-36-25-20	81-36-25-50	81-36-25-60	81-36-25-100
	144-174	81-37-25-00	81-37-25-20	81-37-25-50	81-37-25-60	81-37-25-100
	220-250	81-52-25-00	81-52-25-20	81-52-25-50	81-52-25-60	81-52-25-100
Number of Junctions		2				
Junction Type		Lumped constant				
Max Continuous Input Power		81-35A-15-xx: 100 W; all others: 150 W				
RF Load Model Number		None	82-01-05	82-01-05	82-01-05	82-01-05
			82-01-05	82-01-16	82-01-17	82-01-15
Continuous RF Load Power		None	5/5 W	5/25 W	5/60 W	5/100 W
Isolation Bandwidth		2.5% of center frequency				
Typical Insertion Loss		0.9 dB				
Max Insertion Loss		1.1 dB				
Peak Reverse Isolation		>60 dB				
Min Reverse Isolation		>50 dB				
Nominal Impedance		50 ohm				
Min Return Loss (VSWR)		20 dB (1:22: 1)				
Temperature Range		-30 to +60 Celsius				
Connectors, Input/Output/Load		N				
Dimensions, HxWxD, inches		3.94x6.25x1.78	5.0x6.25x1.78	8.81x6.25x1.78	9.91x6.39x1.78	9.91x6.39x2.9
Dimensions, HxWxD, mm		100x159x45	127x159x45	223x159x45	252x162x45	252x162x74
Weight, lb (Kg)		2.60 (1.18)	2.78 (1.26)	3.24 (1.47)	3.88 (1.76)	4.60 (2.09)

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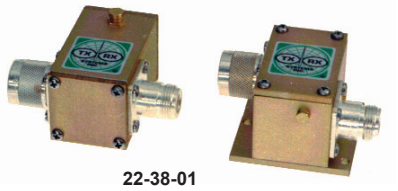
Technical Specifications

RF Loads

Technical Specifications	82-01-05	82-01-16	82-01-17	82-01-15	82-01-19
Frequency Range	5-960 MHz				
Load Type	Dry				
Cooling	Natural air convection				
Ambient Temperature, ° C	-30° to + 60° C				
Duty Cycle	Continuous				
Nominal Impedence, ohms	50				
Maximum RF Input Power, Watts	5	25	60	100	250
Resistor Element Rating, Watts	60	60	250	250	250
Heatsink Area, in² (cm²)	9.2 (59)	57 (368)	172.7 (1114)	334.7 (2159)	898.2 (5795)
Heatsink Power Density, Watts/in²	0.54	0.44	0.35	0.4	0.28
Connector Type	N(M)	N(M)	N(M)	N(M)	N(F)
Typical Return Loos, dB (VSWR)	>30 (1.05:1)				
Dimensions, HxWxD (or LxDiameter), in (mm)	1.31Hx1.50Ø (33x38)	5.06Lx1.50Ø (129x38)	6.3x3.9x1.6 (160x99x41)	6.3x3.9x2.9 (160x99x74)	7.4x8.00x4.3 (188x203x109)
Weight, lb (Kg)	0.18 (0.08)	0.64 (0.29)	1.28 (0.58)	2.00 (0.91)	7.52 (3.41)

SECOND HARMONIC FILTERS

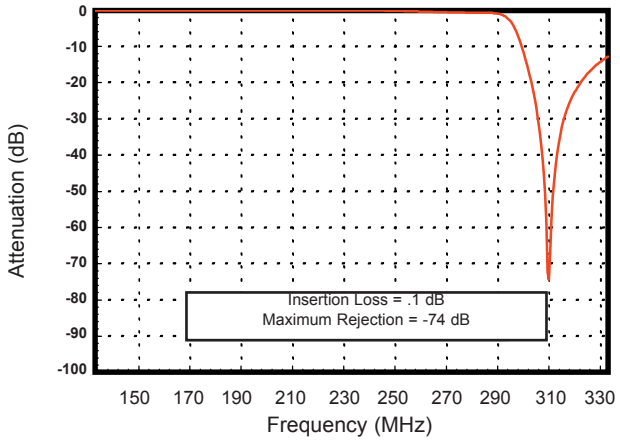
The ferrite used to make circulators is a non-linear material that generates a significant amount of 2nd harmonic power which can contribute to the formation of 3rd order intermodulation products when mixed with other transmitter carriers. For this reason, either a bandpass cavity filter or a harmonic filter must always be installed between an isolator and the antenna. TX RX manufactures single and dual-section filters for applications where bandpass cavities are not used.



22-38-01

- Installed between isolators and antenna when bandpass cavities are not used.
- Single and dual-section models for 30 or 60 dB attenuation.

Model 22-38-01



INTERMODULATION SUPPRESSION PANELS

TX RX manufactures an Intermodulation Suppression Panel which incorporates a single-junction isolator with a 100-watt load and a second harmonic filter on a 19" rack-mount shelf assembly. These are typically used to add an isolator to a transmitter or repeater connected to its own antenna. Although the unit itself is only 2 rack-units high (3.5"), care must be taken to budget enough space above the unit to provide adequate ventilation for the load's heatsink.

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CROSSBAND COUPLERS

VHF><UHF

For transmit or receive operations with optional DC pass-thru models for tower mount Rx systems



80-05-06



80-05-07

Crossband Couplers allow multiband operation of tower transmission lines, reducing cost and tower loading.

Tunable capacitors are replaced with large area transmission line structures for greater reliability.

Models are available for specialized transmit and receive applications. Cascading certain models will allow three frequency bands to use one transmission line. Complete response curves are available on request.

Tower mount models consist of the base station unit, less rack bar, in a weatherproof fiberglass housing which is sealed with silicone rubber adhesive.

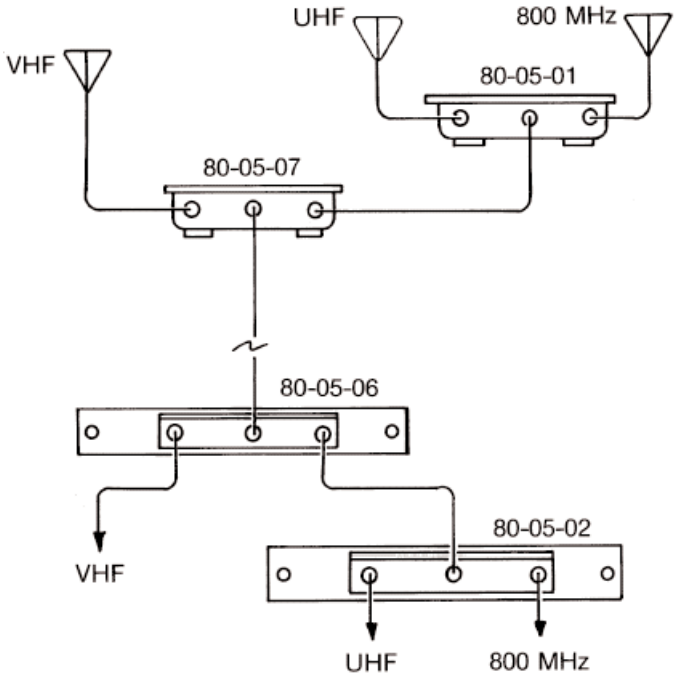
MODEL NUMBER		FREQUENCY BANDS COUPLED (MHz)	TYPICAL LOSS (dB)	ISOLATION (dB)	POWER RATING WATTS
WEATHERPROOF TOWER MOUNT	BASE STATION MOUNT				
80-05-07	80-05-06	25-175 MHz 406-960 MHz	0.25 0.25	40	350 350

COMMON SPECIFICATIONS

Temperature Range ..... -40º to +70ºC
VSWR (50 ohm ref.) 1.25:1
Connectors ..... 'N' female

Dimensions ..... WEATHERPROOF MODELS H 3.5" x W 6" x L 13.75"

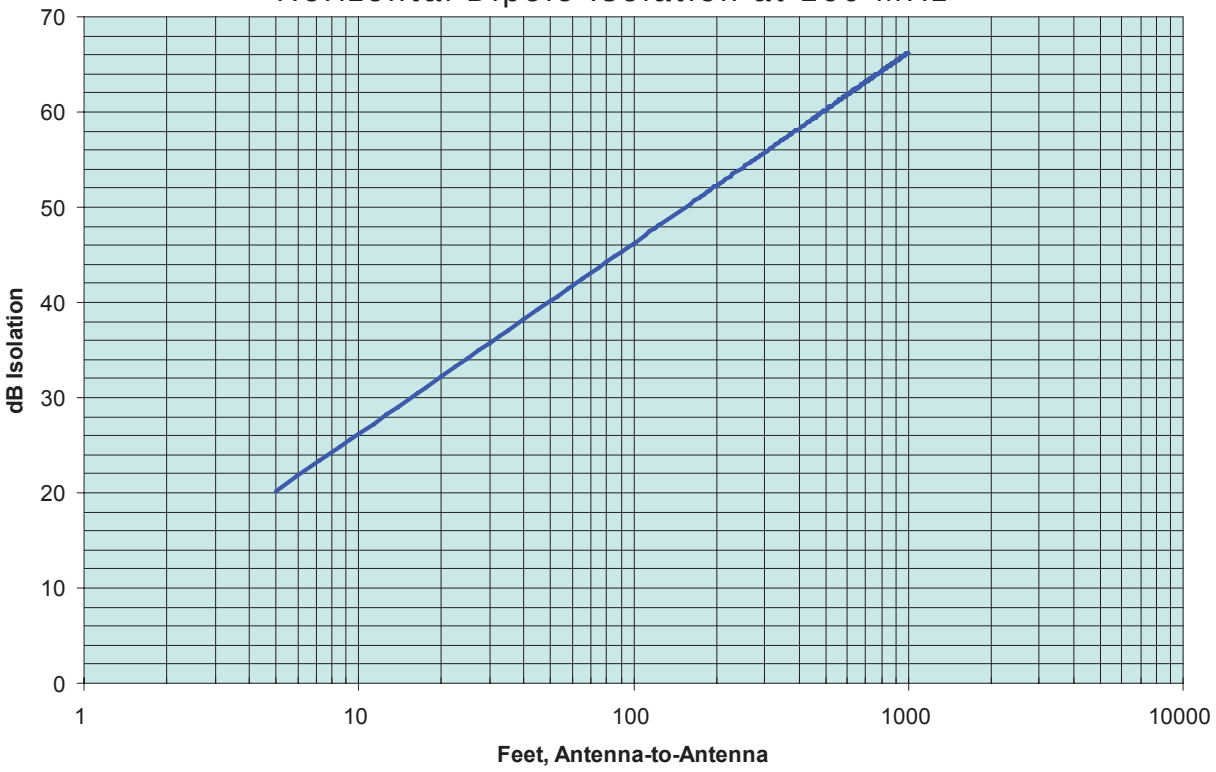
BASE STATION MODELS H 2" x W 19" x L 3"



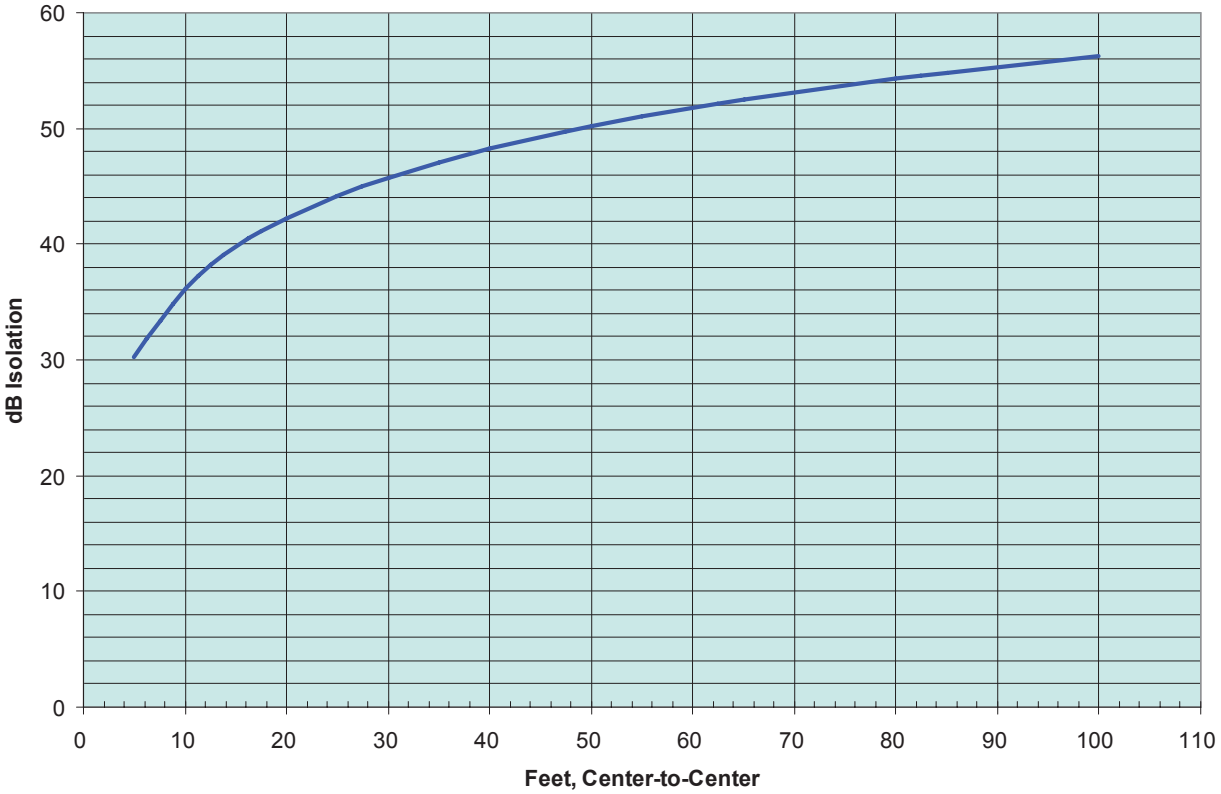
In this configuration, passing dC for Tower Mount Preamp is not a standard option.

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Horizontal Dipole Isolation at 160 MHz



Vertical Dipole Isolation at 160 MHz



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Duplexer Problems and Remedies

Duplexers are passive devices requiring little or no service once installed in a system. The proper design and application of a given Duplexer will give years of trouble free service. When problems do occur in a duplex system it is necessary to identify as many abnormal conditions as possible to zero in on the specific cause of the problem. Unfortunately, there are only a few measurable or observable performance indicators at the disposal of the field serviceman, and any number of conditions may exist, even simultaneously, which are responsible for the observed phenomena. Most Duplexer installation problems fall into three categories. Each of these three conditions will be treated separately, using the typical cause and remedy approach.

KEY

A. High Input VSWR
B. Excessive Loss
C. Desensitization of the receiver when transmitter is keyed.

PROBLEM			POTENTIAL CAUSE	REMEDY
A	B	C	***The number at right corresponds to the remedy paragraph on the next page.***	
●	●		Reverse labeling of Tx and Rx terminals.	1
●	●		Unit tuned to wrong frequencies.	2
●			Bad antenna or interconnect cables.	3
●	●		Use of between series adapters, especially UHF types.	4
●	●	●	Duplexer detuned in shipment.	5
●	●		Water has entered the Duplexer antenna connector from the antenna feed line.	6
●	●		Spurious Tx output is being reflected by the selective Duplexer input terminal and observed on the wattmeter, the wattmeter being unable to discriminate between on-frequency and off-frequency energy.	7
		●	Bad joint in a cable or antenna system beyond the antenna terminal of the Duplexer. All lines may show zero reflected power, but noise can still be produced when a corroded or indefinite metal-to-metal contact is exposed to RF energy. When this occurs beyond the Duplexer, it cannot be filtered out, and the noise backs up into the receiver.	8
		●	Adverse cable length between Duplexer and transmitter using varactor or broadband hybrid combining type transmitter outputs. Even though the Duplexer VSWR is flat on frequency, the reflected impedance of the Duplexer off resonance, transformed by changing cable lengths, can cause parasitics to be generated.	9
		●	Duplexer transmitter mixing with another outside transmitter, producing intermodulation on or near the receiver frequency.	10
		●	Transmitter cable leading to Duplexer in close proximity to Duplexer antenna or receiver cable. This is usually only a problem on close separation Duplexers, (1.0 MHz or less) where the 85 to 100 dB isolation is decreased by adverse coupling, created by running these cables too close together for too great a distance.	11
		●	Inadequate shielding of transmitter and receiver modules in the repeater.	12
		●	Insufficient duplex isolation for the application.	13
		●	A spurious transmitter response outside of the normal Duplexer isolation band or inadequacy of notch filter type Duplexers to suppress a wide enough band of Tx noise to protect the receiver.	14
		●	Impedance change in antenna due to icing. VSWR increase may be sufficient to reflect back through the Duplexer and upset transmitter tuning, causing parasitics, which are not suppressed sufficiently by the Duplexer.	15
		●	The addition of a broadband power amplifier to a low power transmitter. The noise floor of the low power radio is raised by an amount equal to the gain of the power amplifier, and in addition, the power amplifier will contribute its own noise. Power amplifiers are just as prone to the generation of parasitics as transmitters, and may be triggered by an adverse cable length between power amplifier and Duplexer, a problem covered above.	16
		●	Excessive loss with changing temperature and apparent Duplexer detuning.	17

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FIELD SERVICE REMEDIES for problems listed on previous page

1. Tune a signal generator to the receive frequency and inject it into the antenna terminal, sampling for the signal at each equipment terminal. Reverse the labels if necessary. It may be that the unit was ordered to the reverse frequencies. If so, the label will indicate this. If the duplexer is symmetrical in design (usually indicated by the same number of Tx and Rx filter sections) just reverse the equipment labels and operate. Generally, no damage will be done to the duplexer when operated in reverse for a short time period. If other adverse symptoms appear, contact the factory.

2. Check the unit label. If needed, the duplexer may be field tuned. Consult the instructions and/or the factory if the duplexer is still under warranty or beyond field tuning capability.

3. Check cable, by substitution, using a termaline wattmeter, or a thruline wattmeter into a known good load.
Check the antenna line input for reflected power.

4. To eliminate high input VSWR reduce the number of between series adapters by making up proper interconnect cables. UHF connectors are non-constant impedance, and certain combinations can transform a 1.1:1 VSWR into a 2.0:1, or vice versa.

5. Consult the instruction manual for field tuning procedures, or the factory, if the unit is still under warranty or beyond field tuning capability. (We trust that our products will not be prone to this problem).

6. Consult the factory. The affected antenna cables may be field replaceable, or a "baking out" process may be possible.

7. To prove this condition, place a bandpass filter between the Tx and duplexer to clean up the spurious, and put the wattmeter between the bandpass filter and the duplexer to measure reflected power from the duplexer. The bandpass filter selectivity should be equal to or better than that of the duplexer at about the 3.0 dB points.

8. Operate the duplex system into a dummy load. If no desensitization occurs, check out all lines, antennas, and look for potential bad joints close to the radiating antenna where re-radiation of noise may be possible back into the antenna system receiver. Loose metal-to-metal contacts on tower guying systems have also been known to create system noise. Note the effect of vibrating tower guys on system noise.

9. Change the length of cable between the transmitter and duplexer, traversing through a half wave in increments of between 1 and 2 inches until the desensitization ceases or is minimal. A ferrite isolator will also cure this condition when it is installed between the transmitter and duplexer. However, this is a much more expensive remedy.

10. If the IM is in the duplex transmitter, a ferrite isolator in the duplex transmitter line (NOT antenna line) will show this by either reducing or eliminating it. More isolation can be obtained by cascading isolators if needed. However, IM of this magnitude indicates the system should be studied for possible revision to reduce the production of this IM.

11. Cables such as RG-8a/u and RG-213/u should be kept at least 3-4" apart over 5'-10' runs. Use of double shielded cable will reduce the susceptibility to this problem.

12. Consult the radio manufacturer. This condition can be verified by operating the transmitter into a dummy load while injecting a minimum quieting signal into the receiver. Some radios require special modifications before they are suitable for repeater operation.

13. If this problem is suspected, contact the radio manufacturer for recommended duplex isolation for Tx noise suppression and carrier suppression. Duplexer isolation should be measured first per instruction manual to verify rated specifications are present. If more duplex isolation is required, contact TX RX SYSTEMS for recommended filtering.

14. Consult the factory. Bandpass filter tests can be made to confirm this. In extreme cases, adjustments to the transmitter may be required.

15. Either de-ice the antenna, or use an antenna less sensitive to ice. A ferrite isolator can also be put at the transmitter output to improve the impedance match. Ferrite isolators cannot be put in antenna lines, as they will attenuate Rx signals.

16. A mismatch may possibly be reduced by lengthening the cable which runs between the power amplifier output and the duplexer input until the receiver desensitization disappears, as follows:
30 MHz to 512 MHz RANGE
BNC or N type adapters may be inserted in the original cable, one at a time and not to exceed a total of
1/2 wavelength, until desensitization disappears.
800 MHz to 1.3 GHz RANGE
Prepare a cable length 3/4" longer than the original cable and insert. If desensitization does not disappear, repeat with cables each 3/4" longer than the previous length, not to exceed 1/2 wavelength.

17. We find that this cause most commonly relates to shifting impedance of the transmitter or power amplifier with temperature. The duplexer appears detuned, since a "conjugate match" (canceling reactance, and matching resistance component) is approached by shifting the duplexer passband above or below the 50 ohm point, as determined by an increase in output power on the wattmeter. In this case, temperature control of the room is the only answer, other than upgrading the transmitter.

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Power Conversion Chart dBm to dBw to Watts to Volts			
dBm	**dBw**	**Watts**	**Volts (50 Ohm)**
80	50	100 kW	2236
75	45	31.6 kW	1257
70	40	10.0 kW	707
65	35	3.16 kW	398
60	30	1000	224
55	25	316	126
50	20	100	70.7
45	15	31.6	39.8
40	10	10.0	22.4
38	8	6.31	17.8
36	6	3.98	14.1
34	4	2.51	11.2
32	2	1.58	8.90
30	0	1.00	7.07
29	-1	0.79	6.30
28	-2	0.63	5.62
27	-3	0.50	5.01
26	-4	0.40	4.46
25	-5	0.32	3.98
24	-6	0.25	3.54
23	-7	0.20	3.16
22	-8	0.16	2.82
21	-9	0.13	2.51
20	-10	0.10	2.24
19	-11	79 mW	1.99

Power Conversion Chart dBm to dBw to Watts to Volts			
dBm	**dBw**	**Watts**	**Volts (50 Ohm)**
18	-12	63 mW	1.78
17	-13	50 mW	1.58
16	-14	40 mW	1.41
15	-15	32 mW	1.26
14	-16	25 mW	1.12
13	-17	20 mW	1.00
12	-18	16 mW	0.890
11	-19	13 mW	0.793
10	-20	10 mW	0.707
9	-21	7.9 mW	0.630
8	-22	6.3 mW	0.562
7	-23	5.0 mW	0.501
6	-24	4.0 mW	0.446
5	-25	3.2 mW	0.398
4	-26	2.5 mW	0.354
3	-27	2.0 mW	0.316
2	-28	1.6 mW	0.282
1	-29	1.3 mW	0.251
0	-30	1.0 mW	0.224
-5	-35	316 uW	0.126
-10	-40	100 uW	0.071
-15	-45	31.6 uW	0.040
-20	-50	10 uW	0.022
-25	-55	3.16 uW	0.013
-30	-60	1 uW	0.007

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Free Space Path Loss Estimator

Path Length (miles)	Path Loss in dB; Frequency in MHz						
	50	**150**	**170**	**450**	**500**	**800**	**900**
0.1	50.58	60.12	61.21	69.66	70.58	74.66	75.68
0.25	58.54	68.08	69.17	77.62	78.54	82.62	83.64
0.5	64.56	74.10	75.19	83.64	84.56	88.64	89.66
1	70.58	80.12	81.21	89.66	90.58	94.66	95.68
2	76.60	86.14	87.23	95.68	96.60	100.68	101.71
3	80.12	89.66	90.75	99.21	100.12	104.20	105.23
4	82.62	92.16	93.25	101.71	102.62	106.70	107.73
5	84.56	94.10	95.19	103.64	104.56	108.64	109.66
6	86.14	95.68	96.77	105.23	106.14	110.22	111.25
7	87.48	97.02	98.11	106.57	107.48	111.56	112.59
8	88.64	98.18	99.27	107.73	108.64	112.72	113.75
9	89.66	99.21	100.29	108.75	109.66	113.75	114.77
10	90.58	100.12	101.21	109.66	110.58	114.66	115.68
12	92.16	101.71	102.79	111.25	112.16	116.25	117.27
14	93.50	103.04	104.13	112.59	113.50	117.58	118.61
16	94.66	104.20	105.29	113.75	114.66	118.74	119.77
18	95.68	105.23	106.31	114.77	115.68	119.77	120.79
20	96.60	106.14	107.23	115.68	116.60	120.68	121.71
30	100.12	109.66	110.75	119.21	120.12	124.20	125.23
40	102.62	112.16	113.25	121.71	122.62	126.70	127.73
50	104.56	114.10	115.19	123.64	124.56	128.64	129.66

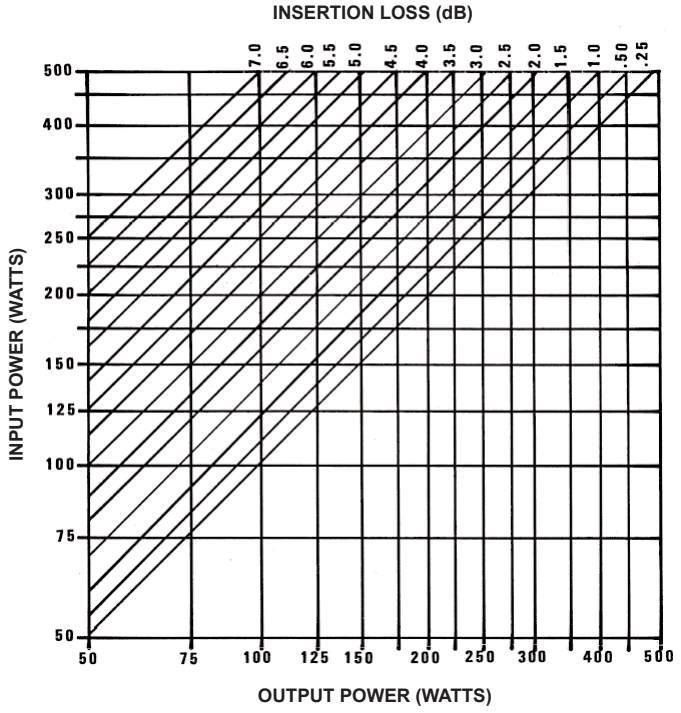
FORMULA: Path Loss (dB) = 36.6 + 20 log (MHz) + 20 log (miles)

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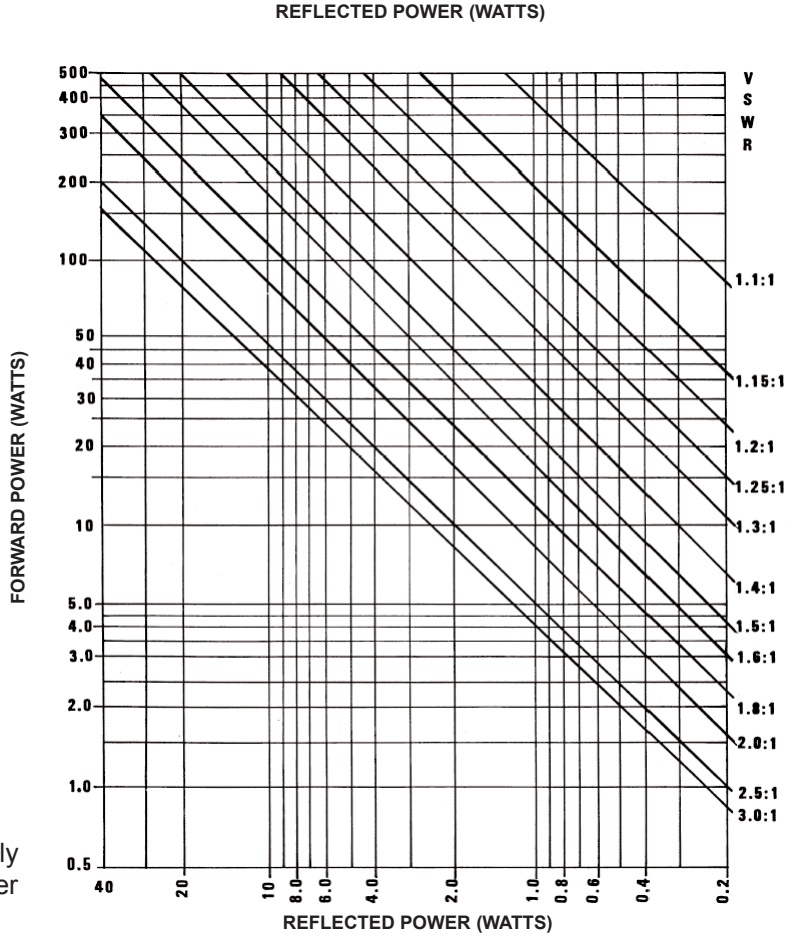
REFERENCE

Loss Nomographs



TX RX Systems, Inc. offers this convenient means of determining the insertion loss of Filters, Duplexers, Multicouplers, and related products.
It should be remembered that the field accuracy of wattmeter readings is subject to considerable variance due to RF connector VSWR and basic wattmeter accuracy, particularly at low end scale readings. However, allowing for these variances, this graph should prove to be a useful reference.

For lower power levels, divide both scales by 10 (5 to 50 watts)

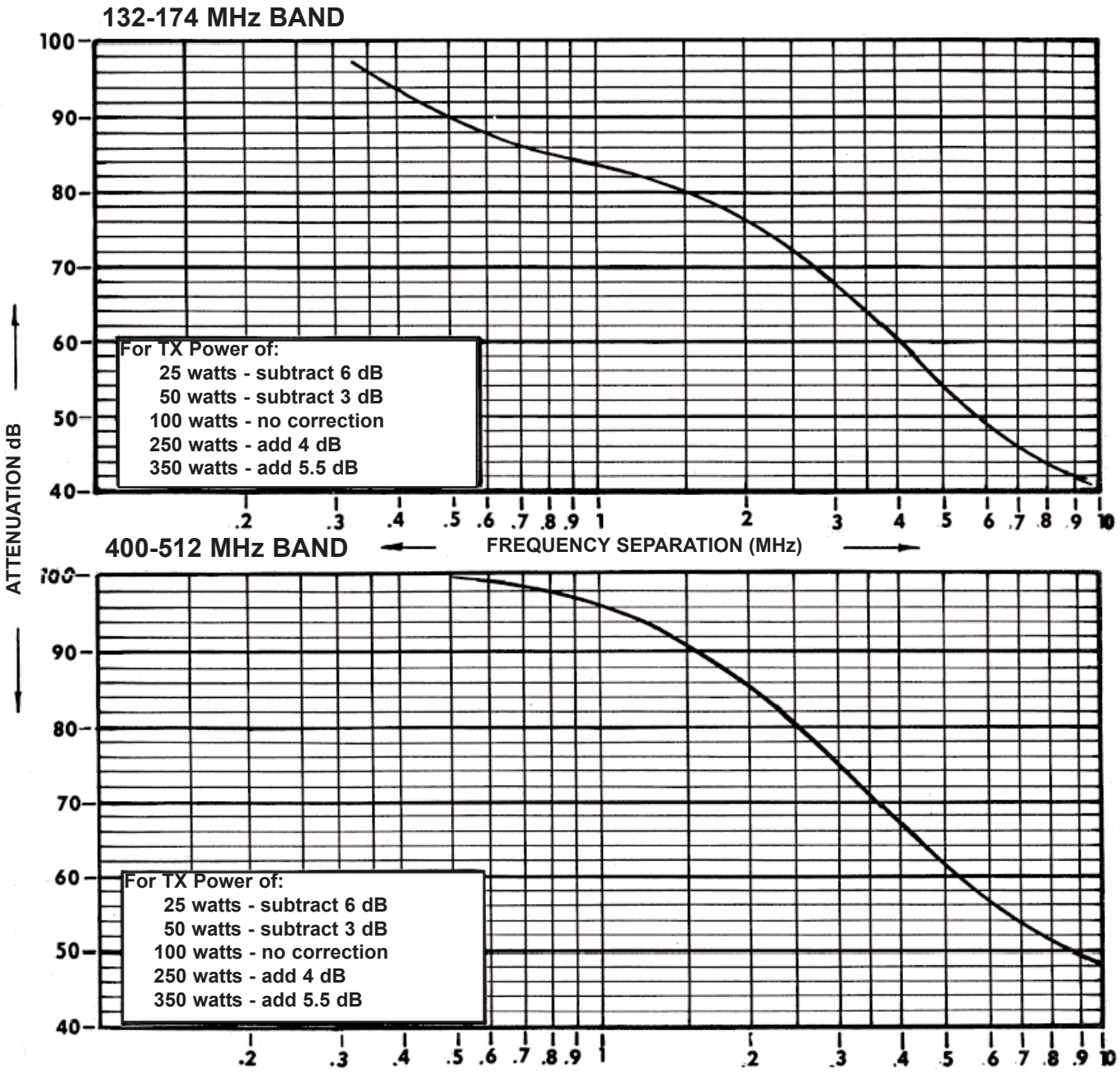


For other power levels, multiply both scales by the same multiplier

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Isolation curves for data reference Transmitter/Receiver

The curves shown below for use with filters, duplexers, and multicouplers, indicate the amount of isolation or attenuation required between a typical 100 watt transmitter and its associated receiver at the Tx (carrier suppression) and Rx (noise suppression) frequency which will result in no more than a 1 db degradation of the 12 db SINAD sensitivity.



Note: These are only “typical curves”. When accuracy is required, consult the radio manufacturer.

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CONVERSION TABLE

POWER AND VOLTAGE RATIOS TO dB

TO ACCOUNT FOR THE SIGN OF THE DECIBEL

For positive (+) values of the decibel - Both voltage and power ratios are greater than unity. Use the two right hand columns.

For negative (-) values of the decibel - Both voltage and power ratios are less than unity. Use the two left hand columns.

Voltage Ratio	Power Ratio	<-- - dB + -->	Voltage Ratio	Power Ratio
1.0000	1.0000	0	1.0000	1.0000
0.9886	0.9772	0.1	1.0116	1.0233
0.9772	0.9550	0.2	1.0233	1.0471
0.9661	0.9333	0.3	1.0351	1.0715
0.9550	0.9120	0.4	1.0471	1.0965
0.9441	0.8913	0.5	1.0593	1.1220
0.9333	0.8710	0.6	1.0715	1.1482
0.9226	0.8511	0.7	1.0839	1.1749
0.9120	0.8318	0.8	1.0965	1.2023
0.9016	0.8128	0.9	1.1092	1.2303
0.8913	0.7943	1	1.1220	1.2589
0.8810	0.7762	1.1	1.1350	1.2882
0.8710	0.7586	1.2	1.1482	1.3183
0.8610	0.7413	1.3	1.1614	1.3490
0.8511	0.7244	1.4	1.1749	1.3804
0.8414	0.7079	1.5	1.1885	1.4125
0.8318	0.6918	1.6	1.2023	1.4454
0.8222	0.6761	1.7	1.2162	1.4791
0.8128	0.6607	1.8	1.2303	1.5136
0.8035	0.6457	1.9	1.2445	1.5488
0.7943	0.6310	2	1.2589	1.5849
0.7852	0.6166	2.1	1.2735	1.6218
0.7762	0.6026	2.2	1.2882	1.6596
0.7674	0.5888	2.3	1.3032	1.6982
0.7586	0.5754	2.4	1.3183	1.7378
0.7499	0.5623	2.5	1.3335	1.7783
0.7413	0.5495	2.6	1.3490	1.8197
0.7328	0.5370	2.7	1.3646	1.8621
0.7244	0.5248	2.8	1.3804	1.9055
0.7161	0.5129	2.9	1.3964	1.9498
0.7079	0.5012	3	1.4125	1.9953
0.6998	0.4898	3.1	1.4289	2.0417
0.6918	0.4786	3.2	1.4454	2.0893
0.6839	0.4677	3.3	1.4622	2.1380
0.6761	0.4571	3.4	1.4791	2.1878
0.6683	0.4467	3.5	1.4962	2.2387
0.6607	0.4365	3.6	1.5136	2.2909
0.6531	0.4266	3.7	1.5311	2.3442
0.6457	0.4169	3.8	1.5488	2.3988
0.6383	0.4074	3.9	1.5668	2.4547
0.6310	0.3981	4	1.5849	2.5119
0.6237	0.3890	4.1	1.6032	2.5704
0.6166	0.3802	4.2	1.6218	2.6303
0.6095	0.3715	4.3	1.6406	2.6915
0.6026	0.3631	4.4	1.6596	2.7542
0.5957	0.3548	4.5	1.6788	2.8184
0.5888	0.3467	4.6	1.6982	2.8840
0.5821	0.3388	4.7	1.7179	2.9512
0.5754	0.3311	4.8	1.7378	3.0200
0.5689	0.3236	4.9	1.7579	3.0903
0.5623	0.3162	5	1.7783	3.1623
0.5559	0.3090	5.1	1.7989	3.2359
0.5495	0.3020	5.2	1.8197	3.3113
0.5433	0.2951	5.3	1.8408	3.3884
0.5370	0.2884	5.4	1.8621	3.4674
0.5309	0.2818	5.5	1.8836	3.5481
0.5248	0.2754	5.6	1.9055	3.6308
0.5188	0.2692	5.7	1.9275	3.7154
0.5129	0.2630	5.8	1.9498	3.8019
0.5070	0.2570	5.9	1.9724	3.8905
0.5012	0.2512	6	1.9953	3.9811
0.4955	0.2455	6.1	2.0184	4.0738
0.4898	0.2399	6.2	2.0417	4.1687
0.4842	0.2344	6.3	2.0654	4.2658
0.4786	0.2291	6.4	2.0893	4.3652
0.4732	0.2239	6.5	2.1135	4.4668
0.4677	0.2188	6.6	2.1380	4.5709
0.4624	0.2138	6.7	2.1627	4.6774
0.4571	0.2089	6.8	2.1878	4.7863
0.4519	0.2042	6.9	2.2131	4.8978
0.4467	0.1995	7	2.2387	5.0119
0.4416	0.1950	7.1	2.2646	5.1286
0.4365	0.1905	7.2	2.2909	5.2481
0.4315	0.1862	7.3	2.3174	5.3703
0.4266	0.1820	7.4	2.3442	5.4954
0.4217	0.1778	7.5	2.3714	5.6234
0.4169	0.1738	7.6	2.3988	5.7544
0.4121	0.1698	7.7	2.4266	5.8884
0.4074	0.1660	7.8	2.4547	6.0256
0.4027	0.1622	7.9	2.4831	6.1660
0.3981	0.1585	8	2.5119	6.3096
0.3936	0.1549	8.1	2.5410	6.4565
0.3890	0.1514	8.2	2.5704	6.6069
0.3846	0.1479	8.3	2.6002	6.7608
0.3802	0.1445	8.4	2.6303	6.9183
0.3758	0.1413	8.5	2.6607	7.0795
0.3715	0.1380	8.6	2.6915	7.2444
0.3673	0.1349	8.7	2.7227	7.4131
0.3631	0.1318	8.8	2.7542	7.5858
0.3589	0.1288	8.9	2.7861	7.7625
0.3548	0.1259	9	2.8184	7.9433
0.3508	0.1230	9.1	2.8510	8.1283
0.3467	0.1202	9.2	2.8840	8.3176
0.3428	0.1175	9.3	2.9174	8.5114
0.3388	0.1148	9.4	2.9512	8.7096
0.3350	0.1122	9.5	2.9854	8.9125
0.3311	0.1096	9.6	3.0200	9.1201
0.3273	0.1072	9.7	3.0549	9.3325
0.3236	0.1047	9.8	3.0903	9.5499
0.3199	0.1023	9.9	3.1261	9.7724
0.3162	0.1000	10	3.1623	10.0000
0.1778	0.0316	15	5.6234	31.6228

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This warranty applies for one year from shipping date.

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464-VHF-0704