

Agilent 85301B/C

Antenna Measurement Systems 45 MHz to 110 GHz

Configuration Guide

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Introduction

This Antenna Measurement Systems Configuration Guide will help you configure a custom Agilent Technologies 85301B or 85301C antenna measurement system that meets your measurement requirements. This guide is primarily for those customers who desire to design, integrate, and install their own antenna measurement systems using Agilent antenna test instrumentation. The guide will lead you through all the steps. For the do-it-yourself customer, this guide will assist you in determining what instrumentation to order from Agilent Technologies. Your Agilent Technologies sales engineer will be glad to assist you in procuring the instrumentation. If desired, technical assistance is available from systems engineers who are experienced in configuring antenna measurement systems.

Some customers may prefer the design, integration, and installation of an antenna instrumentation subsystem be performed for them by a solution supplier who has extensive antenna configuration experience. Nearfield Systems, Inc. (NSI), an Agilent Technologies channel partner, can provide this service. NSI will work with you to understand your measurement needs, and then design an RF subsystem that meets your requirements. In addition to system design and configuration, NSI provides system integration, on-site installation, and performance verification to ensure that the system delivered meets your requirements. NSI will provide a complete RF subsystem, reducing your risk, and eliminating the need for your personnel to design and configure a system.

Other customers may need an application solution: a complete system solution that addresses all aspects of a measurement application, such as a complete near-field or far-field measurement system. You may be designing, building, and testing antennas instead of an antenna measurement system. Agilent Technologies recommends Nearfield Systems, Inc. for complete near-field and far-field application solutions. NSI has the measurement expertise to supply a complete system to meet your application requirement. NSI can configure and supply the RF subsystem, the positioning subsystem, provide the measurement application software, and provide system installation and training.

If you choose to use NSI's services, you will not need to use this configuration guide; NSI will carefully consider all the issues covered in this configuration guide. Your Agilent sales engineer has a technical qualification guide that can be used to help define your measurement requirements, and he or she will be happy to work with you to define your requirements. Your sales engineer can also assist you in contacting NSI, or you can contact NSI directly (California, USA) at (310) 518-4277, FAX (310) 518-4279, by e-mail: sales@nearfield.com, or visit their extensive website at www.nearfield.com.

Main parts of an antenna range

In general, an antenna range measurement system can be divided into two separate parts: the transmit site and the receive site (see Figure 1). The transmit site consists of the microwave transmit source, amplifiers, and the communications link to the receive site. The receive site consists of the receiver, LO source, RF downconverter, positioner, system software, and a computer.

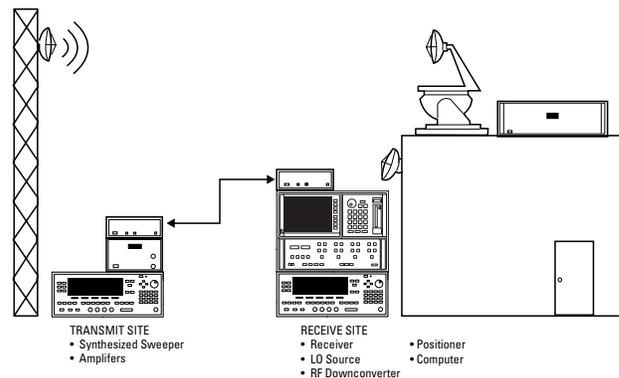


Figure 1. Far-field antenna range

Configuration steps

Configuring an Agilent 85301B/C antenna measurement system involves the following steps. Each step is described in detail in this guide.

1. Select the transmit source, amplifiers, cables and method used to obtain the reference channel signal, and determine the minimum transmit power.
2. Determine the worst-case antenna range transfer function based on range length, maximum test frequency, and transmit antenna gain.
3. Calculate the estimated test channel power level based on transmit power, range transfer function, and expected test antenna gain.
4. Determine required measurement sensitivity based on test channel power level, required measurement dynamic range, and accuracy.
5. Select either an 85301B or 85301C antenna measurement system depending on range type and required microwave performance.
6. Configure the receive site.
7. Calculate the reference channel power level.
8. Review the complete configuration for accuracy and completeness.
9. You may wish to review the completed configuration with your Agilent Technologies sales representative and/or systems engineer, or with Nearfield Systems, Inc.

How to use this guide

You can use Figures 16 through 25 at the end of this guide as worksheets for configuring your antenna measurement system. The bubble numbers in these figures (example: ❶) indicate that a value should be entered. These numbers correspond directly with the bubble numbers by the instructions in this guide. We recommend that you photocopy Figures 16 through 25 and fill them in as you go through the instructions.

General range parameters

❶ Record the range type and length in Figure 16. If a compact antenna test range (CATR) is to be used, record the manufacturer and model number.

Transmit site configuration

The following steps are required to configure the transmit site:

- Select the transmit source.
- Determine RF cable losses and transmit power based on range type.
- Decide how the reference channel signal will be obtained.

Transmit source selection

❷ Record the required minimum and maximum test frequencies for the antenna range in Figure 17. Based on these frequency requirements, select a transmit source from Table 1 below, check the model number in Figure 17, and record its maximum output power level at the upper test frequency on Figure 17. Agilent recommends using only sources with front panel controls; this will allow diagnostics to be performed on the system if necessary. The 1 Hz frequency resolution (Option 008) is recommended for both the RF and LO sources to allow the frequency resolution to be 1 Hz instead of 1 kHz. While most users desire a 1 Hz frequency resolution, it has the additional benefit of ensuring that the signal presented to the receiver is within its passband. If the system is to be used for measuring antennas in pulsed mode of operation, fast pulse modulation (Option 006) should be ordered.

Table 1. Agilent 85301B/C compatible transmit sources

Model Number	Description	Output Power (dBm)
83620B	10 MHz to 20 GHz synthesized sweeper with front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+13 dBm
83622B	2 GHz to 20 GHz synthesized sweeper with front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+13 dBm
83623B	10 MHz to 20 GHz synthesized sweeper with high output power and front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+17 dBm
83624B	2 GHz to 20 GHz synthesized sweeper with high output power and front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+20 dBm
83630B	10 MHz to 26.5 GHz synthesized sweeper with front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	<20 GHz, +13 dBm (20 to 26.5 GHz, +10 dBm)
83640B	10 MHz to 40 GHz synthesized sweeper with front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	<26.5 GHz, +10 dBm (26.5 to 40 GHz, +6 dBm)
83650B	10 MHz to 50 GHz synthesized sweeper with front panel controls. Recommended options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	<26.5 GHz, +10 dBm 26.5 to 40 GHz, +5 dBm (40 to 50 GHz, +2.5 dBm)

Frequency coverage above 50 GHz is available using the Agilent 83550 series millimeter-wave source modules. Source modules are available in R (26.5 to 40 GHz), Q (33 to 50 GHz), U (40 to 60 GHz), V (50 to 75 GHz) and W (75 to 110 GHz) bands. Refer to "Millimeter-wave configuration," under "Optional Capabilities."

Transmit site RF cabling

The transmit site RF cabling will depend on the transmit amplifier and the method used to obtain the reference channel signal. The amplifier should be positioned as closely as possible to the transmit antenna to preserve maximum output power at the transmit antenna.

- 3 If no transmit amplifier is to be used, record the length in meters of cable A1. Skip to 5.
- 4 If a transmit amplifier is to be used, record the frequency range, gain and maximum output power of the transmit amplifier, as well as the length in meters of cables A2 and A3. For example, the frequency range of the Agilent 8349B microwave amplifier is 2 to 20 GHz with 14 dB of gain and +20 dBm output power.
- 5 Record the nominal gain of the transmit antenna. If more than one antenna is used to cover the required frequency range, record the nominal gain of each antenna.

Agilent Technologies can also provide GPIB controllable switch matrices for remote switching of the transmit antennas.

Reference channel signals

Almost all outdoor ranges and some long indoor ranges obtain the reference channel signal using a stationary reference antenna to receive a portion of the radiated transmit signal. Shorter indoor ranges can often use a coupled reference signal to route the reference channel signal to the receiver using coaxial cable or waveguide.

If a radiated reference will be used, skip to 7.

6 If a coupled reference is chosen, one or more directional couplers must be chosen to cover the desired frequency range. Table 2 lists typical coupler parameters. To maximize transmit and reference channel power, select a coupler with the lowest coupling factor and insertion loss that matches the frequency range of the transmit antenna. Broadband couplers (1 to 40 GHz) are also available with 16 dB coupling factors if sufficient power is available. Record the lengths of cables A4 and A5 and the insertion loss and coupling factor of the directional coupler in Figure 17.

Table 2. Directional coupler data

Description	Frequency Range (GHz)	Insertion Loss (dB)	Coupling Factor (dB)
778D	0.1 to 2	0.6	20
87300B	1 to 20	1.5	10
87300C	1 to 26.5	1.7	10
87301D	1 to 40	1.9	13
87301E	2 to 50	2.0	10
Narda 4226-10	0.5 to 18	1.5	10
Narda 4202B-10	1 to 12.4	1.3	10
Narda 4203-10	2 to 18	2.0	10

Cable A4 should be kept as short as possible to preserve transmit power, and can be eliminated if the coupler can be connected directly to the transmit antenna.

Transmit power

7 From the parameters recorded in Figure 17, determine the power level at the input to the transmit antenna by subtracting the cable losses and adding amplifier gain to the output power level of the transmit source. Insertion loss curves for the Agilent 85381 series cables are shown in Figures 12 and 13. Be careful to select a cable that will cover the desired frequency range. Use the maximum test frequency to determine the worst-case transmit power level.

Range transfer function

The range transfer function (P_r/P_t) of an antenna range determines the difference in power levels between the input to the transmit antenna and the output of an isotropic (0 dBi) antenna located at the receive site. This range transfer function (which is a loss) is due to the dispersive nature of a transmitting antenna. A transmitting antenna radiates a spherical wavefront; only a portion of this spherical wavefront is captured by the receiving antenna.

For a free-space far-field range, this range transfer function is easily determined as follows:

$$P_r/P_t = G_t - (32.45 + 20 \cdot \log(R) + 20 \cdot \log(F))$$

where G_t = Transmit antenna gain (dBi)
 R = Range length (meters)
 F = Test frequency (GHz)

This equation does not account for atmospheric attenuation, which can be a significant factor in certain millimeter-wave frequency ranges.

Compact Antenna Test Ranges (CATRs) achieve greater transfer efficiency by collimating, or focusing the transmitted power using one or more shaped reflectors. Transfer functions for most CATRs are available from the manufacturer's data sheet or on request. If the transfer function is unavailable, use the free-space transfer function as a worst-case estimate.

8 Record the transfer function in Figure 16 for the minimum and maximum test frequencies.

The test channel received power level, P_r (TEST), must be calculated to determine the approximate maximum power level present at the output of the antenna-under-test (AUT). The required measurement sensitivity is determined from the test channel received power level, the required dynamic range, and the required measurement accuracy. The maximum test channel received power level will occur when the AUT is boresighted relative to the transmit antenna.

9 Record the estimated minimum boresight AUT gain, G (AUT), calculate the test channel received power level as follows and record it in Figures 16, 18, and 19.

$$P_r (\text{TEST}) = P_t + P_r/P_t + G (\text{AUT})$$

where P_r (TEST) = Test channel received power level (dBm)

P_t = Transmit power (dBm)

P_r/P_t = Range transfer function (dB, at the maximum test frequency)

G (AUT) = Expected minimum boresight gain of AUT (dB)

Required measurement sensitivity

The required measurement sensitivity of the system is a function of measurement transmit power, range transfer function, AUT gain, required measurement dynamic range, and desired measurement accuracy. The previous steps have determined the approximate power level present at the output of the AUT under boresight conditions.

The measurement dynamic range required to test the AUT is the difference, in decibels, between boresight and the lowest AUT level that must be measured. Examples of these include side-lobe level, null depth, and cross-polarization levels.

10 Record the required dynamic range in Figure 16.

Measurement accuracy is also affected by the measurement sensitivity of the system. The signal-to-noise ratio will directly impact the measurement accuracy of the system for both amplitude and phase measurements. Figure 2 illustrates the relationship between signal-to-noise ratio and magnitude and phase errors.

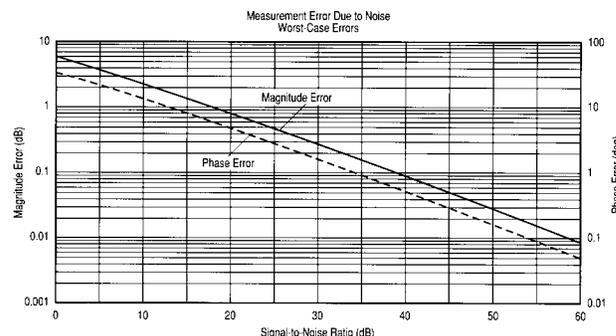


Figure 2. Measurement accuracy as a function of signal-to-noise ratio

11 Record the required signal-to-noise ratio in dB in Figure 16.

The overall system measurement sensitivity required is the test channel received power level minus the sum of the required dynamic range and signal-to-noise ratio.

12 Calculate the required measurement sensitivity by subtracting the required dynamic range and signal-to-noise ratio from the test channel received power level. Record the value in Figure 16.

The required measurement accuracy for low-level AUT responses is not always as stringent as the accuracy required for high-level AUT responses.

Selecting the system

Figure 3 will help you select either an Agilent 85301B or 85301C antenna measurement system, depending on your range type and the required microwave performance. If you select an 85301B system, you will configure the receive site with an

85310A distributed frequency converter (mixer-based). If you choose an 85301C system, you will configure the receive site with either an 8511A (45 MHz to 26.5 GHz) or 8511B (45 MHz to 50 GHz) frequency converter (harmonic sampler-based). System performance with these converters is shown in Tables 3 and 4.

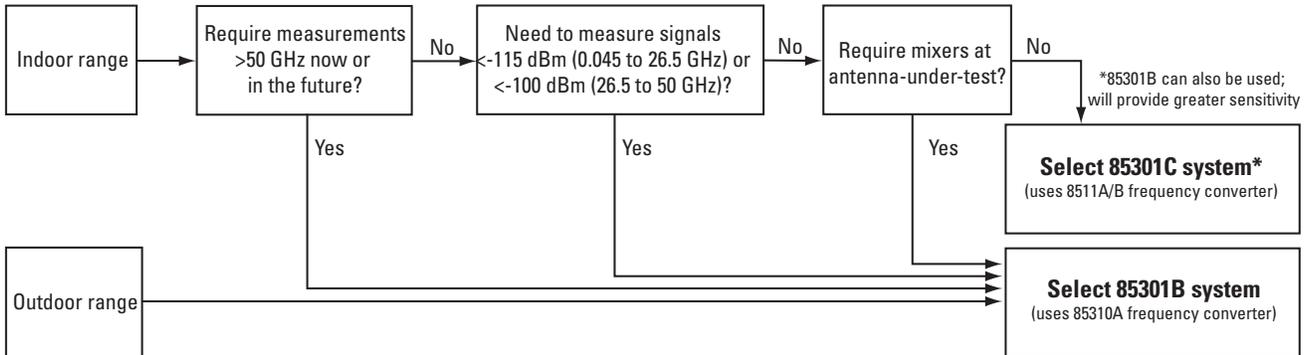


Figure 3. Selecting an antenna measurement system

Table 3. Performance of an 85301B system (with 85310A distributed frequency converter)

Specification	85320A/B Option H20 mixers ³		85320A/B standard mixers		85320A/B Option H50 mixers ³	
	0.1 to 3 GHz	1 to 2 GHz ¹	2 to 18 GHz	6 to 26.5 GHz	2 to 18 GHz	6 to 26.5 GHz
Sensitivity ² (dBm)	-107	-80	-113	-96	-110	-95
Compression level ⁴ (dBm)	-21	-24	-24	-15	-24	-27
Dynamic range ⁵ (dB)	86	56	89	81	86	68
Channel isolation ⁶ (dB)	100	100	100	100	100	100
Typical RF input match (dB)	8	8	8	8	5	5

Table 4. Performance of an 85301C system (with 8511A/B frequency converters)

Specification	0.045 to 8 GHz	8 to 20 GHz	20 to 26.5 GHz	26.5 to 40 GHz	40 to 50 GHz
Maximum output power ⁷ (dBm)					
83630B ⁸	+10	+10	+3	—	—
83650B ⁸	+10	+10	+4	+3	0
Sensitivity ² (dBm) (S/N = 1.0 avgs), 8511A [B]	-98	-98	-94 [-89]	[-89]	[-87]
Sensitivity ² (dBm) (S/N = 1,128 avgs), 8511A [B]	-119	-119	-115 [-110]	[-110]	[-108]
Dynamic range (dB, 0 averages) 8511A [B]	88	88	79 [74]	[74]	[68]
Compression level ⁴ (dBm)	-10	-10	-15	-15	-19
Channel isolation ⁶ (dB, ref to test), 8511A [B]	80 [85]	80 [85]	80 [75]	[75]	[70]
Return loss (dB, RF input)	17	15	9	9	7
Min. phase-lock power ⁹ (dBm), 8511A [B]	-40 [-41]	-38[-39]	-35 [-32]	[-32]	[-30]

- Performance from 1 to 2 GHz is typical.
- Sensitivity is defined as signal = noise, IF bandwidth = 10 kHz. Averaging will improve sensitivity by 10 log (number of averages).
- Typical performance.
- RF level for 0.1 dB compression.
- Broadband dynamic range is the measured difference between the compression level and the average noise floor. Achievable dynamic range for CW measurements is 2 to 3 dB better.
- Channel isolation is the coherent RF leakage from the reference channel to the test channel.
- Cable loss can be determined from Figures 12 and 13.
- Frequency resolution for the 83630B and 83650B = 1 Hz. (with Option 008)
- Minimum phase-lock power is the typical minimum RF power at the a1 or a2 input to achieve phase-lock.

The following factors should also be considered when choosing your system:

- The 85310A distributed frequency converter (85301B system) allows the test mixer to be located at the AUT, avoiding the degradation in measurement sensitivity due to cable insertion loss between the 8511A/B RF inputs and the AUT.
- Measurement sensitivity and acquisition time are directly related. If averaging is used to achieve the required measurement sensitivity, data acquisition times will be increased. Averaging will improve sensitivity by $10 \cdot \log$ (Averaging Factor) until limited by channel-to-channel isolation. The increase in acquisition time can be determined by multiplying the averaging factor by 200 microseconds. If acquisition time is critical, fundamental mixing using the 85310A will reduce or eliminate the need for averaging.
- If the distance between the 8530A and the AUT is large, both the LO source and the 85310A frequency converter can be remoted from the 8530A. Remote distances of up to 25 meters cause no degradation in system sensitivity; beyond 25 meters, the system sensitivity degrades by 0.1 dB per meter.

The 85301C antenna measurement system utilizes an 8511A/B frequency downconverter which uses a harmonic sampling technique with a built-in voltage-tuned oscillator. This type of downconversion does not require a second synthesized source as a local oscillator, so it will be a lower-cost RF system.

The 85301C system has a low-frequency limit of 45 MHz; the 85301B has a low-frequency limit of 100 MHz.

The 85301B system utilizes mixers for frequency downconversion. While these mixers are relatively broadband, they are banded. Mixers are available for the frequency bands of 100 MHz to 3 GHz, 1 to 26.5 GHz, 2 to 50 GHz, 40 to 60 GHz, 50 to 75 GHz, and 75 to 110 GHz.

The 85301C system provides broadband frequency downconversion: either 45 MHz to 26.5 GHz, or 45 MHz to 50 GHz coverage.

Agilent 85301B Antenna Measurement System

The Agilent 85301B antenna measurement system uses the Agilent 85310A distributed frequency converter to downconvert the microwave signal to an IF frequency that can be measured by the receiver.

The 85310A distributed frequency converter is based on an external mixer configuration and consists of the 85309A LO/IF distribution unit, 85320A test mixer module, 85320B reference mixer module and accessories. When combined with an appropriate LO source, the 85310A provides fundamental downconversion from 2 to 18 GHz and third harmonic downconversion from 6 to 26.5 GHz (see Figure 4). The frequency coverage can be extended to 110 GHz by the 85325 millimeter-wave subsystems, which are discussed under “Millimeter-wave configuration.” The 85310A is a single-channel downconverter (one test and one reference). A second test channel can be added by ordering 85310A Option 001. For two additional test channels (a total of one reference channel and three test channels), order Option 002.

The 85309A LO/IF distribution unit provides LO signal amplification and isolation, IF pre-amplification and filtering, and an LO/IF diplexer for the test channel. The 85320A test mixer module contains an LO/IF diplexer, double-balanced mixer and a 3 dB matching pad on the RF port. The 85320B reference mixer module contains a directional coupler, leveling detector, double-balanced mixer and a 3 dB matching pad on the RF port. An adapter cable for IF connections between the 85309A and the 8530A is included with the 85310A as well as 3 dB and 6 dB fixed attenuators.

A leveling detector in the reference mixer is used to provide the proper LO drive to the mixers. It is important to use equal length cables to both the reference and test mixers to ensure the same cable loss, and provide the same LO drive power to both mixers.

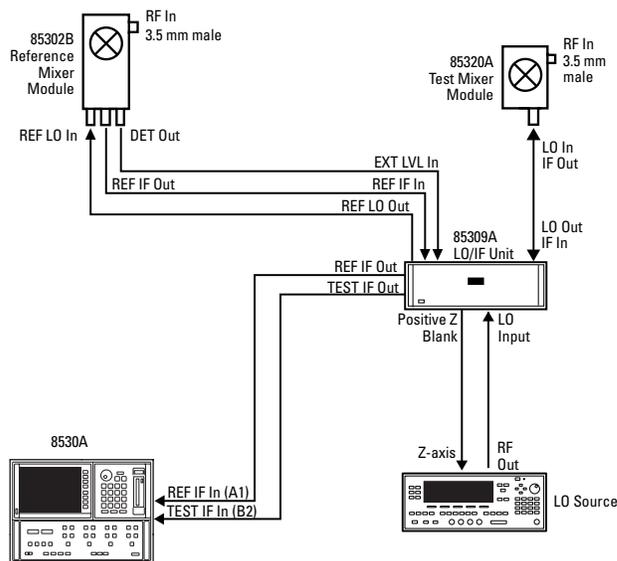


Figure 4. Interconnect diagram of an 85310A distributed frequency converter

Weatherproof enclosures

If the 85309A LO/IF unit and/or the LO source are to be located outdoors, the units must be protected from inclement weather.

System configurations

Figures 5 through 8 illustrate several common range configurations in which an 85310A frequency converter would be used. Figure 5 represents the most common outdoor configuration, where the receiver and LO source are located in the control room, the 85309A LO/IF unit is located close to the antenna positioner and the mixer modules are connected directly to the reference and test antennas. If the distance between the LO source and the 85309A exceeds the maximum LO cable lengths, a synthesized LO source can be remoted with the 85309A using 37204A GPIB extenders (see “GPIB extenders”). Remoting the 85309A LO/IF distribution unit up to 25 meters from the 8530A causes no degradation in system sensitivity; beyond 25 meters, the system sensitivity degrades by 0.1 dB per meter.

In Figure 6, the transmit source and 8530A are located in the control room and a synthesized LO source, 85310A frequency converter and GPIB extender are located on the rail cart with the positioning system and AUT. The GPIB extender cable, together with coaxial cables transmitting the reference and test IF signals, are fed from a spool mounted on the rail cart.

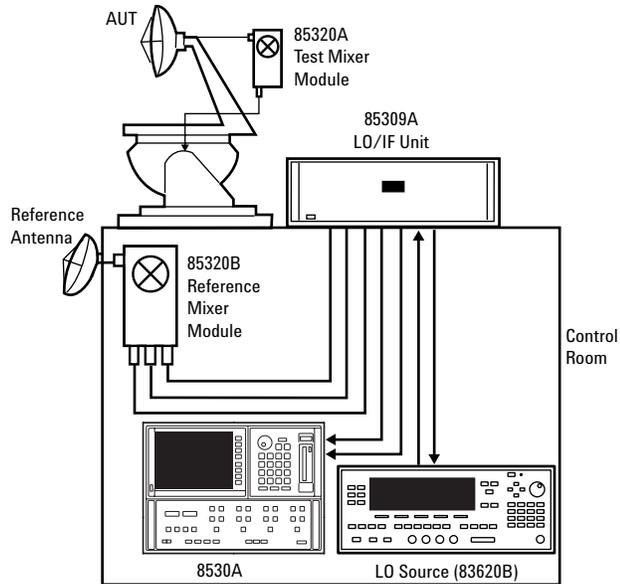


Figure 5. Typical outdoor far-field antenna range configuration

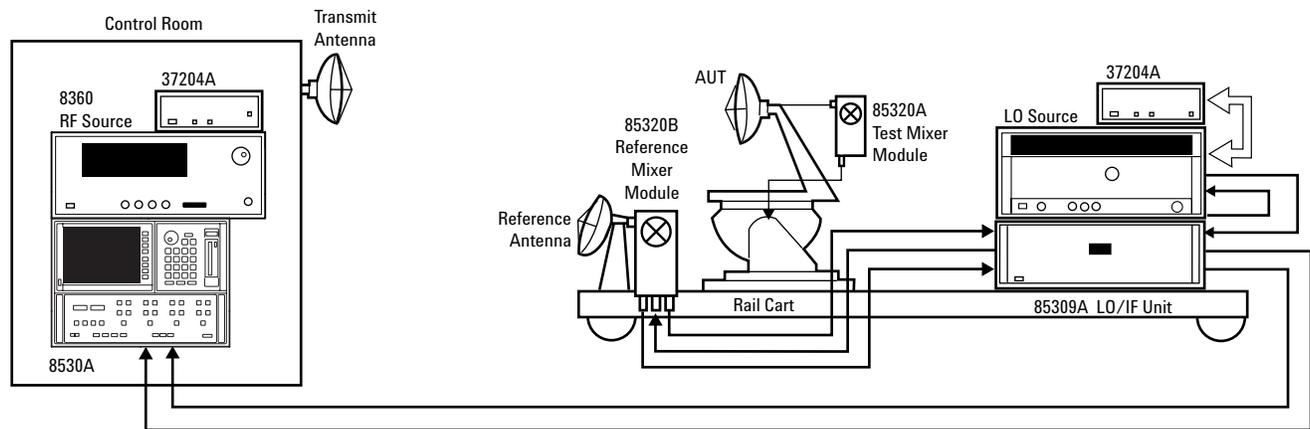


Figure 6. Outdoor range configuration using rail cart

In Figure 7, the range uses a single-reflector CATR to collimate the transmit beam to a plane wave. In this case, the transmit source, LO source, the 85309A LO/IF unit and GPIB extender are located in the positioner/feed pit. The 8530A, positioner controller and computer system are located in the control room.

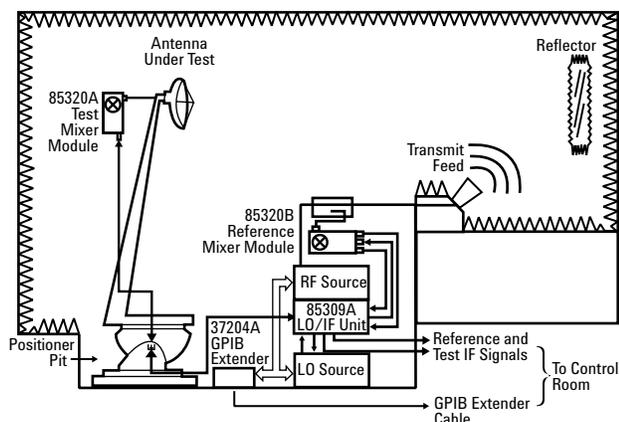


Figure 7. Indoor range using single-reflector CATR

A dual-reflector CATR range is configured slightly differently (Figure 8). The transmit source is located in the control room with the 8530A. If the reference mixer module will not reach the transmit source due to cable length restrictions, the coupled reference signal can be routed to the reference mixer module using coaxial cable.

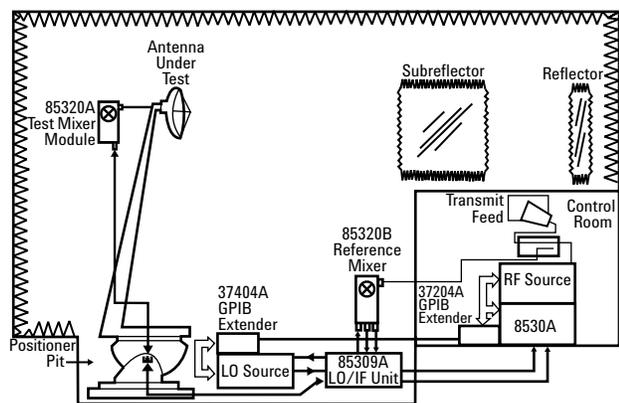


Figure 8. Indoor range using dual-reflector CATR

In all configurations, the cable lengths between the 85309A LO/IF distribution unit and the reference and test mixers should be the same length. Mixer power level is adjusted and leveled at the reference mixer; using the same cable lengths for the test mixer insures proper LO drive power to the test mixer.

Selecting the LO Source

The 85301B antenna measurement system uses synthesized RF and LO sources. Since the RF and LO signals are synthesized, phase lock for the receiver is unnecessary. Microwave mixers used with the 85301B antenna measurement system use fundamental mixing from 100 MHz to 18 GHz, and harmonic mixing for frequencies above 18 GHz. Thus, an LO source that operates over the frequency range of 0.1 to 18 GHz will be adequate for all frequencies of operation of the 85301B. A large selection of synthesized sources is available for LO sources (refer to Table 1). However, because the LO source only needs to operate over the frequency range of 0.1 to 18 GHz, LO source selection can be limited to the synthesizers shown in Table 5.

Table 5. Agilent 85301B LO sources

Model Number	Description	Output Power (dBm)
83620B	10 MHz to 20 GHz synthesized sweeper with front panel controls. Recommended Options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+ 13 dBm
83622B	2 GHz to 20 GHz synthesized sweeper with front panel controls. Recommended Options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+13 dBm
83623B	10 MHz to 20 GHz synthesized sweeper with high output power, and front panel controls Recommended Options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+17 dBm
83624B	2 GHz to 20 GHz synthesized sweeper with high output power, and front panel controls. Recommended Options: Option 004, rear-panel RF output; Option 008, 1 Hz frequency resolution.	+20 dBm

Select a source that meets your individual preferences and needs. The higher-output power sources are useful when the distance between the LO source and the 85309A LO/IF, distribution unit is longer than the standard allowable cable lengths shown in Tables 6 through 11. By using the cable insertion loss curves (Figures 12 and 13) the additional cable length can be calculated for the higher-output power sources. The 1 Hz frequency resolution (Option 008) is recommended for both the RF and LO sources to provide a system frequency resolution of 1 Hz instead of 1 kHz.

Reference signal level

The reference mixer provides a phase reference for the measurement, and a reference signal for a ratioed measurement (b2/a1) to ratio out any variations in signal levels from the system. Since both the RF and LO sources are synthesized, phase locking the receiver is not required. The only requirement for the reference channel is that the signal level be high enough to achieve the desired accuracy for the measurement. Figure 2 shows the magnitude and phase errors as a function of signal-to-noise ratio; this also applies to errors contributed by the reference channel. For most applications, it is desirable to maintain a 50 to 60 dB signal-to-noise ratio. For fundamental mixing (2 to 18 GHz), the sensitivity is -113 dBm; maintaining a 50 to 70 dB signal-to-noise ratio would require a reference channel signal level of -40 to -60 dBm.

- 13 Record the model number of the selected LO source in Figure 18.

Calculating reference power

Calculation of the reference channel power level depends on the method used to obtain the reference signal. Use the sections below to determine the reference channel power level for either a radiated reference signal or a coupled reference signal.

Radiated reference signals

When using a radiated reference, the reference channel power level can be determined from the following equation:

$$P_r(\text{REF}) = P_t + P_r/P_t + G(\text{REF})$$

where $P_r(\text{REF})$ = Power level at the output of the reference antenna

P_t = Transmit power level (dBm)

P_r/P_t = Transfer function of the range

$G(\text{REF})$ = Gain of the reference antenna

- 14 Record the reference antenna gain in Figure 18.
- 15 Record the calculated reference channel power level $P_r(\text{REF})$ in Figure 18.

If the calculated reference channel power level is insufficient to achieve the desired accuracy from the reference channel, the transmit power or the reference antenna gain must be increased.

Coupled reference signals

When using a coupled reference, the reference channel power level can be determined by subtracting the cable insertion losses and the coupling factor of the directional coupler and adding amplifier gain, if any, to the output power of the transmit source. Insertion loss curves for 85381 series cables are shown in Figures 12 and 13.

- 16 Record the calculated reference channel power level $P_r(\text{REF})$ in Figure 18.

Interconnect cables

The Agilent 85310A frequency converter requires coax cables for routing LO, IF and DC leveling signals between the 85309A LO/IF unit, 8530A, mixer modules and the LO source. Agilent Technologies has several different types of cables available to meet these cabling needs. They are described below.

Output power of LO/IF distribution unit

Mixers require a certain LO drive power level; the output power of the 85309A LO/IF distribution unit and the RF loss of the cables will determine the maximum allowable cable lengths. The cable length tables and power level diagrams shown in this configuration guide are based on the standard 85309A specifications.

Higher-output power LO/IF distribution units

Agilent Technologies also offers the 85309A with special options for higher output power. When designing a system with a special high-power unit, verify the output power specifications, and make adjustments to cable lengths based on the power level. Cable lengths shown in Figures 9–11 and 15, and Tables 6–11 and 14–15 are calculated from the following formulas:

$$\text{Cable L1 length (meters)} = \frac{(P_{\text{OUT source}} - P_{\text{IN 85309A}})}{\text{(cable loss/meter @frequency)}}$$

$$\text{Cable L2 length (meters)} = \frac{(P_{\text{OUT 85309A}} - P_{\text{IN mixer}})}{\text{(cable loss/meter @frequency)}}$$

The cable length tables that follow show cable lengths in parentheses for the 85309A Special Option H30, H31, and H32, which are the most popular higher-power specials. These specials have the following minimum specified leveled power: 0.3 to 0.5 GHz, 25 dBm; 0.5 to 8.4 GHz, 27 dBm; 8.4 to 18 GHz, 24.5 dBm. Minimum specified leveled power over 0.3 to 18 GHz is 24.5 dBm.

Fundamental versus harmonic mixing

Loss of LO cables is dependent on RF frequencies; lower frequencies have lower loss per unit length, and higher frequencies have higher loss (refer to Figures 12 and 13). Therefore the maximum LO frequency utilized will affect the maximum length of the cables. The maximum LO frequency is dependent on the frequency specified for the antenna range and whether fundamental or harmonic mixing is used. Lower LO frequencies have less loss and allow longer cable lengths; higher LO frequencies have higher losses, so cable lengths are shorter. There is a trade-off between LO frequency and system sensitivity. Fundamental mixing provides the lowest conversion loss in the mixer, and the best system sensitivity. Harmonic mixing allows lower LO frequencies to be used (with longer cable lengths), but has higher conversion loss in the mixer, and less system sensitivity.

Standard versus low-loss cables

The RF loss of the cables will affect the maximum length of cable that can be used between the 85309A and the mixers. The standard 85381A/C/D cables have losses as shown in Figures 12 and 13. Special low-loss cables, such as the MA/COM FA29RX cable, are about half the loss of the standard cables. Therefore the low-loss cables will provide approximately twice the distance between the 85309A and the mixers. The trade-off is higher price and somewhat less durability. MA/COM can be contacted at (800) 366-2266, FAX (800) 618-8883, or visit their website at www.macom.com. Other cable manufacturers, such as W.L. Gore & Associates, may have similar low-loss cables that would be satisfactory in this application. W.L. Gore & Associates can be contacted at (800) 445-4673, or visit their website at www.gore.com.

The following figures and tables define the allowable cable lengths between the LO source and 85309A LO/IF distribution unit, and between the 85309A and the mixers. Tables 6, 8, and 10 show maximum cable lengths with standard 85301A/C cables. Tables 7, 9, and 11 show maximum cable lengths with MA/COM FA29RX low-loss cables.

Maximum cable lengths with 1 to 26.5 GHz mixers

The standard mixers used in Agilent antenna measurement systems are the 85320A test mixer and the 85320B reference mixer. Both mixers operate from 1 to 18 GHz in fundamental mode, and from 6 to 26.5 GHz in third-harmonic mode. While the 85320A/B mixers are not specified from 1 to 2 GHz, they will operate in this frequency range with degraded sensitivity. Figure 9 shows the RF power

levels required for proper operation with the 85320A/B mixers. Table 6 shows the maximum allowed 85381A/C cable lengths from the LO source to the 85309A, and from the 85309A to the 85320A/B test and reference mixer modules. Table 7 shows the maximum cable lengths with special low-loss cables.

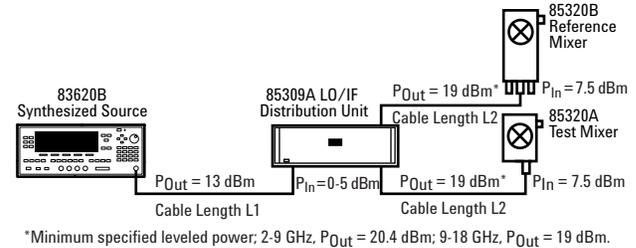


Figure 9. Required RF power levels for 85320A/B mixers

Table 6. 85381A cable lengths with 85320A/B mixers

Maximum LO Frequency bands (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands
18	5 (5) ¹	7 (12) ¹	1 to 18 GHz fundamental 6 to 26.5 GHz 3rd harmonic
12.4	7 (6.2) ¹	9 (15.3) ¹	1 to 12.4 GHz fundamental 6 to 26.5 GHz 3rd harmonic
9	10 (7.4) ¹	12 (18) ¹	1 to 9 GHz fundamental 6 to 26.5 GHz 3rd harmonic
6	13 (9.2) ¹	15 (22.5) ¹	1 to 6 GHz fundamental 6 to 26.5 GHz 3rd harmonic
3.6	27 (11.5) ¹	29 (28) ¹	1 to 3.6 GHz fundamental 3.6 to 18 GHz 5th harmonic

Table 7. Special low-loss cable lengths with 85320A/B mixers, and MA/COM FA29RX cable

Maximum LO Frequency bands (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands
18	10 (10) ¹	15 (25.9) ¹	1 to 18 GHz fundamental 6 to 26.5 GHz 3rd harmonic
12.4	12 (13) ¹	19 (32) ¹	1 to 12.4 GHz fundamental 6 to 26.5 GHz 3rd harmonic
9	15 (15) ¹	24 (38) ¹	1 to 9 GHz fundamental 6 to 26.5 GHz 3rd harmonic
6	20 (19) ¹	31 (47) ¹	1 to 6 GHz fundamental 6 to 26.5 GHz 3rd harmonic

1. Maximum cable lengths with special high-powered 85309A-H30, H31, H32 units.

Maximum cable lengths with 2 to 50 GHz mixers

Agilent Technologies offers 85320A/B Option H50 mixers that operate from 2 to 50 GHz with a single 2.4-mm coaxial connector at the RF input port. These mixers are popular when operation above 26.5 GHz is required. The 85320A-H50 test mixer and the 85320B-H50 reference mixer operate from 2 to 18 GHz in fundamental mode, and from 6 to 50 GHz in third-harmonic mode.

Figure 10 shows the RF power levels required for proper operation with the 85320A/B Option H50 mixers. Table 8 shows the allowed 85381A/C cable lengths from the LO source to the 85309A, and from the 85309A to the 85320A/B-H50 test and reference mixer modules. Table 9 shows the cable lengths with special low-loss cables.

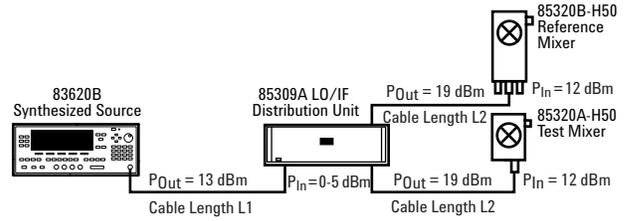


Figure 10. Required RF power levels for Agilent 85320A/B-H50 mixers

Table 8. 85381A cable lengths with 85320A/B-H50 mixers

Maximum LO Frequency bands (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands
18	5 (5) ¹	5 (8.9) ¹	2 to 18 GHz fundamental 18 to 50 GHz 3rd harmonic
16.7	9.5 (5) ¹	5 (9.3) ¹	2 to 16.7 GHz fundamental 16.7 to 50 GHz 3rd harmonic
13.3	7 (6) ¹	6 (10) ¹	2 to 13.3 GHz fundamental 13.3 to 40 GHz 3rd harmonic

Table 9. Special low-loss cable lengths with 85320A/B-H50 mixers, and MA/COM FA29RX cable

Maximum LO Frequency bands (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands
18	10 (10.5) ¹	10 (19) ¹	2 to 18 GHz fundamental 18 to 50 GHz 3rd harmonic
16.7	11 (11.6) ¹	11 (21) ¹	2 to 16.7 GHz fundamental 6.7 to 50 GHz 3rd harmonic
13.3	13 (12.7) ¹	12.4 (22.8) ¹	2 to 13.3 GHz fundamental 13.3 to 40 GHz 3rd harmonic

1. Maximum cable lengths with special high-powered 85309A-H30, H31, H32 units.

Maximum cable lengths with low-frequency mixers

Agilent Technologies offers 85320A/B Option H20 mixers that operate from 0.1 to 3 GHz. These mixers are popular when operation below 2 GHz is required. The 85320A-H20 test mixer and the 85320B-H20 reference mixer operate from 0.1 to 3 GHz in fundamental mode.

A standard 85309A LO/IF distribution unit operates over the frequency range of 1 to 26.5 GHz with standard 85320A/B mixers. It also operates over the frequency range of 0.3 to 3 GHz with 85320A/B Option H20 mixers, and over the range of 2 to 50 GHz with 85320A/B Option H50 mixers. Measurement capability over the frequency range of 0.1 to 0.3 GHz requires an 85309A configured with Special Option H20.

Figure 11 shows the RF power levels required for proper operation with the 85320A/B-H20 mixers. Table 10 shows the allowed 85381A/C Cable lengths from the LO source to the 85309A, and from the 85309A to the 85320A/B-H20 test and reference mixer modules. Table 11 shows the cable lengths with special low-loss cables.

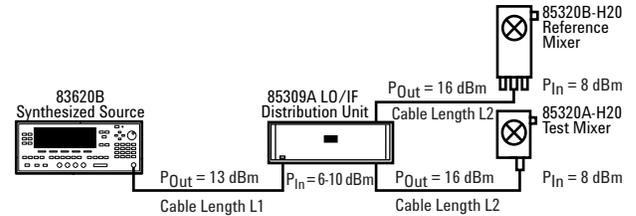


Figure 11. Required RF power levels for 85320A/B-H20 mixers

Table 10. 85381A cable lengths with 85320A/B-H20 mixers

Maximum LO Frequency bands (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands	System Sensitivity (dBm)
3	11 (13.8) ¹	13.8 (37.8) ¹	0.1 to 3 GHz fundamental	-107

Table 11. Special low-loss cable lengths with 85320A/B-H20 mixers, and MA/COM FA29RX cable

Maximum LO Frequency bands (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands	System Sensitivity (dBm)
3	20 (22) ¹	29.5 (61) ¹	0.1 to 3 GHz fundamental	-107

1. Maximum cable lengths with special high-powered 85309A-H20, H31, H32 units

Agilent 85381 series coaxial cables

The 85381A microwave cable is a semi-flexible cable that operates from DC to 18 GHz. It is intended for use as an LO cable between the LO source and the 85309A LO/IF unit (see Figure 11). If a rotary joint is used to route the test LO and IF signals so that the cable is not continuously flexed, the 85381A cable can be used between the 85309A and the 85320A/B test and reference mixers. The maximum orderable length for this cable is 25 meters. (See Figure 18, cables B3, B4 and B5.) Refer to Figure 12 for cable loss characteristics.

The 85381C microwave cable is a flexible cable that operates from DC to 26.5 GHz. It is intended for use as a transmit site RF cable, and to connect the output of the AUT to the mixer modules when direct connection is not possible. The 85381C can also be used as a flexible LO cable in non-rotary joint applications where the 85381A proves unsuitable (see cable B2 in Figure 18). Maximum orderable cable length is 30 meters.

The 85381D cable is a flexible microwave cable that operates from DC to 50 GHz. It is intended for use in 50 GHz systems. It is used to connect the transmit source to the source antenna, and on the AUT side of the antenna range to connect the AUT to the 50 GHz test mixer. Maximum orderable cable length is 10 meters. This cable has significantly higher loss than the 85381A/C cables, and should only be used when 50 GHz capability is required. Refer to Figure 13 for cable loss characteristics.

The 85382A cable is a low-frequency (<100 MHz) flexible cable. It is used to carry the 20 MHz signal from the 85309A frequency converter to the 8530A microwave receiver. This cable is also used to tie the 10 MHz time bases of the RF and LO sources together in applications where this is practical. This cable can be ordered in lengths up to 200 meters.

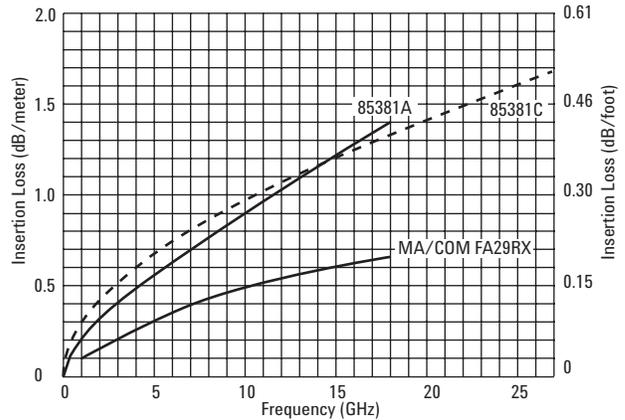


Figure 12. Insertion loss for 85381 series cables

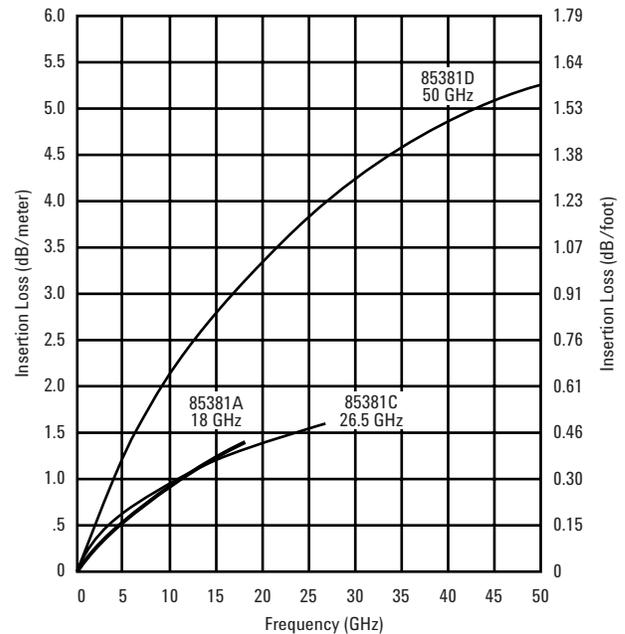


Figure 13. 85381A/C/D cables; typical insertion loss

RF cable ordering information

Cable length

Determine the type and length (in meters) of cable required. Order the cable by type (85381A, C, D or 85382A) and length option Cxx, where 'xx' specifies the length of the cable in meters. To order a one-half meter cable, specify Option C00. To convert feet to meters, multiply the number of feet by 0.3048.

Ordering example: To order a 23-foot cable for use up to 26.5 GHz, order 85381C Option C07 (23 feet x 0.305 = 7 meters).

Cable connectors

A variety of connector types are available for the 85381A/C/D and 85382A RF cables, as shown in Table 12. Two connector options must be ordered for each cable.

Table 12. RF cable connector options

Connector Type	Cable Type			
	85381A ¹ DC to 18 GHz	85381C ¹ DC to 26.5 GHz	85381D ¹ DC to 50 GHz	85382A ¹ DC to 100 MHz
Type-N male	CNM	CNM ²		CNM
Type-N female		CNF ²		
3.5 mm male		C3M		
3.5 mm female		C3F		
SMA male	CSM	CSM ²		
SMA female		CSF ²		
BNC male				CBM
BNC female				CBF
2.4 mm male			C2M	
2.4 mm female			C2F	

1. Minimum bend radii for cables are as follows: 85381A/C/D, 5 cm (2 inches); 85382A, 6 cm (2.5 inches).
2. Maximum frequency is 18 GHz.

Cable ordering example:

To obtain a 23-foot cable for use up to 18 GHz with a Type-N male connector on one end and an SMA male connector on the other end, order an 85381A Option C07, CNM, CSM. To get a 9-meter cable for use up to 26.5 GHz with 3.5-mm male connectors on each end, order an 85381C Option C09, C3M, C3M.

Reference and test LO cables

The same LO cable type and length is required for both the reference and test mixer modules. This is to ensure that the insertion losses through the reference and test mixer module LO paths are the same. Using the same LO cable type also optimizes cable phase tracking versus temperature and, therefore, system phase measurement, stability, and accuracy.

Remote LO source

If the maximum cable distance between the LO source and the 85309A LO/IF unit is insufficient, a synthesized LO source may be remotored with the 85309A using 37204A GPIB extenders. Remote distances of up to 25 meters cause no degradation in system sensitivity; beyond 25 meters, the system sensitivity degrades by 0.1 dB per meter. System sensitivity degradation is due to IF cable loss in the 20 MHz IF cables connecting the 85309A to the 8530A.

Rotary joints

When a rotary joint is used, the equivalent cable length must be added to the reference mixer LO cable due to the rotary joint insertion loss. To determine the equivalent cable length, first determine the insertion loss from the input to the output of the rotary joint at the maximum LO frequency.

17 Record this value in Figure 18. Then use Figure 12 or 13 to calculate the equivalent length in meters at the maximum LO frequency using the same cable type used for the LO cables between the 85309A and the mixer modules. The reference LO cable length must be increased by this amount.

18 Record the lengths and type of the LO cables (B1 through B5) in Figure 18.

19 Record the lengths and type of the IF and leveling cables (C1 through C5) in Figure 18. Normally, 85382A cable is used.

20 In Figure 16, record the connector types of the system components.

The semi-flexible 85381A cable is normally used for cables B1, B3, B4, and B5. The flexible 85381C cable is normally used for cables B2 and B5. The 85382A cable is normally used for cables C1, C2, C3, C4, and C5.

Agilent 85301C Antenna Measurement System

The Agilent 85301C antenna measurement system uses either an 8511A (45 MHz to 26.5 GHz) or an 8511B (45 MHz to 50 GHz) frequency converter for downconversion. 85381A/C microwave cables are used to route the microwave signal from the antenna under test to the 8511A/B frequency downconverter.

IF interconnect cable

The 8511A/B should be located as closely as possible to the test antenna to minimize the RF cable lengths. Several IF interconnect cables are available up to 21 meters (70 feet) to allow remoting of the 8511A/B away from the 8530A, and close to the antenna under test. Also, coupled reference cables are often run through conduit under the range floor to the positioner pit to minimize these lengths.

21 Determine the cable length from the 8530A to the 8511A/B and check one of the IF interconnect cable lengths in Figure 19.

RF cables

22 Determine the lengths of the RF cable(s) (cables B1 or B2 and B3) used to connect the AUT to the frequency converter and record them in Figure 19. Select the cable type (see Figures 12 and 13) based on the maximum test frequency.

The 85381C flexible cable is usually used for cable B1. For cables B2, B3, and B4, either the 85381C flexible or 85381A semi-flexible cable can be used.

The measurement sensitivity of the 8511A/B must be degraded by the insertion loss of the RF cable(s) to determine system measurement sensitivity.

Radiated reference signals

23 If a radiated reference is used, determine the length of cable B4 and record it in Figure 19.

24 In Figure 16, record the connector types of the system components.

Reference phase-lock signal power level

It is important to ensure that sufficient reference phase-lock power is available at the reference input to the 8511A/B. The minimum reference phase-lock power levels are listed in Table 4.

Calculation of the reference channel power level depends on the method used to obtain the reference signal. Use the sections below to determine the reference channel power level for either a radiated reference signal or a coupled reference signal.

When using a radiated reference, the reference phase-lock power level can be determined from the following equation.

$$P_r(\text{REF}) = P_t + P_r/P_t + G(\text{REF}) - B4$$

where $P_r(\text{REF})$ = Power level at the input of the 8511A/B

P_t = Transmit power level (dBm)

P_r/P_t = Transfer function of the range

$G(\text{REF})$ = Gain of the reference antenna

$B4$ = Insertion loss of cable B4

25 Record the reference antenna gain in Figure 19.

Coupled reference signals

When using a coupled reference, the reference phase-lock power level can be determined by subtracting the cable insertion losses and the coupling factor of the directional coupler and adding amplifier gain, if any, to the output power of the transmit source. Insertion loss curves for 85381 series cables are shown in Figures 12 and 13.

If a coupled reference is used, the A5 cable can be connected directly to the reference input of the 8511A/B.

26 Record the calculated value in Figure 19. If the power level is insufficient, increasing the transmit power and/or decreasing the coupling factor of the directional coupler may provide the additional power required.

GPIB cables

A GPIB cable between the 8530A and the 8511A/B is required only if Option 001 (IF switching) is installed in the 8511A/B. In this case, the maximum separation distance between the 8530A and the 8511A/B is 12 meters (40 feet).

GPIB extenders are used to facilitate communication between the 8530A and the transmit source. 37204A GPIB extenders can support distances of up to 250 meters (820 feet) using 75-ohm coaxial cable and up to 2,500 meters (8,200 feet) using 37204A Option 013 and fiber-optic cable.

For extremely long ranges, telephone line modems can be used in conjunction with a leased telephone line to provide communications between the transmit site and the receive site.

When configuring systems with a telephone line link to the RF source, Agilent recommends an ICS Electronics IEEE-488 to RS-232 converter and a Hayes Smartmodem 9600 telephone line modem at each end of the telephone line. For more information on these products, contact the manufacturers:

ICS Electronics model 4886B-H
(408) 263-5500
www.icselect.com

Hayes Smartmodem 9600
Hayes Microcomputer Products, Inc.
(770) 441-1617
www.hayes.com

GPIB extenders

GPIB extenders are also used when remoting the LO source with the 85309A LO/IF unit. 37204A GPIB extenders can be used for this purpose. If the 37204A is also used for communications with the transmit source, only three extenders are required. Extenders must be used in slow mode.

The cable type must be the same between all three extenders.

Optional Capabilities

Manual antenna measurements

The 85301B/C antenna measurement systems can be operated in a manual mode. Manual operation allows the operator to rotate the antenna under test, and measure, analyze, print and archive the pattern manually. As the antenna under test is rotated, the antenna pattern is displayed on the color display of the microwave receiver. Up to five interactive markers can be placed on the pattern, indicating angular position and amplitude (or phase) value. For a hard copy of the antenna pattern, the receiver can print the pattern to a variety of HP printers. For archive purposes, antenna patterns can be stored by the receiver via a built-in 3.5" disk drive in either DOS or LIF format.

The 85370A antenna position encoder allows manual antenna patterns to be measured easily using the 8530A microwave receiver and any antenna position system. The antenna positioner encoder provides positioner information to the 8530A microwave receiver. The encoder monitors the synchro lines from the antenna positioner, decodes the synchro signals and sends the positioning information to the receiver through an encoder interface cable. When the positioner is manually moved through the desired angles, the receiver measures and displays the antenna pattern on the screen display of the receiver. Antenna pattern parameters such as start and stop angles, as well

as angular sampling increment, can be selected from the front panel of the microwave receiver.

Synchro encoder operation is not compatible with pulsed operation.

27 If manual operation capability is desired, select the 85370A antenna position encoder in Figure 18. Also select the proper cabling option depending upon the type of antenna positioning system. Option 001 is for interfacing to Scientific-Atlanta position indicator model numbers SA1842, SA1843, SA1844 and SA4400. Option 002 is for interfacing to Flam & Russell 8502 and Orbit AL-4706-3A positioner controllers. For interfacing to other positioning systems, consult your Agilent Technologies sales representative.

28 To interface the 85370A antenna position encoder to the 8530A microwave receiver requires Option 005 (encoder interface) for the 8530A. For existing 8530A receivers without this option, an upgrade kit is available; consult your Agilent Technologies sales representative for more information.

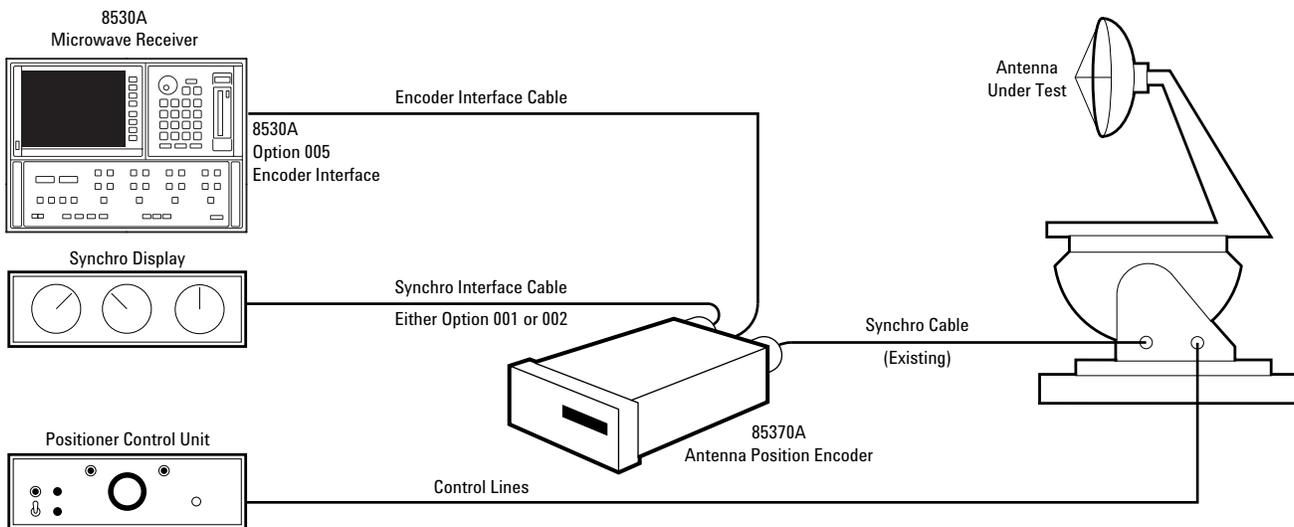


Figure 14. Antenna position encoder interconnect diagram

Measurement automation software

Measurement software is very popular for automating antenna measurements and improving measurement throughput and productivity. Most modern antenna measurement systems use software, since manual antenna pattern measurements are usually not a cost-effective way to analyze antenna performance. Measurement software for 85301B/C systems is provided by Agilent Technologies' channel partner, Nearfield Systems, Inc. (NSI). NSI offers both far-field and near-field measurement automation software.

Far-field measurement software

NSI's far-field measurement software is a Windows®-based program that runs on a personal computer and automates the data acquisition and analysis process. For data acquisition, full control is provided over the start and stop angles, angular sampling increment and number of test channels. For analysis, patterns can be displayed in either Cartesian or polar formats, and data analysis capabilities include gain, beamwidth, sidelobe levels, and pattern overlay and comparisons. The software allows archiving of pattern data to disk or a variety of printers.

Near-field measurement software

Near-field measurement software is also provided by our channel partner, Nearfield Systems, Inc. (NSI). NSI's software runs on a personal computer, and automates the data acquisition and analysis process. Near-field software is available for planar, cylindrical or spherical scanners. Combination scanners such as planar/cylindrical, or planar/spherical are also supported. For data acquisition, full control is provided over all aspects of the data acquisition process. The software includes the capability to transform the near-field data to far-field antenna pattern data. For data analysis, a variety of data presentation formats are available: raw amplitude and phase data, three-dimensional and contour patterns, as well as E-plane and H-plane pattern cuts.

Additionally, the software offers microwave holographic imaging capability, which is often useful for identifying antenna faults. Microwave holography can form images of the sampled RF energy at the surface of an aperture or radome. A further capability is to rotate the imaging plane in yaw so as to view the energy leaving the antenna. These holographic capabilities have been used to find phasing errors in phased-array antennas.

29 Indicate the type of antenna measurement automation software desired on Figure 20.

Personal computer

All of the measurement automation software runs on a PC. Since PC features and configurations change frequently, it is best to consult Nearfield Systems, Inc., for its recommendations on the correct and latest PC configuration for its application software.

30 Indicate on Figure 20 if a PC is required, and if either an HP LaserJet or color printer is desired.

Millimeter-wave configuration

85301C (8511A/B-based)

The 85301C standard system utilizes an 8511A harmonic sampler-based frequency downconverter, which provides frequency coverage from 45 MHz to 26.5 GHz. The 85301C system with Option 001 extends the frequency coverage from 45 MHz to 50 GHz by substituting an 8511B for the 8511A, and substituting an 83651B microwave source for the 83631B source.

85301B (85310A-based)

The 85301B antenna measurement system provides the most flexibility and expandability for millimeter-wave configurations. The standard 85301B antenna measurement system provides frequency coverage from 2 to 20 GHz. By utilizing an 83650B 50 GHz source and 85320A/B-H50 mixers, the frequency coverage can be extended to 50 GHz. The 85320A/B-H50 mixers are special-option 2 to 50 GHz mixers with 2.4-mm male connectors on the RF ports.

Millimeter-wave subsystems

Also available for extending the frequency coverage of the 85301B system are millimeter-wave subsystems, which provide millimeter expansion capability for the standard 85301B system.

The Agilent 85325A millimeter-wave interface kits use 83550 series millimeter-wave source modules, which provide signals from 26.5 to 110 GHz in standard waveguide bands. The millimeter-wave source modules multiply an 11 to 20 GHz signal by either 3, 5 or 7 to produce the desired output frequency. The source modules require a high-power 11 to 20 GHz signal for proper operation.

RF source requirements

The 83623B and 83624B synthesizer sweepers have adequate output power to drive the source modules directly. All other synthesizers require an 8349B microwave amplifier to provide proper RF drive power to the millimeter-wave source modules.

The Agilent 11970 series mixers used in the 85325A millimeter-wave source modules all operate in a harmonic mode with a 3 to 6.09 GHz LO signal.

The 11970 series mixers are weather-resistant but not weatherproof. Use appropriate caution in outdoor applications.

Millimeter-wave performance

Millimeter-wave performance using the 85325A millimeter-wave interface kits is listed in Table 14.

31 Indicate in Figure 21 if millimeter-wave capability is desired for this system.

32 Indicate in Figure 21 if an 8349B microwave amplifier is required.

Table 13. Summary of 83550 series millimeter-wave source modules

Source Module Model Number	Band	Frequency Range (GHz)	Output Power (dBm)
83554A	R	26.5 to 40	+7
83555A	Q	33 to 50	+3
33556A	U	40 to 60	+3
83557A	V	50 to 75	+3
33558A	W	75 to 110	0

Table 14. Millimeter-wave system performance

Characteristic	R-Band 26.5 to 40 GHz	Q-Band 33 to 50 GHz	U-Band 40 to 60 GHz	V-Band 50 to 75 GHz	W-Band 75 to 110 GHz
Sensitivity ¹ (dBm) (No avg)	-109	-106	-107	-99 (-103) ⁴	-92 (-95) ⁴
Sensitivity ¹ (dBm) (128 avg)	-88	-85	-86	-78 (-82) ⁴	-71 (-74) ⁴
Compression level (dBm)	-19	-24	-24	-18	-15
Dynamic range (dB) (No avg)	79	71	72	60 (68) ⁴	56 (62) ⁴
Channel isolation (dB)	100	100	100	100	100
Typical RF input return loss ² (dB)	15.5	15.5	15.5	9.5	9.5

1. Sensitivity is shown where signal = noise.
2. At the input of test and reference isolators. Typical RF input return loss of 11970 mixers is 8.5 dB.
3. Maximum cable lengths with special high-powered 85309A-H30, H31, H32 units.
4. Typical performance values are in parenthesis.

Maximum cable lengths with millimeter-wave mixers

Figure 15 shows the RF power levels required for proper operation with the 85325A millimeter-wave interface kit. Table 15 shows the allowed 85381C cable lengths from the diplexer modules to the 85309A LO/IF distribution unit with standard and low-loss cables.

Multiple test channel configuration

Many of today's antennas have multiple test ports. To increase test productivity, it is often desirable to measure all of the test ports during one rotation of the antenna. Agilent Technologies offers two different multiple-channel measurement configurations: internal IF switching and RF switching.

Internal IF switching

Internal IF switching allows up to three test channels (plus a fourth reference channel) to be measured. This capability requires a test mixer for each test channel and additional test channels in the 85309A LO/IF distribution unit. Internal IF

switching operates by sending the 20 MHz IF signals from each test mixer to the 8530A microwave receiver; the receiver then switches between each of the test signals internally, and detects and processes each test signal.

Internal IF switching has two main benefits:

- Fast switching times of 4000 channel switches per second
- The ability to measure multiple-channel millimeter-wave antennas at frequencies above 40 GHz, where solid-state PIN switches are not readily available

IF switching is limited to a maximum of three test channels.

33 Indicate in Figure 22 if IF switching capability is desired, and the number of test channels required.

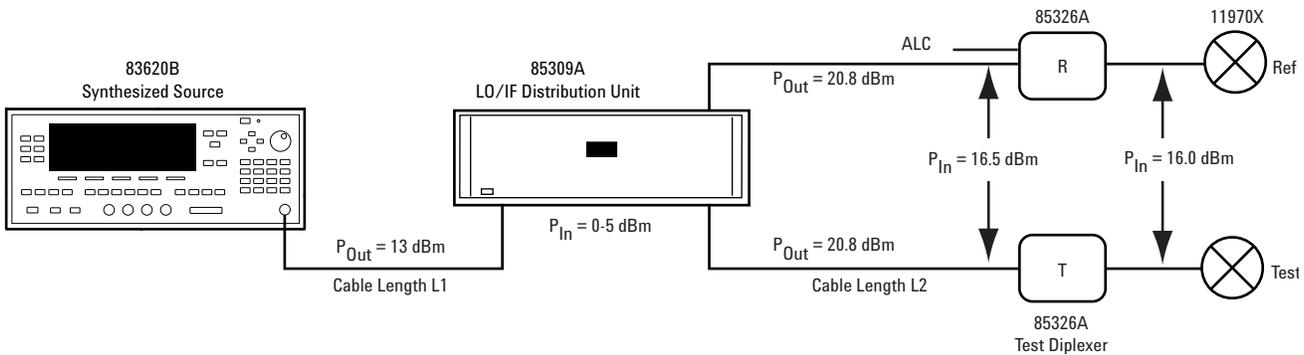


Figure 15. Required RF power levels for millimeter-wave mixers

Table 15. Cable lengths with 11970 series millimeter-wave mixers

Cable type	Maximum LO Frequency (GHz)	Maximum cable length (L1, meters) LO source to 85309A	Maximum cable length (L2, meters) 85309A to 85320A/B	Operating bands
85381A	6	17.1 (9.2) ³	5.5 (13.8) ³	26.5 to 110 GHz
MA/COM FA29RX	6	30 (19) ³	11.5 (28.9) ³	26.5 to 110 GHz

1. Sensitivity is shown where signal = noise.
 2. At the input of test and reference isolators. Typical RF input return loss of 11970 mixers is 8.5 dB.
 3. Maximum cable lengths with special high-powered 85309A-H30, H31, H32 units.
 4. Typical performance values are in parenthesis.

RF switching

RF switching uses a solid-state PIN switch to switch multiple antenna test ports into one test mixer for downconversion and processing by the receiver. With this method, up to 64 test ports can be measured in one rotation of the AUT.

The 85331/32A microwave PIN switches offer SP2T and SP4T configurations, operate over the frequency range of 45 MHz to 40 GHz (50 GHz is optional) and provide 50-ohm termination in the off state. Refer to the Agilent 85330/31/32A Technical Data Sheet (publication no. 5091-9009E) for complete performance specifications.

The benefits of RF switching are:

- High configuration flexibility
- Ability to expand for additional test channels

Steps 34 through 40 are referenced in Figure 23.

34 Indicate if RF switching capability is desired.

35 Indicate if PIN switching is required on the transmit side of the antenna range, and the number of switch positions required. If no RF switching is required, check the 'No RF switching is required' box and skip **36** and **37**.

36 Indicate the desired length of the 85384A cable from the switch control unit to the PIN switch. The 85384A cable is available in lengths of 1, 2, 5, and 10 meters.

37 Indicate the desired length of the 85383A cable from the 85330A multiple channel controller to the switch control unit. The 85383A cable is available in lengths of 2, 5, 10, 20, and 50 meters.

38 Indicate the number of switch positions required on the AUT side of the antenna range. If no RF switching is required on the AUT side, check the appropriate box and skip **39** and **40**.

39 Indicate the length of the 85384A switch control cable from the switch control unit to the PIN switch. The 85384A cable is available in lengths of 1, 2, 5 and 10 meters.

40 Indicate the desired length of the 85383A cable from the 85330A multiple channel controller to the switch control unit. The 85383A cable is available in lengths of 2, 5, 10, 20, and 50 meters.

Antenna positioning systems

Far-field positioning systems

For far-field applications, the Agilent 85301B/C systems are compatible with the Flam & Russell 8502, Orbit AL-4706, Orbit AL-4806-3A and Scientific-Atlanta 4139 positioner controllers. These control a wide variety of synchro-based positioners, allowing the 85301B/C systems to be integrated with almost any positioning system. If a new positioning system is required, Agilent recommends Nearfield Systems' positioning products. An antenna positioner configuration guide is available for configuring an antenna positioner system to meet your far-field application requirements. Contact your Agilent Technologies sales representative, or Nearfield Systems for assistance with all of your positioner requirements. NSI can be contacted at:

Nearfield Systems, Inc.
Telephone: (310) 518-4277
FAX: (310) 518-4279
www.nearfield.com

A brief positioner configuration guide is provided in Figures 24 and 25.

Steps 41, 42 and 43 are referenced in Figure 24.

41 Indicate if a polarization axis positioner is required on the source antenna side of the antenna range. Provide the model number of any polarization axis positioner that is to be used with this system. There are two types of polarization axis positioners: 1) a polarization positioner with a low rotation speed and high position accuracy (used to change the polarization of a source antenna by rotating the source antenna 90 degrees), and 2) a rotating polarization positioner with a high rotation speed (10-30 revolutions per minute) and low positioning accuracy (used to measure the ellipticity or axial ratio of a circularly polarized antenna by rapidly spinning a linear source antenna).

42 Indicate if a positioner controller and positioner power supply are required. If existing units are to be used, indicate their model numbers.

43 Indicate the length of polarization control cables, if required.

Steps 44 through 48 are referenced in Figure 25.

44 Indicate the type of antenna under test (AUT) positioner to be used with this system. If an existing positioner is to be used, indicate the model number of this positioner. If a new AUT positioner is required, indicate the axis required. An upper azimuth axis is almost always required, an elevation axis is frequently required, and a lower azimuth axis is seldom required.

45 Indicate if an existing model tower or roll axis positioner is available or required for this system. A model tower is sometimes used for mounting antennas above the metal AUT positioner. Model towers are usually made from non-conductive materials.

46 Indicate if an existing positioner controller is available or required for this system. If an existing positioner controller is to be used, indicate its model number.

47 Indicate if an existing positioner power supply is available or required for this system. If an existing positioner power supply is to be used, indicate its model number.

48 Indicate if existing positioner control cables are available or required for this system, and the length of these cables.

Near-field positioning systems

For near-field applications, Nearfield Systems, Inc. (NSI) provides a wide variety of standard and custom robotic positioning systems that are all compatible with Nearfield application software. NSI can be contacted at:

Nearfield Systems, Inc.
(310) 518-4277
fax: (310) 518-4279
e-mail: sales@nearfield.com
www.nearfield.com

Configuration Diagrams

Customer: _____
 Address: _____
 Customer contact: _____
 Telephone: _____ FAX: _____
 Sales engineer: _____ Location: _____
 Telephone: _____ FAX: _____
 Agilent systems engineer: _____ Location: _____
 Telephone: _____ FAX: _____
 Date: _____
 Objective: New antenna range or Upgrade of existing range

<p>1</p> <p>Antenna range parameters <i>Select either far- or near-field range</i></p> <p><input type="checkbox"/> Far-field antenna range <input type="checkbox"/> Near-field antenna range</p> <p>Range length: _____ meters Scan surface size: _____</p> <p>Range type: <i>(check one)</i> Range type: <i>(check one)</i></p> <p><input type="checkbox"/> Outdoor (elevated) <input type="checkbox"/> Planar near-field</p> <p><input type="checkbox"/> Outdoor (ground reflection) <input type="checkbox"/> Cylindrical near-field</p> <p><input type="checkbox"/> Indoor (rectangular) <input type="checkbox"/> Spherical near-field</p> <p><input type="checkbox"/> Indoor CATR <input type="checkbox"/> Combination of planar, cylindrical or spherical near-field</p> <p>Manufacturer: _____ <input type="checkbox"/> Type is unknown</p> <p>Model number: _____</p> <p><input type="checkbox"/> Other: _____</p>																	
<p>8</p> <p>Range transfer function* (P_r/P_t)</p> <p>Low frequency _____ -dB</p> <p>High frequency _____ -dB</p>	<p>20 24</p> <p>Connector information</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">System component</th> <th style="text-align: left; border-bottom: 1px solid black;">Connector type</th> </tr> </thead> <tbody> <tr> <td></td> <td style="font-size: small;">e.g., N (F), SMA (m), etc.)</td> </tr> <tr> <td>Transmit antenna _____</td> <td></td> </tr> <tr> <td>Antenna-under-test _____</td> <td></td> </tr> <tr> <td>Reference antenna (if used) _____</td> <td></td> </tr> <tr> <td>Rotary joint both ends (if used) _____</td> <td></td> </tr> <tr> <td>Bulkhead feedthrough _____</td> <td></td> </tr> <tr> <td>Other _____</td> <td></td> </tr> </tbody> </table>	System component	Connector type		e.g., N (F), SMA (m), etc.)	Transmit antenna _____		Antenna-under-test _____		Reference antenna (if used) _____		Rotary joint both ends (if used) _____		Bulkhead feedthrough _____		Other _____	
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Reference antenna (if used) _____																	
Rotary joint both ends (if used) _____																	
Bulkhead feedthrough _____																	
Other _____																	
<p>9</p> <p>Test channel received power*</p> <p>(Boresight)</p> <p>P_r (TEST) = $P_t + P_r/P_t + G$ (AUT)</p> <p>P_r (TEST) = _____ -dBm</p>	<p>Existing equipment</p> <p>Miscellaneous</p> <p>(any equipment to be used that already exists; e.g., amplifiers, enclosures, etc.)</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>																
<p>9</p> <p>Measurement sensitivity</p> <p>Test channel received power =</p> <p>P_r (TEST) = _____ dBm</p> <p>10 Dynamic range = D = _____ dB</p> <p>11 Signal-to-noise ratio</p> <p>(accuracy) = S/N = _____ dB</p> <p>12 Required measurement sensitivity =</p> <p>P_r (TEST) - [D+S/N] = _____ dBm</p>																	

* Only for far-field antenna ranges; not required for near-field ranges.

Figure 16. General antenna range information and system parameter calculation table

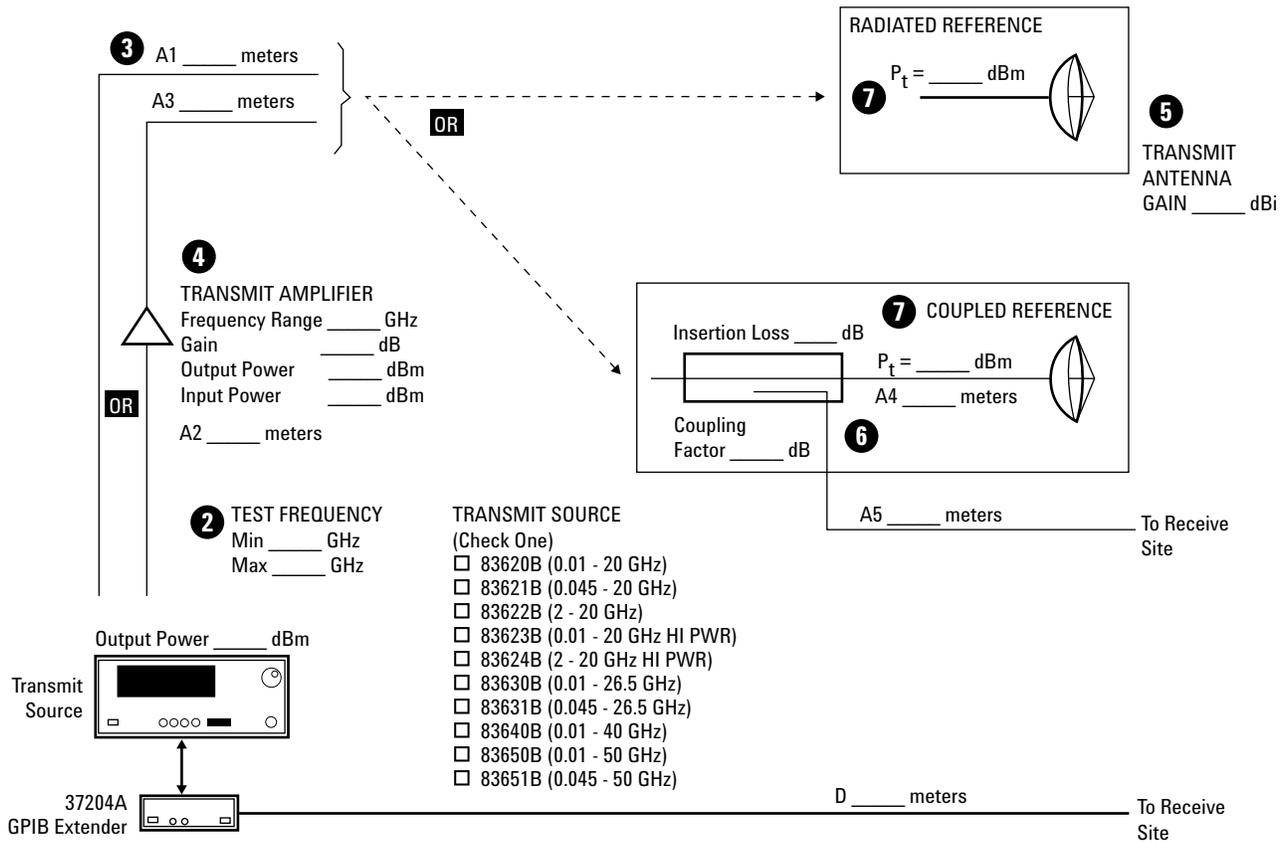


Figure 17. Configuration block diagram for antenna range transmit site

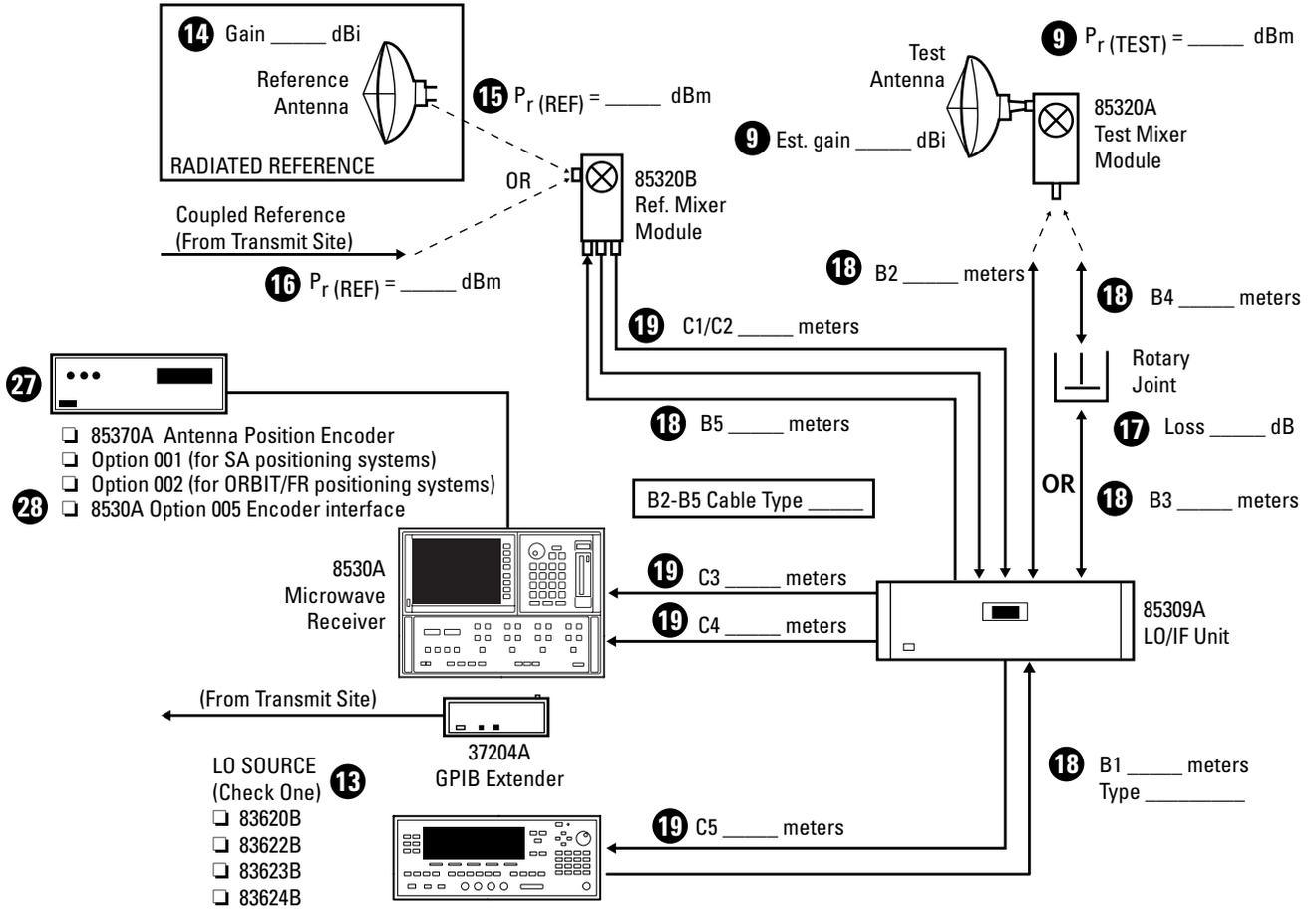


Figure 18. Configuration block diagram for 85301B antenna measurement system receive site

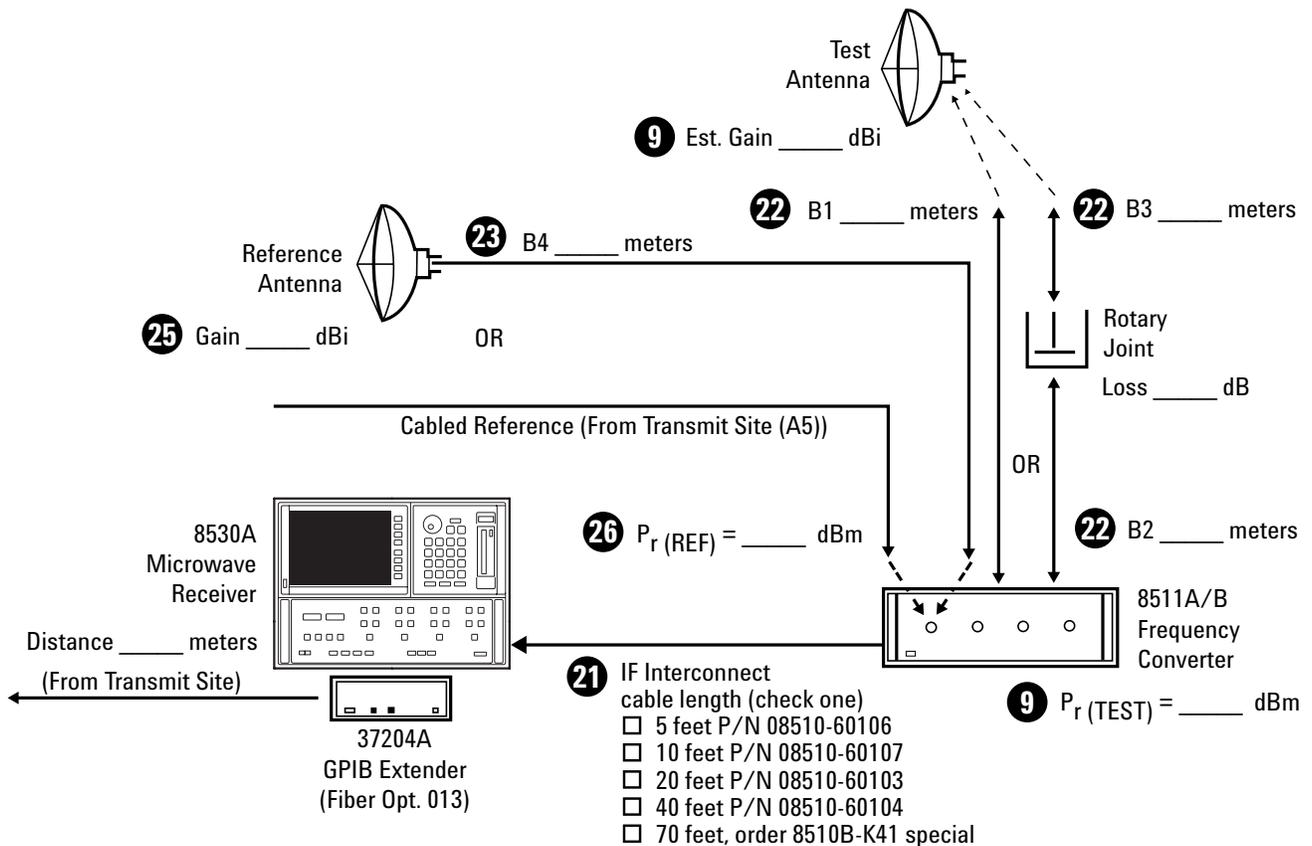


Figure 19. Configuration block diagram for 85301C antenna measurement system receive site

Measurement automation

Measurement automation software

Antenna automation software is provided by Agilent's channel partner, Nearfield Systems Inc.

- Far-field software required.
- Near-field software required.
- No measurement automation software required.

Personal computer

- Personal computer to be supplied; latest model and configuration.
- No personal computer is required.

Printer

- HP LaserJet printer required; latest model and configuration.
- Color printer required; latest model and configuration.
- No printer required.

Figure 20. Measurement automation

- 31** Millimeter-wave capability for 85301B antenna measurement systems
- Millimeter-wave frequencies are not required at this time. Skip the rest of Figure 21.
 - Millimeter-wave frequency capability is required. Complete this section:
 - Millimeter-wave coverage to only 50 GHz or less is required. An 83650B microwave source will be substituted for the standard 83620B, and 85320A/B-H50 mixers (2 to 50 GHz) will be substituted for standard mixers.
 - Millimeter-wave capability beyond 50 GHz is needed. Complete this page.
- Millimeter-wave frequency coverage can be added to an 85301B antenna system by adding an 85326A millimeter-wave interface kit and the appropriate 85325A millimeter-wave subsystem kit.

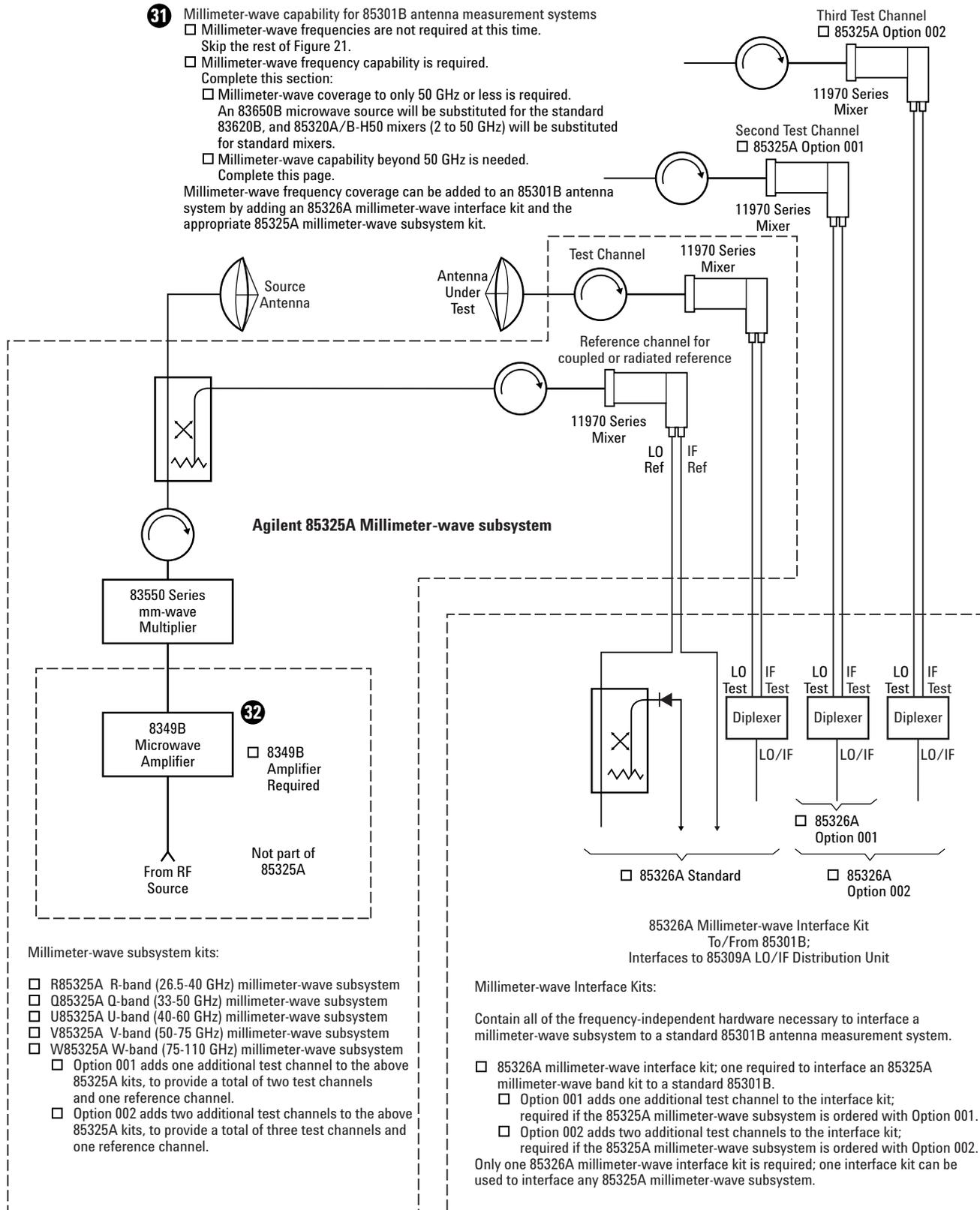


Figure 21. Millimeter-wave subsystem and interface kit

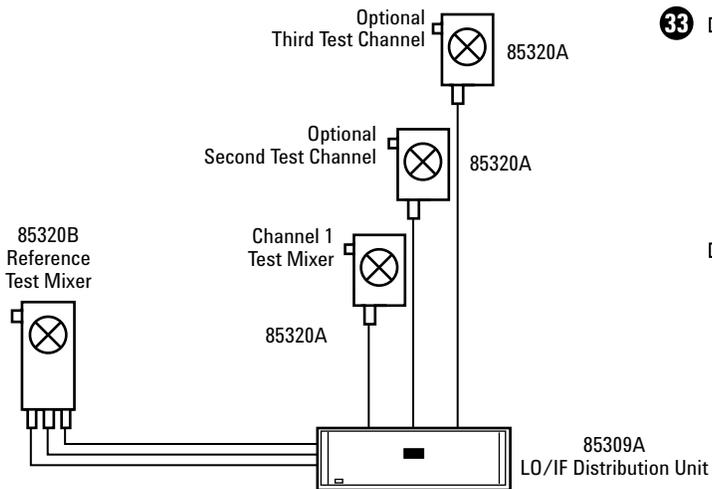
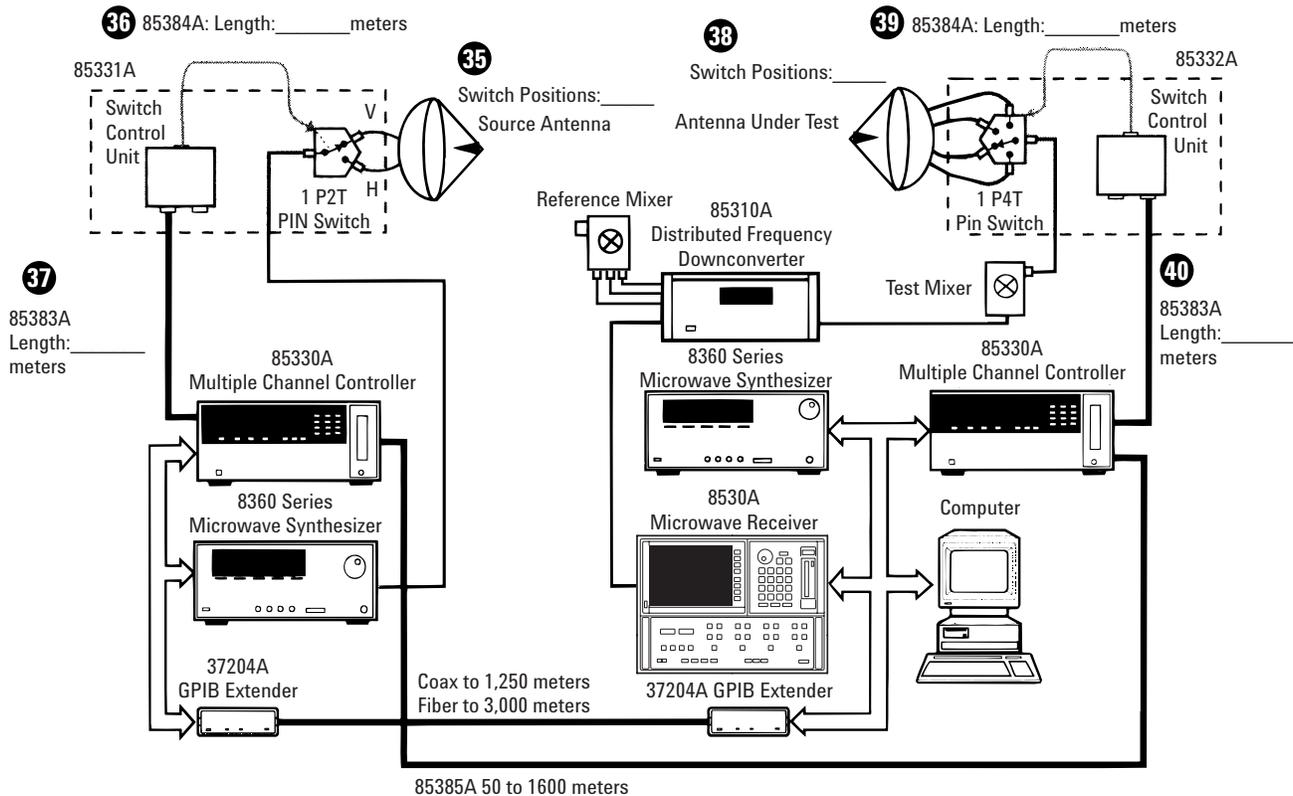


Figure 22. Multiple-channel IF switching configuration

- 33** IF switching capability is desired.
- Standard configuration:
One reference and one test mixer; 7m cables; 85309A has one reference and one test channel.
 - Option 001: add one additional test channel.
One reference and two test mixers; 7m cables; 85309A has one reference and two test channels.
 - Option 002: add two additional test channels.
One reference and three test channels; 7m cables; 85309A has one reference and three test channels.
 - IF switching capability is not required.

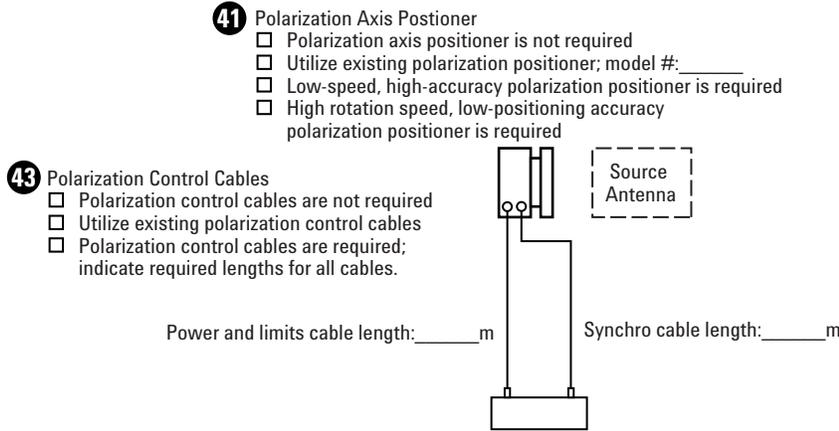
- 34** Multiple-channel capability is not required at this time.
Skip this page; this capability can be added later as an upgrade if desired.
- Multiple-channel capability is desired.
Complete this page.



- 35** No RF switching is required on the transmit side of antenna range.

- 38** No RF switching is required on AUT side of antenna range.

Figure 23. Multiple-channel RF switching configuration



- 42** Polarization Axis Controller
- Polarization axis controller is not required
 - Utilize existing polarization axis controller; model #: _____
 - Polarization axis controller is required

Figure 24. Positioner configuration for source antenna side of range

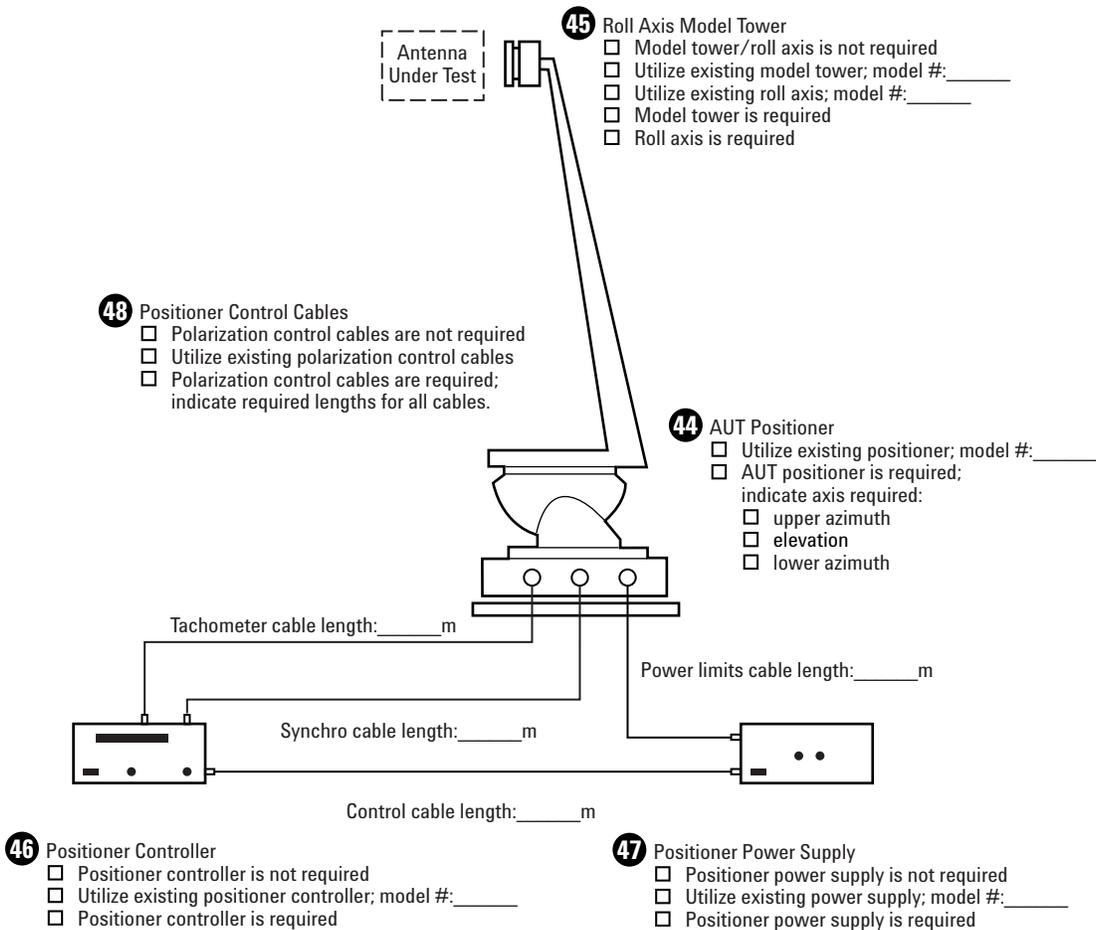


Figure 25. Positioner configuration for AUT side of antenna range

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