HEWLETT PACKARD

Downconverted Measurements Using the HP 89410A and HP 89411A

Product Note 89400-9

The HP 89400 series vector signal analyzers (VSAs) are designed to analyze the complex vector-modulated, burst and transient signals used in modern communications and electronics systems. These signals are difficult, if not impossible, to measure with conventional signal analyzers. Real world signals consist of both magnitude and phase data, and both must be captured and analyzed, if you are to fully understand how your signals are behaving in the time or modulation domains. The HP 89400 VSAs capture the entire signal with real time speed and then evaluate it using powerful analysis features. The result is a broad range of time, frequency and modulation measurement capabilities in a single instrument.

The HP 89400 VSA family

- HP 89410A dc-10 MHz
- HP 89441A dc-2.65 GHz (consists of an HP 89410A and the HP 89431A RF section)
- HP 89440A dc-1.8 GHz (consists of an HP 89410A and an HP 89430A RF section)
- HP 89411A 21.4 MHz downconverter

The HP 89410A handles audio, video, modem, sonar and other baseband signals of up to 10-MHz information bandwidth. The HP 89440A and 89441A RF analyzers cover communications, EW and signal monitoring applications to 1.8 and 2.65 GHz respectively, with a 7-MHz information bandwidth. At higher frequencies, use the HP 89411A 21.4-MHz downconverter to convert the 21.4-MHz IF output of an external receiver or spectrum analyzer to the HP 89410A's input frequency range.

The HP 89411A is a fixed down-converter that translates the 21.4-MHz IF output from several popular RF and microwave spectrum analyzers to a baseband frequency within the range of the HP 89410A. In certain measurement situations an auxiliary source and mixer can provide the translation to baseband frequencies, and the HP 89410A has the firmware to facilitate these measurements.

Selecting a downconversion method

The process of downconverting a signal, or band of signals, simply involves translating it to a lower frequency. Ideally, the translation is accomplished without altering the relationship between the signals in the translated frequency band. There are many reasons to perform this frequency translation, but they usually amount to the same thing—the desire to perform more complex analysis on the signal. At lower frequencies it's possible to digitize the signal to a high degree of precision. Once the signal is digitized, various types of digital signal processing (DSP) can be applied. The HP 89410A provides this advanced analysis capability when the signal of interest can be translated to below 10 MHz.

Ideally, this frequency translation is a simple mixing operation. However, there are a number of pitfalls to avoid, especially when converting high RF or microwave frequencies. For example, spurious signals that may be indistinguishable from the desired mixer product could be generated in the mixing process, unwanted noise could be added to the signal, and often the resulting signal level is not well calibrated. An auxiliary high-frequency source can be used with a mixer to provide this translation, but care is often needed to obtain an accurate measurement.

To avoid these problems you can use the IF output provided by a higher frequency spectrum analyzer. Many RF and microwave spectrum analyzers provide an auxiliary output at one of the last intermediate frequencies. This output will have the benefit of filtering and image-protection where a simple mixer would not.

One of the most common intermediate frequencies is 21.4 MHz, and several families of spectrum analyzers (HP and other manufacturers) provide this output. The HP 89411A provides the link between the higher frequency analyzers and the HP 89410A by performing a frequency translation from 21.4 MHz to a frequency below 10 MHz (5.6 MHz). It provides image protection, step-selectable conversion gain and additional IF filtering to maintain signal integrity. It interfaces directly with the HP 89410A, and is compatible with the HP 70000 and 8566A/B series spectrum analyzers among others. This combination of instrumentation provides unprecedented analysis capability up to and beyond 26.5 GHz.

The choice of downconversion method depends on two factors. If one or just a few signals are present it is sometimes possible to use a signal generator and a mixer for the frequency translation. If many signals are present, especially ones which would appear at the image frequency of the conversion, the measurement could be invalid. If a high frequency spectrum analyzer with the correct IF output is already available, then the combination of the HP 89410A and 89411A provides a much better alternative. This is the solution described in detail in this paper.

Example downconverter system configurations

Signal generator, mixer and the HP 89410A

An example setup involving a source, a mixer, and the HP 89410A is shown in figure 1. The frequency to be converted is 12.4 GHz. A 12.405-GHz local oscillator signal for the mixer is generated by the source. The output frequency is 5 MHz. In a situation such as this, it is very difficult to filter the image frequency before the conversion unless a very high-Q filter is used. The filter would need to reject a signal 10 MHz away at 12.395 GHz. Some post-filtering after the conversion may be desired if the image frequency or any feedthrough from the mixer had the potential of corrupting your measurement. The filter may not be necessary at all if the signal only occupies a narrow frequency span to begin with. In this example, the mixer's LO port is driven by the external source, its RF port is fed with the signal of interest, and its IF port feeds the HP 89410A input. The frequency references of the source and the HP 89410A should be locked together, especially if good quality narrowband or demodulation measurements are desired.

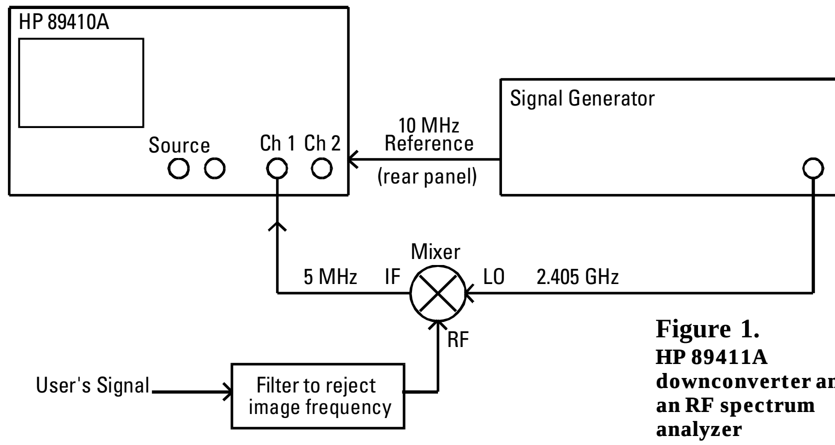


Figure 1.
HP 89411A downconverter and an RF spectrum analyzer

HP 89411A and the HP 70000 series spectrum analyzer

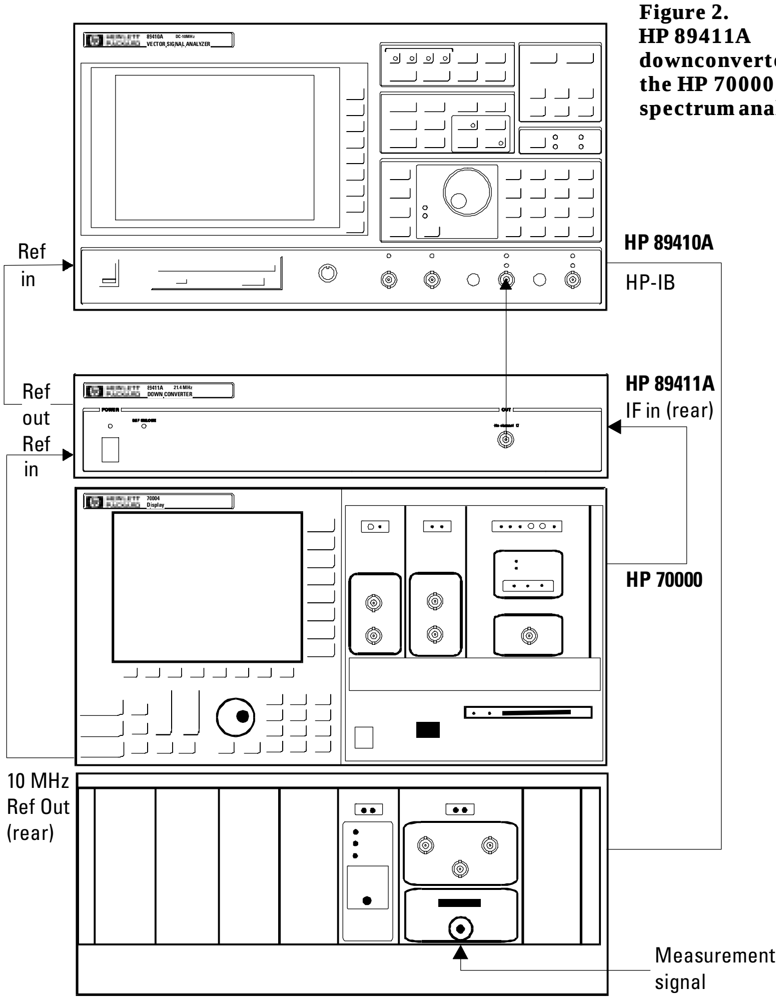
A setup using the HP 89411A and an HP 70000 series spectrum analyzer is shown in figure 2. In this example, the signal is applied to the input of the HP 70000 series analyzer and the resulting IF output is fed to the HP 89411A input. The output of the HP 89411A feeds the HP 89410A. Note that the frequency references of all three instruments should be locked together as shown. In addition, an HP-IB connection is made between the HP 89410A and the HP 70000 analyzer. This allows the HP 89410A to control the center frequency of the HP 70000 analyzer, producing a single point of control for the system. A setup using an HP 8566B in place of the HP 70000 analyzer would be very similar.

HP 89411A and other spectrum analyzers

Other spectrum analyzers with an auxiliary IF output may be compatible with the HP 89410A and 89411A. Your choice of analyzer may depend on what you have available as well as their suitability for the measurements you intend to make.

The HP 8568A/B are compatible with the HP 89411A and can provide very good performance as a downconverter, functioning in a similar fashion to the HP 8566A/B. However, it is not usually recommended for the following two reasons. First, its frequency range (1.5 GHz) is covered completely by the HP 89440A and 89441A which provide a more integrated measurement solution. The second reason is only important when making narrowband measurements or when absolute frequency accuracy is important. Because of the way the HP 8568A/B local oscillator works, (it is not phase-locked during the entire sweep), there is a possibility of including small frequency or phase errors in your measurements. The HP 8590E series spectrum analyzers (HP 8591E, 8593E, 8594E, 8595E, 8596E) also can be used in a downconversion system by using the auxilliary 21.4-MHz IF output. They

Figure 2.
HP 89411A downconverter and the HP 70000 series spectrum analyzer



are well suited for making spectral occupancy and band power measurements, but are less so for making narrowband or phase measurements. Since they use a local oscillator that is not continuously phase locked, they exhibit higher close-in phase noise than analyzers that use a phase locked LO. This could degrade close-in sideband measurements or phase measurements. For signals occupying a larger bandwidth (>100 kHz) this may not be an issue. For example, high quality measurements of digitally-modulated signals such as Personal Handyphone System (PHS) can be made with the HP 89410A and 89411A in conjunction with an HP 8593E.

The HP 8560E series spectrum analyzers are incompatible with the HP 89410A and 89411A because they do not produce an IF output signal at 21.4 MHz.

Other analyzers which provide a 21.4-MHz output may also be used. Important parameters to consider are the bandwidth and level of the IF output, and whether the instrument in question provides a logged or linear version of its IF signal (it should be linear for best results). For measurements such as characterizing phase noise, it is critical to use an analyzer whose LO stability or phase noise won't corrupt the results. The specification of interest might be stated as phase noise or as residual FM.

In summary, if only a small band of frequencies is to be downconverted and images or other spurious products will not corrupt the measurement—then a mixer, source and possibly a simple filter would comprise your downconversion setup. If you have a large range of frequencies to analyze and elimination of unwanted mixing products is important, then you should use the HP 89411A and an RF or microwave spectrum analyzer to perform the measurement. Your choice may also be based on the availability of the necessary equipment and the need for calibration of your setup.

The HP 70000 series of spectrum analyzers has an important advantage over the other spectrum analyzers mentioned in that it provides a wider bandwidth IF signal. The bandwidth of the IF signal on the HP 70000 series analyzers is approximately 10 MHz, whether it is taken from the RF section or IF section, while the other analyzers mentioned only support a 3 MHz information bandwidth.

Setting up the test equipment for downconversion

RF or microwave spectrum analyzer
The RF or microwave spectrum analyzer should have its center frequency set to the center of the frequency band you wish to analyze and its span set to zero Hz. In general, the resolution bandwidth (RBW) should be set to the largest value that the RF or microwave spectrum analyzer supports (not to exceed 8 MHz). The reference level or input attenuation should be set to accommodate the level of the signal. In general this means setting up the analyzer so that the signal is near but does not exceed the reference level or range setting. Set the analyzer's display scaling to linear. To further understand the effects of range and attenuation in the RF analyzer or other parts of the system, see the discussion of conversion gain in appendix A.

HP 89410A dc to 10 MHz VSA
The HP 89410A contains firmware to support a diverse set of downconverted measurements. When the choice of receiver (a softkey under the [**Instrument Mode**] hard key) is set to external, the characteristics of the external downconverter affect the displayed measurement results. The output frequency (final IF) of the

converter can be specified, as can the converter's tuning range. In addition, you can account for the spectrum mirroring which may occur. Mirroring (sometimes termed spectrum flip or inversion) describes the reversal of the frequency axis which occurs when the conversion process employs an LO that is above the signal of interest. For spectrum analyzers that use harmonic mixing, mirroring can occur for some harmonic bands but not for others. The conversion scheme used in the HP 89411A contributes another mirroring that should be accounted for in your setup. The [freq mirror] selection should be set to 'on' in those bands where a spectrum mirroring would occur. A table of the important frequency boundaries on several HP spectrum analyzers is included in appendix B.

If in doubt about whether the spectrum is mirrored, adjust the measured frequency slightly if possible, and confirm that the displayed result on the HP 89410A moves in the anticipated direction. Even though this discussion references setting up the HP 89410A for use with the HP 89411A, all of these parameters can be set to aid a downconverted measurement using a source and a mixer.

When using the HP 89411A set the input range of the HP 89410A to -14 dBm and its impedance to 50 ohms. When using the HP 89410A with a source and mixer set its range to a value larger than the highest signal you expect to measure to avoid distorting the signal.

HP 89411A 21.4 MHz downconverter

The HP 89411A has only one adjustable parameter—conversion gain. For most measurement situations this control should be set to its maximum value (+5 dB). Refer to the discussion in appendix A which describes how to set the conversion gain to its optimum value.

Automatic control of the downconversion system by the HP 89410A

The bottom key in the external setup menu on the HP 89410A enables HP-IB control of the attached RF or microwave spectrum analyzer from the HP 89410A. To access this key selection, press the [receiver] softkey under [**Instrument Mode**]. When external control is enabled, the HP 89410A sends several HP-IB commands to the attached spectrum analyzer to set the center frequency, span, RBW and display scaling. This last step is necessary when the auxiliary IF output on the spectrum analyzer is taken after the logarithmic amplifier. (Not all spectrum analyzers log the signal before the IF output, in fact some analyzers don't do it at all. In this case the command has no effect.) If this logging circuitry remained enabled, it would add undesirable distortion to the signal. If a log (dB) display is desired, the correct way to obtain it is to set the displayed data type (under the **[Data Format]** hardkey) to log magnitude on the HP 89410A.

Note: When option UFG (4 MBytes extended RAM and additional I/O) is installed on the HP 89410A, the HP-IB port on the option board is used to control the attached RF or microwave spectrum analyzer. This capability allows the instrument's main HP-IB port to be used for other purposes. For example, a computer could be controlling the HP 89410A as part of a larger system while the HP 89410A is controlling the external receiver hardware. For this example, the main HP-IB port would be configured as a talker/listener. The auxiliary HP-IB port on the option board is always configured as system controller. This port can also be accessed from HP Instrument BASIC (option IC2) at select code 10.

The default values for the parameters in the external setup menu are oriented toward use with the HP 89411A, but they can be set to a wide range of values. These values are maintained in the instrument's nonvolatile RAM and are not affected by an instrument preset.

Interpreting the results

When the external receiver type is selected, the frequency axis and marker readout will reflect the actual input frequency to the RF or microwave spectrum analyzer, as long as the external receiver control is enabled or the user has manually tuned the analyzer to the correct frequency. Because of the large variation in conversion gains for various setups, it is not possible for the HP 89410A to automatically display the correct amplitude. With a little care however, the amplitude readings can be corrected with the instrument's trace math capability.

Two approaches exist for correcting the amplitude readings. The first involves dividing the trace data by a constant that represents the nominal conversion gain for the current instrument setup (usually the value at the center of the IF band). The trace math function would be spectrum ch1*K1, where K1 was set to the nominal conversion gain. This level can be calculated, or measured directly if a signal of a known level is available. The most obvious choice for this signal is the HP 89410A source, but this requires that your downconversion setup be able to tune below 10 MHz. If you need to predict the conversion gain without measuring it, you will have to know the gain through the instrument. The conversion gain of the RF or microwave spectrum analyzer depends on the particular analyzer selected and on its attenuation or reference level settings. The conversion gain of the HP 89411A is selectable over a 15 dB range. Two example conversion gain calculations are included in appendix A.

The second method of obtaining corrected amplitude values involves measuring the frequency response of the entire conversion chain and normalizing all subsequent data by this response. This requires the ability to tune the RF or microwave spectrum analyzer to a frequency below 10 MHz, since the HP 89410A source is used as the stimulus for this measurement. (This may not be possible when a source and mixer are used for the downconversion.) The procedure for making this normalization and an HP I-BASIC program to automate the necessary measurements are included in appendix C.

Downconverted phase noise measurements

Measuring phase noise requires care if accurate results are to be obtained. Measuring phase noise from a signal that has been downconverted poses additional challenges. It is important to realize that the measured phase noise is affected by all stages of frequency conversion used. In other words, every local oscillator that is part of the downconversion process impresses its own phase noise characteristics on the signal. When measuring a microwave-frequency signal, great care should be taken to insure that the signal is not corrupted. In general, the highest frequency LO used in the measurement will have the greatest effect on signal quality. This is usually the external source or the first LO in the spectrum analyzer used for the downconversion. To estimate the contribution of the instrumentation to your measurement you will need to look at the combined phase noise contributions due to each instrument. In a system using the HP 89411A, 89410A and an RF or microwave spectrum analyzer, the RF or microwave analyzer would make the largest contribution, while the HP 89410A and 89411A would contribute to a lesser extent. For more information on making phase noise measurements with the HP 89410A see product note 89400-2, *Measuring Phase Noise with the HP 89400 Series Vector Signal Analyzers,* publication number 5091-7193E. Graphs comparing the phase noise characteristics of several sources and spectrum analyzers as well as the contribution of HP 89410A and 89411A are included in product note 89400-11, *Phase Noise Performance of the HP 89400 Series Vector Signal Analyzers,* publication number 5963-0039E.

Additional applications

In addition to making phase noise measurements, a downconverted measurement system involving the HP 89410A can facilitate other measurements.

By taking advantage of both channels on the HP 89410A, a simple signal monitoring and direction-finding system can be implemented. One possible configuration would use an HP 89410A with the second channel (Option AY7) and extended time capture RAM (Option AY9), two HP 89411A downconverters, and an HP 70000 series analyzer front-end configured with two RF sections. (The complement of HP 70000 hardware could include a 70310A reference section, a 70900B LO module, and two 70904A RF sections installed in a 70001A mainframe.) By configuring the HP 89410A as an HP-IB controller, the whole system can be controlled via an HP I-BASIC program. Instrument setup, measurements and data collection could all be coordinated by the HP I-BASIC program. This would make it unnecessary for the HP 70000 mainframe to have a display, since all of the measurements would be run from the HP 89410A.

There are a couple of limitations when making two channel downconverted measurements. First, both channels must have the same center frequency and span. Also, the frequency annotation on the second channel will not reflect the RF fre- quency the downconverter is tuned to.

Coordination of multiple systems can be accomplished via a LAN if the HP 89410A is equipped with option UFG (4 Mbyte extended RAM and additional I/O).

There are many ways to downconvert a signal for additional processing. Your particular measurement will dictate which is most appropriate. The HP 89400 series vector signal analyzers can be used as individual building blocks or as part of a system providing an unprecedented set of capabilities for making downconverted measurements.

For additional information, refer to chapter 10, “Using the HP 89411A Downconverter” of the HP 89410A, 89440A and 89441A Operators Guide.

Closely related to downconversion is the measurement of systems involving frequency translation or modulation. For additional information on this subject see product note 89400-6, *Making Translated Frequency Response Measurements with the HP 89440A,* publication number 5091-7412E.

Appendix A: Determining Conversion Gain

The conversion gain for a downconverted measurement should be tailored for the signal levels you expect to measure, if good signal-to-noise and distortion performance are to be achieved. The spectrum analyzers discussed in this paper follow one of two general block diagrams. Basically, the translated IF output is taken either before or after the IF gain and filtering.

In the HP 70000 series spectrum analyzers, the best place to obtain the downconverted signal is at the auxiliary IF output of the IF section (HP 70902A or 70903A), or directly from the RF section, if no IF section is present. The signal level at this point is nominally 5 dB above the RF input level when the attenuation is set to 0 dB. Every increase in attenuation reduces the downconverted signal level by an equal amount. The power-on attenuator setting on the RF sections is 10 dB, which results in a conversion gain of -5 dB. Unless you are very sure of your signal levels, you should probably leave 10 dB of attenuation switched in to prevent large signals from damaging the first mixer in the RF section.

In the HP 8566A/B, the auxiliary IF output is taken after the IF stages and immediately before the detector. Because of this, the RF attenuation and IF gain should both be set correctly to obtain the best dynamic range for your measurement. This is accomplished automatically by adjusting the reference level to the level of the largest signal of interest. This level produces a -20 dBm nominal output level. This adjustment sometimes will be easier if it is done before the display scaling is set to linear.

The conversion gain of the HP 89411A can be set explicitly by the user via a rear panel switch. The nominal values of conversion gain are -10, -5, 0 and +5 dB. The HP 89411A will achieve its best dynamic range when the input signal level is around -20 dBm. As explained earlier, this produces a -15 dBm output which is then sent to the HP 89410A, whose range setting should be -14 dBm.

We can use this information to illustrate some sample measurement setups. For the first example, the input signal has a level of -10 dBm, assuming the RF analyzer in the system is an HP 70000 series spectrum analyzer. If the signal level was +20 dBm, using 40 dB of RF attenuation would yield a signal level of -15 dBm at the IF output. Setting the conversion gain of the HP 89411A to 0 dB presents a level of -15 dBm to the HP 89410A, as desired. For the second example an HP 8566B is used. Its reference level would be adjusted to bring the signal to full scale (top of screen). This would produce an IF output of approximately -20 dBm. This signal is already at the optimum input level for the HP 89411A, so its conversion gain would be set to the maximum (+ 5 dB), to produce the correct level at the HP 89410A input.

Appendix B: Frequency conversion band boundaries for several HP spectrum analyzers

HP 70000 series spectrum analyzer conversion bands listed by RF section used.

	Frequency (GHz)	Spectrum mirrored?
HP 70904A	0 - 2.9	Yes
HP 70905A	0 - 2.9	Yes
	2.7 - 6.2	Yes
	6.0 - 12.8	Yes
	12.5 - 19.9	No
	19.7 - 22.0	No
HP 70906A	0 - 2.9	Yes
	2.7 - 6.2	Yes
	6.0 - 12.7	Yes
	12.5 - 19.9	No
	19.7 - 26.5	No
HP 70908A	0 - 2.9	Yes
	2.7 - 6.2	Yes
	6.0 - 12.8	Yes
	12.6 - 22.0	Yes
HP 70909A	0 - 2.9	Yes
	2.7 - 6.2	Yes
	6.0 - 12.8	Yes
	12.6 - 26.5	No
HP 70910A	100 - 6.2	Yes
	6.0 - 12.8	Yes
	12.6 - 26.5	No

	Frequency (GHz)	Spectrum mirrored?
HP 8566A/B	0 - 2.5	Yes
	2.0 - 5.8	Yes
	5.8-12.5	No
	12.5-18.6	No
	18.6-22.0	No
HP 8568A/B	0-1.5	Yes

HP 8590 series spectrum analyzer conversion bands

HP 8591E	0-1.8	Yes
HP 8593E	0-2.9	Yes
	2.7-6.5	Yes
	6.0-12.8	Yes
	12.4-19.4	Yes
	19.1-22.0	Yes
HP 8594E	0-2.9	Yes
HP 8595E	0-2.9	Yes
	2.75-6.5	Yes
HP 8596E	0-2.9	Yes
	2.75-6.5	Yes
	6.0-12.8	Yes

Appendix C: Example calibration procedure

It is important to note that this calibration procedure only provides a method to correct for frequency domain response errors. The time domain correction capability of the HP 89410A does not have the ability to correct for external hardware such as an IF downconverter. In many measurement situations this is not a limitation since many signals occupy a bandwidth much narrower than that of the downconversion hardware. In this case, the response of the downconversion hardware varies slowly over the bandwidth of the signal and the effects are not significant.

The HP Instrument BASIC program segment below implements a calibration procedure to correct for any frequency response anomalies in the IF of a downconversion system involving the HP 89411A and a RF spectrum analyzer (most likely the HP 70000 or HP 8566A/B series analyzers). This program could also be adapted to other downconversion setups since most of the operations performed by the HP 89410A would be the same.

The procedure involves generating and storing a periodic chirp waveform into one of the data registers and using the arbitrary source to play back this chirp in the external receiver mode. The chirp is used to stimulate the entire IF bandwidth of the conversion chain and the resulting frequency response can be used to calibrate subsequent measurements. To use this method of calibration the RF or microwave analyzer used must be able to tune below 10 MHz.

The code segment that follows is intended to be used as a subroutine. There are other HP 89410A instrument parameters that are not set in this routine. For example, it may be necessary to include an instrument preset command as well as commands to set other instrument parameters to non-default values.

```
10 ! Example program to perform calibration for downconverted
20 ! measurements using HP 89411A, HP 89410A and an RF spectrum
30 ! analyzer.
40 ! Hewlett-Packard Co. 1993
50 ! No warranty expressed or implied.
60  ASSIGN @Hp894x0a TO 800
70  OUTPUT @Hp894x0a;"ROUT:REC IF"
80  OUTPUT @Hp894x0a;"*OPC?"
90  ENTER @Hp894x0a;Opc_response
100  OUTPUT @Hp894x0a;"FREQ:CENT 5600000 HZ"
110  OUTPUT @Hp894x0a;"FREQ:SPAN 3000000HZ"
120 ! Set conversion frequency suitable for HP 89411A
130  OUTPUT @Hp894x0a;"FREQ:EXT:CENT 5600000 HZ"
140 ! Set IF bandwidth (suitable for HP 8566A/B)
150  OUTPUT @Hp894x0a;"FREQ:EXT:BAND 3000000 HZ"
160 ! Mirror or flip spectrum if needed
170  OUTPUT @Hp894x0a;"FREQ:EXT:MIRR ON"
180 ! Enable control of external RF analyzer by
190 ! HP 89410A
200  OUTPUT @Hp894x0a;"FREQ:EXT:COMM ON"
210  OUTPUT @Hp894x0a;"*OPC?"
220  ENTER @Hp894x0a;Opc_response
230  DISP "Connect source to 89410A Ch 1 Input"
240  PAUSE
250  DISP "Measuring response of HP 89410A ..."
260 !This section of the program creates a chirp and stores it in
270 ! D2 so it can be later output by the source
280  OUTPUT @Hp894x0a;"DISP:WIND1:ACT ON"
290  OUTPUT @Hp894x0a;"CALC1:FEED 'XTIM:VOLT 1'"
300  OUTPUT @Hp894x0a;"BAND:MODE:ARB ON"
310  OUTPUT @Hp894x0a;"WIND UNIF"
320  OUTPUT @Hp894x0a;"SOUR:FUNC PCH"
330  OUTPUT @Hp894x0a;"VOLT1:RANG -14 DBM"
340  OUTPUT @Hp894x0a;"SOUR:VOLT:UNIT:VOLT DBM"
350  OUTPUT @Hp894x0a;"SOUR:VOLT -20 DBM"
360  OUTPUT @Hp894x0a;"OUTP ON"
370  OUTPUT @Hp894x0a;"TRIG:SOUR OUTP"
380  OUTPUT @Hp894x0a;"AVER:TYPE COMP;TCON NORM"
390 ! The averaging count should be set larger if a
400 ! less noisy calibration trace is desired.
410  OUTPUT @Hp894x0a;"AVER:COUN 100 "
420  OUTPUT @Hp894x0a;"AVER ON"
430 ! Trigger measurement of chirp
440  OUTPUT @Hp894x0a;"ABOR;*WAI"
450  OUTPUT @Hp894x0a;"TRAC:COPY D2,TRAC1"
460  OUTPUT @Hp894x0a;"*OPC?"
470  ENTER @Hp894x0a;Opc_response
480 ! Configure HP 89410A for external receiver type.
490  OUTPUT @Hp894x0a;"ROUT:REC EXT"
500  OUTPUT @Hp894x0a;"*OPC?"
```

```
510  ENTER @Hp894x0a;Opc_response
520  OUTPUT @Hp894x0a;"FREQ:CENT 5600000 HZ"
530  OUTPUT @Hp894x0a;"VOLT1:RANG:UNIT:VOLT DBM"
540  OUTPUT @Hp894x0a;"VOLT1:RANG -14 DBM"
550 ! Switch source type to arb., use register D2
560  OUTPUT @Hp894x0a;"SOUR:FUNC USER"
570  OUTPUT @Hp894x0a;"SOUR:USER:REP ON"
580  OUTPUT @Hp894x0a;"SOUR:FUNC:USER:FEED 'D2'"
590  ! Set source level for arb waveform
600  OUTPUT @Hp894x0a;"SOUR:VOLT:UNIT:VOLT DBVPK"
610  OUTPUT @Hp894x0a;"SOUR:VOLT -26 DBVPK"
620 ! Trigger measurement of arb. output
630  OUTPUT @Hp894x0a;"ABOR;*WAI"
640 ! Display measured spectrum
650  OUTPUT @Hp894x0a;"CALC1:FEED 'XFR:POW 1'"
660 ! Store away the measured spectrum
670  OUTPUT @Hp894x0a;"TRAC:COPY D1,TRAC1"
680 ! Remove the source response.
690  OUTPUT @Hp894x0a;"CALC:MATH:EXPR5 (SPEC1/D1)"
700  OUTPUT @Hp894x0a;"*OPC?"
710  ENTER @Hp894x0a;Opc_response
720  DISP "Connect source to RF input, and reconnect 89410A"
730  PAUSE
740  DISP "Removing response of RF analyzer ..."
750 ! Trigger measurement through RF analyzer
760  OUTPUT @Hp894x0a;"ABOR;*WAI"
770 ! Remove effects of RF analyzer from measurement
780  OUTPUT @Hp894x0a;"CALC1:MATH:SEL F5"
790  OUTPUT @Hp894x0a;"TRAC:COPY D1,TRAC1"
800  OUTPUT @Hp894x0a;"*OPC?"
810  ENTER @Hp894x0a;Opc_response
820  DISP "Calibration complete, disconnect source from RF input."
830  END
```


HEWLETT PACKARD

United States:
Hewlett-Packard Company
Test and Measurement Organization
5301 Stevens Creek Blvd.
Bldg. 51L-SC
Santa Clara, CA 95052-8059
1 800 452 4844

Canada:
Hewlett-Packard Canada Ltd.
5150 Spectrum Way
Mississauga, Ontario
L4W 5G1
(905) 206 4725

Europe:
Hewlett-Packard
European Marketing Centre
P.O. Box 999
1180 AZ Amstelveen
The Netherlands

Japan:
Yokogawa-Hewlett-Packard Ltd.
Measurement Assistance Center
9-1, Takakura-Cho, Hachioji-Shi,
Tokyo 192, Japan
(81) 426 48 0722

Latin America:
Hewlett-Packard
Latin American Region Headquarters
5200 Blue Lagoon Drive
9th Floor
Miami, Florida 33126
U.S.A.
(305) 267 4245/4220

Australia/New Zealand:
Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia
Melbourne Caller 272 2555
(008) 13 1347

Asia Pacific:
Hewlett-Packard Asia Pacific Ltd.
17-21/F Shell Tower, Time Square,
1 Matherson Street, Causeway Bay,
Hong Kong
(852) 599 7070

Printed in U.S.A. 11/94
5091-8691E