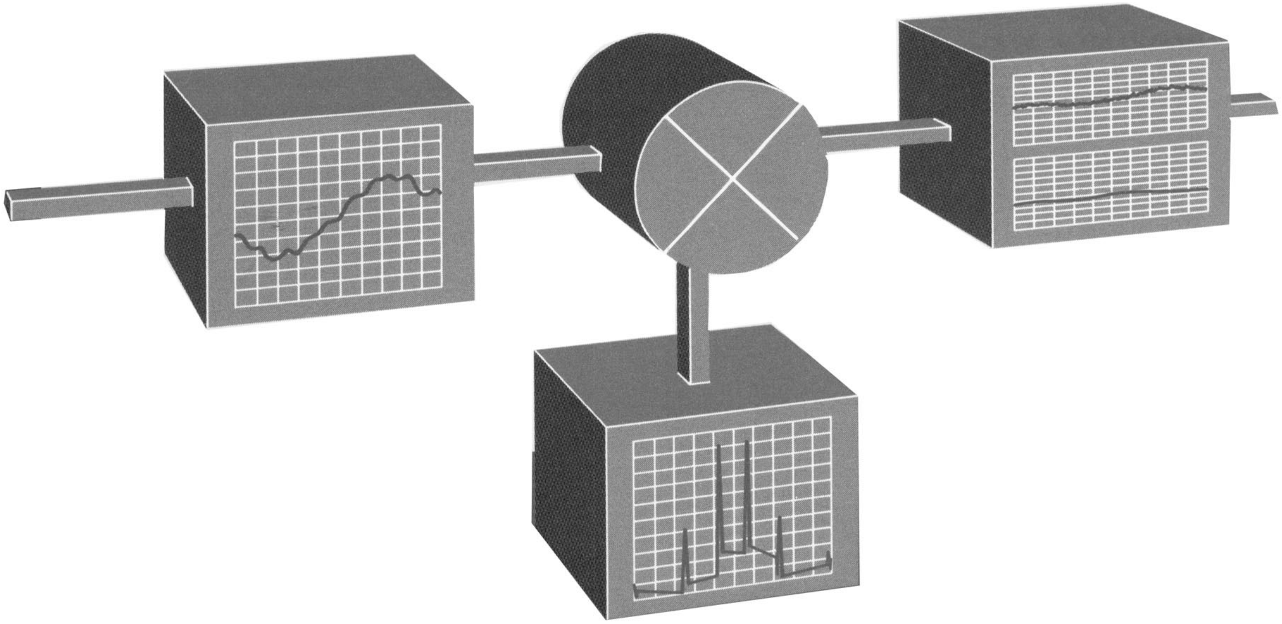
Agilent PN 8753-2

RF Component Measurements—Mixer Measurements Using the 8753B Network Analyzer

Product Note



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Introduction

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This note describes several procedures and hardware setups for measuring the performance of a mixer or frequency translator using the Agilent Technologies 8753B vector network analyzer.

The measurements described in this note are conversion loss, conversion compression, amplitude and phase tracking, two-tone third order intermodulation distortion, isolation (feedthrough), and SWR.

Vector network analyzers have typically been used for measuring the transmission and reflection characteristics of linear components and networks. The 8753B simplifies and speeds the testing of non-linear devices such as mixers (the focus of this note) and amplifiers (see Product Note 8753-1, *Amplifier Measurements Using the Agilent 8753,* lit. no. 5956-4361).

Traditionally, vector network analyzers working at a single stimulus and response frequency were unable to test the transmission characteristics of a mixer. The 8753B has the ability to offset or decouple its receiver from its own internal synthesized source. This enables you to stimulate a device over one frequency range and view its response over another. This, along with its vector network analyzer capabilities, makes the 8753B a significant enhancement to any environment where comprehensive mixer testing is required.

Because a mixer is a 3-port non-linear device it is impossible to take advantage of traditional 2-port vector accuracy enhancement. However, there are necessary considerations when making any mixer measurement: IF port filtering, reducing the number of unwanted signals that enter the receiver, attenuation at all mixer ports, reducing refections, and frequency selection (frequency list mode). These techniques will be discussed in greater detail in the “Measurement Considerations” section of this note.

Throughout the procedures described in this note, front panel keys appear in bold type, e.g. **[MENU]**. Softkeys such as POWER appear in bold italics, e.g. ***[POWER]***.

Typical equipment list used to make the measurements in this note

Network analyzer	8753B
Transmission/Reflection test set	85044A
External synthesized signal generator	8656A/B (8657A/8642A/B could also be used.)
Power meter GPIB	436A/7B/8A
Mixer Under Test	Mini-Circuits ZFM-15 or equivalent
Various cables, filters, amplifiers, connectors, and attenuators	

Mixer term definitions

Conversion loss

Conversion loss is the measure of efficiency of a mixer. It is the ratio of sideband IF power to RF signal power, and is usually expressed in dB. The mixer translates the incoming signal, RF, to a replica, IF, displaced in frequency by the local oscillator, LO. This frequency translation exacts a penalty that is characterized by a loss in signal amplitude and the generation of additional sidebands. For a given translation, two equal output signals are expected, a lower sideband and an upper sideband (Figure 1a).

Conversion compression

Conversion compression is a measure of the maximum RF input signal level for which the mixer will provide linear operation. The conversion loss is the ratio of the IF output level to the RF input level, and this value remains constant over a specified input power range. When the input power level exceeds a certain maximum, the constant ratio between IF and RF power levels will begin to change. The point at which the ratio has decreased 1 dB is called the 1-dB compression point. See Figure 1b.

Amplitude and phase tracking

The match between mixers is defined as the absolute difference in amplitude and/or phase response over a specified frequency range. The tracking between mixers is essentially how well the devices are matched over a specified interval. This interval may be a frequency interval or a temperature interval, or a combination of both.

Third order intermodulation distortion

This term describes the distortion of the mixer's conversion loss, caused by two or more sinusoidal signals interacting at the mixer's RF port. The two-tone third order distortion term is the amount of the signal at the IF port of the mixer due to third order frequency terms. This is usually expressed relative to the desired IF mixing product, (dBc). These third order terms are given by (2RF1 – RF2) ±LO, and (2RF2 – RF1) ±LO.

RF1 = Fixed RF frequency # 1
RF2 = Fixed RF frequency # 2
LO = Local oscillator frequency

Isolation

Isolation is the measure of signal leakage in a mixer. Feedthrough is specifically the forward signal leakage to the IF port. High isolation means that the amount of leakage or feedthrough between the mixer's ports is very small. Figure 1c diagrams the signal flow in a mixer.

The LO to RF isolation and the LO feedthrough are typically measured with the third port terminated in 50 ohms. Measurement of the RF feedthrough is made as the LO signal is being applied to the mixer.

SWR/Return loss

Reflection coefficient (Γ) is defined as the ratio between the reflected voltage (Vr) and incident voltage (Vi). Standing wave ratio (SWR) is defined as the ratio of maximum standing wave voltage to the minimum standing wave voltage, and can be derived from the reflection coefficient (Γ) using the equation shown below.

$$\Gamma = Vr/Vi$$

$$SWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

Return loss is equal to $-20 \log |\Gamma|$.

Because mixers are three-port devices, making an SWR measurement on one is more complicated than making an SWR measurement on a two-port device. The operating conditions the mixer will encounter during use should be the test levels at which the SWR measurements are made. For example, to make RF port SWR measurements, the LO must be connected and set at the desired frequency and power level, and the IF port must be terminated in 50 ohms.

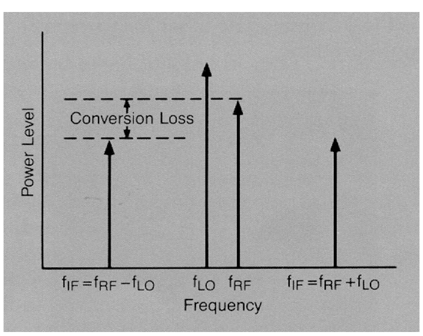

Figure 1a. Spectrum of RF, LO, and IF signals present in mixer measurements

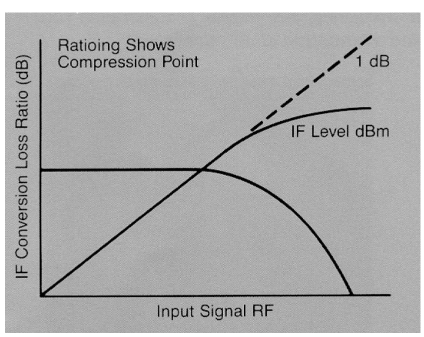

Figure 1b. Plot of conversion loss and IF output power as a function of RF input power level, note that the IF output power increases linearly with the increasing RF signal, until mixer compression begins and the mixer saturates.

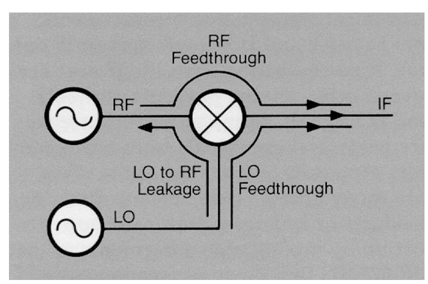

Figure 1c. Diagram showing the signal flow in a mixer, note that RF and LO feedthrough signals may appear at the mixer IF output, together with the desired IF signal.

Measurement considerations

In mixer transmission measurements you have RF and LO inputs and an IF output. Also emanating from the IF port are several other mixing products of the RF and LO signals. In mixer reflection measurements, leakage signals propagate from one mixer port and appear at the other two mixer ports. These unwanted mixing products or leakage signals can cause distortion by mixing with a harmonic of the Agilent 8753B's first down conversion stage. To ensure that measurement accuracy is not degraded, certain frequencies must be filtered or avoided by frequency selection. Attenuators placed at all mixer ports can be used to reduce mismatch uncertainties.

For frequency offset measurements made on the 8753B, it is necessary to choose the 8753B's source to supply the highest frequency in the measurement, whether it is being used to drive the RF or LO of the mixer. It is also necessary to configure the measurement so that the lowest frequency is incident upon the 8753B's receiver; this simply means measuring the lower of the two IF mixing products.

Filtering

Proper filtering between the mixer's IF port and the receiver's input port can eliminate unwanted mixing and leakage signals from entering the analyzer's receiver. Figure 2a shows a plot of mixer conversion loss when proper IF filtering was neglected. Figure 2b shows the same mixer's conversion loss with the addition of a low pass filter at the mixer's IF port. Filtering is required in both fixed and broadband measurements, but will be more easily implemented in the fixed situation. Therefore, when configuring broadband (swept) measurements you may need to trade some measurement bandwidth for the ability to more selectively filter signals entering the 8753B's receiver.

Attenuation at mixer ports

When characterizing linear devices, (single test frequency) vector accuracy enhancement can be used to mathematically remove all systematic errors, including source and load mismatches, from the measurement. This is not possible when the device you are characterizing is a mixer operating over multiple frequency ranges. Therefore, source and load mismatches are not corrected for and will add to overall measurement uncertainty.

As in a scalar measurement system, to reduce the measurement errors associated with the interaction between mixer port matches and system port matches, it is advisable to place attenuators at all of the mixer's ports. Figure 2c shows a plot of swept conversion loss where no attenuation at mixer ports was used. The ripple versus frequency is due to source and load mismatches. In contrast, Figure 2b made use of appropriate attenuation at all mixer ports. Extra care should be given to the selection of the attenuator located at the mixer's IF port to avoid overdriving the receiver. For best results, the value of this attenuator should be chosen so that the power incident on the 8753B's receiver ports is less than -10 dBm.

Frequency selection

Choosing test frequencies (frequency list mode) can reduce the effect of spurious responses on measurements by avoiding frequencies that produce IF signal path distortion.

The first step in avoiding or eliminating spurs is determining at what frequencies they will occur. To aid you in predicting where these frequencies will occur, a spur prediction program is included in Appendix 1 of this note. Although this spur prediction program is specialized for the measurement of the swept IF/fixed LO response of a mixer, it can easily be modified to accommodate other measurement configurations.

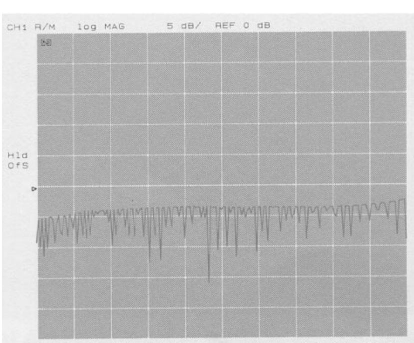

Figure 2a. Plot of a mixer's conversion loss vs. IF frequency without the use of appropriate IF signal path filtering, resulting in unusable data

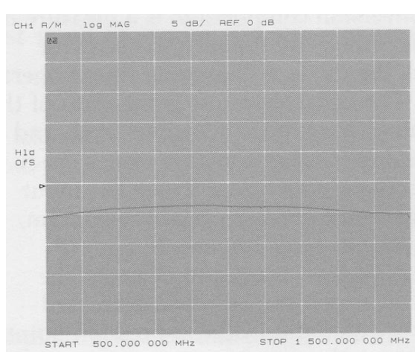

Figure 2b. Plot of a mixer's conversion loss vs. IF frequency with proper IF signal path filtering, and attenuation at all mixer ports

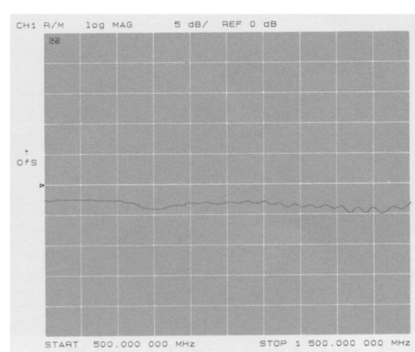

Figure 2c. Plot of a mixer's conversion loss vs. IF frequency neglecting attenuation at mixer ports. The frequency ripple seen is due to mixer and system port mismatches.

Conversion loss

Fixed IF conversion loss

The simplest of all conversion loss measurements is the fixed IF/fixed LO measurement where all three frequencies are held constant. Figure 3 shows the block diagram for a fixed IF/fixed LO conversion loss measurement.

The frequencies to be used in this measurement are:
RF = 1400 MHz
LO = 800 MHz
IF = 600 MHz

In all conversion loss measurements, the IF and LO frequencies are entered directly as parameters, while the RF frequency is entered by adding the IF and LO frequencies using frequency offset mode.

Frequency offset mode

This mode of operation allows you to offset the 8753B's source, by a fixed value, above the 8753B's receiver. This allows you to stimulate a device under test at one frequency and view its response at another frequency. This mode of operation has an RF source frequency limit of 3 GHz.

Measurement procedure

1. Connect the instruments as shown in Figure 3.

2. Press **[PRESET]** on the front panels of the 8753B and the local oscillator (LO) source.

3. From the front panel of the 8753B, set the desired IF frequency and RF source output power to be used.
   [MENU]
   [CW FREQ] [600] [M/µ]
   [POWER] **[6] [x1]**
   [MEAS]
   [R]

4. On the external signal generator, select the desired LO frequency and power level to be used in this measurement.
   [CW] [800] [MHz]
   [POWER] [13] [dBm]

5. Turn frequency offset on to set up a constant offset between the IF and RF signals. This sets the RF source frequency.
   [SYSTEM]
   [INSTRUMENT MODE]
   [OFFSET VALUE]
   [800] [M/µ]
   [FREQ OFFS ON]

6. Figure 4 shows the attenuated output power of the mixer's IF at the receiver. The conversion loss of the mixer is found by subtracting the attenuation from the total loss between the RF source and IF receiver.

Source power	= 6 dBm
Output power	= –17.5 dB
Total loss	= 23.5 dB
Total attenuation	= 16 dB
Conversion loss	= 7.5 dB

Swept IF measurements

One of the primary contributions of the 8753B to mixer testing is its ability to make a swept IF conversion loss measurement. Frequency translators can also be measured using the techniques described in this note, for example the downconverter module in Figure 5.

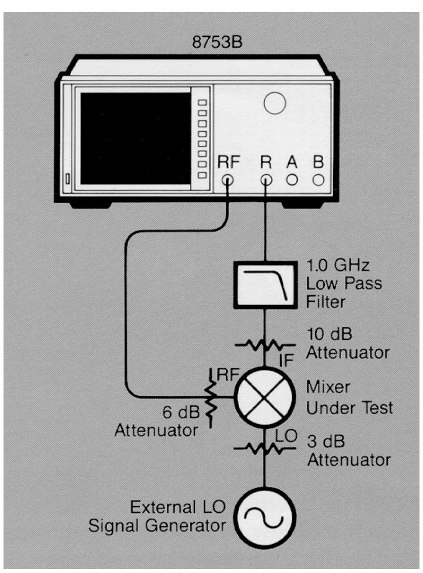

Figure 3. Block diagram for a fixed IF/fixed LO/fixed RF conversion loss measurement

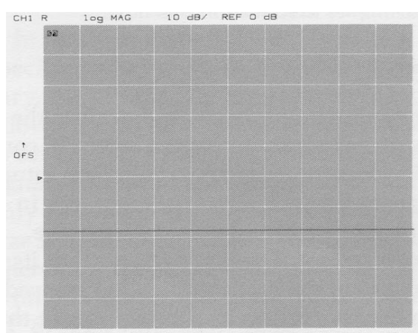

Figure 4. Plot of a mixer's fixed IF/fixed LO/fixed RF output power

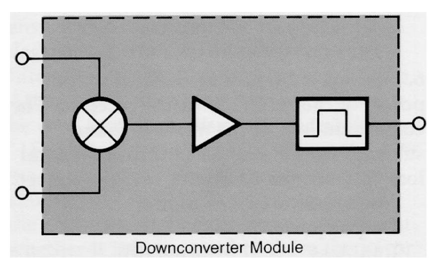

Figure 5. Block diagram of a typical downconverter module which can be characterized using the techniques described in this note.

Measurement procedure

The following procedure describes the steps necessary to perform a swept IF conversion loss measurement using the setups in Figures 6 and 7. The first five steps in this procedure are used to measure the response of the IF signal path, so that its response can be mathematically removed from the conversion loss measurement that follows.

1. Connect the hardware in Figure 6 with a thru connection between the power splitter and the receiver's B port.

2. Press **[PRESET]** on the front panels of the 8753B and the local oscillator (LO) source.

3. From the front panel of the Agilent 8753B, set the desired IF frequency range and RF output power to be used in this measurement.

[START] [100] [M/μ]
[STOP] [1.0] [G/n]
[MENU]
***[POWER]* [6] [x1]**

4. Using the keystrokes shown below, perform a frequency response calibration.

[MEAS]
[B/R]
[CAL]
[CALIBRATE MENU]
[RESPONSE]
[THRU]
[DONE: RESPONSE]

5. Leaving the thru cable in place connect the IF attenuator, filter, and cable between the power splitter and the receiver's B port. The IF low pass filter was chosen not only to eliminate unwanted mixing products from entering the analyzer's receiver, but also to pass the largest of the IF frequencies. Store the response into memory.

[DISPLAY]
[DATA → MEMORY]

This step measures the frequency response of the components in the IF signal path (attenuator, filter, and cable) and stores it into memory. This memory trace will be used to remove the frequency response of these components from the conversion loss measurement to be made with the setup in Figure 7.

6. View the absolute input power to the R channel.

[MEAS]
[R]

7. Connect the hardware as shown in Figure 7, terminating the open port of the power splitter with a 50-ohm load.

8. Set the external local oscillator (LO) source to the desired fixed frequency and power level.

[CW] [1.5] [GHz]
[POWER] [13] [dBm]

9. Remove the frequency response of the IF attenuator, filter, and cable from the measurement by viewing ***[DATA/MEM]***.

[DISPLAY]
[DATA/MEM]

10.Turn frequency offset on to set a constant offset between the IF and RF signals. This sets the RF source's frequency range. In this example, the RF frequency range is 1.6 GHz to 2.5 GHz.

[SYSTEM]
[INSTRUMENT MODE]
[OFFSET VALUE]
[1500] [M/μ]
[FREQ OFFS ON]

11. Since the mixer's RF input power was chosen to be 0 dBm and the loss due to the IF components was removed, the resulting display shows the swept IF conversion loss of the mixer versus IF frequency. A plot of this is shown in Figure 8.

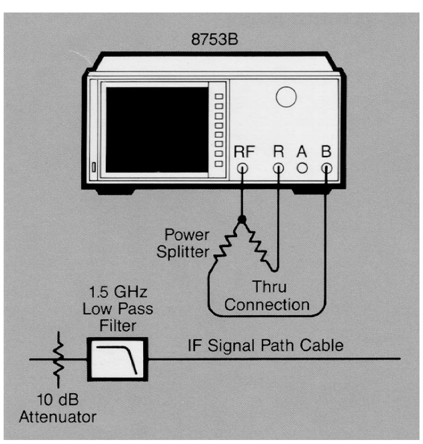

Figure 6. Block diagram for a B/R response calibration and device normalization

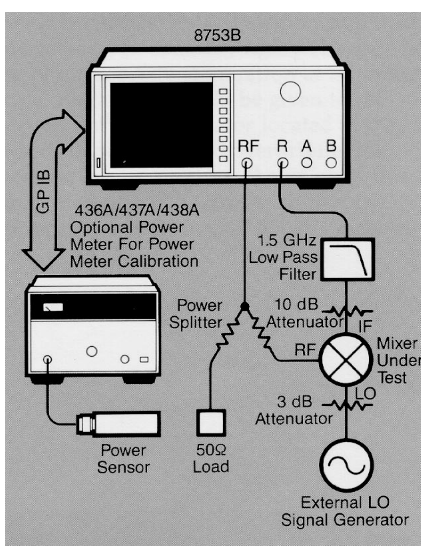

Figure 7. Block diagram for a swept IF/fixed LO conversion loss measurement

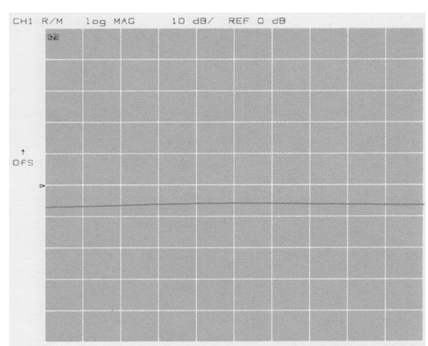

Figure 8. Plot of swept IF/fixed LO conversion loss of a mixer

Optional procedure

To enhance measurement accuracy, replace the 50-ohm load at the power splitter with the power meter and power meter sensor, as shown in Figure 7. Perform a one sweep power meter calibration. This will level the power splitter's output power to a user specified value over the frequency range of the measurement.

Zero the power meter. Prepare the 8753B to interface with the power meter.

[LOCAL]
[SYSTEM CONTROLLER]
[SET ADDRESSES]
[ADDRESS: P MTR/HPIB]
[#] [x1]

Press the power meter softkey (shown below) until the desired power meter has been chosen.

[POWER MTR: [438/437]]

Perform the power meter calibration.

[CAL]
[PWR METER]
[ONE SWEEP]
***[CAL POWER]* [0] [x1]**
[TAKE CAL SWEEP]

Once this power calibration is complete the power at the mixer's RF port is leveled to 0 dBm.

Disconnect the power meter and terminate this open port with the 50-ohm load.

NOTE: For more information on power meter calibration see the *Agilent 8753B System Operating and Programming Manual* (08753-90119). For more information on power meter measurements and accuracy see the appropriate power meter manual.

Conversion loss greater than 35 dB

Since the dynamic range of the receiver's R channel is limited, a modification of this procedure is required for conversion loss measurements where the R channel input is less than –35 dBm. The measurement procedure is the same as for the conversion loss measurements previously discussed. Figure 9 shows the hardware configuration for this measurement. Note that the mixer under test is being measured on the B channel which has greater than 35 dB dynamic range, while the reference signal on channel R (used for phase lock) has been increased by an external amplifier.

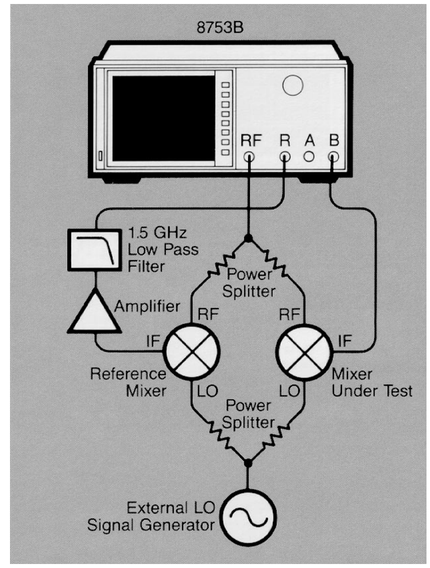

Figure 9. Block diagram for a conversion loss measurement greater than 35 dB

Fixed IF stepped LO & RF

An extension of the previous measurements is the case of fixed IF/stepped LO and RF frequencies. Figure 10 shows the hardware configuration for this fixed IF measurement. The simplest way to make this type of measurement without the use of an external controller is through the use of the 8753B's test sequence function. An excerpt from a sequence written to control two external synthesizers in tuned receiver mode appears below.

```
                    .
                    .
                    .
ADDRESS: PRINTER
 19x1
ADDRESS: P MTR/HPIB
 27x1
MANUAL TRG ON POINT
HOLD
CONTINUOUS
TITLE
 AP13DM;FA50MZ;FB1050MZ;ST2.9SC;SM;
TITLE TO PRINTER
TITLE
 AP10DM;W1;FA60MZ;FB1060MZ;N350MZ;Y1;CTY3;
TITLE TO P MTR/HPIB
LOOP COUNTER
 21x1
DO SEQUENCE
 SEQUENCE 2
                    .
                    .
                    .
```

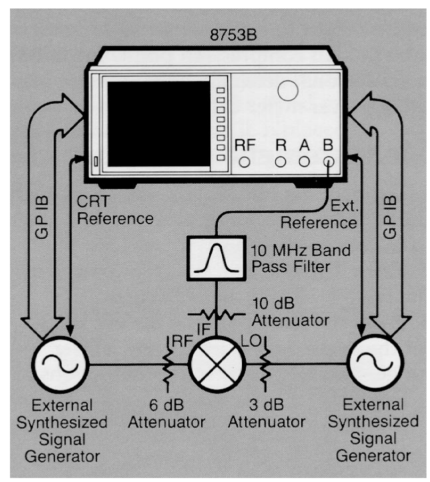

Figure 10. Block diagram for a Fixed IF stepped RF and LO measurement

Tuned receiver mode

In situations when the analysis of a specific signal or mixing product is necessary, the 8753B's tuned receiver mode allows you to tune the 8753B's receiver to an arbitrary frequency and analyze a signal without phase locking to it. This is only possible if the signal we wish to analyze is at an exact known frequency. Therefore, the RF and LO must be synthesized and synchronized with the 8753B's time base.

Figure 11 shows a plot of the stepped LO and RF fixed IF conversion loss of a mixer.

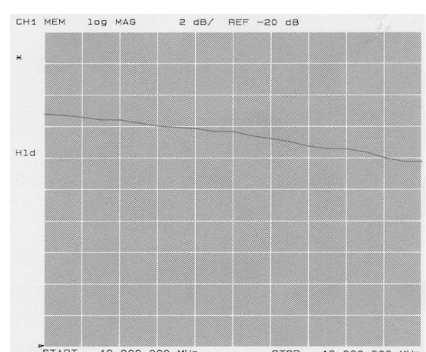

Figure 11. Plot of fixed IF/stepped LO and RF conversion loss of a mixer

Conversion compression

The following example uses a ratio of mixer output to input power to locate the mixer's 1-dB compression point. Included is an optional accuracy enhancement step using power meter calibration.

Measurement procedure

1. Connect the Agilent 8753B's source through the 20-dB IF attenuator and low-pass filter to the receiver's R port.

2. Press **[PRESET]** on the front panels of the 8753B and the LO source.

3. From the front panel of the 8753B set the desired fixed frequency, power range, and measurement specifications.

    [MENU]
    [SWEEP TYPE MENU]
    [POWER SWEEP]
    [RETURN]
    [CW FREQ]
    [700] [M/μ]
    [START] [0] [×1]
    [STOP] [15] [×1]
    [MEAS]
    [R]

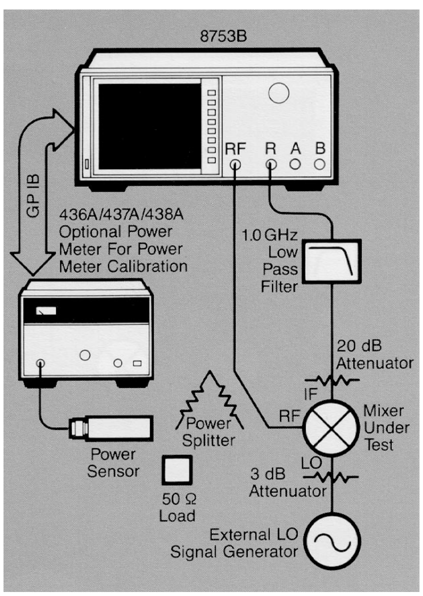

Figure 12. Block diagram for a conversion compression measurement

4. Store a trace of receiver power vs. source power into memory and view ***[DATA/ MEM]***. This removes the loss between the IF port of a mixer and the receiver, and will provide a linear power sweep for use in subsequent measurements.

    [DISPLAY]
    [DATA → MEMORY]
    [DATA/MEM]

5. Connect the instruments as shown in Figure 12.

6. Set the LO source to the desired fixed frequency and power level.

    [CW] [800] [MHz]
    [POWER] [13] [dBm]

7. Turn on a frequency offset equal to the LO's fixed frequency. This specifies the RF source, frequency.

    [SYSTEM]
    [INSTRUMENT MODE]
    [OFFSET VALUE]
    [800] [M/μ]
    [FREQ OFFS ON]

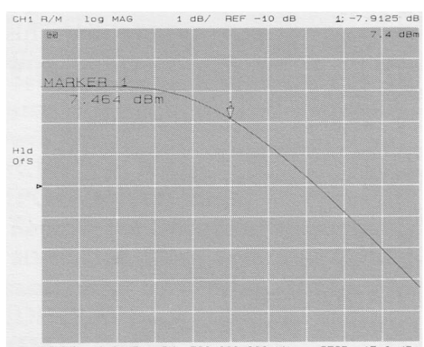

Figure 13. Plot of a mixer's conversion compression, including a marker locating the 1 dB compression point

8. The resulting display shows the mixer's output power as a function of its input power.

9. Set up an active marker to search for the 1-dB compression point of the mixer.

    [SCALE REF]
    [AUTO SCALE]
    [MKR]

Move the marker to a point of zero slope on the trace (zero slope indicates the mixer's linear region of operation).

    [MKR ZERO]
    [MKR FCTN]
    [MKR SEARCH ON]
    [TARGET]
    [-1] [×1]
    [MKR]
    [Δ MODE MENU]
    [Δ MODE OFF]

The following display (Figure 13) shows the mixer's 1-dB compression point. By changing the target value, you can easily locate other compression points (e.g., 0.5 dB, 3 dB).

Optional procedure

To enhance measurement accuracy, insert a power splitter between the RF source and the mixer's RF port. Connect the power meter (shown in Figure 12), to the power splitter's open port. Perform a one sweep power meter calibration.

For the necessary procedure, see the swept IF conversion loss measurement on page 6.

Once this procedure is complete, the mixer's RF input power is referenced to a power meter standard.

Amplitude and phase tracking

The 8753B can be used to measure swept IF amplitude and phase tracking between mixers over a specified frequency interval. A block diagram of the hardware configuration necessary for this measurement is shown in Figure 14.

In this measurement, we compare mixers having the same stimulus and response signal paths, so that any difference seen in response is due to the mixers and not the measurement system. Mixer B is replaced with the mixer that you wish to compare to it, while mixer A remains in place, used by all mixers as a reference.

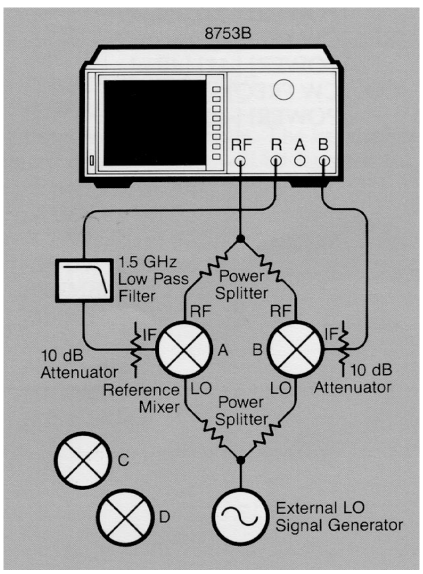

Figure 14. Block diagram for an amplitude and phase tracking measurement

Measurement procedure

1. Connect the hardware, including mixers A and 13, as shown in Figure 14.

2. Press **[PRESET]** on all instruments.

3. Set the RF source output power and frequency range of the IF receiver.
   [MENU]
   [POWER] **[6] [×1]**
   [START] [100] [M/µ]
   [STOP] [1.0] [G/n]

4. Set the fixed frequency and output power of your LO source.
   [CW] [1.5] [GHz]
   [POWER] [16] [dBm]

5. Set the RF source frequency range using frequency offset mode. In this measurement the RF range covers 1.6 GHz to 2.5 GHz.
   [SYSTEM]
   [INSTRUMENT MODE]
   [OFFSET VALUE]
   [1.51] [G/n]
   [FREQ OFFS ON]

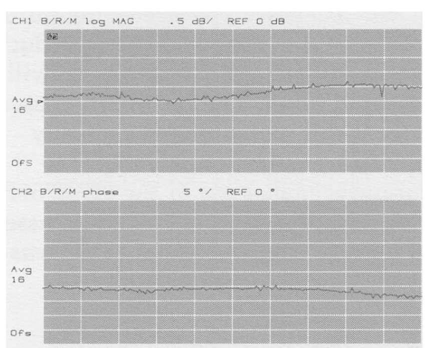

Figure 15. Plot of amplitude and phase tracking between two mixers

6. Display the magnitude and phase of the IF output of mixer B divided by that of mixer A. Store this data into memory an display future data relative to it. This display shows two flat lines.
   [CH 1]
   [MEAS]
   [B/R]
   [FORMAT]
   [LOG MAG]
   [DISPLAY]
   [DUAL CHAN ON]
   [DATA → MEMORY]
   [DATA/MEM]
   [CH 2]
   [MEAS]
   [B/R]
   [FORMAT]
   [PHASE]
   [DISPLAY]
   [DATA → MEMORY]
   [DATA/MEM]

7. Remove mixer B from the test setup and replace it with the mixer you wish to compare it to (in this case mixer C). The resulting display is the amplitude and phase match between the third mixer and the original mixer that it replaced (mixer C/ mixer B), see Figure 15.

When comparing several mixers, it is good measurement procedure to periodically reinsert the original mixer, (mixer B) and observe the display. This display should look as it did in step 6 of the above procedure. This procedure will verify that your measurement system is time invariant.

Two-tone third order intermodulation distortion

When two signals are applied to the input of a device, they interact to produce third order intermodulation distortion. In this measurement procedure two closely spaced fixed frequencies of equal amplitude are input at the mixer's RF port, while a single frequency is used to drive the mixer's LO port. The size of the third order intermodulation distortion products relative to the desired IF frequencies will be measured (dBc). The Agilent 8753B is used to perform this measurement typically made with a spectrum analyzer. This measurement makes use of the 8753B's tuned receiver mode, previously discussed in the fixed IF/stepped RF and LO measurement (page 7).

RF1 = Fixed RF frequency #1
RF2 = Fixed RF frequency #2
LO = Local oscillator frequency
IF1 = RF1 – LO
IF2 = RF2 – LO

3rd order intermodulation products
3rd1 = 2RF1 – RF2 – LO
3rd2 = 2RF2 – RF1 – LO

Figure 16 shows a block diagram for a third order INID measurement made with the 8753B. The filters, attenuators, and amplifiers provide isolation and remove unwanted signals from the system. These are essential to accurate measurements, because signal levels as low as 60 dBc can degrade third order IMD measurements.

Measurement procedure

1. Connect the hardware in Figure 6 (Page 6) with a thru connection between the power splitter and the receiver's B port.

2. Press **[PRESET]** on all instruments.

3. Select the fixed frequencies and output power levels for all three external signal sources. To ensure accurate measurement independent of source distinction, power levels should be chosen given third order IMD sidebands between –40 and –50 dBc. The power levels below were chosen for a +30 dB amplifier gain.

RF1: **[CW FREQ] [1] [GHz]**
[POWER] [–24] [dBm]
RF2: **[CW FREQ] [1.00003] [GHz]**
[POWERI [–17] [dBm]
LO: **[CW FREQ] [.9] [GHz]**
[POWER] [–10] [dBm]

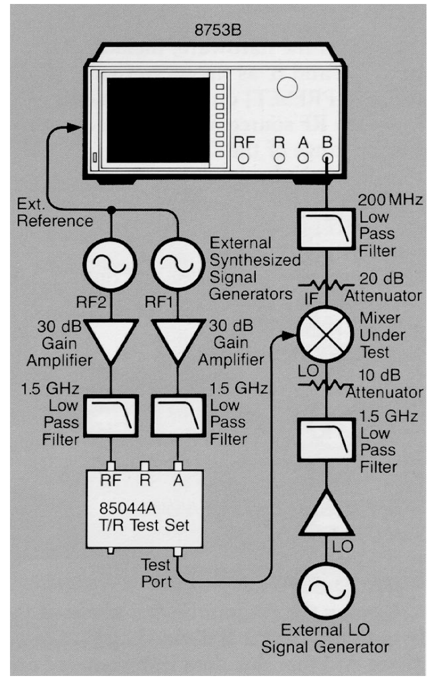

Figure 16. Block diagram for a two-tone third order intermodulation distortion (IMD) measurement

4. Set up a frequency list (frequency list mode) of points where the 8753B's receiver is to take data. This includes the four points of interest IF1, IF2, 3rd1, and 3rd2, and the two endpoints that are used to center the plot. In this example RF1 is 1 GHz, RF2 is 1.00003 GHz, the LO is 0.9 GHz, and the two third order products are .09997, and .10006 GHz.

Frequency list data points:

.09992 GHz
.09997 GHz
.10000 GHz
.10003 GHz
.10006 GHz
.10011 GHz
[MENU]
[SWEEP TYPE MENU]
[EDIT LIST]

Enter frequency points. The keystrokes found directly below will be repeated for each point in the list.

[ADD]
[CENTER] **[#] [G/n]**
[SPAN] **[2] [k/m]**
[NUMBER of POINTS]
[5] [×1]
[DONE]

Next point:

[DONE]
[LIST FREQ]

5. Reduce the IF bandwidth to lower the noise floor of the trace, and resolve the measurement data.

[AVG]
[IF BW [3000 Hz]
[100] [×1]

6. With the configuration in Figure 6 still connected, repeat steps 4 and 5 of the swept IF conversion loss measurement (Page 6).

7. Connect the instruments as shown in Figure 16, tying all time bases together (EXT REF). To minimize the effect of system distortion, it is suggested that attenuation at the mixer's IF port be chosen to give receiver input levels of -10 dBm or less.

8. View the absolute power present at port B relative to the trace of the IF attenuator, filter, and cable stored in memory.

[MEAS]
[B]
[DATA/MEM]

9. Select tuned receiver mode. This mode of operation allows the 8753B to receive external signals without the need to phase lock.

[SYSTEM]
[INSTRUMENT MODE]
[TUNED RECEIVER]

10. Figure 17 shows a comparison of two-tone third order IMD measured on a spectrum analyzer and on the 8753B.

If the displayed third order IMD products are of unequal magnitude, or appear to be unstable, change the frequency spacing between the RF input signals until the display stabilizes.

Third order intercept point (TOI)

Third order intercept point can be calculated using the equation below. TOI = DR/2 + (P in), where (P in) is the RF input signal level and DR is the difference between mixer IF output power and third order product mixer output power (dBc).

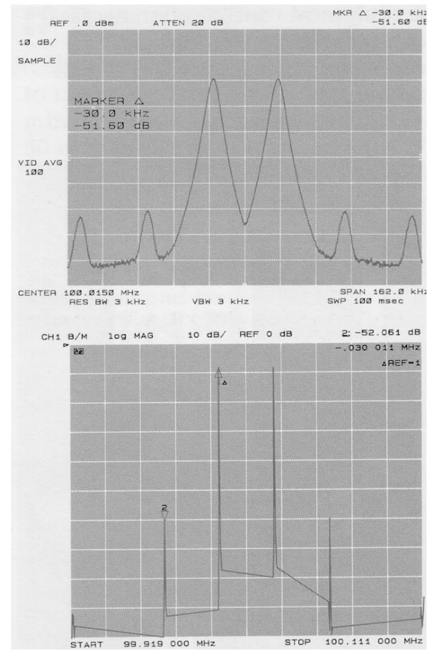

Figure 17. Comparison of third order IMD measurements made on a spectrum analyzer and the Agilent 8753B

Isolation

The equipment configuration necessary to measure isolation (feedthrough) between mixer ports is identical to that used in a transmission (B/R) measurement, shown in Figure 18.

Measurement procedure

LO to RF isolation

1. Connect the hardware as shown in Figure 18.

2. Preset the Agilent 8753B by pressing **[PRESET]**.

3. Using the 8753B's source as your local oscillator, select the LO frequency range and source output power.
   [START] [10] [M/µ]
   [STOP] [3] [G/n]
   [MENU]
   [POWER] **[16] [×1]**

4. Perform a frequency response calibration.
   [MEAS]
   [B/R]
   [CAL]
   [CALIBRATE MENU]
   [RESPONSE]
   [THRU]
   [DONE RESPONSE]

5. Terminate the mixer's IF port with a 50-ohm load.

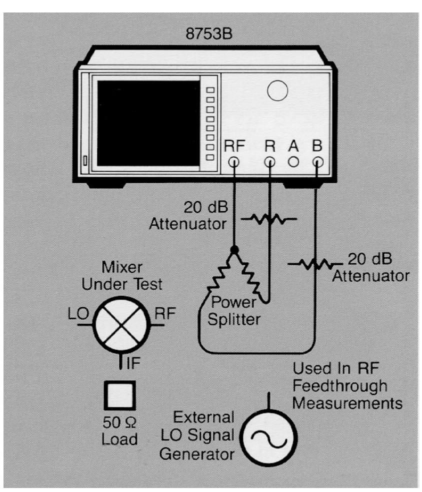

Figure 18. Block diagram for an isolation measurement

6. Insert the mixer to be tested between the power splitter and attenuator leading to the receiver's B port. The incident signal should be entering the mixer's LO port and exiting the mixer's RF port.

7. Adjust scale.
   [SCALE REF]
   [AUTO SCALE]

The resulting display shows the mixer's LO to RF isolation (Figure 19).

Measuring the IF to LO or LO feedthrough would follow a similar procedure.

RF feedthrough

The procedure and equipment configuration necessary for this measurement are very similar to those above, with the addition of an external source to drive the mixer's LO port as we measure the mixer's RF feedthrough.

1. Connect the hardware as shown in Figure 18.

2. Preset the instruments by pressing **[PRESET]** on the instrument front panels.

3. Using the 8753B as the RF source, select the frequency range and source power.
   [START] [10] [M/µ]
   [STOP] [3] [G/n]
   [MENU]
   [POWER] **[0] [×1]**

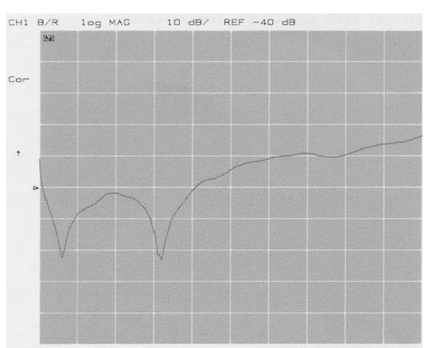

Figure 19. Plot of LO to RF isolation of a mixer

4. Perform a frequency response calibration.
   [MEAS]
   [B/R]
   [CAL]
   [CALIBRATE MENU]
   [RESPONSE]
   [THRU]
   [DONE: RESPONSE]

5. Insert the mixer to be tested between the power splitter and attenuator leading to the receiver's B port. The incident signal should be entering the mixer's RF port and exiting the mixer's IF port, with the external source connected to the mixer's LO port.

6. Select a fixed LO frequency and source power from the front panel of the external source. Isolation is dependent on LO power level and frequency. To ensure good test results, these parameters should be chosen as close to actual operating conditions as possible.
   [CW] [300] [MHz]
   [POWER] [10] [dBm]

7. The resulting display shows the mixer's RF feedthrough.

Measuring IF to RF isolation is done in a similar manner using the 8753B's source as the IF signal, driving the LO port with an external source, and viewing the leakage signal at the RF port.

SWR/Return loss

RF Port SWR

Mixer reflection measurements can be made simply and quickly using the setup shown in Figure 20.

Measurement procedure

1. Connect the Agilent 85044A Transmission/ Reflection test set to the 8753B.

2. Preset the 8753B by pressing **[PRESET]**.

3. Select the frequency and source output power for the 8753B.

   [START] [10] [M/µ]
   [STOP] [3] [G/n]
   [MENU]
   [POWER] **[13] [xl]**
   [FORMAT]
   [SWR]

4. Perform an S11 1-port calibration at the point to be connected to the RF port of the mixer. This removes systematic errors from the reflection measurement.

   [CAL]
   [CALIBRATE MENU]
   [S11 1-PORT]

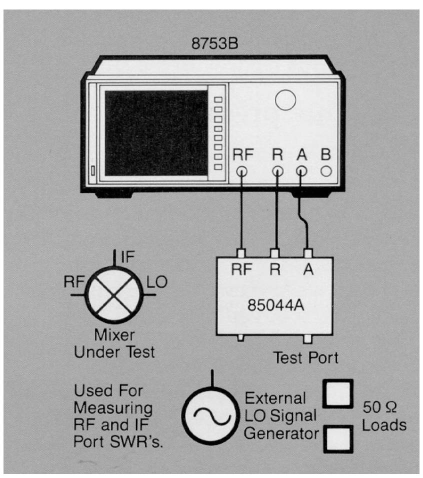

Figure 20. Block diagram for an SWR/return loss measurement

5. Select a fixed LO frequency and output power level. SWR is dependent on both LO power level and frequency. To ensure accurate test results select these parameters to simulate the conditions that the mixer will encounter during normal operation.

   [CW] [300] [MHz]
   [POWER] [13] [dBm]

6. Connect the mixer's RF port to the 85044A test set.

7. Connect the mixer's LO port to the output of the local oscillator.

8. Terminate the mixer's IF port with a 50-ohm load.

9. Adjust scale.

   [SCALE REF]
   [AUTO SCALE]

10. The resulting display (Figure 21) is the SWR of the mixer's RF port between 10 MHz and 3 GHz.

IF Port SWR

By connecting the IF port of the mixer to the front of the 85044A, and terminating the mixer's RF port with a 50-ohm load, you can measure the IF port SWR by using the procedure above.

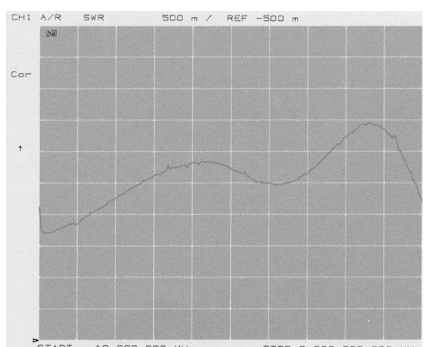

Figure 21. Plot of a mixer's RF port SWR

LO Port SWR

By adding 10 dB attenuators between the test set and the receiver's R and A ports, LO port SWR can be measured using a procedure similar to the one listed above, using the 8753B as the local oscillator.

Measurement procedure

1. Connect the 85044A Transmission/ Reflection test set to the 8753B.

2. **[PRESET]** the 8753B.

3. Select the frequency and output power the local oscillator will be set at under the mixer's normal operating conditions. If more power is needed than is available at the test port, you may insert an amplifier (<1 Watt) between source and test set, or replace the test set with a dual directional coupler.

4. Perform an S11 1-port calibration at the point to be connected to the mixer's LO port.

5. Terminate the mixer's RF and IF ports with 50-ohm loads.

6. Connect the mixer's LO port to the LO signal generator.

The resulting display of LO SWR shows signal reflection under typical operating conditions, and therefore more accurately predicts the reflections that will be present during actual operation.

Appendix. Spur analysis and prediction

As described in the "Measurement Considerations" section of this note, the Agilent 8753B is susceptible to spurious responses caused by unwanted mixing products of the device entering and mixing with the analyzer's sampler-based receiver. The easiest way to eliminate these spurs is to stop the unwanted signals from entering the 8753B. For fixed IF mixer measurements, this is easily accomplished by the use of a bandpass filter (BPF) centered around the mixer's IF signal. For swept measurements, filtering alone may not remove all unwanted signals. If this is the case, both filtering and frequency selection (frequency list mode) will be necessary. The spur prediction program found at the end of this appendix will help you select the frequencies to avoid when measuring the mixer's response.

Spur analysis

Shown in Figure A1 is a mixer under test having RF and LO inputs and an IF output. Also emanating from the mixer's IF port are several other mixing products of the RF and LO signals. These unwanted mixing products can cause spurious responses in the 8753B's IF signal path that will degrade measurement accuracy. For this reason, spurious responses must be avoided or reduced.

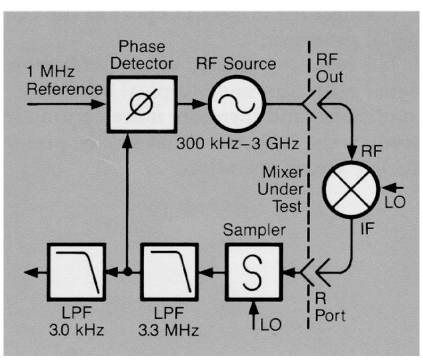

Figure A1. Block diagram of the 8753B receiver and a mixer under test

The method used in the 8753B to down-convert incoming IF signals to 1 MHz for internal processing is called sampling. The sampling method presents all of the frequency harmonics of the receiver's voltage-tuned oscillator (VTO) to the incoming IF signal. The VTO is retuned and phase-locked so that one of its harmonics mixes with the incoming IF signal to give exactly 1 MHz. An internal 1-MHz BPF stops all other mixing products of the RF, LO, and VTO which are not at 1 MHz from continuing on inside the 8753B. However, if the incoming IF signal is composed of many different frequency components, it is possible that some other component of the IF signal will combine with a different harmonic of the VTO and also produce a signal at 1 MHz (see Figure A2). This unwanted signal will then proceed through the internal 1-MHz BPF, along with the desired signal, and cause a spurious measurement response.

If you are concerned about spurious measurement responses it is suggested that you reduce the instrument's IF bandwidth, and avoid frequencies and frequency spacings of 1 MHz. Reducing the IF bandwidth will more selectively filter signals in the instrument's IF signal path. 1 MHz is the 8753B's first internal IF frequency, therefore 1 MHz and multiples thereof should be avoided when choosing frequencies and frequency spacings for mixer measurements made with the 8753B.

The spur prediction program

The first step in avoiding or eliminating spurs is to determine at what frequencies they may occur. This program predicts the frequencies that may cause spurious responses when they enter the 8753B's receiver, so that you may avoid them using frequency list mode. This spur prediction program is written in BASIC 5.0, and although it is specialized for fixed LO/swept IF mixer measurements, it can easily be modified for other measurement configurations. This program only predicts the possible occurrence of a spur, it does not predict its power level. Also, this program does not consider RF and LO subharmonics.

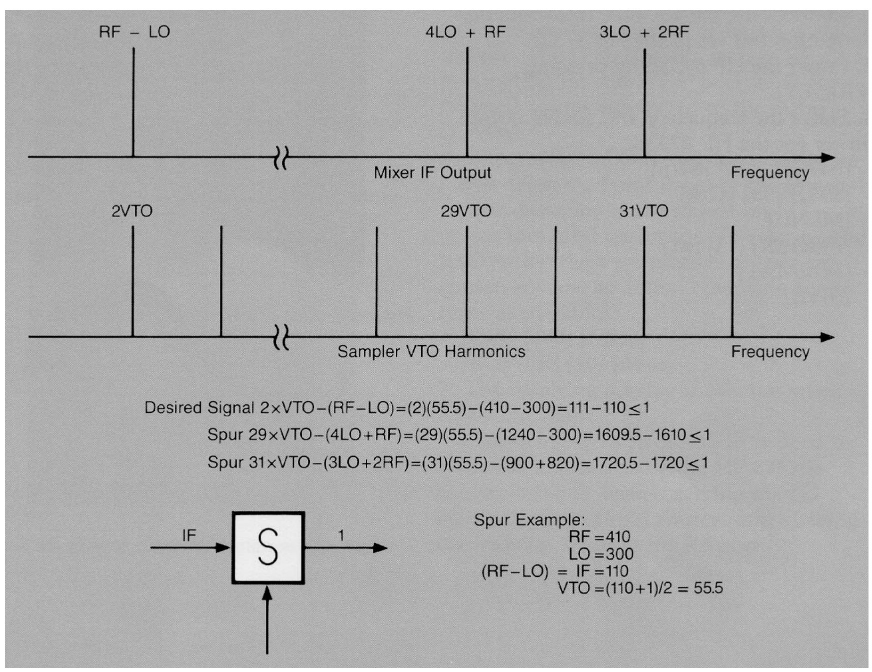

Figure A2. Diagram of mixer IF output and sampler VTO harmonics vs. frequency

```
10    !TEST SPUR
20    !8753 MIXER SPUR PROGRAM                        REV. 1.0   1/8/88    TR
30    OUTPUT KBD;CHR$(255)&CHR$(75);                         !CLEAR SCREEN
40    INPUT "ENTER RF START FREQ (MHz)",R start
50    INPUT "ENTER RF STOP FREQ (MHz)",R stop
60    PRINT USING "2(3A,5D.3D)";"R=",R start," - ",R stop
70    INPUT "ENTER LO FREQ (MHz)",L freq
80    PRINT USING "3A,5D.3D";"L=",L freq
90    INPUT "ENTER THE NUMBER OF 8753 TRACE POINTS",N pnts
100   PRINT USING "14A,4D";"NO. OF POINTS=",N pnts
110   INPUT "ENTER IF FILTER LOWER FREQ EDGE (MHz)",B start
120   INPUT "ENTER IF FILTER UPPER FREQ EDGE (MHz)",B stop
130   PRINT USING "13A,6D.3D,1X,3A,4X";"Filter start=",B start,"MHz","Filter sto
p=",B stop,"MHz"
140   PRINT " "
150   PRINT "    R            L             I          F vto*  X=   Y         mL
- nR=  Spur"
160   !
170   Mm=1
180   Nn=-1
190   R step=(R stop-R start)/(N pnts-1)
200   FOR Pnt=0 TO N pnts-1
210     R=R start+Pnt*R step
220     L=L freq
230     I=ABS(Mm*L+Nn*R)                               !DETERMINES I
240       CALL Vto(I,V)                                !DETERMINES Vto FREQ
250     !
260     FOR M=0 TO 10                                  !CONSIDER 0-10 L HARMONIC
270       FOR N=-10 TO 10                              !CONSIDER 0-10 R HARMONIC
280         IF M=Mm AND N=Nn THEN Necst                !Mm*L+Nn*R=I, IS NOT SPUR
290         CALL Spur(M,L,N,R,V,B start,B stop)        !DETERMINES SPUR FREQ
300 Necst:NEXT N
310     NEXT M
320   NEXT Pnt
330   END
340   !
350   SUB Vto(I,V)                                     !USES 8753 BAND SWITCH &
360   V=(I+1)/101                                      !HARMONIC INFORMATION
370   IF I<3060 THEN V=(I+1)/51                        !TO CALCULATE Vto FREQ
380   IF I<1607 THEN V=(I+1)/27
390   IF I<893 THEN V=(I+1)/15
400   IF I<536 THEN V=(I+1)/9
410   IF I<296 THEN V=(I+1)/5
420   IF I<178 THEN V=(I+1)/3
430   IF I<121 THEN V=(I+1)/2
440   IF I<61 THEN V=(I+1)/1
450   SUBEND
460   SUB Spur(M,L,N,R,V,B start,B stop)
470     X=ABS(M*L+N*R)
480     IF X<B start OR X>B stop THEN Here             !IF FILTER SECTION
481     P=X DIV V
490     IF P>(6000/V) THEN Here                        !CONSIDER Vto < 6 GHz
500     FOR H=0 TO 1
510       Y=ABS(X-(P+H)*V)
520       IF Y<2.000 THEN                              !8753 INTERNAL IF FILTER
530         PRINT USING "3(5D.3D,4X),3D.3D,1A,3D,1A,5D.3D,3X,2D,1A,3D,2A,5D.3D,"
;R,L,ABS(L-R),V,"*",P+H,"=",V*(P+H),M,"L",N,"R=",X
540       END IF
550     NEXT H
560 Here:SUBEND
```

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