

Practical Tips on Transmission Measurements

Spectrum Master MS2711D, S332D and MT8212B

1.0 Introduction

This is a practical Transmission Measurement Procedures Note. The objective of this note is to present measurement tips and procedures which will help a field technician verify a Tower Mounted Amplifier (TMA) or duplexer (send/receive path filter), typically found in wireless communication applications.

1.1 Tracking Generators Are Not Always a Perfect Fit for Wireless Applications

Traditionally, transmission measurements have been made using a tracking generator (TG). A tracking generator is a signal generator with an output that tracks or follows the tuning of a spectrum analyzer, and that allows a spectrum analyzer to perform scalar network measurements. It has an adjustable-level output that is used with a fixed-level input.

To make a transmission measurement, the output of the tracking generator is connected to the input of the device under test (DUT). The frequency response of the DUT is measured with the spectrum analyzer's receiver. The transfer characteristics of the DUT can be obtained and documented. Under ideal conditions, the TG will sweep exactly in synchronization with the spectrum analyzer.

A tracking generator can be a relatively inexpensive addition to a spectrum analyzer for making scalar frequency response measurements. It is not, however, a perfect fit for wireless measurement applications where the low-power, input device limits the source power that can be applied to the input of the DUT. In this case, a low noise floor is required and non-linear measurements must be made. For measurements in this type of environment, an alternate measurement capability is required.

2.0 An Improved Transmission Measurement

The Anritsu Transmission Measurement Option 21 (TM Option 21) for the Spectrum Master MS2711D, S332D or MT8212B is an excellent tool for measuring the loss or gain of two-port devices such as filters, cables, attenuators, and amplifiers. It combines the capabilities of a tracking generator with a spectrum analyzer to realize significant performance benefits.



What differentiates TM Option 21 from a traditional tracking generator is its use of a fixed-level output with a dynamically-adjustable input level. This unique DYNAMIC ATTENUATION mode automatically tracks the input signal level and seamlessly adjusts the input attenuator value to appropriately display gain at each measurement frequency (see Figure 1). The reference level remains fixed at all times, regardless of dynamic attenuation changes. The result is a wider dynamic range display. Also, the power to the input mixer is always maintained in the linear region. This delivers excellent dynamic range in difficult measurement situations such as when external attenuation is needed to reduce the input level as a means of keeping the signal in the linear region of an amplifier.

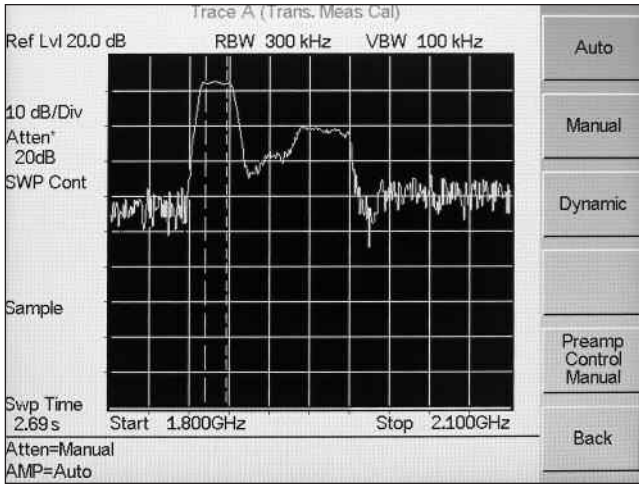


Figure 1A. Measurement of an amplifier with normal attenuation.

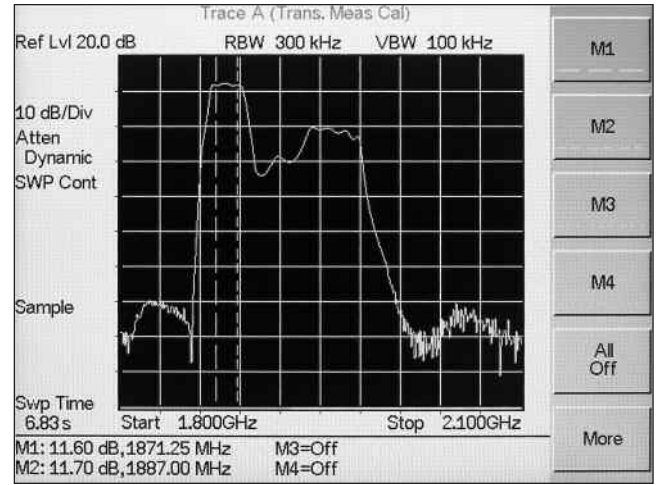


Figure 1B. Amplifier characteristics with the DYNAMIC ATTENUATION mode enabled.

TM Option 21 provides a 25 MHz to 3 GHz radio frequency (RF) internal signal source that is tuned to the same frequency as the spectrum analyzer and has a power output of approximately -10 dBm. It can be used to calibrate and remove signal source power variations, as well as to test cable frequency response.

A typical use of the TM Option 21 capability is for verification of a TMA or duplexer. Other potential applications include CATV installation and maintenance measurements requiring a source that is combined with a spectrum analyzer. EMC pre-compliance testing, for example, may be performed to verify the field strength that is radiated. Here, a tracking generator acts as stimulus, while a spectrum analyzer behaves as the receiver. Many traditional component test measurements also have requirements that can be satisfied with the Anritsu spectrum analyzer/TM Option 21 configuration.

Specific wireless applications where the Anritsu MS2711D handheld spectrum analyzer with TM Option 21 is especially well suited include: measurement of repeaters, power amplifiers and antenna isolation. This application note focuses on wireless communication applications with TMAs and associated filters.

In a Cell Site, the TMA combines the receive/transmit signals to/from the antenna and provides pre-amplification of the signals received from cellular phones. It is mounted close to the antenna. Verifying the correct receive and transmit signal path is essentially a measurement of filter performance for the two distinct paths and the separation between them.

A number of different types of TMAs are available today. They include the two-port TMA-S, two-port TMA-DD, three-port TMA-D, and four-port dual-TMA-DD.

Tower Mounted Filters are used to limit and direct the correct signals coming from cellular and PCS phones. The two types of Tower Mounted Filters used with cellular antennas are a two-port band-pass filter and a three-port duplexer filter.

3.0 Understanding Transmission Measurements

While there are two fundamental scalar measurements – reflection and transmission – this application note will only discuss the latter. A scalar transmission measurement measures how much signal passes through the device and can be used to determine the device’s gain or insertion loss.

To better understand how to make a transmission measurement you must first know a few basic transmission terms. The transmission coefficient, τ , is defined as the ratio of the transmitted voltage, $V_{\text{transmitted}}$, to the incident voltage, V_{incident} , as shown in Figure 2.

$$\tau = V_{\text{transmitted}}/V_{\text{incident}}$$

Since typical spectrum analyzer displays are logarithmic, the transmission coefficient can be expressed in dB as:

$$20 \log [\tau] \text{ or } 20 \log [V_{\text{transmitted}}] - 20 \log [V_{\text{incident}}]$$

This coefficient can be applied to all transmission measurements, with both passive and active DUTs.

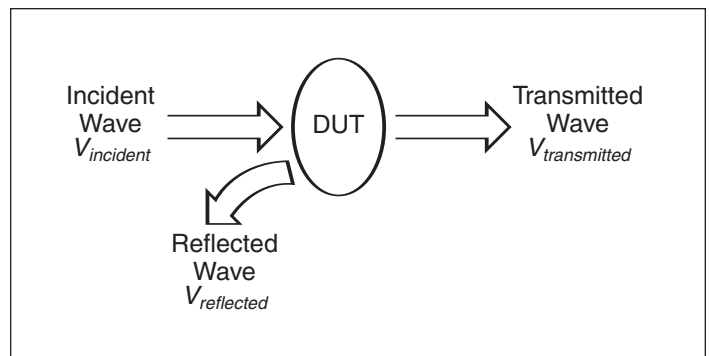


Figure 2. This graphic depicts the transmission and reflection parameters that are important to know when making a transmission measurement.

3.1 Making the Transmission Measurement

TM Option 21 is the perfect tool to perform transmission and isolation tests. In conjunction with MS2711D's excellent sensitivity and dynamic attenuation, it provides an easy test solution for amplifier measurements. To make a transmission measurement with the Anritsu MS2711D Spectrum Analyzer and TM Option 21, you will need the basic setup defined in Figure 3.

During the measurement, the output of TM Option 21 transmits a signal (Tx) to the amplifier (see Figure 4). The MS2711D receiver tracks the signal. This is a typical measurement that can be taken before the TMA is installed. Gain measurements are generally between 10 to 20 dB above the 0 dB reference level established during calibration.

In this example, the TMA-DD measurement was swept across the entire frequency range of the 1960 to 1990 MHz transmit and the 1880 to 1910 MHz receive (Rx) bands. Markers M1 and M2 highlight the signal level in the TMA's receive band where gain is measured. In all four TMA types, gain is measured between the antenna port and the Rx port of the amplifier.

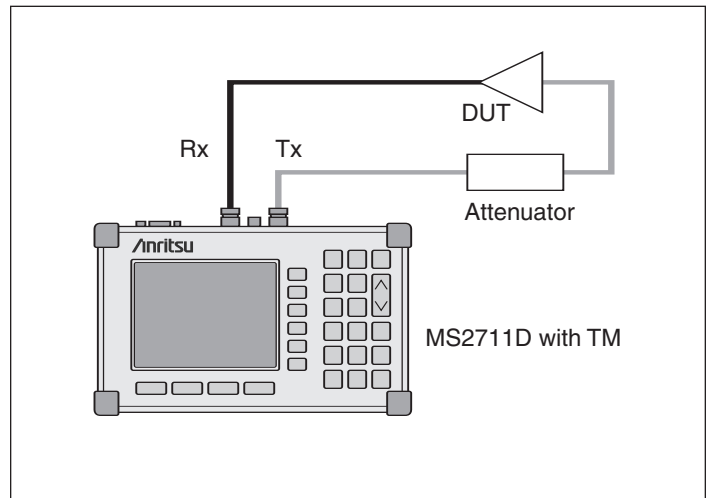


Figure 3. As shown here, the RF output of TM Option 21 is connected to the input of the DUT. The output of the DUT is connected to the spectrum analyzer input of the MS2711D.

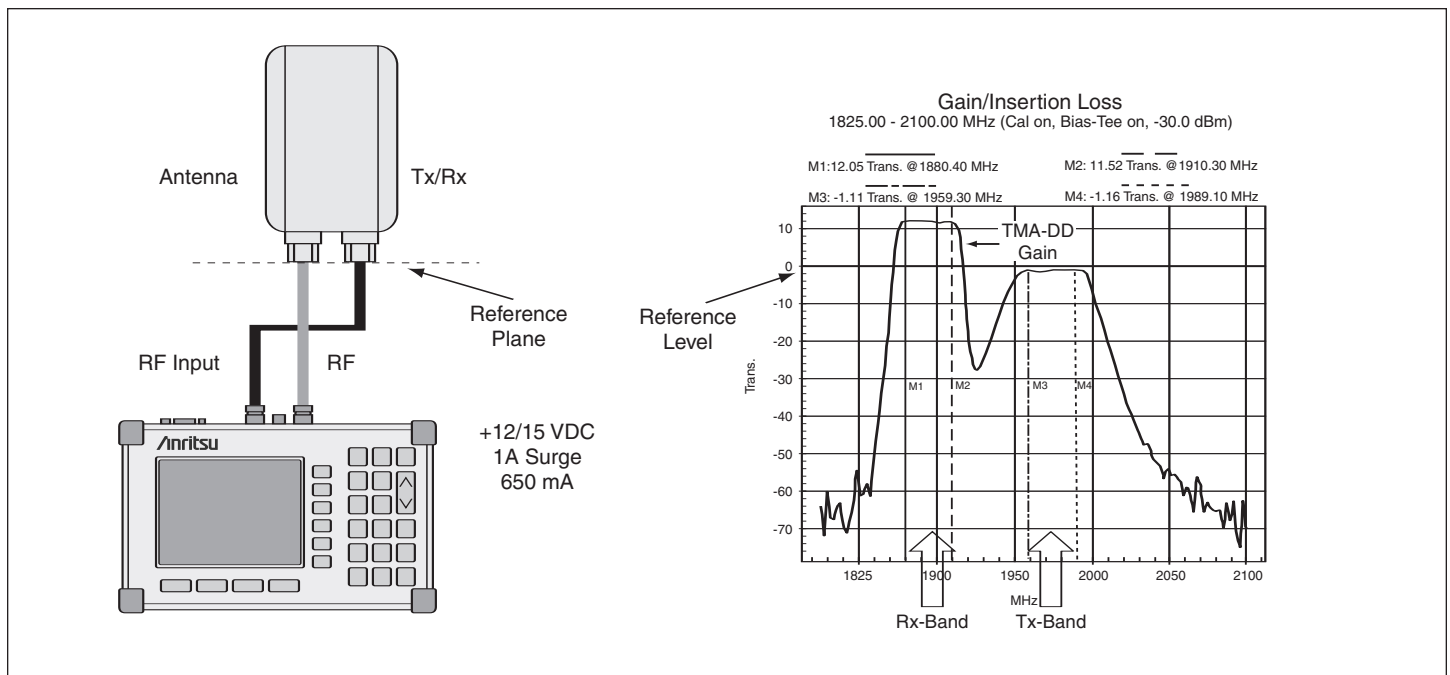


Figure 4. The set-up for a TMA-DD gain measurement using MS2711D/TM Option 21 is illustrated here. Note that to prevent over-saturation of the receive signal or possible damage to the TMA, this test requires an external 30 dB attenuator.

To make this measurement, first configure the spectrum analyzer/transmission measurement system according to Figure 3. Next, turn the transmission measurement on by hitting the **MODE** hard function key. Use the up/down arrow keys to select the **TRANSMISSION MEASUREMENT** mode. Hit the **ENTER** key to complete the selection. The MS2711D is now in **TRANSMISSION MEASUREMENT** mode. Next:

1. Set up the desired control settings (start/stop frequency, span, resolution bandwidth, dynamic attenuation, etc.), and appropriate external attenuation with the device connected (see Figure 5).
2. Establish a 0 dB reference level. To do this, remove the DUT and calibrate the tracking generator signal level with the output cable directly coupled to the input cable. Select **CALIBRATE TM** in the measurement menu.
3. Re-insert the DUT. Obtain the transmission measurement by sweeping the DUT over the desired frequency span.

Since amplifiers increase power over a limited power range, care must be taken to manage the power levels at the input and output of the amplifier. If linear operating-power levels are exceeded, then the amplifier gain measurements may have errors (see Figure 5).

Choose the value of the source attenuator between the MS2711D signal source and the amplifier input so that the specified amplifier output power for 1 dB gain compression is not exceeded. The MS2711D input attenuator should be set so that the maximum power to the MS2711D mixer is always less than -45 dBm.

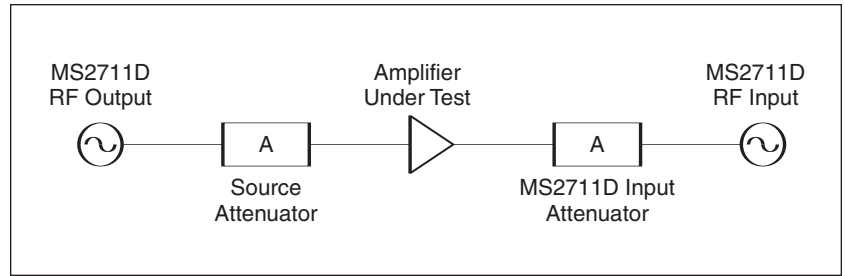


Figure 5. Here, the two critical power levels that must be managed are the specified amplifier output power for 1 dB gain compression and the power level at the MS2711D input mixer.

Table 1 offers an example of how to calculate these power levels and then select the proper attenuator values.

Table 2 shows the power levels with the source attenuator removed. Here the amplifier output power is 2 dBm and would cause non-linear operation of the amplifier. The MS211D input mixer would see -18 dBm and therefore cause an amplitude measurement error.

MS2711D Source Power		-10 dBm
	minus	$-$
Source Attenuator		30 dB
	plus	$+$
Specified Amplifier Gain		12 dB
	equals	$=$
Amplifier Output Power		-28 dBm
	minus	$-$
MS2711D Input Attenuator Setting		20 dB
	equals	$=$
Power Level into the MS2711D mixer		-48 dBm

Table 1. Example power levels calculation for an amplifier with 12 dB gain and 1 dB gain compression power.

MS2711D Source Power		-10 dBm
	minus	$-$
Source Attenuator		0 dB
	plus	$+$
Specified Amplifier Gain		12 dB
	equals	$=$
Amplifier Output Power		2 dBm
	minus	$-$
MS2711D Input Attenuator Setting		20 dB
	equals	$=$
Power Level into the MS2711D mixer		-18 dBm

Table 2. Example of power levels calculation with the source attenuator removed.

With the amplifier and source attenuator inserted, turn on the MS2711D. Select the **TRANSMISSION MEASUREMENT** mode. Select the appropriate frequency range and reference level for the amplifier under test (see Figure 6). Replace the amplifier with a through connection.

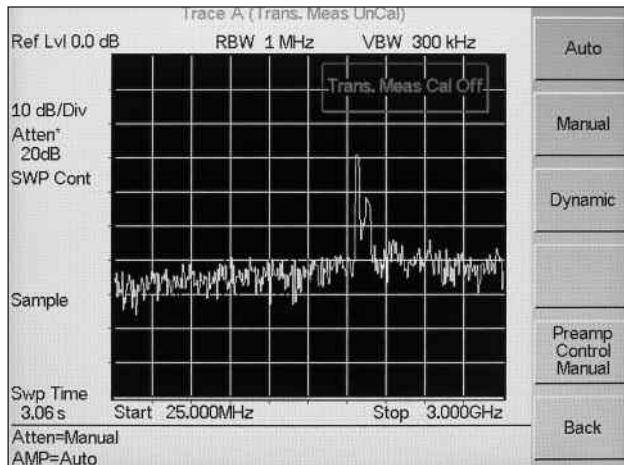


Figure 6A. Display of the amplifier response using the default 25 MHz to 3 GHz frequency range and 0 dB reference level.

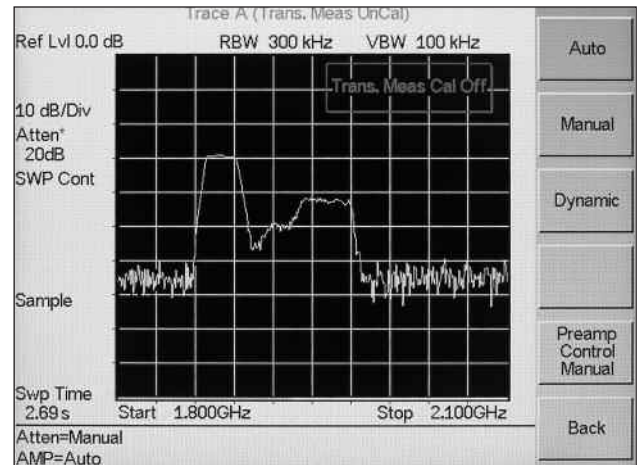


Figure 6B. Display of the amplifier response after reducing the frequency range to 1.8 to 2.1 GHz and setting the reference level to 20 dB.

Press the **BW/SWEEP** key, the **CALIBRATE TM** soft key, and **ENTER**. This performs a measurement of the test system loss (test cables and source attenuator) and establishes a 0 dB transmission loss level.

Reconnect the amplifier and use markers, as needed, to characterize the amplifier gain profile. If the test frequency range is changed, remove the amplifier and perform a new calibration prior to making amplifier measurements over the new frequency range.

4.0 Measuring Passive Devices

The MS2711D/TM Option 21 configuration is the ideal choice for measuring filters with very deep stop bands of 60 dB or more. TM Option 21 takes advantage of the dynamic attenuation/dynamic preamplifier feature of the MS2711D to yield an effective dynamic range of greater than 90 dB.

The filter response can be measured between the RF In and RF Out ports of the Spectrum Master MS2711D according to the following steps:

1. Connect the filter between the Spectrum Master RF In and RF Out ports (see Figure 7).
2. Set the start and stop frequencies to cover the frequency range of the filter.
3. Disconnect the filter and connect the cables together. Use all adapters and cables that are needed to connect the filter to the Spectrum Master.
4. Calibrate the Spectrum Master for transmission measurements as described in Section 8.0.
5. Reconnect the filter and make the measurements (see Figure 8).

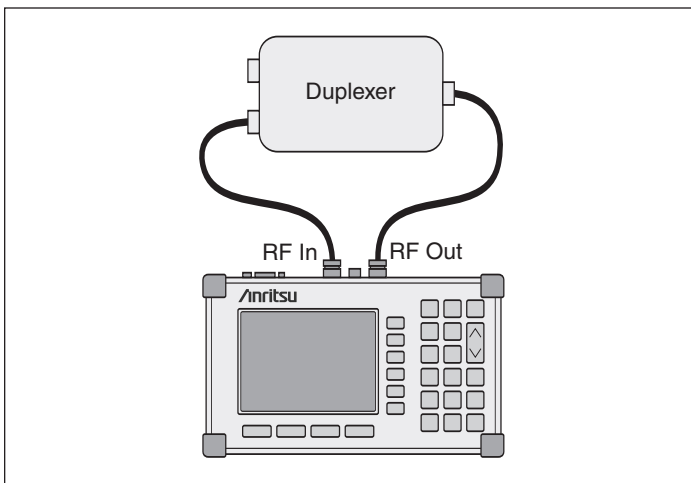


Figure 7. Transmission measurement connections for a passive device.

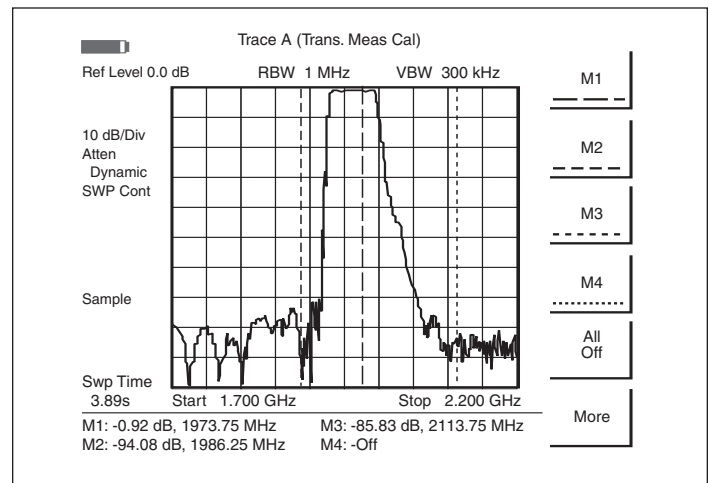


Figure 8. Transmission measurement results for a passive device.

4.1 Filters

Depending on the application, one of four basic filter types may be used. The filter types include a low-pass filter which passes only those signals below a certain frequency, a high-pass filter which passes only those signals above a certain frequency and a band-pass filter which passes only those signals within the pass band and a band-stop, or notch filter that attenuates a narrow slice of spectrum.

Low-pass filters are normally found in applications where the reduction of the harmonic content of a transmitter is desired. They are also used in the telephone and broadcast industry to limit the higher frequencies of a voice broadcast. Similarly, a high-pass filter blocks the low frequency signal and allows high frequencies to pass.

A good example of using both low-pass and high-pass filters to create a band-pass filter is the bass and treble controls on a stereo or car audio system. Band-pass filters are built into TMAs and duplexers.

A Notch filter is typically used to reduce the amplitude of an off-frequency interfering signal at a receiver input. Often more than one notch filter is employed to mitigate odd-order intermodulation problems at high level sites that are populated with many transmitters.

4.2 Duplexer Versus Diplexer

A duplexer allows simultaneous transmitter and receiver operation in a single antenna system. The duplexer isolates the receiver from the transmitter and reduces Tx noise. By comparison, a diplexer is a device that permits parallel feeding of one antenna from two transmitters at different frequencies, without the transmitters interfering with each other. Duplexers and diplexers are very similar and frequently confused.

The duplexer separates 2 frequencies within the same band, while the diplexer separates 2 different bands. Diplexers are three-port frequency-dependent devices that may be used as a separator or a combiner of signals. The device consists of two fixed, tuned band-pass filters sharing a common port. The common port and the output of the two filters (Rx and Tx) form the three terminals of the diplexer. Signals applied to the common port are combined in accordance with the pass-band frequencies of the filters. Signals applied to one uncommon port are isolated from the other uncommon port and are then combined at the common port.

Diplexers are the simplest form of a multiplexer. In contrast, duplexers allow a transmitter operating on one frequency and a receiver operating on a different frequency to share one common antenna with minimal interaction or degradation of the different RF signals.

4.3 Measuring a Band-Pass or Duplex Filter

To measure a band-pass or duplex filter, follow these steps:

- Set MS2711D to **TRANSMISSION MEASUREMENT** mode.
- Connect the filter as shown in Figure 7.
- Set the frequency control settings to the operating frequency of the amplifier. For example, for the PCS band, the starting frequency should be set to 800 MHz and the stopping frequency should be set to 925 MHz.
- Disconnect the filter and connect the cables together. If possible, use all of the adapters and cables that are needed to connect the duplexer to the Spectrum Master.
- Calibrate the Spectrum Master for transmission measurements as described in Section 8.0.
- Reconnect the filter between the Spectrum Master RF In and RF Out ports.
- Measure the band pass characteristics of the filter by measuring the frequency response of the filter’s output power (see Figure 9).

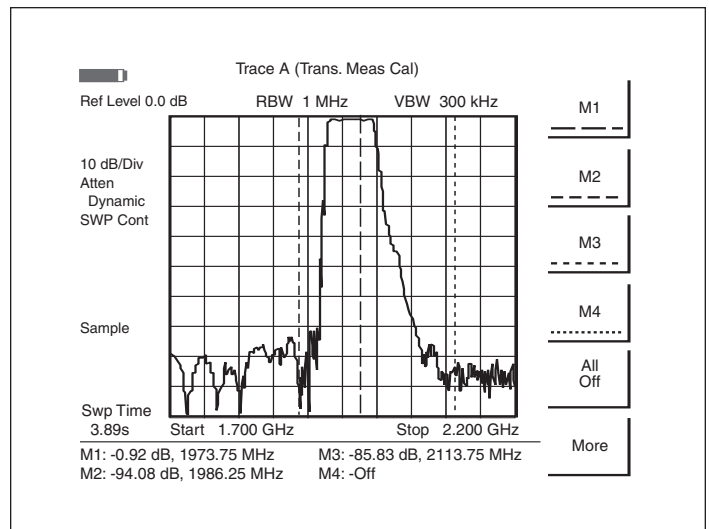


Figure 9. Transmission measurement results for a filter.

5.0 Measuring Active Devices

TM Option 21 can be used to measure amplifiers, provided an external attenuator is installed between the RF Out port of MS2711D and the input of the amplifier. The value of this attenuator depends on the required input signal level into the amplifier. Note that the output power of the signal source is not leveled, making it most suitable for gain measurements in the linear region of an amplifier.

To make accurate amplifier transmission measurements with the MS2711D Spectrum Master, follow the steps:

1. Set MS2711D to **TRANSMISSION MEASUREMENT** mode.
2. Connect the amplifier between the RF Out port of TM Option 21 and RF In port of the MS2711D as shown in Figure 10.

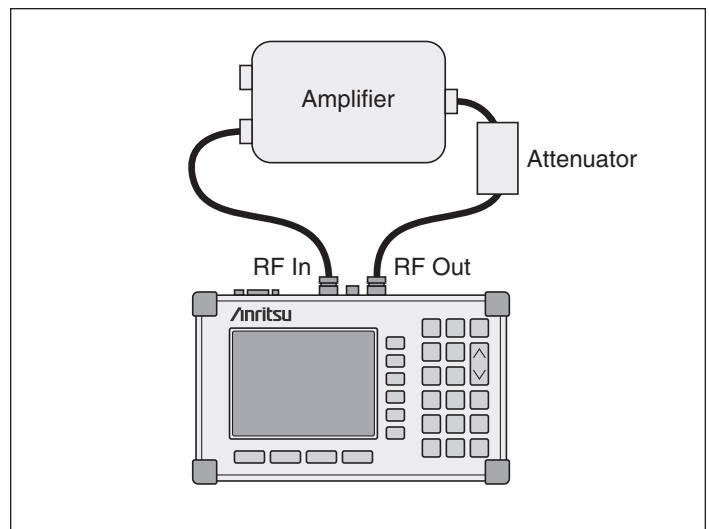


Figure 10. Transmission measurement connections for an amplifier.

3. Set the frequency control settings to the operating frequency of the amplifier. For example, for the PCS band, the start frequency should be set to 800 MHz and the stop frequency should be set to 925 MHz.
4. Set the output level to approximately -30 dBm by adding a 20 dB attenuator to the output.
5. Disconnect the amplifier and connect the cables together. Use all of the adapters and cables that are needed to connect the duplexer to the Spectrum Master.
6. Calibrate the Spectrum Master for transmission measurements as described in Section 8.0.
7. Reconnect the amplifier between the Spectrum Master RF In and RF Out ports.
8. Measure the gain of the amplifier by measuring the frequency response of the amplifier without power. Then measure the gain with the power supply to the amplifier tuned on (see Figures 11 and 12).

5.1 Measuring Tower-Mounted Amplifiers

To measure the TMA before it is installed in the antenna system you must ensure that the input level on the antenna side of the TMA does not significantly exceed the maximum input level value specified in the TMA data sheet (generally about -40 dBm). The level of the RF output generator is approximately -10 dBm and a 30 dB attenuator must be inserted between the RF output and the TMA.

For TMAs with a high level of gain you may need to protect the input of the Spectrum Analyzer by selecting additional attenuation at the RF input of the test equipment. The maximum permitted power at the input is 20 dBm, although 43 dBm applied indefinitely will not cause damage. For good measurements results, it is recommended that the signal after the internal attenuator be below -45 dBm.

If an overload occurs on the TMA, an invalid, low-gain value will be measured. To determine the gain of the TMA in this situation, make a measurement with the supply voltage connected and then disconnected. Compare the two test results.

Note that most TMAs require a DC source typically 18V DC, provided by the base station, to power them up. For testing purposes, the MS2711D with Bias Tee Option 10 can provide the DC voltage for the TMA. Also note that not all TMAs have a bypass switch installed and therefore may need to be bypassed with a jumper.

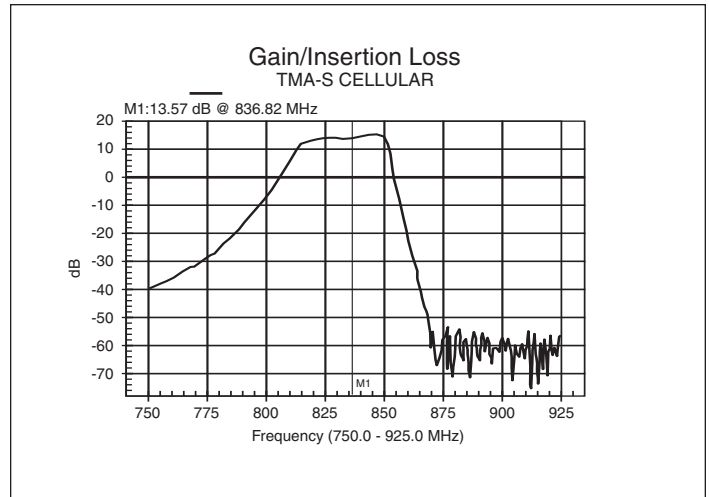


Figure 11. Transmission measurement results for an amplifier.

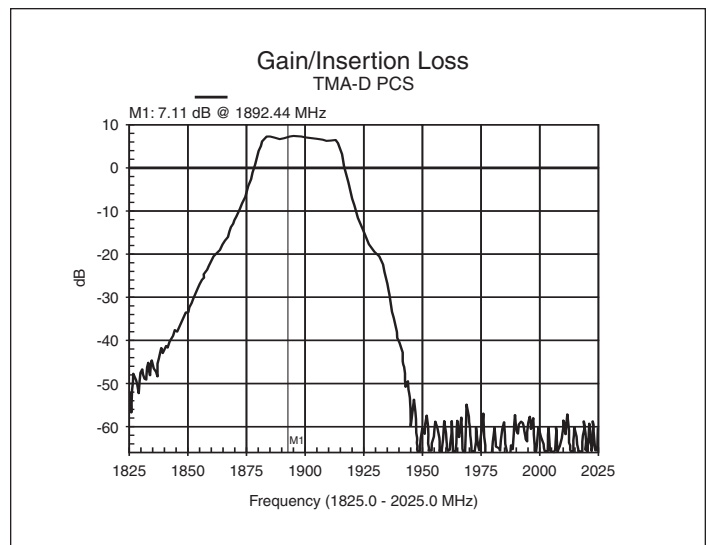


Figure 12. Shown here is the typical gain response from a TMA-D in a cell system. A reference line has been placed at 0 dB after calibrating the Spectrum Master. Note that the gain is only to the Rx band. The insertion gain trace for TMA-D looks similar to that of the TMA-S. Only the receive band shows any gain. The transmit port is left disconnected for this measurement.

5.2 Measuring a Two-Port TMA-S

The TMA-S is a receive-only TMA which connects between the receive antenna and the radio (see Figure 13). Its purpose is to boost weak signals. In a two-port TMA-S, one port is connected to the receive antenna while the other is connected to the base station. Two antennas are required, one for transmit and one for receive. The transmit side is not connected to this type of TMA.

The main components in the TMA-S are a band-pass filter which passes only signals at the receive bandwidth, a low noise amplifier (LNA) which provides the signal gain, and a bypass switch which opens when the TMA is powered up and closes when there is no power (see Figure 14).

A two-port TMA-S can be measured according to the steps detailed in Section 5.0. The transmission measurement results for a two-port TMA-S are depicted in Figure 15.

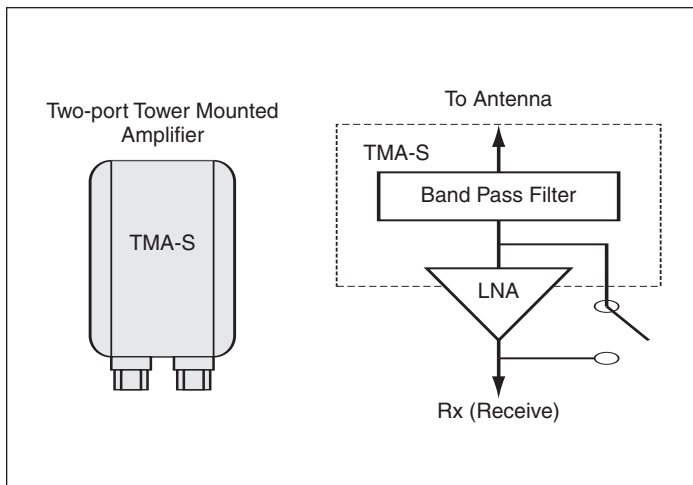


Figure 14. Shown here is a receive-only TMA-S with bypass switch

5.3 Measuring a Two-Port TMA-DD

The dual-duplex TMA (TMA-DD) is commonly called a transceiver as one port is connected to the antenna while the other connects to the base station. Unlike the TMA-S, the TMA-DD is used in systems where a single antenna is used to transmit AND receive (see Figure 16). Also, there must be a single connection to the base station for both transmit and receive. Even though both transmit and receive signals pass through the TMA-DD, the receive signal is the only one that passes through the LNA. No gain is applied to the transmit signal.

The TMA-DD is composed of the same components as a TMA-S, with the addition of 2 duplex filters that provide isolation between the Tx and Rx at the antenna and the base station (see Figure 17).

A two-port TMA-DD can be measured according to the steps detailed in Section 5.0, with one exception. In Step 3, set the output level to -40 dBm by adding a 30 dB attenuator to the output. The transmission measurement results for a two-port TMA-DD are depicted in Figure 18.

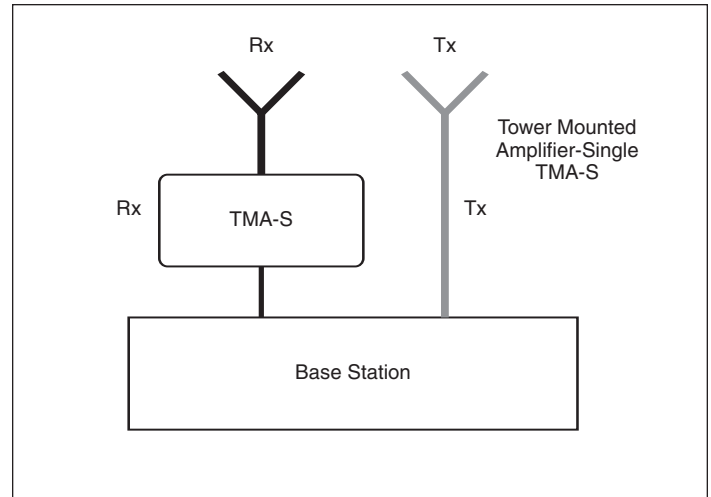


Figure 13. Shown here is a TMA-S. This configuration is specific to systems that implement separate antennas for transmit and receive.

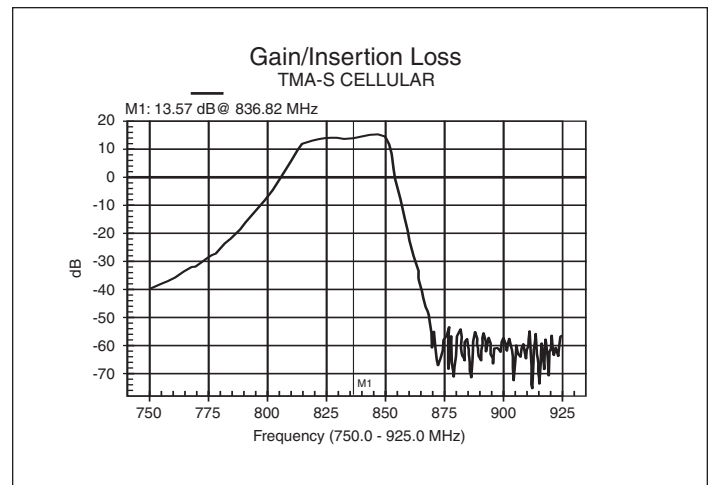


Figure 15. This is the typical measured gain response from a TMA-S for a cellular system. A reference line has been placed at 0 dB after calibrating the Spectrum Master. Note that the gain is only in the Rx band.

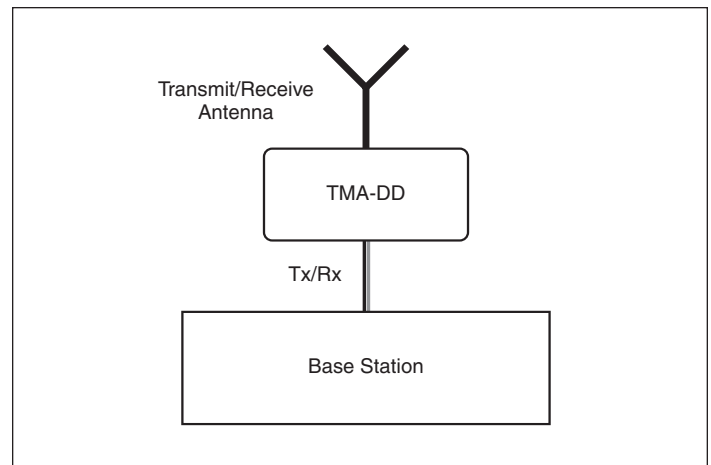


Figure 16. This diagram illustrates a TMA-DD.

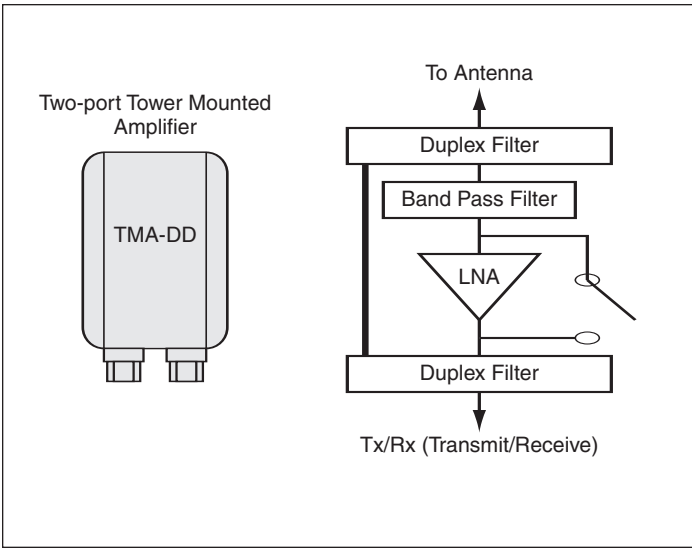


Figure 17. Shown here is a two-port TMA-DD with bypass switch.

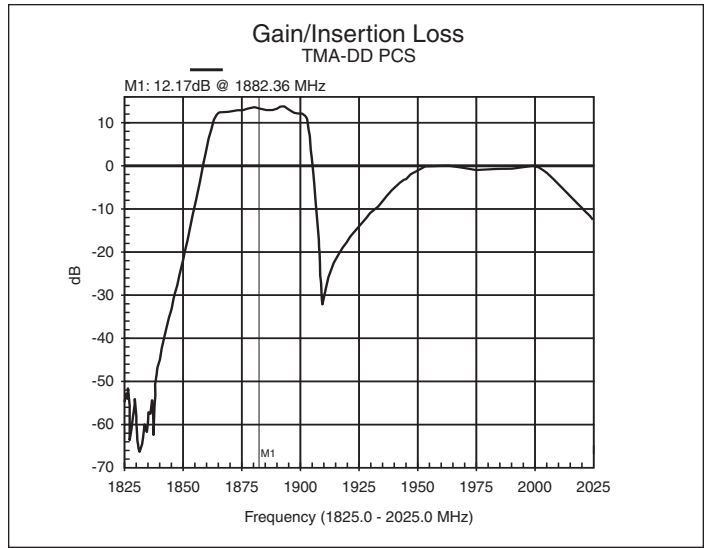


Figure 18. This graph illustrates the typical gain response from a TMA-DD. The gain is only applied to the receive signal. A gain of about 12 dB above the reference line is achieved. Because the transmit signal also passes through the same cable as the receive signal, but no gain is added to it, the transmit band is at the 0 dB reference line.

5.4 Measuring a Three-Port TMA-D

The duplex TMA (TMA-D) is used for radio systems with a single antenna port connection for transmit and receive (see Figure 19). There are separate ports for transmit and receive (to/from the base station), and a third connection to the antenna. Even though both transmit and receive signals pass through the TMA-D, the receive signal is the only one that passes through the LNA. There is no gain applied to the transmit signal.

The TMA-D is comprised of the same components as a TMA-DD, with one exception. The TMA-D requires only one duplex filter to provide isolation between Tx and Rx at the antenna (see Figure 20).

A three-port TMA-D can be measured according to the steps detailed in Section 5.0. The transmission measurement results for a three-port TMA-D are depicted in Figure 21.

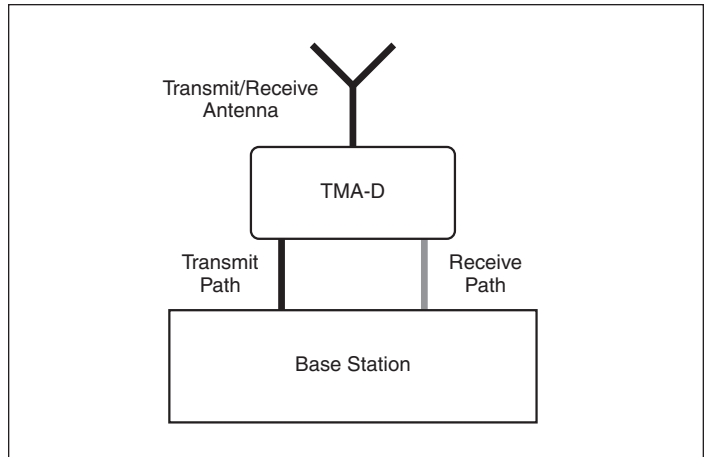


Figure 19. This illustration depicts a three-port TMA-D.

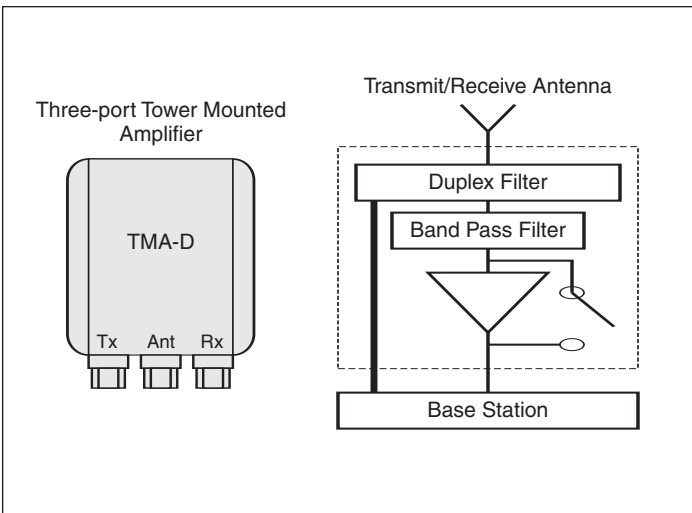


Figure 20. Shown here is a three-port TMA-D with bypass switch.

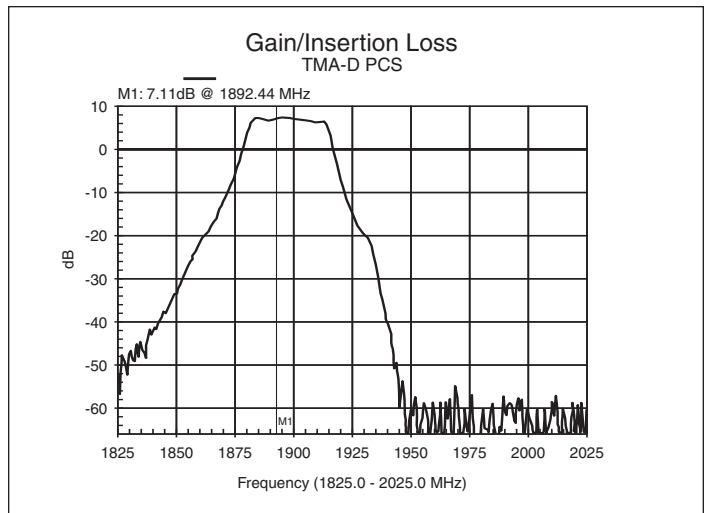


Figure 21. This graph reflects the typical gain response from a TMA-D for a cellular system. A reference line was placed at 0 dB after calibrating the Spectrum Master. Note that the gain is only to the Rx band. The insertion gain trace for TMA-D looks similar to that of TMA-S. Only the receive band shows any gain. The transmit port is left disconnected for this measurement.

6.0 Measuring System Gain

The TMA measurement procedures discussed thus far should be used for testing TMA functionality exclusively. In contrast, a system gain measurement is a method of verification that can be used on a TMA after it has been installed. It requires the use of the system's Tx antenna to deliver a signal to the Rx antenna (see Figure 22).

When measuring TMA gain, the components in the receive path of the mobile-radio base station must be considered. The TMA should compensate for the receive cable loss. Also, the TMA may not be used for excessive level gain as this can make the defined Rx parameters (e.g. for detecting Rx level handover or for power regulation at the mobile station) impracticable or even dangerous.

To make a system gain measurement, follow these steps:

1. Measure the insertion gain/loss with the Bias Tee option turned off. Save the display.
2. Turn the Bias Tee option on. Take another insertion gain/loss measurement. Compare this trace to the previously saved display.
3. Calculate the dB gain by measuring the difference between the two traces.

Note that while this method may be used to verify that the TMA is functioning, it should not be used as an accurate gain measurement of the TMA. Performance of this test requires that a sufficiently large signal reach the Rx antenna.

Due to insertion losses in the system from such things as cables, connectors, and antennas, the reference level used for measuring gain is not 0 dB. Rather, the gain is the difference between measurements taken with the Bias Tee turned off and then on. Be advised also that the gain of a TMA without a bypass switch cannot be measured. However, by connecting and disconnecting the power, it is possible to determine whether the TMA is functional.

To make an accurate amplifier measurement, follow the steps detailed in Section 5.0. The transmission measurement results are depicted in Figure 23.

The relative gain measurement of the TMA, after installation, is very similar to other gain measurements with the exception of signal-level offsets due to cable losses and the system isolation level shown by the blue line in Figure 23. Here, two plots are compared with the trace overlay feature. The black plot represents a non-active Bias Tee. The blue plot gain depicts when the Bias Tee is applied to the TMA. A comparison of the amplifier plots before and after Bias Tee activation will not produce great accuracy. It will, though, provide a good test for operation and verification of the TMA-DD, TMA-D, TMA-S or dual-TMA-DD.

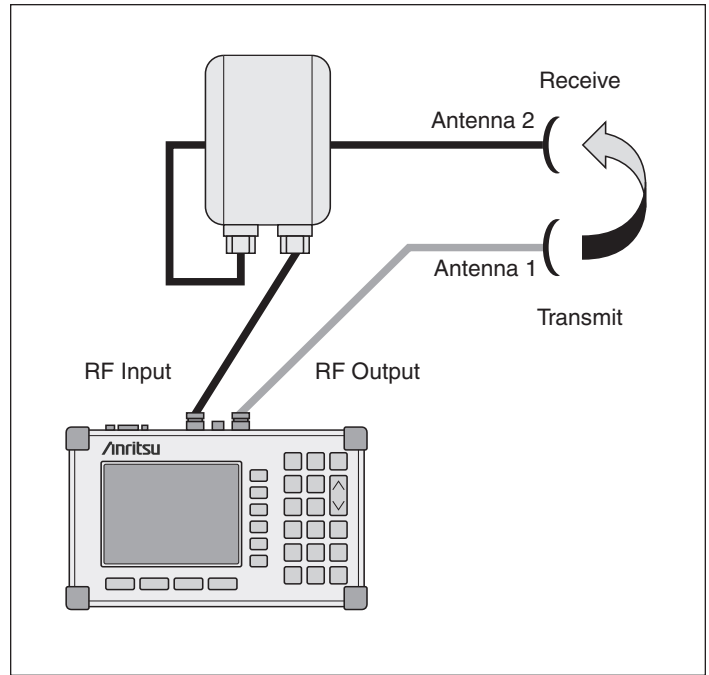


Figure 22. Here is a typical system gain measurement setup for a TMA-D.

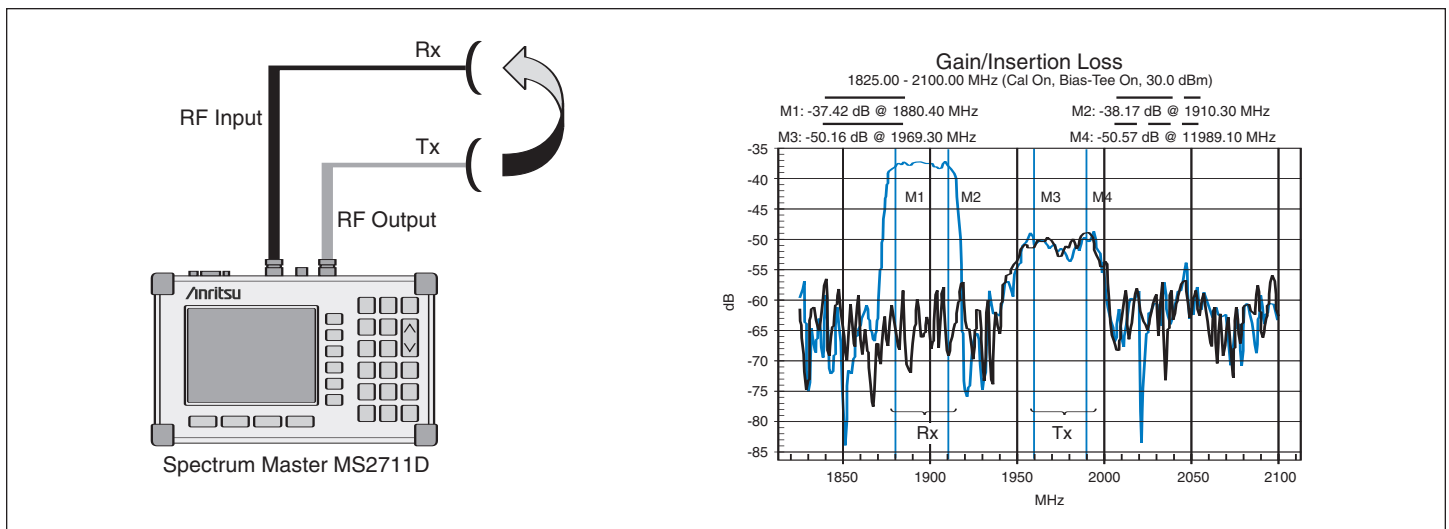


Figure 23. Transmission measurement connections and results for a TMA. The graph indicates TMA gain of about 12 dB, which is very close to the specified TMA gain of 14 dB.

7.0 Measuring Antenna Isolation

TM Option 21 can perform an antenna isolation test to determine the presence of any unwanted coupling between antennas in adjacent systems. If the transmit antenna were to transmit in a specific direction, then the amount of signal from it to the adjacent receive antenna would need to be minimized.

This test can be performed on systems with or without a TMA. Typical antenna-to-antenna isolation shows results from -50 to -100 dB below the 0 dB reference line established by calibration. When the measured isolation level is more negative, there is a better chance of co-location without system degradation. An isolation level of -89 dB (as in this example) is very good. RF system engineers/technicians must determine the “acceptable level” for their particular system. If the measured antenna-to-antenna isolation is closer to -60 dB, then re-alignment of the antennas may be necessary to improve isolation. In some cases, alternative channel plans must be used to ensure that all systems at the same location can operate successfully.

When conducting this test, make sure that the input level on the antenna side of the TMA does not significantly exceed the maximum input level value specified in the TMA data sheet (generally about -40 dBm).

To make an accurate amplifier transmission measurement, follow the steps detailed in Section 5.0. The antenna isolation measurement results are depicted in Figure 25.

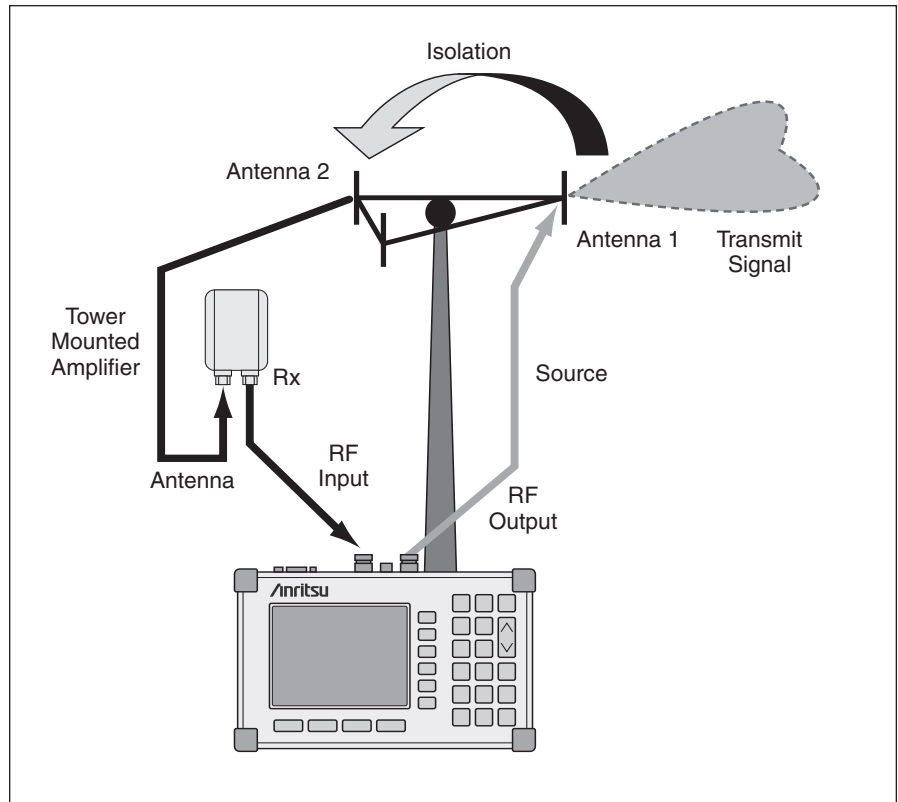


Figure 24. Transmission measurement set-up for measuring antenna isolation.

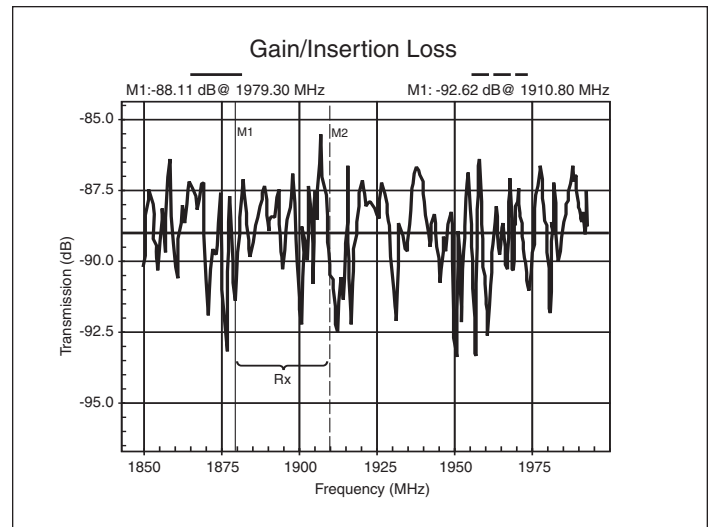


Figure 25. Antenna isolation measurement results.

8.0. How to Calibrate

To calibrate the Anritsu MS2711D Spectrum Master for transmission measurements, use the set-up specified in Figure 26. Follow these steps:

1. Press the **FREQ/SPAN** key. Set the desired frequency range.
2. Press the **BW/SWEEP** key. Then, press the **Calibrate TM** soft key.
3. Following the on-screen prompt, connect a phase-stable cable between the RF Out and RF In ports. If an attenuator is required for the measurement, connect it directly to the RF Out port and connect the cable to the attenuator output. The displayed trace before calibration should be similar to Figure 1A.
4. Press the **ENTER** key. The unit will sweep once and store transmission correction information. On the next sweep, the trace should be flat at the 0 dB reference line and ready for measurements. The calibration information is lost when the instrument is turned off.
5. Following calibration, verify that the trace is displayed at the 0 dB reference point.

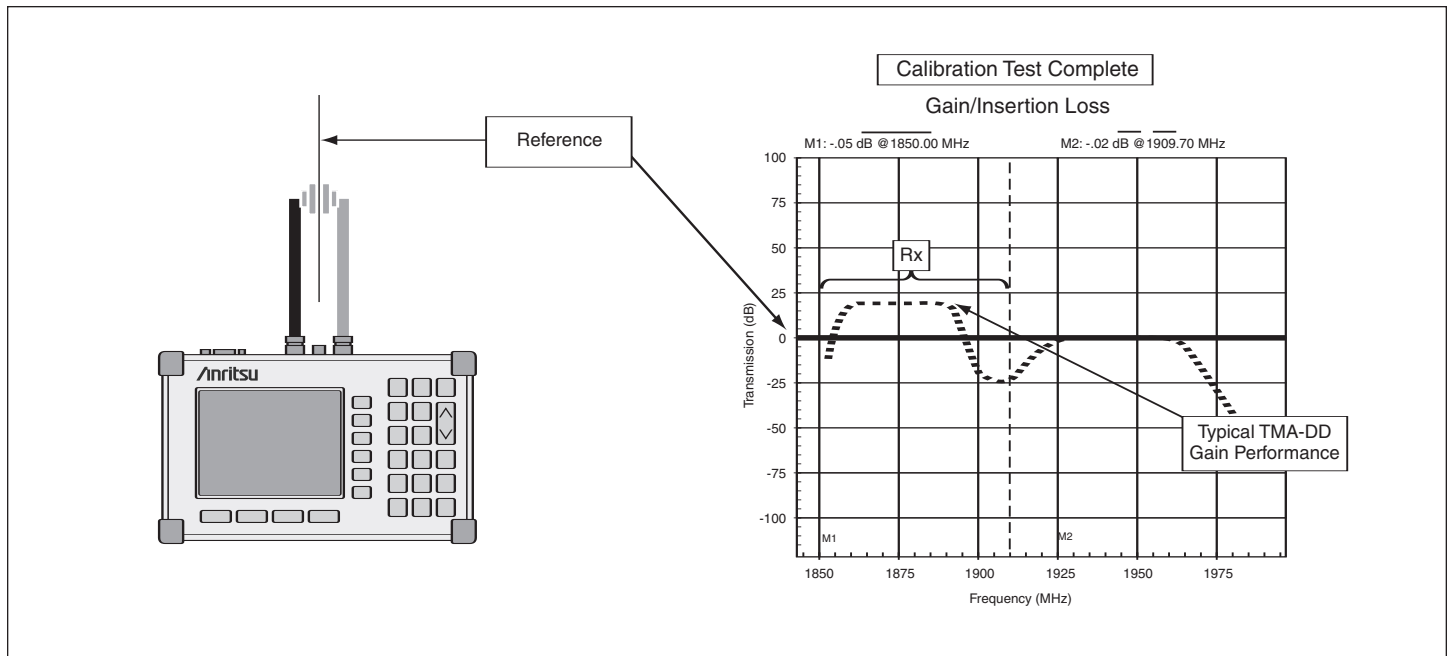


Figure 26. TM Option 21 calibration setup. Note that ripple can be reduced by including a 6 dB attenuator in the transmission path during both calibration and measurement.

9.0. Conclusion

The combination of Anritsu's MS2711D Spectrum Master and TM Option 21 provides an ideal tool for measuring amplifiers within the 25 MHz to 3 GHz frequency range. TM Option 21's unique DYNAMIC ATTENUATION mode automatically optimizes input signal levels and dynamic range.

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