Receiver Multicouplers

Functionality and Application

The receiver multicoupler is an antenna subsystem component that allows for the operation of two or more receivers connected to a common receive antenna. Resulting signal quality to the receiver is equal to, or superior to, a dedicated antenna for each receiver. By maximizing the effective utilization of the tower-mounted receive antenna over several base stations, increased capacity can be achieved without additional tower loading by antennas. Wind loading on towers will limit the number and type of antennas placed on a tower in a given geographic region.

What makes one receiver multicoupler better than another is the optimum performance provided by the key operating components.

- Preselector (Filter)
- Low Noise Amplifier
- Power Divider

PRESELECTOR FILTER

The functional purpose of this component is to selectively pass desired signals and exclude unwanted signals from entering the amplifier. Band pass filters can vary in their degrees of selectivity and should be specified on the basis of end-use application. For rural applications where the RF signal density is reasonably low, a filter offering lower selectivity could be deployed. However, as geographic areas become more populated and additional RF activities (such as Paging, SMR, Data Transmission, and Cellular) increase, high selectivity performance is necessary to exclude unwanted signals. The Narda filter used in our standard catalog receiver multicoupler unit uses a band pass filter offering greater than 65 dB rejection of unwanted signals. Our OEM receiver multicoupler unit features a band pass filter typically providing greater than 75 dB rejection. It is critical to obtain as much information as possible with regard to the conditions of RF density in which the receiver multicoupler will be used.

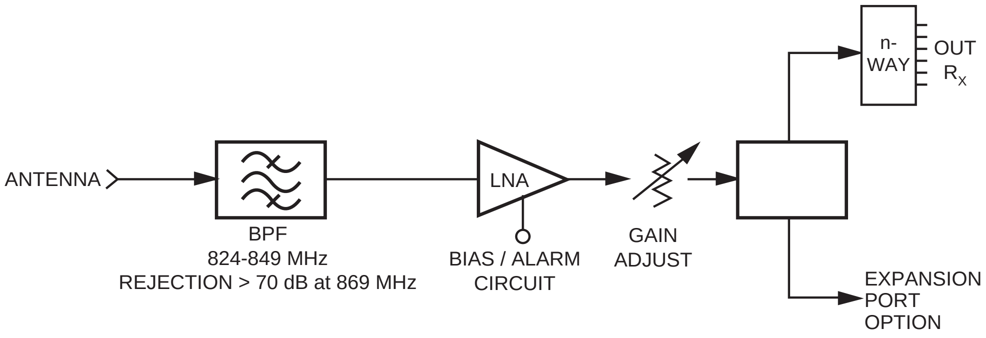

Figure 1
Typical Block Diagram (Single Channel)

LOW NOISE AMPLIFIER

The low noise amplifier is a critical component in the overall receiver multicoupler system. In a relatively dense RF environment, desired signals must be amplified while being immune to the effect of adjacent-channel frequencies and out-of-band signals. While amplification occurs, very little noise should be contributed by the amplifier. Measurement criteria that gauge the performance of the amplifier in accomplishing optimum signal transmission are:

- Third Order Intercept Point
- Intermodulation Distortion
- Noise Figure
- Amplifier Sensitivity
- Dynamic Range
- 12 dB SINAD

Third Order Intercept Point

The theoretical output level at which the third order products and the fundamental response are equal. The higher the third order intercept point the more linear the performance of the amplifier. This parameter provides the basis for control of signal levels to minimize the effect of intermodulation distortion. The third order intercept point is generally 10 dB above the 1 dB compression point.

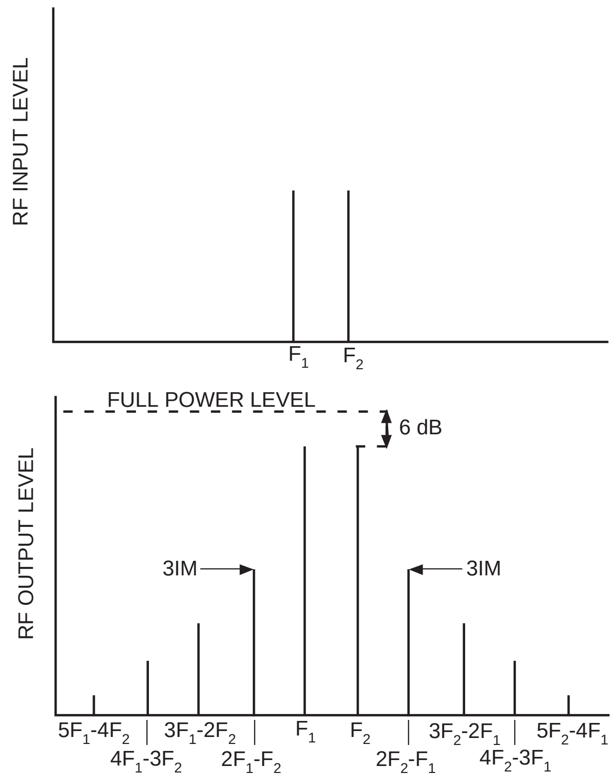

Figure 3
Intermodulation Performance of an Amplifier

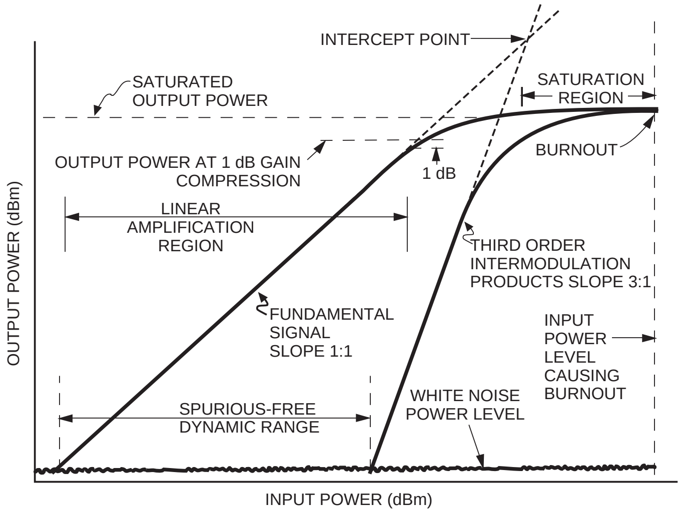

Figure 2

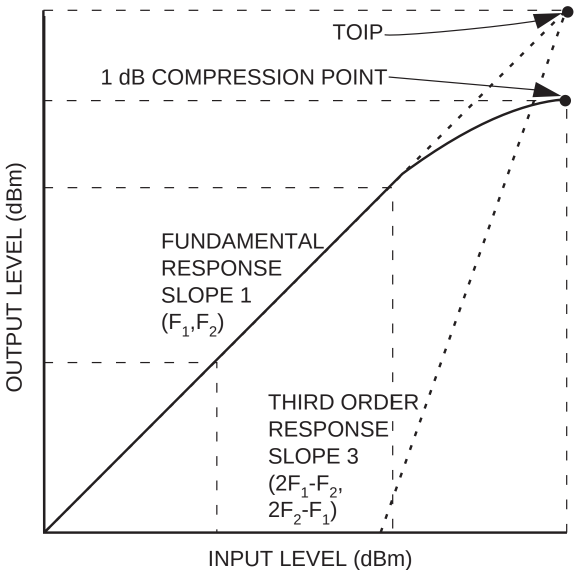

Figure 4
The Determination of the Third Order Intercept Point (TOIP)

Intermodulation Distortion

The transfer characteristic of an input signal to any amplifier is not perfectly linear and the output signal is distorted as compared to the input. As the transfer characteristic is expanded as a polynomial of the input, the output will contain a fundamental signal term and spurious signal terms. These signals are generated as a result of the second, third, and higher order powers of the expansion.

Second Order Terms	F_1 +/- F_2, $2F_1 + 2F_2$
Third Order Terms	$2F_1$ +/- F_2, $2F_2$ +/- F_1

The third order intermodulation product (3IM), is the largest distortion product and is the key element in defining the third order intercept point (IP3). It is the product of concern because it usually falls close to or within the desired communication band.

Noise Figure

A direct measure of the noise added by the receiver to the thermal noise present at the output. An increase in the overall noise figure results in a decrease in receiver sensitivity and a decrease in the spurious-free dynamic range of the system.

Amplifier Sensitivity

This is the minimum detectable signal (MDS) at the input of an amplifier that will generate a signal at the output that is detectable above the noise level.

MDS = -114 dBm + 10 Log (NBW / 1MHz) + NF

MDS = Minimum Detectable Signal

NBW = Noise Bandwidth of the System in MHz.

Note: *As a first approximation, 3dB BW is used to replace NBW*

NBW = $1/G \int gdf$ where G is the gain of the system and g is the differential available gain.

Dynamic Range

The spurious-free dynamic range of an amplifier is the range of input signals over which spurious outputs are below the noise level of the output signal.

DRspf = 2/3 (IP3 - G - MDS)

DRspf = Spurious-Free Dynamic Range
G = gain
MDS = Min. detectable signal
IP3 = Third order intercept point.

Example: Assume the following conditions:

NBW as a first approximation = 3dB BW
3dB BW = 10 MHz
Gain = 12 dB
IP3 = 25 dBm
NF = 2.5 dB

(Minimum detectable signal calculation)

MDS = -114 dBm + 10 Log (3dB Bw/ 1 MHz) + NF
= -114 dBm + 10 Log (10 MHz/ 1 MHz) + NF
MDS = -101.5 dBm

(Spurious-Free Dynamic Range Calculation)

DRspf = 2/3 (IP3 - G - MDS)
DRspf = 2/3 [25 dBm - 12 dB - (-101.5 dBm)]

Spurious-Free Dynamic Range = 76.33 dB

12 dB SINAD

The industry standard for measuring receiver sensitivity. SINAD is the measurement of the quality of a communication signal . It is the ratio of the total output signal, plus noise, plus distortion, to the power of the noise plus distortion only. The ratio is usually expressed in decibel units. (See the two expressions for data obtained in the form of power or in the form of voltage below.)

SINAD (Expressed in Power)

SINAD = 10 Log (Signal + Noise + Distortion)/ Noise + Distortion

SINAD (Expressed in Voltage)

SINAD = 20 Log (Signal + Noise + Distortion) / Noise +Distortion

Note: *Commonly data is obtained in the form of a voltage by means of a voltmeter whereby the above expression would apply.*

The 12 dB ratio stands as an ideal figure of merit for the optimization of the amplifier or the overall receiver multicoupler assembly.

POWER DIVIDERS

A signal distribution network that assures the equalized distribution of signal level and quality across a designated number of ports. Low insertion loss and flexibility to expand the number of ports are essential characteristics of these components. Isolation between ports is also an essential parameter for the signal power divider. Narda offers excellent isolation between ports by deploying a fully-shielded microstrip design using hybrid and Wilkinson network sections.

Bearing in mind the performance criteria for low noise amplifiers and selectivity requirements of filters, the following are design goals for receiver multicoupler integration.

- Lowest Noise Figure
- Highest third order intercept point performance to assure widest dynamic range.
- Gain values high enough to overcome insertion losses of filters, dividers, and cables, yet not overpower the input level threshold of the receiver.

Upon examining the performance specification for both the standard catalog receiver multicoupler (Model 94000-8) and the high-performance OEM version (Model 92000-8), numerous applications are served, ranging from cellular antenna sites to two-way radio and SMR (Special Mobile Radio) repeater networks. To assist in understanding the subsequent Narda Receiver Multicoupler specifications, outlined below is an itemized description and explanation of the importance of each electrical parameter. The receiver multicoupler described is the 92000-8, the OEM high performance unit.

Narda Standard Catalog Receiver Multicoupler

(1) Frequency: 824 - 849 MHz

The frequency band the receiver multicoupler is designed to operate over at the lowest noise figure and highest third order intercept point.

(2) Output Channels: 8 ports

There are 8 output ports per channel side. This offers the user redundancy, should a failure occur in either channel side.

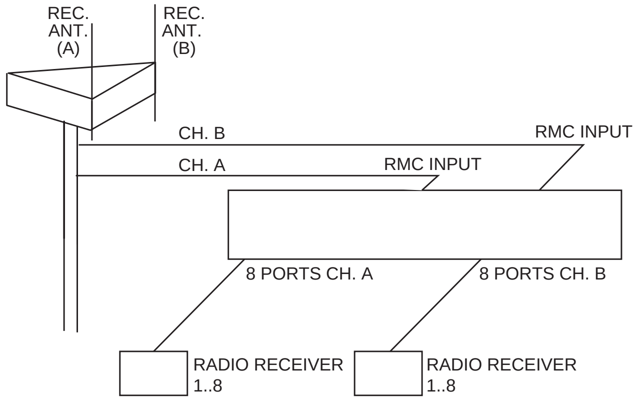

Figure 5
Antenna Diversity

(3) Expansion Channels: 8

The expansion channel divider board offers an addition of 8 ports per channel side. Sixteen output ports per channel can be achieved bringing the total number of ports to thirty two.

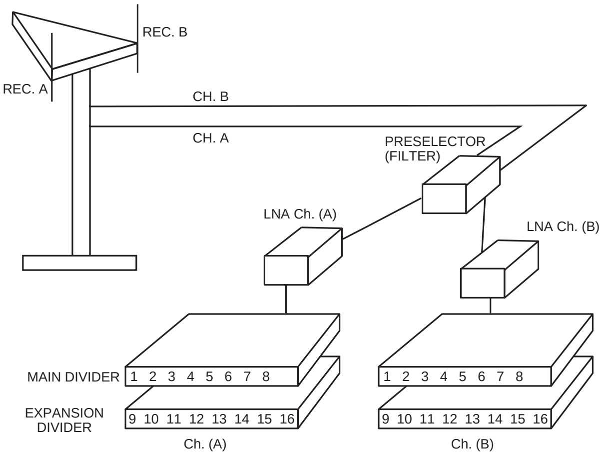

Figure 6
Two Receive Antennas Provide Diversity Should a Failure Occur

Previous T.O.C. Next Home

(4) Nominal Gain @ Maximum Gain Setting

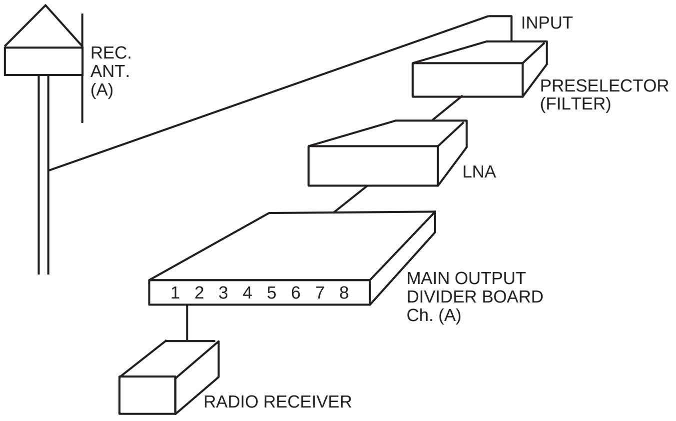

Figure 7
Input to Main Output Ports: 31 dB +/- 1 dB

@ 24 dB of gain the RMC unit is capable of receiving the following minimum detectable signal :

MDS = -114 dBm + 10 Log (3 dB BW/ 1 MHz) + NF

[As a first approximation, 3 dB bandwidth is used to replace NBW (Noise Bandwidth)]

Assuming: 3 dB BW = 10 MHz
NF = 3.0 dB max. @ 25°C

MDS = -114 dBm + 10 log (10MHz/1 MHz) + 3.0 dB

Minimum detectable signal of the RMC = -101 dBm

(5) Nominal Gain @ Maximum Gain Setting

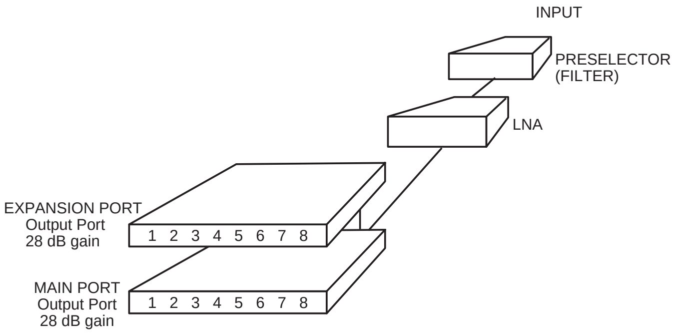

Figure 8 – Input to Expansion Channel: 28 dB

(6) Gain Adjustment: 0 to 12 dB

Gain can be adjusted down manually by a maximum of 12 dB. This would be necessary in cases where the receiver input threshold would be exceeded.

(7) Noise Figure Max. @ Maximum Gain @ 25°C: 2.5 dB max.

This value represents the total noise figure of the RMC unit at the output port to the receiver.

(8) Third Order Intercept Point (min. @ 25°C, and maximum gain).

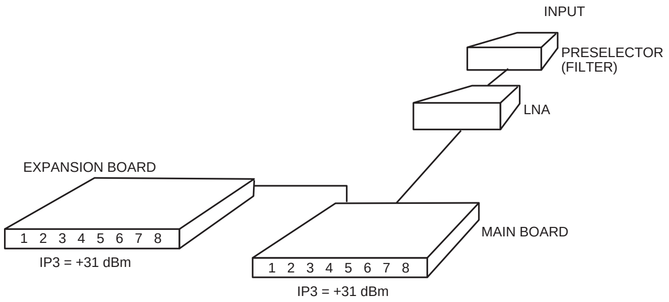

Figure 9
Input IP3 = +3 dBm

Changes in Electrical Performance Due to Expansion of the Number of Ports

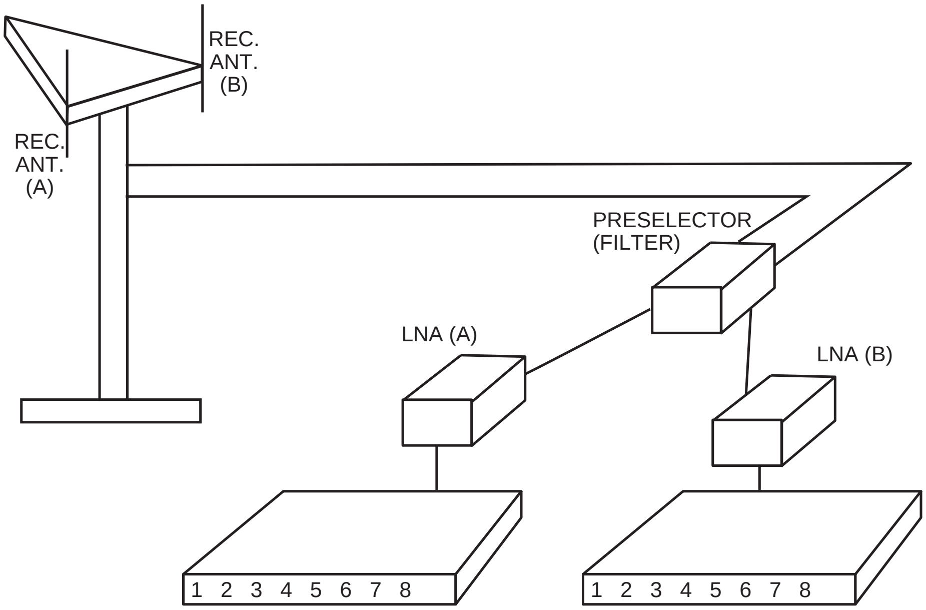

Figure 10 (Non-Expanded)

Electrical Specifications	**Value**
(1) Number of Ports* Ch. (B) 8 ports	Ch. (A) 8 ports
(2) Nominal gain @ max. gain setting (At the output of each port)	31 ±1 dB
(3) Third order intercept point (At the output of each port) (At 25°C Max. Gain)	+34 dBm
(4) Gain adjustment	12 dB
(5) Gain variation over temperature	±1 dB
(6) Noise Figure at max. gain	2.5 dB
(7) Rej. 869 - 894 MHz	-72 dB
(8) Input/Output VSWR	1.5:1

*Both Ch. (A) and Ch. (B) are each autonomous receiver multicoupler units

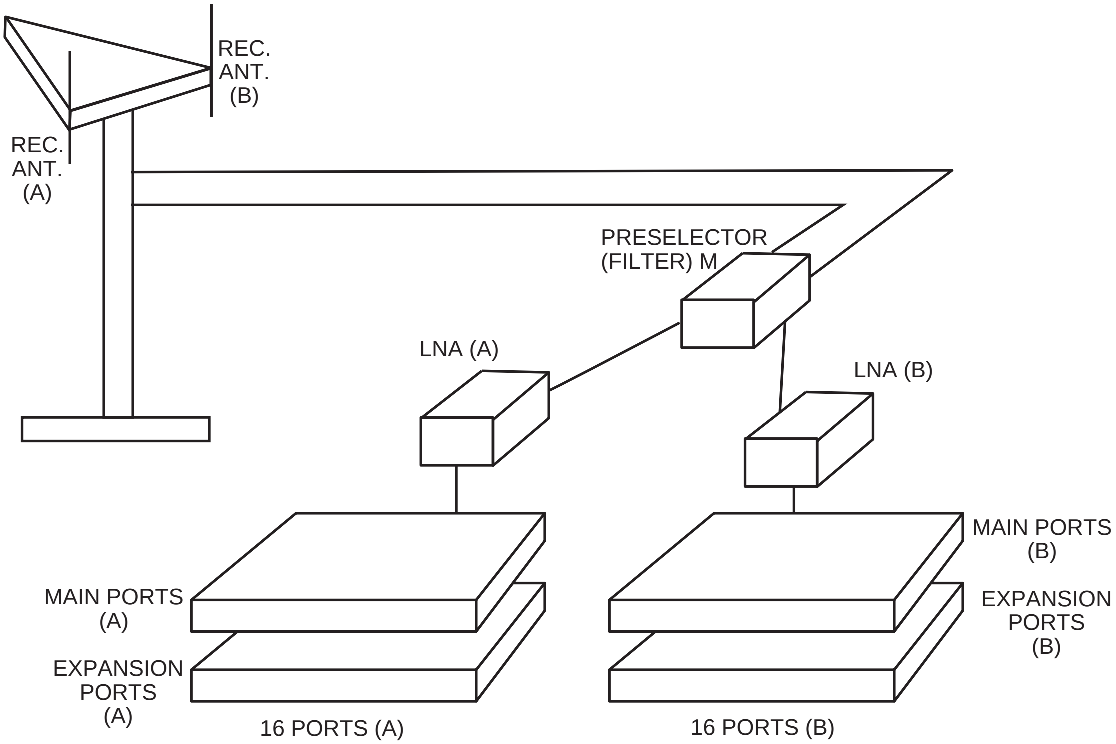

Figure 11 (Expanded)

Electrical Specifications	**Value**
(1) Number of Ports*	Ch. (A) 16 ports Ch. (B) 16 ports
(2) Nominal gain @ max. gain setting (At the output of each port)	28 ± 1 dB
(3) Third order intercept point (At the output of each port) (@ 25°C Max. Gain)	+31 dBm
(4) Gain adjustment	12 dB
(5) Gain variation over temperature	±1 dB
(6) Noise Figure	2.5 dB
(7) Rej. 869 - 894 MHz	-72 dB
(8) Input/Output VSWR	1.5:1

*Both Ch. (A) and Ch. (B) are each autonomous receiver multicoupler units

(9) Rejection 869-894 MHz : 65 dB min

In this specification, rejection refers to the undesired adjacent channel frequencies outside of the desired passband as well as the base station transmit frequencies. All undesired signals would be kept 65 dB below the carrier signal.

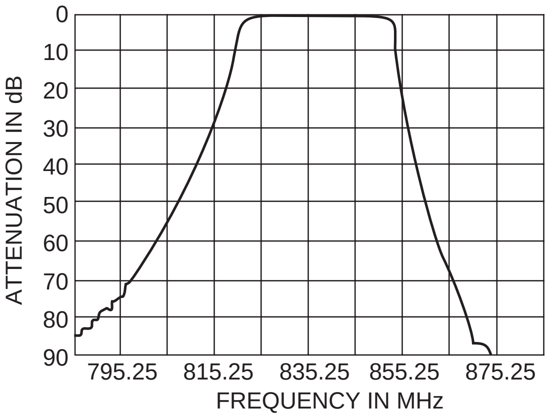

Figure 12
Input Filter Response Curve

(10) Output Port Isolation: 23 dB

Output port isolation is the ratio of separation of signals from one output port to the other. The importance of this separation is to assure maximum feedthrough and lowest leakage interference.

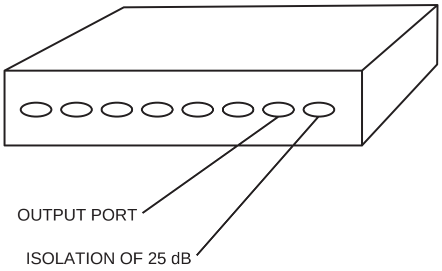

Figure 13
Output Port Isolation

(11) Input/Output VSWR: 1.5:1

Voltage standing wave ratio (VSWR) is a measure of how well-matched or mismatched a load is to a resistive source. A well-matched load will carry the signal forward with a minimum amount of reflected power. The VSWR ratio of 1.5:1 is equivalent to 96% of the signal transmitted forward and only 4% of the signal reflected back. The lower the VSWR ratio, the higher the percentage of signal transmitted forward.

Configuration

Receiver multicouplers can be provided in a wide variety of output port combinations and frequency bands. Catalog products are currently offered at 824-849 MHz and 806-821 MHz, but could be made available in the 900 MHz frequency band with modifications to filters and amplifiers. Narda receiver multicouplers can also be designed to work in conjunction with tower-top amplifiers to further enchance receiver coverage.

Once the basic criteria separating one receiver multicoupler from another is fully understood, you will come to realize and appreciate, the engineered performance of Narda receiver multicoupler products.