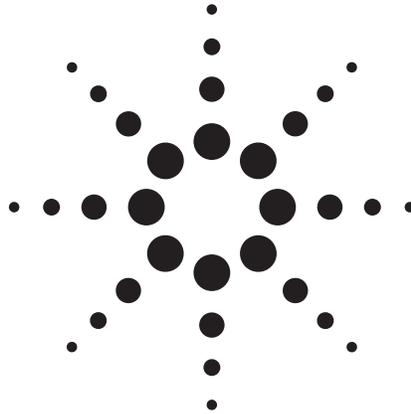


Phase and Amplitude versus Time (PAvT) Measurement Solution

For Power Amplifier Characterization

Application Note



Introduction

This paper discusses the need for measuring phase and amplitude versus time in mobile wireless appliances and presents measurement solution to enable characterization of the power amplifier for wireless devices. A general description of a discrete power step test signal is provided and explains the use of key measurement setup parameters, as well as the measurement arming and triggering methods and timing requirements. Measurement result data formats are described, followed by a list of 8960 remote user interface (RUI) commands and a description of a typical measurement procedure.



Table of Contents

Introduction to Phase and Amplitude versus Time Measurement	3
Polar Distortion of 8PSK Signals	4
RF Transmitter Characterization Technique	5
Agilent Technologies PAVT Measurement System	6
Measurement setup parameters	6
Measurement result data formats	6
Implementing an Agilent Automated Manufacturing solution	7
Measurement algorithm	7
Programming example	7
Appendix I	10
Introduction	10
Measurement receiver (RF analyzer) controls	10
PAvT measurement 'SETup' commands	10
PAvT measurement initiation and arming	13
PAvT measurement abort	13
PAvT measurement FETCh? queries	13
PAvT measurement READ? query syntax	15
Typical measurement procedure and setup using the PAVT	15

Introduction to Phase and Amplitude Versus Time Measurement

The European Telecommunications Standards Institute (ETSI) adopted an 8PSK modulation format, known as EDGE (EGPRS), to provide high data rate communications to GSM systems. The required modulation accuracy specifications and varying amplitude for 8PSK gives rise to new challenges in the design of power amplification for wireless devices. Because GSM generates a constant-amplitude signal, power amplifier linearity has not been an issue. With EGPRS, nonlinearities in the power amplifier can significantly and negatively affect the performance of the EGPRS phone. To allow reuse of the power amplifier with GSM and EGPRS, it is necessary to have phase and amplitude information with respect to time to create the necessary calibration factors which compensate for the amplifier's nonlinearities and ensure the mobile phone transmits properly.

The phase and amplitude versus time measurement (PAvT) provides a means to characterize the magnitude and phase variations introduced by the non-linearity of power amplifiers operating over a wide dynamic range. By measuring the variations in power, magnitude, phase, and frequency as a function of varying power output levels of a transmitting device. This data can be used to pre-distort the magnitude and phase control signals that modulate the final power amplification stage. The use of this approach results in a more accurate phase trajectory of the modulated output signal.

The Agilent 8960 (E5515C) Wireless Communications Test Set with PAVT measurement capability combines measurement speed, accuracy, and a unique flexibility to enable manufacturers to optimize phone performance now and through subsequent design iterations. Current users of the 8960 test set can upgrade their test set with PAVT capability with a single software upgrade - thus leveraging their previous investment, saving time, and achieving a lower cost of test.

With today's single-chipset solutions, the power amplifier is integrated into the chipset, and mobile developers will also need custom proprietary software from the chipset provider. This is generally provided under terms of the chipset licensing agreements. This software will cause the chipset to provide the necessary test signal, will receive the measurement data from the test set, and will calculate the calibration factors and download to the chipset.

Polar Distortion of 8PSK Signals

Consider an ideal 8PSK signal. The eight magnitude/phase states of the output signal will occur at precisely defined locations on a constellation diagram. These locations will lie along a circular contour and be evenly spaced at $\pi/4$ intervals. Furthermore, each magnitude/phase state will occur at a defined offset from the constellation's defined phase origin. Typically, in an EDGE system these locations are at integer multiples of $3\pi/8$ intervals from the constellation coordinate reference axes.

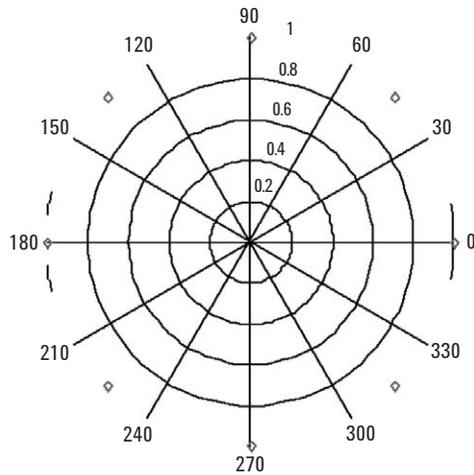


Figure 1: Perfect 8PSK constellation at one power level

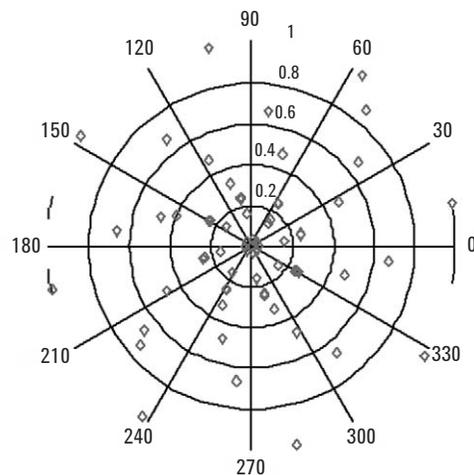


Figure 3: 8PSK constellation with polar distortion

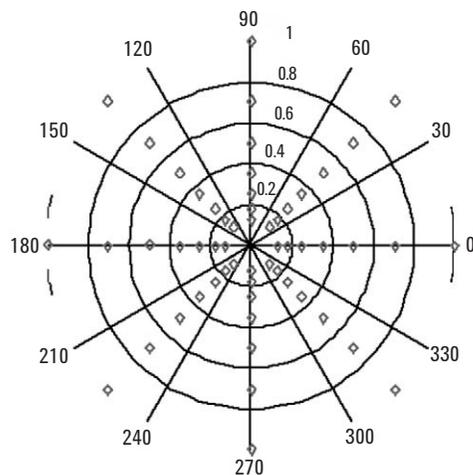


Figure 2: The 8PSK constellation versus power level with no distortion

Next, consider the effects of passing this “perfect” signal through a power amplifier stage with its inherent non-linear behavior. “Non-linear behavior” refers to the phase shift introduced by the amplifier at varying power levels (power gain). Also, a given change of power gain of the amplifier may not result in the desired output power being achieved. These effects will manifest themselves with an 8PSK constellation whose phase trajectory is not circular and with phase states not precisely located at the expected points, i.e. polar distortion.

RF Transmitter Characterization Technique

An efficient technique for characterizing the magnitude, phase, and frequency variations as a function of the output level of an RF transmitter requires only a CW carrier signal whose amplitude can be controlled with simple pulse amplitude modulation. The advantage to using a CW signal is that multi-format devices can have their hardware characterized with the same technique, without concern for providing unique signals for each modulation format mode of the device under test (DUT). A customized test signal is generated that exhibits the desired power versus time profile. The output signal of the device has its power, relative phase, and relative frequency measured at prescribed time intervals. These measurements can be used to create control data correction tables in whatever proprietary format that suits the design of the DUT.

A class of test signal suitable for this type of calibration procedure is illustrated in Figure 4. This power versus time profile consists of a number of discrete power steps. The profile shows a piecewise monotonic power versus time pattern. This pattern can be customized by the device manufacturer to suit specific requirements. Note that monotonicity is not necessarily a requirement.

The design of this profile includes elements to control what portions of the waveform are measured. These elements include a defined physical event to trigger the acquisition of waveform samples by the measurement system, a power level reference and user-specified locations, and time intervals for each settled, stable, and measurable portion of each power step.

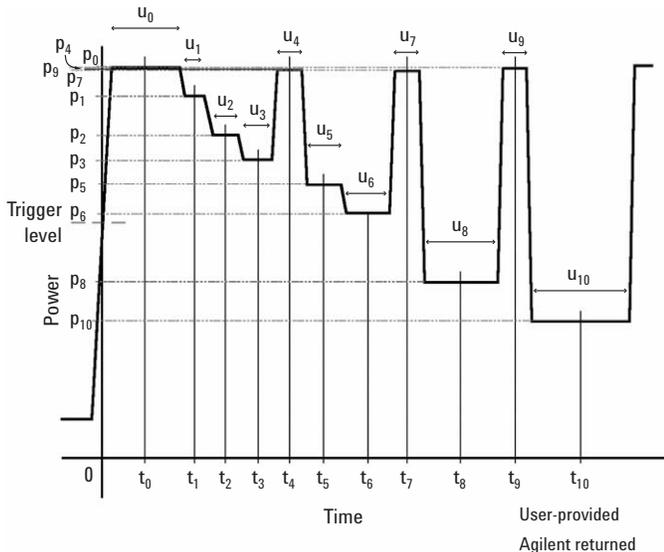


Figure 4: Generalized discrete step waveform

Figure 5 illustrates a more realistic depiction of a typical power burst in a discrete step test signal waveform. With this discrete step power versus time profile there are real world physical behaviors of the hardware to take into consideration. Most notably is that overshoot and ringing is likely to be present on the maximum excursions of the pulse envelopes. Also, phase jitter will cause considerable measurement error in the regions near the pulse edges. Consequently, one must plan to characterize the power, phase, and frequency parameters of each power step over a sufficiently settled and stable measurement interval.

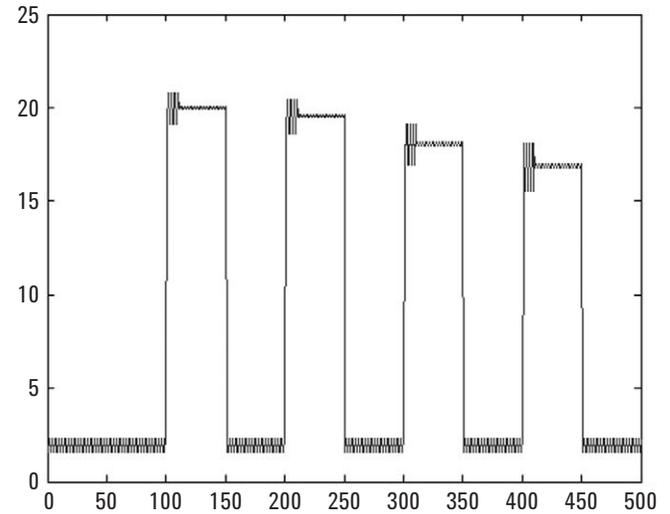


Figure 5: Discrete step test signal waveform with realistic physical attributes

Agilent Technologies PAVT Measurement System

The Agilent Technologies 8960 test set with E1968A test application software with the PAVT option provides a fully-contained phase and amplitude versus time measurement system. Agilent’s solution allows a flexible measurement configuration where the parameters of a discrete step test signal waveform can be fully described and measurement results easily obtained.

Agilent’s measurement solution operates without a direct communications link between the 8960 and the user equipment (UE). In fact, the only physical connect between the UE and the 8960 is the RF output of the UE to the RF In/Out port of the instrument. Therefore, an intermediary controller is required to set up and control the 8960 PAVT measurement parameters and to control the UE to transmit its test signal waveform. Figure 6 illustrates a typical hardware configuration.

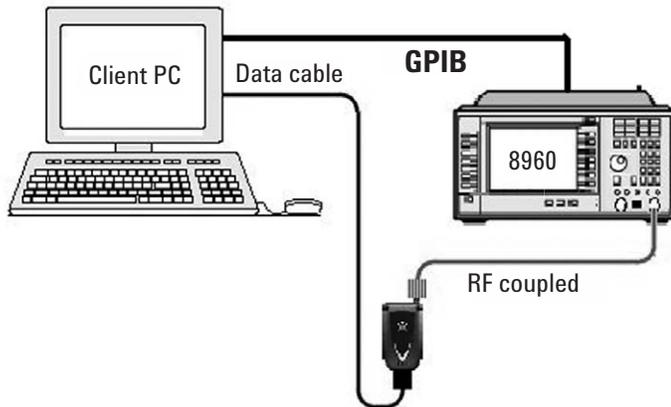


Figure 6: Diagram of the UE, 8960, and external controller interconnections

Measurement setup parameters

The Agilent PAVT measurement places minimum requirements upon the characteristics of the user’s discrete step test signal waveform. A UE transmit waveform of up to 400 ms in duration can be measured. The measurement algorithm expects the rising edge of the first power step in the sequence to trigger the measurement, i.e. initiate the waveform sampling process. The user can specify the maximum power level that will occur in the waveform so that the 8960 measurement hardware can be configured for optimum dynamic range. Then, the user further specifies at what amplitude relative to the maximum power level in the waveform that the trigger should occur. These values are entered into the 8960 as setup parameters and control the gain range of the measurement’s hardware signal path.

The measurement interval specification is facilitated via simple, remote user interface programming commands, which allow specification of the center time locations and widths of the desired measurement intervals across the sample record acquired from the test signal waveform. Measurement intervals may be of variable width and can be specified in any order. Measurement interval center times are referenced to the time of the physical trigger event, meaning the time at which the leading edge of the UE’s transmitted signal crosses through the specified trigger threshold (RF RISE trigger). Specification of discrete measurement intervals of as many as 512 steps is accommodated.

Measurement result data formats

Agilent’s measurement solution also provides two useful formats for measured results. The standard format provides relative power, relative phase, and relative frequency output suitable for user processing into correction factors for the device being produced. The output is presented as a sequence of three arrays that provide relative magnitude, relative phase, and relative frequency of each step in the UE’s transmit waveform. The first values returned in each of these result arrays are absolute measurements, which provide the reference for the subsequent relative measurements. See Appendix I for a detailed description of measurement result interpretation.

A typical set of result data is shown below. (Note: The formatting illustrated is provided by the external application program that is controlling the 8960.)

	Meas interval center time	Meas interval width(s)	Relative power (dB)	Relative phase (deg)	Relative freq. (Hz)
1	.0025	.002	3.27E+1 dBm	0E+0	-9.57E+2
2	.004608	.000768	-1.51E+1	-2.67E+1	2.67E+0
3	.005632	.000768	-2.6E-3	1.49E+0	8.51E-1
4	.006656	.000768	-1.51E+1	-2.53E+1	2.29E+0
5	.00768	.000768	-7.46E-1	1.66E+0	5.66E+0
6	.008704	.000768	-1.51E+1	-2.42E+1	1.46E+0
7	.009728	.000768	-1.57E+0	1.18E+0	-1.64E+0
8	.010752	.000768	-1.51E+1	-2.35E+1	6.92E-1
9	.011776	.000768	-2.39E+0	9.97E-1	3.27E+0
10	.0128	.000768	-1.51E+1	-2.25E+1	2.69E+0

A second result format called a SAMPLE format simply returns the filtered IF samples of the UE transmit waveform. The samples are analyzed into orthogonal vector components and then converted to polar coordinates of voltage amplitude and phase. This result format is useful for examining the characteristics of the UE transmit signal so that appropriate measurement intervals for a standard PAVT measurement can be specified.

The sample period associated with data in the sample format depends on the waveform type specified. The measurement system supports DISCReTe step measurements and piecewise CONTInuous waveform types. For DISCReTe waveforms measurements, SAMPLE format data is output with an effective sample rate of 156.25 k-sa. When the measurement system is configured for the CONTInuous waveform type, the SAMPLE result format is the only one supported and the effective sample rate of the output data is 13/12 MHz. The number of sample results generated depends upon measurement interval timing specifications supplied to the measurement system via the appropriate RUI commands. For measurements of the DISCReTe waveform type, a maximum of 400 ms of samples can be acquired. For the CONTInuous waveform type, approximately 80 ms of samples is the maximum record length.

Implementing an Agilent Automated Manufacturing Solution

The following programming example illustrates a typical automated procedure using the command interface provided in the Agilent Technologies PAVT measurement system.

Measurement algorithm

A procedure that can be used to make a discrete PAVT measurement is described below. Prior to executing the procedure, connect the mobile station to the test set's RF In/Out connector. Also connect the mobile's digital control port to a suitable controller to facilitate RF transmission. A generic procedure to make a PAVT measurement is represented in flowchart form in Figure 7.

Instrument setup

1. Set the Operating Mode to CW.
2. Set the 8960 RF source outputs to RF OFF and de-tune their RF generator frequencies from the desired measurement frequency.
3. Set the Measurement Frequency.
4. Set the Expected Power.

PAvT measurement setup

5. Set the Phase and Amplitude versus Time Timeout.
6. Set the Phase and Amplitude versus Time Trigger source to RF Rise.
7. Set the Phase and Amplitude versus Time Waveform type to Discrete.

Initiate and fetch the PAVT measurement

8. Use the READ:PCALibration? command to start the PAVT measurement and retrieve the results.

Note 1: Because the PAVT results are typically used for calibration of power amplifiers, PCALibration or PCAL has been chosen as the RUI syntax.

Note 2: You could also use the Init:PCALibration and FETCh:PCALibration[:ALL] commands to initiate and return measurement results.

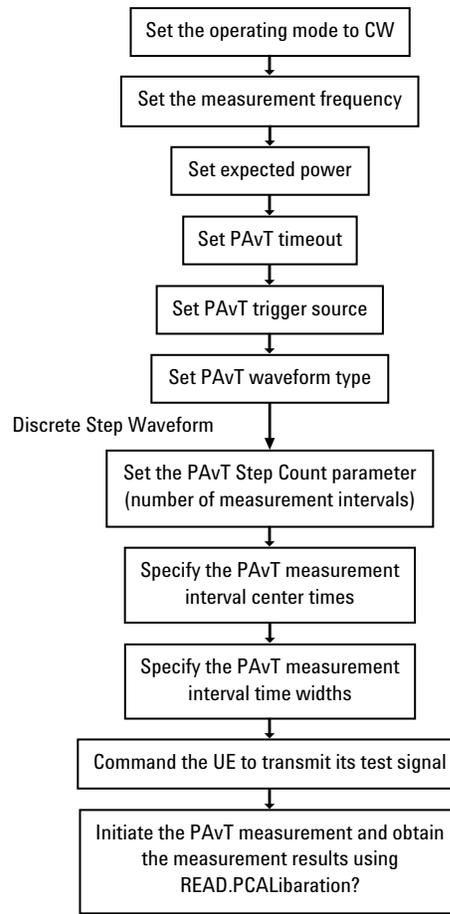


Figure 7: Commands for configuring PAVT measurement

Programming example

```
10      ! This program demonstrates use of the
"Agilent E1968A Phase & Amplitude versus
20      ! Time Measurement" for a discrete
waveform. (NOTE: this example program does
30      ! not apply for a continuous input
waveform).
40      !
50      ! This measurement is designed for fixed-
frequency CW input signals only.
60      !
70      ! Values for measurement interval center
times and measurement interval widths
80      ! will be loaded into the Test Set.
These data values are in the "Time_specs"
90      ! subroutine at the end of this pro-
gram.
100     !
110     ! S. Johnson, M. Brodeur, G. Brandle;
Agilent Technologies 6/3/05
120     !
130 Test_set=714
140 !Sets program variable "Test_set" equal to
the Test Set's default GPIB address
150 !
160 !****Test Set Setup****!
170 OUTPUT Test_set;"*RST"
180 !Resets all Test Set values to their default
settings.
190 !
200 OUTPUT Test_set;"CALL:CELL:OPERating:MODE CW"
210 !Sets the operating mode to continuous wave.
220 !
230 OUTPUT
Test_set;"RFAlyzer:MANual:MEASurement:MFRequenc
y 890.2 MHz"
240 !Sets the expected input frequency.
250 !
260 OUTPUT Test_set;"RFAlyzer:CW:EXPeCted:POWer
5 dbm"
270 !Adjusts the Test Set to the expected power
level (the maximum input level in the TX wave-
form).
280 !
290 OUTPUT Test_set;"CALL:POWer:STATe OFF"
300 !Turn off the RF generator cell power.
310 !
320 !
330 !****Measurement Setup for Phase & Amplitude
vs. Time Measurement****!
340 OUTPUT
Test_set;"SETup:PCALibration:TIMEout:STIME 10"
350 !Sets the measurement timeout period to 10
seconds, and the state to on.
360 !
370 OUTPUT Test_set;"SETup:PCAL:TRIGger:SOURce
EXT"
380 !Sets the trigger source as desired (typi-
cally RISE, IMMEDIATE, or EXTERNAL).
390 !
400 OUTPUT Test_set;"SETup:PCAL:TRIGger:THReshold
15"
410 !Adjusts the trigger level in dB below the
expected input power level.
420 !
430 OUTPUT Test_set;"SETup:PCAL:WAVEform:TYPe
DISCRETE"
440 !Chooses the discrete version of the meas-
urement
450 !
460 ! The following section sets up data arrays
for this measurement:
470     RESTORE Time_specs
480     !Points to the first data item on or
after the beginning of the Time_specs subroutine.
490 !
500     READ Step_count
510     !Assigns Step_count to the first data
item on or after the beginning of the Time_specs
subroutine.
520 !
530     ALLOCATE
Center(1:Step_count),Width(1:Step_count)
540     !Dimensions the Center and Width arrays
to contain the same number of elements as the
number
550     !of measurement intervals (Step_count);
reserves computer memory for the arrays.
560 !
570     OUTPUT Test_set;"SETup:PCAL:STEP:COUNT
";Step_count
580     !Tells the Test Set how many measurement
intervals it will perform (Step_count).
590 !
600     FOR I=1 TO Step_count
610     !Creates separate Center and Width
arrays from the data items.
620         READ Time_cent,Time_width
630         Center(I)=Time_cent
640         Width(I)=Time_width
650     NEXT I
660 !
670     OUTPUT Test_set;"SETup:PCAL:STEP:CENTer
";Center(*)
680     !Sets the expected center location of
each measurement interval using the Center array.
690 !
700     OUTPUT Test_set;"SETup:PCAL:STEP:WIDth
";Width(*)
710     !Sets the expected width of each meas-
urement interval using the Width array.
720 !
730 !
740 !****Initialize the measurement & obtain
results.****!
750 !
760 !!! *****
770 ! *** ??? check the following 2 lines before
including in document !!! *****
780 OUTPUT 714;"SETUP:PCAL:STEP:COUNT?" ! This
probably verifies the E5515B/C data was loaded
correctly
790 ENTER 714;Step_count
800 !!! *****
810 !
```

```

820 ALLOCATE
Power_results(1:Step_count),Phase_results(1:Step_
count),Freq_results(1:Step_count)
830 !Dimensions results arrays to contain the
same number of elements
840 !as the Center array and Width array;
reserves computer memory for the arrays.
850 !
860 OUTPUT Test_set;"READ:PCAL?"
870 !Initiates the Phase & Amplitude vs. Time
measurement and waits until results are returned
880 ! (or until the measurement timeout interval
elapses).
890 !
900 PRINT "*** Agilent E1968A Phase & Amplitude
vs. Time Measurement ***"
910 PRINT ""
920 !
930 PRINT "INSTRUCTIONS TO USER:"
940 PRINT "-> Command the device to transmit the
signal (before the measurement timeout inter-
val)."
```

```

950 PRINT ""
960 !
970 ENTER
714;Integrity,Power_results(*),Phase_results(*),F
req_results(*)
980 !Read and sort the measurement results from
the Test Set.
990 !
1000 IF Integrity<>0 THEN ! If measurement
integrity value does not equal zero, there is an
error
1010 PRINT "Measurement Error; Integrity
Value = ";Integrity
1020 PRINT ""
1030 ELSE
1040 END IF
1050 !
1060 PRINT "Reference Measurement Data:"
1070 PRINT " Absolute Power Reference =
";Power_results(1);" dBm"
1080 PRINT " Phase error = 0 degrees by defi-
nition."
1090 PRINT " Frequency Error (compared to pro-
grammed input frequency) = ";Freq_results(1);"
Hz"
1100 PRINT ""
1110 ! First measurement results are reference
values; see documentation for details.
1120 !
1130 PRINT "Results below are compared to the
Reference Measurement Data above."
1140 PRINT ""
1150 !
1160 PRINT "Power Phase
Frequency"
1170 PRINT "Difference Difference
Difference"
1180 PRINT "in dB in degrees
in Hz"
1190 PRINT "-----"
1200 !
1210 FOR I=2 TO Step_count! Reads and prints the
results arrays (not including the first measure-
ment results).
1220 PRINT Power_results(I);"
";Phase_results(I);" ";Freq_results(I)
1230 NEXT I
1240 !
1250 DEALLOCATE
Power_results(*),Phase_results(*),Freq_results(*)
1260 ! Releases computer memory allocated for
arrays
1270 !
1280 STOP
1290 !****Ends the program.****!
1300 !
1310 !
1320 !
1330 Time_specs:!
```

```

1340 !
1350 DATA 10 ! The first data item is equal to
the number of measurement
1360 ! intervals being specified
(Step_count).
1370 !
1380 ! The following data values are used by this
program to set the measurement
1390 ! interval center time (in seconds) and the
measurement interval width (in seconds)
1400 ! for each step of a discrete input wave-
form.
1410 ! (These values do not apply to a continuous
waveform measurement).
1420 !
1430 ! center (sec), width (sec)
1440 DATA .0005,.0008
1450 DATA .0015,.0008
1460 DATA .0025,.0008
1470 DATA .0035,.0008
1480 DATA .0045,.0008
1490 DATA .0055,.0008
1500 DATA .0065,.0008
1510 DATA .0075,.0008
1520 DATA .0085,.0008
1530 DATA .0095,.0008
1540 !
1550 DEALLOCATE Center(*),Width(*)
1560 ! Releases computer memory allocated for
arrays
1570 !
1580 END
1590 !

```

Appendix I

Introduction

The phase and amplitude versus time (PAvT) measurement available in the E1968A test application provides a suite of measurement SETup and result FETCh/READ commands for operation of the phase and amplitude versus time measurement feature via remote user interface. In addition, several other 8960 instrument setup controls must be used to completely configure the instrument to perform a PAVT measurement.

Measurement receiver (RF analyzer) controls

The test set normally sets all receiver parameters automatically using data connection control settings. However, manual receiver parameter settings are recommended for PAVT measurements.

Selecting manual or automatic receiver control

Automatic receiver control modes are the default for all operating modes. This means parameters such as the receiver's expected power, measurement frequency, and modulation format settings are set automatically according to the control parameters you specify (for example: Traffic Channel, Packet Data Traffic Channel, Packet Data Traffic Band, MS TX Level, and Modulation and Coding Scheme).

Manual mode allows you to override some or all of the automatic settings by first selecting the manual mode for the setting and then specifying the desired value. You can view the affected settings by selecting F12 (Receiver Control) from the Call Setup screen. A full or partial preset of the test set, including cycling power, returns the test set back to auto mode.

Manually setting the expected input power

Manual operation of the measurement receiver's 'expected input power' can be accomplished with two different RUI commands, depending on the operating mode of the test set. The two different RUI commands that make this setting are:

RFANalyzer:CW:EXPEcted:POWer <nr3>
(active when CALL[:CELL]:OPERating:MODE is set to CW)

and

RFANalyzer:MANual:POWer[:SElected]:BURSt1 <nr3>
(active when CALL[:CELL]:OPERating:MODE is set to Active Cell (GSM), Active Cell (GPRS), Active Cell (EGPRS), GSM BCH, GSM BCH + TCH, GPRS BCH, GPRS BCH+TDTCH, EGPRS BCH, EGPRS BCH+PDTCH, Cell Off)

These two commands actually provide two separate and independent internal settings within the test set. The setting that is actually used to control the measurement receiver hardware configuration depends on the test set's operating mode.

For PAVT measurements, the expected input power setting should be set to the maximum power level that will occur in the UE transmit waveform. The 8960 PAVT measurement will not autorange. So, to optimize measurement dynamic range, the maximum power level that occurs at the RF In/Out connector must be within 2 dB of the expected input power setting.

Units: dBm
Min: -30
Max: +43
Default: +13

RFANalyzer:CONTRol:POWer:AUTO ON|OFF

When the expected input power is set via the RFANalyzer:MANual:POWer[:SElected]:BURSt1 command, its value will be stored but not applied to hardware unless the RFANalyzer:CONTRol:POWer:AUTO ON|OFF is set to OFF.

Default: ON

RFANalyzer:MANual:MEASurement[:MFRrequency] <nr3>

This tunes the 8960 measurement receiver hardware to the UE's carrier frequency.

Units: Hz, MHz, GHz
Default: 896.0 MHz

PAvT measurement 'SETup' commands

SETup:PCALibration:WAVEform:TYPE DISCrete|CONTInuous

The :WAVEform:TYPE command selects the class of UE transmit waveform and configures the measurement to perform the appropriate internal measurement algorithm.

DISCrete refers to a UE transmit waveform consisting of a sequence of discrete, finite length power bursts, with the rising edge of the first burst providing the transition through the defined trigger level threshold.

CONTInuous refers to a UE transmit waveform consisting of an initial 577 μ s wide power burst followed by a piecewise continuous power versus time profile.

Default: DISCrete

SETup:PCALibration:STEP:COUNT <nr1>

The :STEP:COUNT command sets the number of discrete measurement intervals for which results are to be returned when the PAVT measurement is set up to use a UE transmit waveform of :WAVEform:TYPE DISCcrete. This value specifies the number of measurement time intervals that will be analyzed in the sample record of the UE's transmit waveform. In any case, the number of results returned from the measurement will correspond to this count.

Note: It is essential that the value set by the :STEP:COUNT parameter be consistent with the number of :STEP:WIDTH and :STEP:CENTer values provided. If the :STEP:CENTer and/or :STEP:WIDTH lists contain fewer entries than specified by :STEP:COUNT, some measurement results will be invalid. If the :STEP:CENTer and/or :STEP:WIDTH lists contain more entries than specified by :STEP:COUNT, the number of results returned will correspond to the value specified by :STEP:COUNT.

Units:	none
MIN Value:	1
Max Value:	512
Default:	1

SETup:PCALibration:STEP:WIDTH <nr3>,<nr3>,...,<nr3>

The :STEP:WIDTH command sets the time width of each measurement interval within the sample record of the UE transmit waveform of WAVEform:TYPE DISCcrete. This width will commonly be less than the maximum width of the power step. The command takes as its argument a comma separated list of width values.

Note: It is essential that the value set by the :STEP:COUNT parameter be consistent with the number of :STEP:WIDTH and :STEP:CENTer values provided. If the :STEP:CENTer and/or :STEP:WIDTH lists contain fewer entries than specified by :STEP:COUNT, some measurement results will be invalid. If the :STEP:CENTer and/or :STEP:WIDTH lists contain more entries than specified by :STEP:COUNT, the number of results returned will correspond to the value specified by :STEP:COUNT.

The list of widths need not be ordered as they will occur in the actual UE signal. However, a one to one correspondence between each :STEP:WIDTH entry and each :STEP:CENTer entry must be maintained or invalid results may be returned.

For any given measurement interval specified, the value of (:STEP:CENTer - :STEP:WIDTH/2) must be greater than or equal to zero. Also, each measurement interval must meet the criterion: :STEP:CENTer + (:STEP:WIDTH)/2 ≤ 400 ms. Failure to meet these criteria will cause the measurement to fail to run and all measurement result values be set to NAN (9.91E+37) to be returned from the FETCh:PCAL[:ALL]? query.

Units:	seconds
Min value:	0.0001
Max value:	0.4
Default value:	0.001

SETup:PCALibration:STEP:CENTer <nr3>,<nr3>,...,<nr3>

The :STEP:CENTer command sets the expected center location of the each measurement interval within the sample record of the UE transmit waveform of WAVEform:TYPE DISCcrete relative to the RF rising edge trigger point. This value will commonly not be the actual center of the power step. The command takes as its argument a comma separated list of center values.

Note: It is essential that the value set by the :STEP:COUNT parameter be consistent with the number of :STEP:WIDTH and :STEP:CENTer values provided. If the :STEP:CENTer and/or :STEP:WIDTH lists contain fewer entries than specified by :STEP:COUNT, some measurement results will be invalid. If the :STEP:CENTer and/or :STEP:WIDTH lists contain more entries than specified by :STEP:COUNT, the number of results returned will correspond to the value specified by :STEP:COUNT.

The list of centers need not be ordered as they will occur in the actual UE signal. However, a one to one correspondence between each :STEP:WIDTH entry and each :STEP:CENTer entry must be maintained or invalid results may be returned. For any given measurement interval specified, the value of :STEP:CENTer - :STEP:WIDTH/2 must be greater than or equal to zero. Also, each measurement interval must meet the criterion :STEP:CENTer + (:STEP:WIDTH)/2 ≤ 400 ms. Failure to meet these criteria will cause the measurement to fail to run and all measurement result values be set to NAN (9.91E+37) to be returned from the FETCh:PCAL[:ALL]? query.

Units:	seconds
Min value:	0.00005
Max value:	0.39995
Default value:	0.001

SETup:PCALibration:TRIGger:SOURce RISE|IMMediate|EXternal
The :TRIGger:SOURce command selects the source of the physical trigger event that will cause the DSP measurement subsystem ADC sampler to begin acquiring samples of the UE transmit waveform.

Default: RISE

SETup:PCALibration:TRIGger:THReshold <nr3>
The :TRIGger:THReshold command sets the power level at which an RF RISE trigger event will trigger the measurement. This value is stated in units of dB and represents the number of dB below the expected input level (see RFAnalyzer settings).

Note that the value of the trigger threshold is an offset from the value entered for expected input level. The absolute trigger level may be computed as:

Trigger level (dBm) = expected input level (dBm) – trigger threshold (db)

Units: dB
Min Value: 0
Max Value: 30
Default: 10

SETup:PCALibration:TRIGger:DElay <nr3>
The :TRIGger:DElay setting sets the number of seconds after the occurrence of the trigger event to delay before allowing the DSP measurement subsystem ADC sample to begin data acquisition of the UE transmit waveform.

Units: seconds
Min: 0
Max: 0.01
Defaults: 0

SETup:PCALibration:TIMEout:TIME <nr3>
The :TIMEout:TIME command allows setting the measurement timeout value. This is the time that an initialized measurement will wait for a trigger before aborting.

Units: seconds
Min: 0.1
Max: 999.9
Default: 10

SETup:PCALibration:TIMEout:STATe 1|0
The :TIMEout:STATe command enables or disables the timeout function.

SETup:PCALibration:TIMEout[:STIME] <nr3>
When the timeout value is set via the :TIMEout:STIME command, the timeout counter is enabled. This is a complex command, i.e. it performs the functions of :TIMEout:TIME and :TIMEout:STATe simultaneously.

Units: seconds
Min: 0.1
Max: 999.9
Default: 10

SETup:PCALibration:RESult:TYPE PCAL|SAMPlE|BOTH
The :RESult:TYPE setting sets the results data format. For measurements of WAVEform:TYPE DISCREte, all result type settings are available. For CONTInuous waveform measurement, only SAMPlE results are available.

PCAL result format refers to the ‘relative power, relative phase, relative frequency’ result data available from a FETCh:PCAL[:ALL]? query or the associated individual FETCh:PCAL:POWER?, FETCh:PCAL:PHASE? and FETCh:PCAL:FREQuency? queries.

SAMPlE data format refers to amplitude and phase measurements of the filtered waveform samples. These are reported in polar coordinates, i.e. {amplitude}{phase} data doublets. SAMPlE format results are only retrievable via the :SAMPlE:AMPLitude? and :SAMPlE:PHASE? queries. The effective output rate of the data samples depends on the selection for :WAVEform:TYPE. For DISCREte waveform measurements it is 156.25 Ksa/s. For measurement of CONTInuous waveforms it is 13/12 MHz.

When BOTH is selected, both result formats are available via the appropriate FETCh queries. However, this mode slows down the measurement considerably due to the possibility of a high volume of SAMPlE results being generated. This data volume is dependent upon the STEP:WIDTh and STEP:CENTer lists.

SAMPlE results format is the only result format for measurements of the :WAVEform:TYPE CONTInuous.

The following commands apply only when the WAVEform:TYPE is set to CONTInuous.

SETup:PCALibration:MEASurement:DELay <nr3>

The :MEASurement:DELay command sets the time at which the measurement begins. This time is measured relative to the time of the physical trigger event. Take care not to confuse this delay value with :TRIGger:DELay. The latter determines the time at which the ADC sampler acquires waveform samples. The measurement delay determines where the analysis of the samples, i.e., the filtering and vector analysis into amplitude, and phase, begins.

Note: This setting will always be accepted by the RUI but it only applies to measurements of WAVEform:TYPE CONTInuous.

Units: seconds
 Min: 0
 Max: 0.500
 Default: 0

SETup:PCALibration:MEASurement:COUNt <nr3>

The :MEASurement:COUNt command sets the number of samples requested by the user to be reported in the measurement results. Note: This setting will always be accepted by the RUI but it only applies to measurements of WAVEform:TYPE CONTInuous.

Units: numeric integer
 Min: 1
 Max: 5000
 Default: 1

PAvT measurement initiation and arming

INIT:PCALibration[:ON]

The PAvT measurement is activated with the INIT:PCALibration[:ON] command. Upon receipt of this command, the 8960 DSP measurement subsystem will become armed and ready to detect a physical trigger event to start the ADC sampler. The arming process requires a finite amount of time. This measurement is designed for asynchronous arming synchronization only. This means that the user must provide a suitable delay between sending the INIT:PCALibration[:ON] command to the 8960 and the subsequent digital control signal to the UE to initiate its transmission of the waveform. An estimated time delay of 250 ms should be sufficiently conservative to ensure that the UE doesn't begin transmitting until the 8960 is armed and ready to make the measurement.

INIT:PCALibration:OFF

Deactivates the PAvT measurement.

PAvT measurement abort

ABORt:PCALibration

PAvT measurement FETCh? queries

FETCh:PCALibration[:ALL]? <nr1>,{<nr3>},{<nr3>}, {<nr3>}

This FETCh[:ALL] query is used when a measurement has been made of a UE transmit waveform of WAVEform:TYPE DISCReTE and the :RESult:TYPE setting is PCAL. The data returned are a single measurement integrity value followed by three arrays. Each array is the complete range of relative power, relative phase and relative frequency, respectively.

A typical set of result data is shown below. (Note: The formatting illustrated is provided by the external application program that is controlling the 8960.)

	Meas interval center time	Meas interval width(s)	Relative power (dB)	Relative phase (deg)	Relative freq. (Hz)
1	.0025	.002	3.27E+1 dBm	0E+0	-9.57E+2
2	.004608	.000768	-1.51E+1	-2.67E+1	2.67E+0
3	.005632	.000768	-2.6E-3	1.49E+0	8.51E-1
4	.006656	.000768	-1.51E+1	-2.53E+1	2.29E+0
5	.00768	.000768	-7.46E-1	1.66E+0	5.66E+0
6	.008704	.000768	-1.51E+1	-2.42E+1	1.46E+0
7	.009728	.000768	-1.57E+0	1.18E+0	-1.64E+0
8	.010752	.000768	-1.51E+1	-2.35E+1	6.92E-1
9	.011776	.000768	-2.39E+0	9.97E-1	3.27E+0
10	.0128	.000768	-1.51E+1	-2.25E+1	2.69E+0

The first row of data gives the results of the first specified measurement interval. This measurement interval is special because its measurement results are stated differently than the remaining results.

1. The power value is the absolute power level measured in the first measurement interval.
2. The phase value is defined to be 0 degrees. It will be the reference phase against which all remaining phase data are relative.
3. The frequency value is the offset from the value of expected input frequency to which the 8960 RF analyzer was tuned via (RFANalyzer:MANual:MEASurement[:MFRequency] <nr3>)

A positive value indicates the measured frequency of the first specified measurement interval is above the expected frequency and a negative value indicates the measured value was below the expected frequency.

Subsequent array values give relative power offset as compared to the power measured in the first measurement interval, phase variation relative to the first measurement interval, and frequency delta values relative to the value reported in the first measurement interval

The number of results returned, i.e., the length of the relative power, relative phase and relative frequency arrays, will match the value set in the :STEP:COUNT setting. That is, results are returned for each measurement interval specified. See notes for setting :STEP:COUNT, :STEP:CENter, and :STEP:WIDth for further cautions regarding how the validity of results is affected by those settings.

Units: integrity is unitless, then <dB(m)>, <degrees>, <Hz>

If this FETCh is used when the WAVEform:TYPE is set to CONTInuous and/or the RESult:TYPE is set to SAMPlE, the integrity value will be reported correctly, but the array values will have all values set to NAN.

FETCh:PCALibration:POWer? {<nr3>}
FETCh:PCALibration:PHASe? {<nr3>}
FETCh:PCALibration:FREQUency? {<nr3>}

These FETCh queries return the components of the array values available from the FETCh:PCAL[:ALL]? query. They are available under the same conditions as described for FETCh:PCAL[:ALL]?

FETCh:PCALibration:INTegrity? <nr1>
This FETCh query provides the measurement integrity value for any type of PCALibration measurement.

FETCh:PCALibration:SAMPlE:COUNT? <nr1>
The SAMPlE:COUNT? FETCh query returns an integer value stating the number of results of RESult:TYPE SAMPlE that are available. This can be a large integer and so the data are grouped into result range blocks of 1000 amplitude/phase pairs. Thus, this value is important to ensure that all of the desired SAMPlE measurement results are retrieved with the :SAMPlE:AMPLitude and :SAMPlE:PHASe queries.

FETCh:PCALibration:SAMPlE:AMPLitude? <nr1> <nr3>
The SAMPlE:AMPLitude query returns blocks of waveform sample amplitudes in units of Volts. This FETCh requires an integer argument to specify which block of 1000 amplitude results is to be returned. The maximum value of this argument for a given measurement can be determined by using the value returned by the :SAMPlE:COUNT? query thusly:

Max count = INTEGER (0.5 + (value returned from :SAMPlE:COUNT?/1000))

The sample period associated with data in the sample format depends on the waveform type specified. The measurement system supports DISCReTe step measurements and piecewise CONTInuous waveform types. Sample data for DISCReTe waveforms is generated at 2.5 MHz and the results decimated by a factor of 16 before being reported. When the measurement system is configured for the CONTInuous waveform type, the SAMPlE result format is the only one supported and samples are generated at 13/12 MHz. The number of sample results generated depends upon measurement interval timing specifications supplied to the measurement system via the appropriate RUI commands.

FETCh:PCALibration:SAMPlE:PHASe? <nr1> <nr3>
The SAMPlE:PHASe query returns blocks of waveform sample phase values in units of degrees. This FETCh requires an integer argument to specify which block of 1000 phase results is to be returned. The maximum value of this argument for a given measurement can be determined by using the value returned by the :SAMPlE:COUNT? query thusly:

Max count = INTEGER (0.5 + (value returned from :SAMPlE:COUNT?/1000))

The sample period associated with data in the sample format depends on the waveform type specified. The measurement system supports DISCReTe step measurements and piecewise CONTInuous waveform types. Sample data for DISCReTe waveforms is generated at 2.5 MHz and the results decimated by a factor of 16 before being reported. When the measurement system is configured for the CONTInuous waveform type, the SAMPlE result format is the only one supported and samples are generated at 13/12 MHz. The number of sample results generated depends upon measurement interval timing specifications supplied to the measurement system via the appropriate RUI commands.

FETCh:PCALibration:REFerence:POWer? <nr1> <nr3>
The :REFerence:POWer? query applies to measurement of WAVEform:TYPE CONTInuous only. It returns the average power measurement of the trigger/reference burst that precedes the piecewise continuous power versus time profile of the calibration signal.

PAvT measurement READ? query syntax

READ:PCALibration[:ALL]? <nr1>, {<nr3>}, {<nr3>}, {<nr3>}

The READ:PCALibration[:ALL]? query returns the same data as the FETCH:PCALibration[:ALL]? query. Otherwise, behavior of this query is the same as for all READ queries in the 8960 test application suite.

Typical measurement procedure and setup using the PAVT

1. Connect the UE RF output to the 8960 RF In/Out connector through suitable fixturing and cabling.
2. Connect the UE digital control port to a suitable controller to facilitate initiation of the RF transmission when the 8960 is armed and ready to be triggered. A typical example of such a controller is a PC with a GPIB interface to run the 8960 and a serial, USB or other compatible digital control interface for the UE. The PC would be running an automation script that sends 8960 RUI commands, retrieves 8960 measurement results, and controls the UE.
3. Determine UE transmit waveform type, DISCcrete or CONTinuous and set up the 8960 accordingly with the appropriate RUI command.
4. If the UE transmit waveform type is DISCcrete, determine the waveform step timing specifications (step centers and widths) and the step count. The number of step centers should be equal to the number of widths. These are presented to the 8960 as two separate lists. Each list must be ordered so that Center 1 corresponds to Width 1, etc. The length of the lists is the value to be used in the step count setting.
5. Set up these lists in the 8960 with the appropriate RUI commands.
6. If the UE transmit waveform type is CONTinuous, determine the desired trigger delay, measurement delay and measurement time. Set up the 8960 with these settings using the appropriate RUI commands.
7. Set up up the 8960 RF analyzer expected input frequency.
8. Set up the 8960 RF analyzer manual expected input power setting.
9. Set up the 8960 with the desired trigger source.
10. Set up the 8960 trigger threshold. This is the number of dB below the expected input power setting. This is relevant to RF RISE trigger source only.
11. Set up the 8960 with an appropriate measurement timeout value to avoid a hung FETCH query if the measurement configuration is defective.
12. Initiate the 8960 phase and amplitude versus time measurement. Observe the blind wait time prior to commanding the UE to transmit its signal.
13. Command the UE to transmit its signal.
14. Retrieve the desired measurement results from the 8960 with the appropriate FETCH query.

www.agilent.com

Agilent Technologies' Test and Measurement Support, Services, and Assistance

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise

Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you receive your new Agilent equipment, we can help verify that it works properly and help with initial product operation.

Your Advantage

Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and onsite education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.



Agilent Open

www.agilent.com/find/open

Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

United States:

(tel) 800 829 4444
(fax) 800 829 4433

Canada:

(tel) 877 894 4414
(fax) 800 746 4866

China:

(tel) 800 810 0189
(fax) 800 820 2816

Europe:

(tel) 31 20 547 2111

Japan:

(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Korea:

(tel) (080) 769 0800
(fax) (080)769 0900

Latin America:

(tel) (305) 269 7500

Taiwan:

(tel) 0800 047 866
(fax) 0800 286 331

Other Asia Pacific

Countries:

(tel) (65) 6375 8100
(fax) (65) 6755 0042

Email: tm_ap@agilent.com

Contacts revised: 05/27/05

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus



Agilent Email Updates

www.agilent.com/find/emailupdates

Get the latest information on the products and applications you select.

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2005

Printed in USA, August 10, 2005

5989-3484EN



Agilent Technologies