Using R&S® audio analyzers in remote control applications to replace the Agilent (HP) 8903B
Application Note

Products:

| R&S®UPV

| R&S®UPP200

This Application Note describes how the R&S® UPV and R&S® UPP200 audio analyzers can be used to replace the obsolete Agilent (HP) model 8903B audio analyzer in remote control applications. The paper provides a guidance how to replace the old HP specific remote control commands by UPV/UPP SCPI compliant commands. And it describes how to use the HP 8903B emulation mode which enables the R&S audio analyzers to be controlled by the command set of the obsolete Agilent (HP) instrument.

ROHDE&SCHWARZ

Table of Contents

1 Note

The following abbreviations are used in this Application Note:

- The R&S® UPV/UPV66 audio analyzers are referred to as UPV.
- The R&S® UPP200audio analyzer is referred to as UPP.
- The Agilent Technologies or Hewlett-Packard HP 8903B audio analyzer is referred to as 8903B.

2 Introduction

In the early 1980s, Hewlett-Packard introduced the HP 8903B audio analyzer, which is still in use in many automated test systems.

The Rohde & Schwarz instruments UPV and UPP are modern, high performance audio analyzers. They provide all the measurement functions - and even many more – which the old 8903B instruments had, while state of the art hardware and signal processing functionality allow higher measurement speed and accuracy.

They can thus easily replace the old 8903B instrument in all applications.

Furthermore UPV and UPP200 are two channel instruments, making all measurements simultaneously in both channels. With this capability the R&S instruments can measure two devices under test instead of one at the same time, thus simply doubling the production line throughput.

The features of the Agilent and the Rohde & Schwarz instruments are not identical, and especially the remote programming using the modern SCPI standard is quite different to the old 8903B programming style.
This paper will provide help and guidence, how the 8903B can be replaced by UPV or UPP.

Many of the old 8903B commands can be directly replaced by a new SCPI command for the UPV/UPP. Several old commands need more than one SCPI command to be replaced. The function of some other old commands cannot be realized in that easy way. Resulting from the different instrument architecture, there are some constraints to consider, concerning e.g. frequency and level ranges, implementation of filters, selection of measurement functions or display units, etc.

Two topics are handled in this application note:
- Migrating remote control code:
  This application note will assist users in migrating their 8903B remote control code to work with the modern UPV and UPP audio analyzers, and it explains in detail how to cope with the differences between 8903B and UPV/UPP instruments.
  Also differences between the 8903B and the older A model will be pointed out.
- Emulation mode:
  From firmware version 3.2.0 UPV/UPP provide an emulation mode for 8903B. Both instruments can then be remote controlled with the command set of the 8903B.

3 Command set compatibility

Before SCPI (Standard Commands for Programmable Instruments) emerged as the standard for instrument programming in the early 1990s, all the instruments had command sets using very short alpha-numeric keywords, like R1, M2, LN, etc. So, also the 8903B command set has its own unique syntax, where command keywords are concatenated with parameter values and units, without any delimiters such as colons or spaces.

The Rohde & Schwarz audio analyzers UPV and UPP implement the modern SCPI standard for the remote control command set, which is considerably different from the old instrument-specific command set used by the 8903B.

3.1 SCPI commands

SCPI commands consist of a header and usually one or more parameters. The header and parameters are separated by a space, parameters are separated by commas. Headers may be composed of several keywords, which are separated by a colon. Angle brackets < > indicate that a value and a unit must be entered for the parameter. Query commands are available to read the value of the parameter, which was previously set in the instrument. Queries are formed by adding a question mark directly to the header.

Example:	SOURce:FREQuency 1 KHZ	sets the generator frequency to 1 kHz
	INPut:BANDwidth:MODE B80	sets the analyzer bandwidth to 80 kHz
	SOURce:FREQuency?	queries the generator frequency, the return value is "1 KHZ"
	INPut:BANDwidth:MODE?	queries the analyzer bandwidth, the return value is "B80"

The keywords have a long form and a short form. They may be entered either in long or in short form, other abbreviations are not allowed.

| **Example:** | SENSe:POWer:REFerence:RESistance <nu> | Long form |
| | SENS:POW:REF:RES <nu> | Short form |

In SCPI, multiple commands can also be written in the same statement, just as for the 8903B, except that a semicolon followed by a colon must be used to separate one command from the other.

Example:
The 8903B commands, which set the generator frequency to 2 kHz and the amplitude to 1.0 V are "FR2KZ" for the frequency and "AP1VL" for the amplitude.
These two commands can be concatenated to "FR2KZAP1VL".

The UPV and UPP commands, which set the generator frequency to 2 kHz and the amplitude to 1.0 V comply to the SCPI standard and are:

"SOURce:FREQuency 2 KHZ" for the frequency, and

"SOURce:VOLTage 1 V" for the amplitude.

These two commands can be concatenated to

"SOURce:FREQuency 2 KHZ;:SOURce:VOLTage 1 V"

and they can be abbreviated as

"SOUR:FREQ 2 KHZ;:SOUR:VOLT 1 V".

It may be considered as disadvantage that there are several characters more to code. But obviously even the abbreviated SCPI compliant command line

"SOUR:FREQ 2 KHZ;:SOUR:VOLT 1 V"

is easier to understand than the command line

"FR2KZAP1VL".

3.2 Command recording on UPV and UPP

Commands for instrument settings can be recorded using the item "SCPI Recording" of the "Sequence" menu in the user interface. For example, setting the frequency of the generator function "Sine" to 1250 Hz produces the recorded command

SOURce:FREQuency 1250 HZ

Figure 1: Command recording

The recorded commands can by copied from the Local SCPI Recorder window to the clipbord or a file and then pasted into the program code, which shall later on remote control the UPV or UPP. Thus there's no need to look up the commands in a manual. Just make the desired instrument settings manually while simultaneously the corresponding SCPI commands are recorded.

4 Differences between the instruments

The 8903B fits into 3U of rack space, while the UPV needs 4U of rack space, the UPP needs 2U only.
After power up the 8903B has always the same instrument settings, it does not restore the settings it had before being switched off.
UPV and UPP always power up with the settings they had before being shut down. This is considered to be very helpful, because the user can continue measurements without the need to reconfigure the instrument. If it is really necessary, it would be easy to restore the 8903B power-up settings with UPV/UPP for manual operation as well as under remote control. This is described later in this document.

4.1 Analyzer and generator characteristics

This section compares important physical characteristics, like frequency, amplitude and impedances of the instruments.

One of the main differences to the 8903B is the lower input voltage range of UPV and UPP. But only very few applications require voltages above 100 V. And most applications do not need more than 50 V. An external attenuator can be used, if higher voltages must be measured.
Another difference is the higher bandwidth of the 8903B analyzer. But usually a bandwidth of 80 kHz or even limited to 20 kHz would be sufficient for most of the typical audio applications.

Analyzer characteristics			
	8903B	UPV	UPP
Frequency range	> 500 kHz (3 dB)	250 kHz (0.3 dB)	80 kHz (0.2 dB)
Max input voltage (RMS)	300 V	110 V	50 V
Impedance	100 kΩ	100 kΩ	100 kΩ

Table 1: Analyzer characteristics

Generator characteristics			
	8903B	UPV	UPP
Frequency range	20 Hz to 100 kHz	0.1 Hz to 80 kHz	0.1 Hz to 80 kHz
Max amplitude	6 V	10 V	7 V
Impedance	50 Ω / 600 Ω	5 Ω / 10 Ω* / 200 Ω* / 600 Ω*	25 Ω

Table 2: Generator characteristics

The generator frequency range of UPV can be extended to 185 kHz with UPV-B1 option.

Due to the very low output impedance of the UPV, any desired output impedance > 5 Ω can be achieved using an external adapter. Output impedances marked with an asterisk are provided in the balanced mode.
And also with the UPP the impedances of 50 Ω or 600 Ω of the 8903B or any other required output impedance > 25 Ω can be realized with an external adapter.

4.2 Differences between 8903A and B

Also the older 8903A model can be replaced by UPV or UPP. Some differences between both A and B models, shown in the table below, must be considered.

Differences between 8903A and B			
Function	**8903A**	**8903B**	**UPV/UPP**
Source impedance	600 Ω	50 Ω / 600 Ω	UPV 5 Ω / UPP 25 Ω (note 1)
Source max frequency	100 kHz	100 kHz	80 kHz 185 kHz for UPV with UPV-B1 option
Filter (HP or weighting)	HP 400 Hz (7th order) CCITT	2 of 6 hardware filters can be installed as options: HP 400 Hz (7th order) CCITT C-Message CCIR weighting CCIR arm weighting A weighting	All filters of 8903B (and many more) can be realized by a wide range of software defined filters
Leveldetector	RMS	RMS Average Quasi-peak	RMS --- Quasi-peak (UPV only)
Source unit (command DV)	dBV	dBm into 600 Ω	Both units available
Analyzer AC, DC and distortion level unit (command LG)	dBV	dBm into 600 Ω	Both units available

Table 3: Differences between 8903A and B models

There is another model, the 8903E, which has no generator built in. The analyzer characteristics are the same as for the B model. UPV and UPP can replace this model, too, because the analyzer is completely independent from the generator.

Note 1
The UPV provides a 10 Ω, 200 Ω and 600 Ω output impedance in the balanced mode. It can be activated with the following commands:
OUTPut:TYPE BALanced
OUTPut:IMPedance R10 | R200 | R600

4.3 Instrument setting after start-up

When switched on, the 8903B always has the same instrument state, it does not restore the settings it had before being switched off:

8903B settings after start-up	
Generator	
Signal	Sine (the only available generator signal)
Frequency	1 kHz
Level	0 V
Analyzer	
Measurement function	AC Level (RMS)
Highpass / Weighting filter	OFF
Lowpass	80 kHz

Table 4: 8903B settings after start-up

This is the default setting and can be achieved via remote control with the "clear" message.

The UPV or UPP stores the actual instrument setting when switched off, and restores this setting, when switched on again. This is considered to be very helpful, because the user can continue measurements without the need to reconfigure the instrument.

The default setting of both UPV or UPP can be achieved via remote control with the "*rst" command. In manual operation it can be loaded by selecting Preset from the File menu…
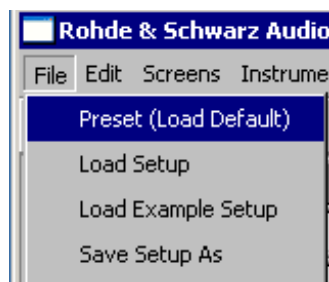
Figure 2: UPV/UPP Preset from the File menu

… or by pressing the PRESET button on the front panel (UPV only).

The default instrument state is identical for UPV and UPP and the settings are shown in the next table. Settings which are different to the 8903B, and thus have to be changed afterwards, are marked **blue bold**.

Default settings of UPV/UPP	
Generator	
Channels	**Both channels ON**
Bandwidth	**22 kHz**
Signal	Sine
Frequency	1 kHz
Level	**0.1 V**
Analyzer	
Channels	**All channels ON**
Bandwidth	**22 kHz**
Input Peak monitor	**ON**
Measurement function	AC Level (RMS)
Highpass / Weighting filter	OFF
Lowpass	OFF

Table 5: Default settings of UPV/UPP

The following remote control commands are necessary to set the UPV/UPP to the default state of the 8903B:

Set UPV/UPP to the default state of 8903B	
Function	**UPV/UPP remote control commands**
Load default setting (Preset)	*rst
Switch off generator channel 2	OUTPut:CHANnel CH1
Set generator bandwidth to 80 kHz	OUTPut:BANDwidth:MODE B80
Set generator output amplitude to 0 V	SOURce:VOLTage 0 V
Switch off analyzer channel 2 UPV UPP200	INPut:CHANnel CH1 INPut:MCHannels2 OFF (note 1)
Set analyzer bandwidth to 80 kHz	INPut:BANDwidth:MODE B80
Switch off input peak measurement	SENSe2:FUNCtion OFF
Clear status	*cls
Enable service request due to command errors	*SRE 32;:*ESE 32

Table 6: Set UPV/UPP to the default state of 8903B

Note 1

This command is sufficient for the 2-channel model UPP200. If a 4- or 8-channel UPP400 or UPP800 should be used, which is considered to be very unlikely when replacing the 8903B, the remaining channels have to be switched off, too, by using the following additional commands:

UPP400:
"INPut:MCHannels3 OFF;:INPut:MCHannels4 OFF"
UPP800:
"INPut:MCHannels3 OFF;:INPut:MCHannels4 OFF;:INPut:MCHannels5
OFF;:INPut:MCHannels6 OFF;:INPut:MCHannels7 OFF;:INPut:MCHannels8 OFF"

Instead of sending the above commands, a special setup file 'hp8903_default_upv.set' for UPV or 'hp8903_default_upp.set' for UPP could be loaded, which sets the UPV or UPP to the hp8903 power-up settings.
If this file is stored in the folder 'D:/hp8903' on the UPV's or UPP's harddrive, then the GPIB command would be as follows:

MMEMory:LOAD:STATe 'D:/hp8903/hp8903_default_upv.set' for the UPV
or
MMEMory:LOAD:STATe 'D:/hp8903/hp8903_default_upp.set' for the UPP

Both files are provided together with this application note.

The service request conditions cannot be stored in a setup file. Thus after loading the above setup files, the command *SRE 32;:*ESE 32 must be sent to the UPV/UPP in order to enable service request due to command errors, which is the default for the 8903B and A.

5 Generator settings

The 8903B can only output a sine wave. Since sine wave is the default setting for the UPV/UPP generator, there is no need to send a command to set the waveform type. You only need to send commands to set generator frequency and amplitude.

Set generator frequency and amplitude		
Parameter	**8903B command**	**UPV/UPP command**
Frequency	FR<value><unit>	SOURce:FREQuency <value> <unit>
Amplitude	AP<value><unit>	SOURce:VOLTage <value> <unit>

Table 7: Generator frequency and amplitude settings

Set frequency and amplitude units		
Unit	**8903B**	**UPV/UPP**
Hz	HZ	Hz
kHz	KZ	kHz
mV	MV	mV
V	VL	V
dBm (into 600 Ω)	DV	dBmg

Table 8: Generator units settings

Set generator output impedance		
Impedance	**8903B command**	**UPVcommand**
600 Ω	47.0SP	OUTPut:TYPE BALanced OUTPut:IMPedance R600
50 Ω	47.1SP	-----

Table 9: Generator impedance settings

Please note that in the older model 8903A, DV is used to set the unit to dBV.
The UPV/UPP offers both units, dBm and dBV.

If the unit dBmg is used, the UPV/UPP calculates the source level, which is necessary to provide e.g. a power of 1 mW into 600 Ω (which is equivalent to 0 dBm), while the source impedance is taken into account. Due to the voltage drop across the source impedance, the generator's open circuit source voltage must be higher than the voltage of 0.7746 V, required for 1 mW in the 600 Ω load resistor.
If the source impedance shall not be taken into account, the unit dBu must be used for the UPV/UPP. Then the source voltage of 0.7746 V is calculated, which would be equivalent to 0 dBm, if the 600 Ω load resistance would not be connected or if the source impedance would be zero.

Rapid source frequency setting using the remote control command ''RS'' is not supported by UPV and UPP. This function was useful to bypass the slow internal controller of the 8903B and is no longer needed for modern instruments having very fast internal calculating capability.

As it is possible with the 8903B, the frequency of the UPV/UPP generator can be swept while the analyzer makes measurements. Of course UPV and UPP do not have DC outputs to drive an X-Y recorder. This was a functionality which is obsolete nowadays. The swept data can be displayed in several graphics windows on the screen of the instruments and can be read out via remote control connection by the controlling PC. The graphic display can also be stored to file or printed on an external printer connected to UPV/UPP.

In addition to the capabilities of the 8903B, UPV/UPP provide a sweep over voltage, which allows to conduct linearity measurements. Frequency and voltage sweep may be nested, e.g. to perform linearity measurements at different frequencies, or distortion over frequency at different levels.

Before the sweep parameters can be defined for UPV/UPP the sweep mode must be enabled first. The sweep is not started with this command. The automatic sweep (ASWeep) is by default a frequency sweep, which is synchronised to the measurement speed of the selected analyzer measurement function. Thus no other commands are needed to enable this kind of sweep, which is the only one the 8903B provides.

When the sweep is defined it waits for the start command. The sweep is treated as a kind of extended measurement, and thus uses the same commands for start and stop. Besides a single sweep (one run from start to stop) a continuous sweep is available, which repeats forever until the stop command is received.

Generator frequency sweep settings		
Parameter	**8903B command**	**UPV/UPP command**
Enable sweep	-----	SOURce:SWEep:CONTrol ASWeep
Start frequency	FA<value><unit>	SOURce:SWEep:FREQuency:STARt <value> <unit>
Stop frequency	FB<value><unit>	SOURce:SWEep:FREQuency:STOP <value> <unit>
Resolution (note 1)	17.0SP to 17.9SP	SOURce:SWEep:FREQuency:SPACing LOGPoints SOURce:SWEep:FREQuency:POINts <value>
Start continuous sweep	-----	INITiate:CONTinuous ON
Start single sweep	W1	INITiate:CONTinuous OFF
Stop Sweep	W0	INITiate:FORCe STOP

Table 10: Generator frequency sweep settings

Note 1

For UPV/UPP the number of points (SOURce:SWEep:FREQuency:POINts <value>) is not defined as points/decade, but as the total number of sweep points from start to stop frequency, which may be between 2 and 1024. The first command (SOURce:SWEep:FREQuency:SPACing LOGPoints) switches to logarithmic spacing of the points.

6 Analyzer range settings

Both 8903B and UPV/UPP provide an auto ranging mode, which is the default state after preset or *rst. According to the input signal amplitude the instrument automatically selects the input measurement range for best dynamic range. This is very convenient for manual operation. But of course it takes time to find the correct range, after the signal has been applied to the instrument. Thus in system applications where time is a critical factor, the fixed range mode is often the better choice.

6.1 Auto range mode

Auto range mode commands	
8903B	**UPV/UPP**
AU (Automatic operation)	Not supported

Auto range mode commands	
1.0SP (AC level)	SENSe:VOLTage:RANGe:MODE AUTO
2.0SP (DC level)	SENSe:VOLTage:RANGe:MODE AUTO

Table 11: Auto range mode

The 8903B automatic operation command AU does not only switch to auto range mode, but also switches off all previously selected special functions. As UPV and UPP do not use special functions to control the instrument, there is no equivalent command.

When UPV and UPP are operated in auto range mode, the range can be queried with the command:
SENSe:VOLTage:RANGe:VALue?
The returned value is the nominal value of the actually used range.

6.2 AC and DC voltage fix range mode

Before the required range can be selected for UPV/UPP with the commands listed in the tables below, the input ranging mode must be once changed from the default auto mode to fix range mode using the command:
"SENSe:VOLTage:RANGe:MODE FIXed"
This command holds the input level range which was selected by the previously used auto ranging mode. This behaviour is a part of the 8903B special function 9.0SP (Hold Settings).

Though this command is only necessary once to select the fix range mode, it is recommended to use always both commands for a complete fixed range setting:

SENSe:VOLTage:RANGe:MODE FIXed
SENSe:VOLTage:RANGe:VALue <n>

In the tables below in the UPV and UPP columns only the parameter <n> of the complete command SENSe:VOLTage:RANGe:VALue <n> is listed, which is the nominal value of the range. Without unit specified, the value is interpreted as given in Volt, as this is the basic unit.

AC voltage ranges		
8903B command (range)	UPV <n>	UPP <n>
1.1SP (300 V)	(not available)	(not available)
1.2SP (189 V)	(not available)	(not available)
1.3SP (119 V)	(not available)	(not available)
1.4SP (75.4 V)	100	(not available)
1.5SP (47.6 V)	60	50
1.6SP (30.0 V)	30	50
1.7SP (18.9 V)	18	50

AC voltage ranges			
1.8SP	(11.9 V)	18	12
1.9SP	(7.54 V)	10	12
1.10SP	(4.76 V)	6	12
1.11SP	(3.00 V)	3	3
1.12SP	(1.89 V)	3	3
1.13SP	(1.19 V)	1.8	3
1.14SP	(0.754 V)	1	0.8
1.15SP	(0.476 V)	0.6	0.8
1.16SP	(0.300 V)	0.3	0.8
1.17SP	(0.189 V)	0.3	0.2
1.18SP	(0.119 V)	0.18	0.2
1.19SP	(0.0754 V)	0.1	0.2

Table 12: AC voltage ranges

DC voltage ranges			
8903B command (range)		UPV <n>	UPP <n>
2.1SP	(300 V)	(not available)	(not available)
2.2SP	(64 V)	100	(not available)
2.3SP	(16 V)	18	50
2.4SP	(4 V)	6	12

Table 13: DC voltage ranges

Please note, that both the available AC and DC input ranges are different for UPV and UPP.

Both UPV and UPP do not require the exact nominal value to be given as parameter in the remote control command, but for even more convenience, they just expect any voltage value which shall be measured. If you know the maximum voltage, which you want to measure, then just send this value to the UPV/UPP and the instrument will select the appropriate fixed input range.

Example:
If you want to measure up to 0.4 V then send the commands
SENSe:VOLTage:RANGe:MODE FIXed
SENSe:VOLTage:RANGe:VALue 0.4
The UPV will select the 0.6 V range, while the UPP will use the 0.8 V range.

When the range is queried with the command
SENSe:VOLTage:RANGe:VALue?
the returned value will be the nominal value of the selected range.

7 Measurements

7.1 Measurement functions

The measurement functions available in the 8903B are listed in the table below.

8903B measurement functions		
Measurement function	**8903B commands**	**UPV/UPP commands**
AC level RMS fast	M1 A0 or 5.0SP	INPut:COUPling AC SENSe:FUNCtion RMS SENSe:FUNCtion:APERture:MODE AFASt
AC level RMS slow	M1 5.1SP	INPut:COUPling AC SENSe:FUNCtion RMS SENSe:FUNCtion:APERture:MODE AUTO
AC level Average fast Average slow	M1 A1 or 5.2SP 5.3SP	The nowadays obsolete average detector is not supported. Modern instruments usually use true RMS detection.
AC level Quasi-peak	M1 5.7SP	Available for UPV only: INPut:COUPling AC SENSe:FUNCtion QPEak
SINAD (note1)	M2	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe SNDRatio
Distortion ratio (note 3)	M3	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe THDN SENSe:UNIT PCT
DC level (note 2)	S1	INPut:COUPling DC SENSe6:FUNCtion DC
Signal/Noise (note 3)	S2	INPut:COUPling AC SENSe:FUNCtion SN
Distortion level (note 4)	S3	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe LTHDn

Table 14: Measurement functions

Default units (after preset)
The 8903B and UPV/UPP have the same default units **Volt** for AC, DC and Distortion level, and **dB** for SINAD and S/N.

For the distortion ratio function the 8903B has **%** as default unit. UPV/UPP must be set to % with the command SENSe:UNIT PCT, because their default unit is **dB**.

When later on switching between measurement functions both 8903B and UPV/UPP restore the previously selected unit.

Note 1
In SINAD mode the notch filter of the 8903B is tuned to the generator frequency. By default the notch filter of UPV/UPP is automatically tuned to the input signal frequency (as it is done in the 8903E model, which has no generator). But it is also possible to lock the notch filter to the generator frequency:
    SENSe:VOLTage:FUNDamental:MODE GENTrack
or to a fixed frequency, e.g. 1 kHz:
    SENSe:VOLTage:FUNDamental:MODE VALue
    SENSe:VOLTage:FUNDamental 1 KHZ

Note 2
The UPV/UPP can set DC/AC coupling independent from the measurement function, while the 8903B tracks the input coupling with the measurement function.
Switch to DC measurement:
  8903B automatically selects DC coupling, while the UPV/UPP does not.
Switch to any other (AC) measurement function:
  8903B automatically selects AC coupling, while the UPV/UPP does not.
Thus when switching to a measurement function, check for the correct input coupling in the UPV/UPP.

Note 3
8903B provides special functions 12.0SP to 12.9SP to specify a signal-to-noise measurement delay. UPV and UPP provide such a delay setting not only for signal-to-noise, but for all measurement functions. It can be set by the command:
    TRIGger:DELay <value> S
to an arbitrary value between 0 s and 5 s.

Note 4
By default the notch filter of the 8903B is automatically tuned to the fundamental frequency, but can be fixed to the actual input frequency. UPV/UPP does not provide a single command for such a function. But it is possible to emulate this function by the commands given in the table below: UPV/UPP measures the actual input frequency in automatic mode and then fixes the notch filter to this frequency.

Notch tuning for distortion measurement		
Notch tuning	**8903B command**	**UPV/UPP commands**
Automatic	N0 or 6.0SP	SENSe:VOLTage:FUNDamental:MODE AUTO
Hold	N1 or 6.1SP	SENSe:VOLTage:FUNDamental:MODE AUTO INITiate:CONTinuous OFF;*wai SENSe:VOLTage:FUNDamental:MODE VALue

Table 15: Notch filter tuning

If UPV/UPP is running in continuous trigger mode "INITiate:CONTinuous ON" (equivalent to T0 trigger of 8903B), then the "INITiate:CONTinuous OFF;*wai" command to measure the actual frequency is not needed and must not to be sent, because this would switch from continuous to single triggered measurements.

7.2 Measurement result units

The results of all level and distortion measurements can be displayed in linear or logarithmic units.

Linear and logarithmic units		
Measurement	**Lin unit**	**Log unit**
AC or DC level	V or mV	dBm into 600 Ω
SINAD	%	dB
Signal to Noise	%	dB
Distortion	%	dB
Distortion level	V or mV	dBm into 600 Ω

Table 16: Measurement result units

Today SINAD and Signal to Noise measurements are commonly measured in dB. The unit % is very unusual and may have been useful in very special applications. It can only be displayed if the reading is less than 10,000 % (< 40 dB).
UPV and UPP only support the unit dB for those measurements. If % is really needed, the value can be easily calculated from the dB value in the PC which remote controls the system.

Ratio units
For each of the above lin or log units, additionally ratio units are available, which calculate the results as ratio to a measured or entered reference value. The ratio unit is % for a lin unit and dB for a log unit.
When the ratio mode is set to ON, the actual measurement result is stored as reference. So the first ratio value is 1, which results in a linear ratio of 100 % and a logarithmic ratio of 0 dB.

Ratio settings for % and dB ratio units		
Function	**8903B**	**UPV/UPP**
Ratio On	R1	INITiate:CONTinuous OFF;*wai SENSe:REFerence:MODE STORe (note 1)
Ratio Off	R0	Not supported (note 1)
Enter reference value	<data>R1	SENSe:REFerence:MODE VALue SENSe:REFerence <data> V
Read ratio reference	11.1SP	SENSe:REFerence?

Ratio settings for % and dB ratio units		
Re-enter ratio with the previous reference	11.0SP	No command necessary, because UPV/UPP always restore the previous reference

Table 17: Ratio mode settings

Ratio On:
Stores the actual reading as reference, and displays the ratio unit (lin or log, depending on the actually selected absolute lin or log unit. There is no such command for the UPV/UPP.

Ratio Off:
Switches ratio off and returns to the absolute unit (lin or log). The resulting unit depends on the LOG/LIN setting, which was made before entering the ratio mode. There is no such command for the UPV/UPP.

Note 1
UPV/UPP does not support a ratio mode, as it is implemented in the 8903B, and therefore has no commands to switch a ratio mode on or off. The required ratio display can be directly selected with the appropriate ratio unit:
%   SENSe:UNIT PCTVVR
dB   SENSe:UNIT DBR
Beside those two units, UPV/UPP provide many more ratio units.

If UPV/UPP is running in continuous trigger mode "INITiate:CONTinuous ON" (equivalent to T0 trigger of 8903B), then the "INITiate:CONTinuous OFF;*wai" command to measure the actual level is not needed and must not to be sent, because this would switch from continuous to single triggered measurements.

When the 8903B is in ratio mode, if a new measurement is selected, ratio is disabled. The UPV/UPP does not disable ratio, but remembers the previously selected ratio unit and the corresponding reference value.

When translating 8903B code in this context, it is not recommended to emulate the 8903B lin/log and ratio unit implementation. It is easier, and does not depend on settings made before, to directly select the required absolute or ratio unit for each measurement.

AC level units		
Unit	**8903B commands**	**UPV/UPP commands**
Volt	M1, LN, R0	INPut:COUPling AC SENSe:FUNCtion RMS SENSe:UNIT V
dBm (1 mW into 600 Ω)	M1, LG, R0 (note 1)	INPut:COUPling AC SENSe:FUNCtion RMS SENSe:UNIT DBM SENSe:POWer:REFerence:RESistance 600

AC level units		
% (lin ratio)	M1, LN, R1	INPut:COUPling AC SENSe:FUNCtion RMS INITiate:CONTinuous OFF;*wai SENSe:REFerence:MODE STORe (UPV) SENSe:REFerence:MODE CH1Store (UPP) SENSe:UNIT PCTVVR
dB (log ratio)	M1, LG, R1	INPut:COUPling AC SENSe:FUNCtion RMS INITiate:CONTinuous OFF;*wai SENSe:REFerence:MODE STORe (UPV) SENSe:REFerence:MODE CH1Store (UPP) SENSe:UNIT DBR
W (into 8 Ω)	M1, 19.0SP (note 2)	INPut:COUPling AC SENSe:FUNCtion RMS SENSe:UNIT W SENSe:POWer:REFerence:RESistance 8
W (into NNN Ω)	M1, 19.NNNSP	INPut:COUPling AC SENSe:FUNCtion RMS SENSe:UNIT W SENSe:POWer:REFerence:RESistance NNN

Table 18: AC level units

Note 1
Please note that in the A model these commands activate the unit dBV.
UPV/UPP provide both possibilities: dBm or dBV.

Note 2
19. may be also coded instead of 19.0

DC level units		
Unit	**8903B commands**	**UPV/UPP commands**
Volt	S1, LN, R0	INPut:COUPling DC SENSe6:FUNCtion DC SENSe6:UNIT V
dBm (1 mW into 600 Ω)	S1, LG, R0	INPut:COUPling DC SENSe6:FUNCtion DC SENSe6:UNIT DBM SENSe:POWer:REFerence:RESistance 600

DC level units		
% (lin ratio)	S1, LN, R1	INPut:COUPling DC SENSe6:FUNCtion DC INITiate:CONTinuous OFF;*wai SENSe6:REFerence:MODE STORe (UPV) SENSe6:REFerence:MODE CH1Store (UPP) SENSe6:UNIT PCTVVR
dB (log ratio)	S1, LG, R1	INPut:COUPling DC SENSe6:FUNCtion DC INITiate:CONTinuous OFF;*wai SENSe6:REFerence:MODE STORe (UPV) SENSe6:REFerence:MODE CH1Store (UPP) SENSe6:UNIT DBR

Table 19: DC level units

DC level must not be negative for log ratio.

Distortion units		
Unit	**8903B commands**	**UPV/UPP commands**
% (lin)	M3, LN, R0	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe THDN SENSe:UNIT PCT
dB (log)	M3, LG, R0	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe THDN SENSe:UNIT DB
Volt (level lin)	S3, LN, R0	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe LTHDn SENSe:UNIT V
dBm (level log)	S3, LG, R0	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe LTHDn SENSe:UNIT DBM SENSe:POWer:REFerence:RESistance 600
% (lin ratio)	M3, LN, R1 S3, LN, R1	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe LTHDn INITiate:CONTinuous OFF;*wai

Distortion units		
		SENSe:REFerence:MODE STORe (UPV)
		SENSe:REFerence:MODE CH1Store (UPP)
		SENSe:UNIT PCTVVR
dB (log ratio)	M3, LG, R1 S3, LG, R1	INPut:COUPling AC
		SENSe:FUNCtion THDNsndr
		SENSe:FUNCtion:MMODe LTHDn
		INITiate:CONTinuous OFF;*wai
		SENSe:REFerence:MODE STORe (UPV)
		SENSe:REFerence:MODE CH1Store (UPP)
		SENSe:UNIT DBR

Table 20: Distortion units

If UPV/UPP is running in continuous trigger mode "INITiate:CONTinuous ON" (equivalent to T0 trigger of 8903B), then the "INITiate:CONTinuous OFF;*wai" command to measure the actual level is not needed and must not to be sent, because this would switch from continuous to single triggered measurements.

SINAD units		
Unit	**8903B commands**	**UPV/UPP commands**
% (lin)	M2, LN, R0	Not supported
dB (log)	M2, LG, R0	INPut:COUPling AC SENSe:FUNCtion THDNsndr SENSe:FUNCtion:MMODe SNDRatio
% (lin ratio)	M2, LN, R1	Not supported
dB (log ratio)	M2, LG, R1	Not supported

Table 21: SINAD units

Signal to Noise units		
Unit	**8903B commands**	**UPV/UPP commands**
% (lin)	S2, LN, R0	Not supported
dB (log)	S2, LG, R0	INPut:COUPling AC SENSe:FUNCtion SN
% (lin ratio)	S2, LN, R1	Not supported
dB (log ratio)	S2, LG, R1	Not supported

Table 22: Signal to Noise units

If ratio units are really needed for SINAD or Signal to Noise measurements, it is recommended to do this calculation in the PC which remote controls the system.

8 Filter settings

The 8903B has two filter sections, one with the highpass/weighting filters and the other with the lowpass filters. All filters are realized in hardware, of course. The highpass/weighting filter section contains 2 filters out of a selection of 5 different weighting filters and a 400 Hz highpass. The lowpass section has a 30 kHz and a 80 kHz lowpass. One filter of each filter section can be selected at a time.

Within the UPV/UPP all filters are implemented in software. With the digital highpass and lowpass filters a flat passband to the cut-off frequency, a steep roll-off and a high stopband attenuation can be achieved. The filters can be cut in at different stages of the signal processing chain. Up to 4 filters can be combined for level measurements.

When replacing the 8903B, the following configuration should be used: The highpass/weighting filter section is covered by the pre-filter, which is selected in the analyzer config panel, while the lowpass section is covered by the function filter 1, which is selected in the analyzer function panel.

The filter settings in the 8903B are independent of the selected measurement function. This means, they are kept unchanged, when the function is changed. In the UPV/UPP this is the same only for the pre-filter, which covers the highpass/weighting filter section, but is different for the lowpass filter which is cut in as function filter. The function filters can be individually selected for each measurement function. If a measurement function is changed, care has to be taken to maintain the correct lowpass filter setting.
The pre-filter does not depend on the measurement function, but is not automatically switched off, when DC measurement is selected. In the 8903B, even if DC measurement is selected, the previously selected filters are still indicated, but obviously not used (because DC measurement is performed correctly, even if a highpass is selected).

For THD or SINAD measurements it is important to use the pre-filter when a weighting filter is needed for the measurement. The prefilter of UPV/UPP is applied to the complete input signal, as it is done in the 8903B. Thus also the fundamental frequency of the signal may be attenuated by this filter. The function filters of UPV/UPP are applied after the level measurement of the fundamental frequency. This might cause differences in the measurement results of 8903B and UPV/UPP if the weighting filters would be applied as function filters and if the fundamental frequency would be attenuated by the weighting function.

8.1 Highpass and weighting filters

The pre-filter (remote control command INPut:FILTer) in the UPV/UPP is used to implement the highpass and weighting filters.

Highpass and weighting filters		
Function	**8903B command**	**UPV/UPP command**
All plug-in HP/BP filters off	H0	INPut:FILTer OFF
Left plug-in filter on	H1	INPut:FILTer UFIL2 | CCIT | CMES | CCIR | CARM | AWE
Right plug-in filter on	H2	INPut:FILTer UFIL2 | CCIT | CMES | CCIR | CARM | AWE

Table 23: Highpass and weighting filters for 8903B model

The analyzer hardware of the 8903B provides 2 slots (H1 and H2) for highpass and weighting filters. In each slot one filter out of a selection of 6 filters can be fitted as an option. By manual or remote operation it is only possible to select one of the two slots, the user must know which filter is mounted in which slot.
Therefore, before it is possible to translate the 8903B commands H1 and H2 to the appropriate UPV/UPP commands, you have to determine which kind of filter is plugged-in in the left (H1) and the right (H2) slot.

Filter designations in 8903B and UPV/UPP		
8903B	**UPV/UPP**	**UPV/UPP command**
400 Hz high-pass	2:HP400.0Hz	INPut:FILTer UFIL2
CCITT weighting filter	CCITT	INPut:FILTer CCIT
CCIR weighting filter	CCIR 1k wtd	INPut:FILTer CCIR
C-Message weighting filter	C Message	INPut:FILTer CMES
CCIR/ARM weighting filter	CCIR 2k wtd	INPut:FILTer CARM
"A" weighting filter	A weighting	INPut:FILTer AWE

Table 24: Filter designations

According to the 8903B data sheet the HP 400 Hz should have a stopband rejection of > 40 dB for frequencies below 250 Hz. In the UPV/UPP this attenuation can not be achieved with the fixed HighPass 400 Hz. The default user definable filter no. 2 (HP 400 Hz, 8th order, 60 dB attenuation), with the short name 2:HP400.0Hz must be used to meet the required filter specifications.
The UPV/UPP highpass filter has an attenuation of -0.1 dB at the passband edge frequency of 400 Hz. If the soft -3 dB roll-off at 400 Hz is really needed, the fixed HP 400 Hz must be cut in in addition as function filter 2, using the remote control command "SENSe:FILTer2 HP400". Only in case of this very special situation, this filter must be switched off, before switching to another filter in the UPV, corresponding to the plug-in filter in the other slot of the 8903B.

Be sure, that the user definable filter #2 is defined to be a HP, 8th order, 400 Hz passband frequency and 60 dB stopband attenuation, which is the case after preset or loading the pre-defined setup"hp8903_default_upv.set" or "hp8903_default_upp.set".

The older 8903A model has only a 400 Hz highpass and a psophometric (CCITT) weighting filter, which are selected with the following commands:

Highpass and weighting filters		
Function	**8903A command**	**UPV/UPP command**
All plug-in HP/BP filters off	H0	INPut:FILTer OFF
400 Hz filter on	H1	INPut:FILTer UFIL2
Psophometric BP filter on	H2	INPut:FILTer CCIT

Table 25: Highpass and weighting filters for 8903A model

8.2 Lowpass filters

To implement the lowpass filters in the UPV/UPP the function filter and the bandwidth setting are used.

Lowpass filters		
Function	**8903B command**	**UPV/UPP command**
All LP filters off	L0	SENSe:FILTer OFF INPut:BANDwidth:Mode B250 (UPV) INPut:BANDwidth:Mode B80 (UPP)
30 kHz LP filter on	L1	INPut:BANDwidth:Mode B80 SENSe:FILTer LP30
80 kHz LP filter on	L2	INPut:BANDwidth:Mode B80 SENSe:FILTer OFF

Table 26: Lowpass filters

When the lowpass filter is switched off, the UPV/UPP analyzer bandwidth is set to the maximum range, which is 250 kHz for the UPV and 80 kHz for the UPP.

The 80 kHz lowpass is realized with the 80 kHz bandwidth setting and is thus independent of the measurement function.

The 30 kHz lowpass is cut in as function filter. The function filters can be individually selected for each measurement function. If a measurement function is changed, care has to be taken to maintain the correct filter setting.

9 Retrieving measurement results

In the default free run trigger mode T0 of the 8903B, it is possible to read the measurement result directly from the bus without having to send a query command first. With the UPV/UPP you need to send a query command before the result can be read from the bus by the controller. UPV and UPP provide a free run trigger mode (like T0) as well as a single triggered mode (like T2 or T3). You can set the UPV/UPP to a continuous measuring mode and then query and read measurement results at any time you want. Or you can trigger a single measurement and then read the settled result. All measurements which are set to ON, are triggered simultaneously and will provide a result.

When first addressed, the UPV/UPP resumes the continuous or single trigger mode, which was selected before changing from local to remote mode.

Set the measuring mode (trigger mode)		
Measuring mode	**8903B**	**UPV/UPP**
Continuous	T0	INITiate:CONTinuous ON
Hold	T1	INITiate:FORCe STOP
Single triggered	T2	INITiate:CONTinuous OFF
Single triggered	T3	INITiate:CONTinuous OFF;*wai

Table 27: Measuring mode (trigger mode)

Rapid frequency count using the remote control command "RF" is not supported. This was used to bypass the slow internal controller of the 8903B and is no longer needed for modern instruments having very fast internal calculating capability.

8903B
Before reading a result, you have to select, if you want to read the result from the left (Frequency) display by using the command RL or 20.1SP, or from the right (any AC measurement function or DC measurement) display by using the command RR or 20.0SP. There is no extra query command.

UPV/UPP
Within the command SENSe<n>:DATA[1]? you can select, which result you want to read. The parameter <n> specifies the type of measurement whose result is queried in channel 1.

Reading measurement results		
Result	**8903B command**	**UPV/UPP command**
AC Measurement Functions	RR; (or 20.0SP) Read <meas funct result>	SENSe1:DATA[1]?; Read < meas funct result >
DC measurement	RR; (or 20.0SP) Read <meas funct result>	SENSe6:DATA[1]?; Read <DC level>
Frequency	RL; (or 20.1SP) Read <frequency>	SENSe3:DATA[1]?; Read <frequency>

Table 28: Reading measurement results

Time between measurements (start delay)		
Function	**8903B command**	**UPV/UPP command**
Minimum time between single triggered measurements	14.0SP	TRIGger:DELay 0 S
Add 1 s delay between measurements	14.1SP	TRIGger:DELay 1 S
Add 0 to 5 s delay between measurements	-----	TRIGger:DELay <value> S

Table 29: Time between measurements

10 Status byte and service request

The R&S UPV and UPP audio analyzers support GPIB service requests, just like the 8903B (and the older A model, too) does. However, unlike the 8903B/A, which has only one status byte, the UPV/UPP has several registers in its status reporting system. Besides the status byte (STB, condition set with *ESR command), the UPV/UPP also uses the event status register (ESR, condition set with *ESE command) for reporting the same conditions as the 8903B and A. The next tables show the equivalent commands for setting the service request conditions.

10.1 Setting the service request conditions

Setting the service request conditions in the 8903B status byte			
Bit	**Value**	**Condition**	**8903B command**
0	**1**	Data ready	22.**1**SP
1	**2**	Command error	22.**2**SP
2	**4**	Instrument error	22.**4**SP
3	8		
4	16		
5	32		
6	64	Require Service Bit	
7	128		

Table 30:Service request in 8903B

Setting the service request conditions in the UPV/UPP status system			
Bit	Value	Condition	UPV/UPP command
0	1		
1	2		
2	**4**	Instrument error	*SRE **4**
3	8		
4	**16**	Data ready	*SRE **16**
5	**32**	Command error	*SRE **32**;: *ESE 32
6	64	Require Service Bit	
7	128		

Table 31:Service request in UPV/UPP

The 8903B/A powers up in the 22.2SP state. This means, that service request is enabled due to command errors. UPV and UPP power up without any service request condition set. A "*SRE 32;:*ESE 32" command must be sent to enable service request due to command errors, to be compatible with the 8903B/A default setting.

To enable more than one condition, e.g. to combine data ready and instrument error, the sum of the relevant values must be sent.
8903B/A   22.**5**SP
UPV/UPP   *SRE **20**

10.2 Reading the error code

When the controller receives the service request, it will usually read the status byte via serial poll from the instrument and then detect the condition for the service request.

The 8903B/A returns both the data and the error code via the GPIB data buffer. An error is coded as part of a data value which is greater than 9×10^9.
For example: Error **24** (Command Error) is returned as +900**24**E+05.

UPV and UPP put only the data (if queried before) into the data buffer. Thus, if the service request is due to data ready, the controller can then read the queried data using the Read <data> command.
But with modern SCPI compliant instruments, it is easier to read measurement results (data) without using the service request mechanism, but using the method described in the section **Retrieving measurement results**.

Any error code is entered into the error queue of UPV/UPP. Thus, if the service request is due to error(s), the controller must first query the data in the error queue and then read the error string from the data buffer.
  SYSTem:ERRor?
  Read <data>

To read all errors, these commands must be repeated, until the error queue is empty, which is indicated by the return string 0, "No error"

Return strings consist of an error number and an additional text describing the reason for the error, e.g.:

   -222,"Data out of range;SOUR:VOLT 25 V"
   -410,"Query interrupted"

11 Unsupported commands

The 8903B functionality and commands that are supported by equivalent commands on the UPV and UPP have been listed and explained in detail in the previous sections.

Some obsolete, not necessary or non supported functionality is summarized in the following table:

Unsupported commands	
Commands	**Function**
FN, AN, UP, DN	Amplitude and frequency increment This can be easily calculated in the controlling program
UL, LL, PL, 13.0SP, 13.1SP	Settings for controlling an x-y recorder Obsolete, because nowadays x-y recorders are not used any more.
3.0SP to 3.4SP	Post Notch Gain Not necessary due to digital implementation of notch
4.0SP to 4.8SP	Hold decimal point Obsolete
7.0SP, 7.1SP	SINAD Meter Range Both UPV and UPP do not provide an analog SINAD meter
8.0SP to 8.3SP	Error Disable For UPV/UPP it is not possible to suppress the indication of instrument errors.
9.0SP	Hold input level range and hold notch tuning is supported (see relevant previous sections). Hold post-notch gain and decimal point is obsolete.
10.0SP	Display Source Settings Not necessary: Settings are always displayed in the panel and can be queried via remote control.
16.0SP, 16.1SP	SINAD and Signal-to-Noise Display resolution Obsolete

Unsupported commands	
21.0SP, 21.1SP	GPIB address displayed in binary
	Obsolete
	Decimal address (21.1SP) is always displayed in the panel and can be queried via remote control.
47.0SP, 47.1SP	Source output impedance
	50 Ω are not supported, 600 Ω for UPV only in balanced output mode

Table 32: Unsupported commands

12 Remote Control Emulation Mode

From firmware version 3.2.0 UPV/UPP can be remote controlled with the command set of the 8903B. The 8903B emulation mode can be invoked in the UPV/UPP Configuration Panel by selecting the remote language HP 8903B instead of SCPI.
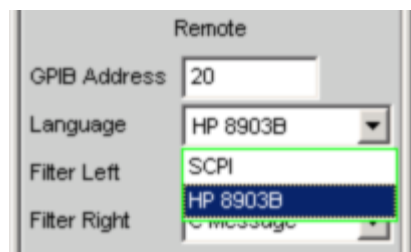
Figure 3: Select the remote language

The analyzer hardware of the 8903B provides 2 slots for highpass and weighting filters, a left and a right one. In each slot one filter out of a selection of 6 filters can be fitted as an option. For details about the 8903B filter settings see section 8.
It is only possible to select one of the two slots. The UPV/UPP needs to know which filter is mounted in which slot to be able to activate the correct filter for the commands H1 (left slot) and H2 (right slot). You can select the filters which are fitted in the left and right slots of the 8903B in the UPV/UPP Configuration Panel.
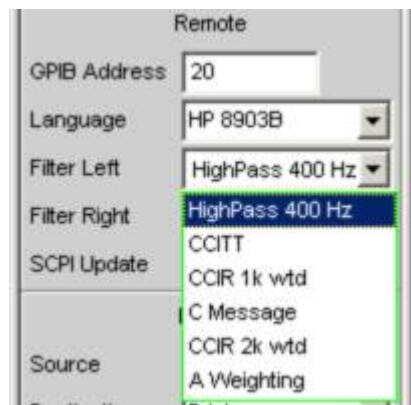

Figure 4: Select the plug-in filters

13 Ordering Information

R&S® UPV Audio Analyzer   1146.2003.02

R&S® UPV66 Audio Analyzer   1146.2003.66

R&S® UPP200 Audio Analyzer   1411.1003.02

For additional information about audio analyzers and other measurement equipment, see the Rohde&Schwarz website www.rohde-schwarz.com.

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment
- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

Regional contact

USA & Canada
USA: 1-888-TEST-RSA (1-888-837-8772)
from outside USA: +1 410 910 7800
CustomerSupport@rohde-schwarz.com

East Asia
+65 65 13 04 88
CustomerSupport@rohde-schwarz.com

Rest of the World
+49 89 4129 12345
CustomerSupport@rohde-schwarz.com

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.