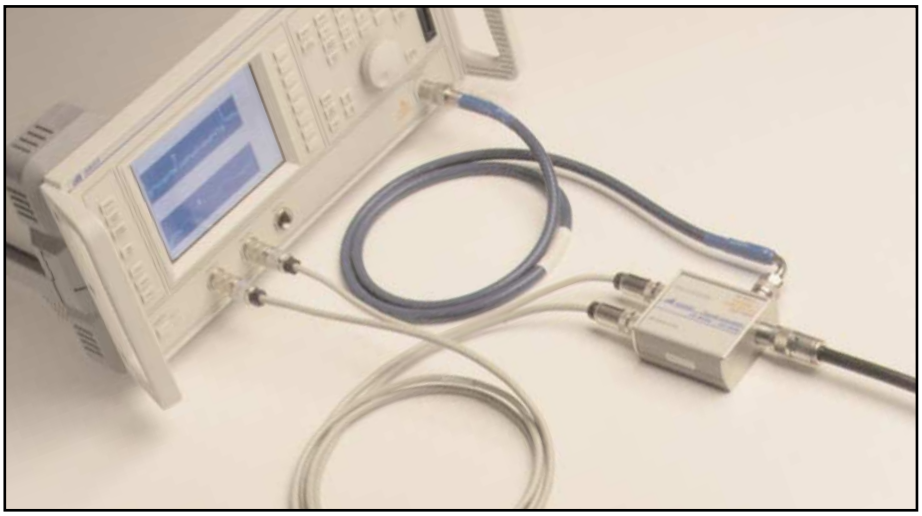
application note

The Use of Guided Scalar Measurements with the 6800 series Scalar and System Analyzers

Clive Piggott



How to set up the instrument in 'Supervisor Mode', and how to operate it in 'Operator Mode' in the guided measurement of Components, Assemblies, Antennas, Cables and Waveguides

INTRODUCTION

This Application Note describes the Guided Scalar Measurement Application for the 6820 series Microwave Scalar Analyzers and 6840 series Microwave System Analyzers.

The user is guided through a series of screens which help to: select a pre-defined measurement, set relevant measurement options, calibrate the instrument, connect the device under test, and carry out the desired measurement.

In normal use the application runs in Operator Mode, but it may be set into Supervisor Mode by entering a password. Supervisor mode provides all facilities available under operator mode, but also allows a supervisor to enable or disable certain operator options and to create additional custom measurements (based on built-in pre-defined types) for use by the operator.

Throughout this document, a user running the application in operator mode is termed an Operator, and a user running the application in supervisor mode is termed a Supervisor. All facilities which are available to an operator are also available to a supervisor.

Although the set-up screens show measurements on transmission lines, the application can be used on any component or assembly.

Language

Application text may be displayed in English, French, German or Spanish.

Conventions

The following conventions are used to indicate keypresses:

[BOLD] -	Hardkey press, i.e. a dedicated front panel function key
[normal] -	data entry via numeric keypad
[*italic*] -	Softkey press, i.e. a software menu key
[●] -	toggle function enabled
[O] -	toggle function disabled

Numeric entries are made using either the keypad or the rotary control. Keypad entries must be followed by a terminator key. To delete a partial entry use the back space key.

AVAILABLE MEASUREMENTS

The application offers six pre-defined measurement types:

- Return Loss / VSWR
- Insertion Loss
- Fault Location
- Single-ended Insertion Loss
- Return Loss plus Fault Location
- Return Loss plus Insertion Loss

To facilitate the creation of a new measurement, the supervisor is guided through a series of screens and prompted to set relevant measurement options (such as medium, accessories to be used, start and stop frequencies etc.).

The application leads the operator through the measurement by displaying the appropriate connection diagrams for calibration and the calibration process. If allowed by the supervisor, the operator may be able to change some of the measurement parameters. A final connection diagram then shows how the device under test should be connected.

Once the operator has completed the measurement, the application offers certain facilities such as marker operations, store functions and hard copy functions.

Example of the use of this Application to make a Measurement

- The supervisor sets up the 6800 with the settings to allow the necessary measurements to be made by the operator.
- The operator carries the 6800 to a site where transmission line measurements are to be made.
- The primary measurement is return loss, although insertion loss measurements are sometimes made.
- In the event of a problem being discovered with this measurement, a fault location measurement is made.
- When the problem has been corrected, the return loss (or insertion loss) measurement is repeated.
- Hard copy may be produced.
- The measurement trace may be saved for later analysis or comparison with subsequent traces.

SETTINGS FILES

The Application's Use of Settings Files

The application uses standard instrument settings files (*.set) to configure its measurements[1] and save operator changes.

For example, the settings files listed below are used by the application to provide the basic set-up for each of the measurement types supported. Other settings files may also be created by the application if it requires them.

GSM_FL.SET	fault location measurements
GSM_RL.SET	return loss/VSWR measurements
GSM_IL.SET	insertion loss measurements
GSM_SEIL.SET	single ended insertion loss measurements
GSM_RLFL.SET	return loss plus fault location measurements
GSM_IL.SET	return loss plus insertion loss measurements

WARNING: These settings files should not be modified outside of the application. Such action may prevent the application from functioning correctly.

[1] AC detection mode is set for all measurements. AC detection gives improved performance where there are strong interfering RF signals present.

MEASUREMENT TYPE	SET-UP
Fault Location	Fault location measurement on channel 1, measurement 1
Return Loss/VSWR	Scalar measurement on channel 1, measurement 1
Insertion Loss	Scalar measurement on channel 1, measurement 1
Single-Ended Insertion Loss	Scalar measurement on channel 1, measurement 1
Return Loss / VSWR & Fault Location	Scalar measurement on channel 1, measurement 1 and a fault location measurement on channel 2, measurement 1
Return Loss / VSWR & Insertion Loss	Scalar measurements on channel 1, measurements 1 and 2.

Table 1 shows the channel and measurement allocations for each measurement type.

Measurement Configurations

Depending on the accessories chosen by the operator, the measurement configurations are shown in Table 2.

MEASUREMENT TYPE	ACCESSORIES	INPUTS
Return Loss/VSWR	Fault Locator	A
	Bridge	A
	Autotester	A
	Single Coupler	A
	Twin Couplers	A/C
Insertion Loss	Fault Locator + Detector	C
	Autotester+Detector	C
	Single Detector	C
	Single Coupler	B/C
Fault Location	Fault Locator	B
	Divider + Detector	B
Single-Ended Insertion Loss	Fault Locator	A
	Bridge	A
	Single Coupler	A
	Autotester	A
	Twin Couplers	A/C
Return Loss/VSWR & Fault Location	Fault Locator (624x Series)	Ch1, M1 = A Ch2, M1 = B
Return Loss/VSWR & Insertion Loss	Fault Locator & Detector (624x Series)	Ch1, M1 = A Ch1, M2 = C
	Autotester & Detector	Ch1, M1 = A Ch1, M2 = C
	Single Coupler	Ch1, M1 = B Ch1, M2 = C
	Twin Couplers	Ch1, M1 = A/C Ch1, M2 = B/C

Table 2 Measurement configurations

SUPERVISOR MODE

To use the application in Supervisor Mode the following keypresses should be used:

[RUN APPS] Use the softkey Up and Down arrows to select 'Guided Scalar Measurements'

[*Run*]

The **Welcome** screen is displayed, showing the title of the application, its part number and its software release number.

To put the application into Supervisor mode, clear the keypad by pressing **[ENTER]** and enter the password (default **.742200.**).

Several softkeys may now be accessed.

[*Select Language*] to choose English (UK), French, German, Spanish or English (US).

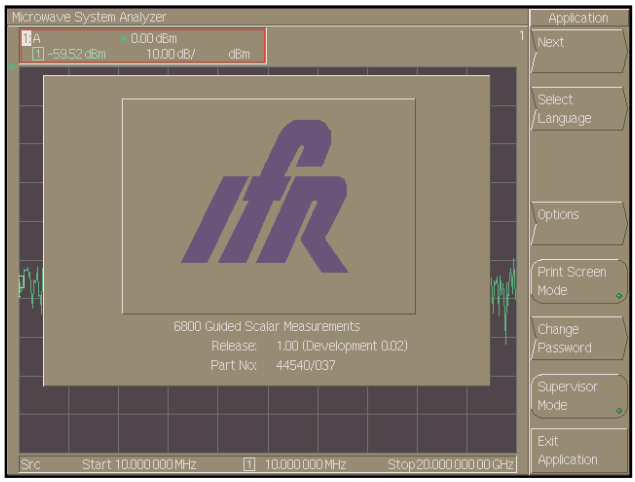
[*Options*] to enable/disable the [*Exit Application*] key for the operator, so that, if disabled, whenever the instrument is switched on, it starts in the Guided Scalar Measurements application; to bypass the Welcome screen and go straight to the Select Measurement Type screen.

(Note that when the Welcome screen is bypassed, it can be displayed by pressing [*Previous*].)

[*Print Screen Mode*] enables the **[PRINT]** function, so that any screen can be dumped onto a floppy disk.

[*Change Password*] to allow the supervisor to change the password.

[*Supervisor Mode*] when disabled sets the instrument into Operator mode.



Press [*Next*] to move to the……

Select Measurement Type Screen

The application displays a list of pre-defined measurement types from which the operator can select using the arrows.

Press [*Next*] to move to the……

Select Measurement Screen

The application displays a measurement or a list of measurements (based on the measurement type chosen in the Select Measurement Type Screen) from which the operator can select.

The supervisor can create new measurements by cloning any measurement in the list, pressing

[*Measurement*] [*Copy*].

The supervisor can delete a measurement in the list (apart from the pre-defined measurement which is always retained as the first measurement in the list).

The supervisor can rename a measurement in the list, pressing [*Measurement*] [*Rename*].

The supervisor can import a list of measurements from a floppy disk pressing [*Floppy Disk*] [*Import Measurements*]. They will replace any existing measurements.

The supervisor can export the list of measurements to a floppy disk, e.g. for backup or for porting to another instrument pressing [*Floppy Disk*] [*Export Measurements*].

The supervisor can enable/disable various operator options for a measurement, e.g. display of equipment set-up screen, display of measurement set-up screen, operator facility to save or print a result, pressing [*Options*].

For the pre-defined measurement only, the supervisor can restore the default copy of the settings file (as loaded when the application was originally installed).

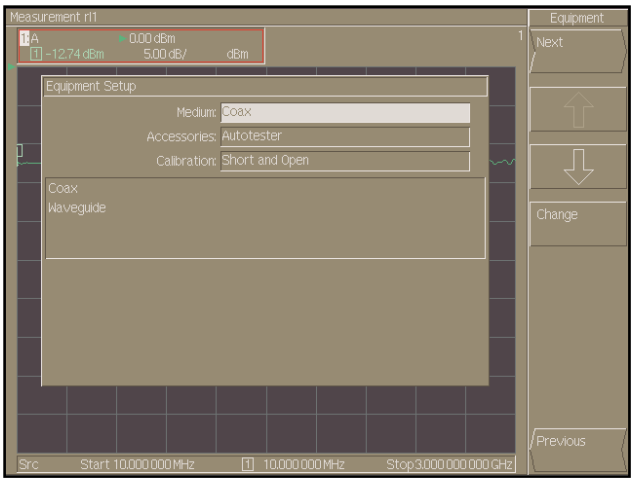
[*Next*] to move to the...

Equipment Set-up Screen

This screen is always displayed in supervisor mode and will be displayed in operator mode unless disabled for the measurement by the supervisor.

Depending on the type of measurement selected (e.g. Fault Location, Return Loss/VSWR or Insertion Loss etc), it displays the appropriate selections (e.g. Medium, Accessory, Calibration) and allows the operator to change them.

A new measurement is configured using this screen.

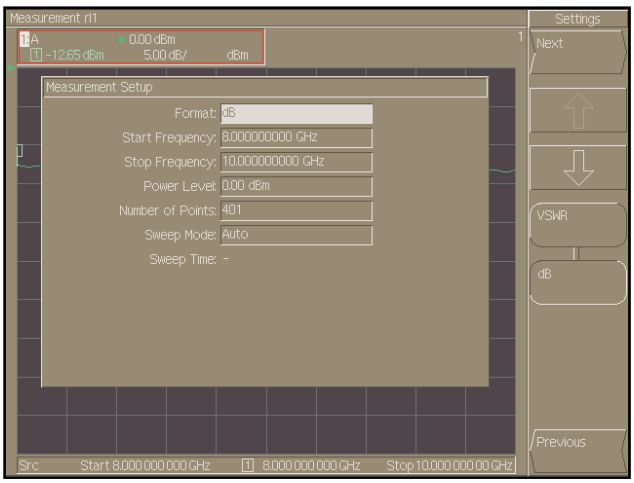


Press [*Next*] to move to the...

Measurement Set-up Screen

This screen is always displayed in supervisor mode and will be displayed in operator mode unless disabled for the measurement by the supervisor.

It displays the appropriate parameters for the measurement selected, and allows the operator to change them. Note that the range of valid values for each parameter is dependent on the medium as well as the type of measurement. Details of dependencies between parameters and the default selections are given in the following section.



PARAMETERS FOR THE MEASUREMENT SET-UP SCREENS

Return Loss / VSWR Measurements

In coaxial systems the signals are transmitted in coaxial cables; in waveguide systems they are transmitted in (usually) hollow pipes of usually rectangular (but sometimes elliptical) cross section.

When we make a return loss measurement, we are trying to find out what proportion of a signal incident on a component or system is reflected back. (Microwave energy behaves more like light than lower frequency signals, so 'reflection' is an appropriate term to use.)

To discover what proportion of the signal is being reflected, we need a device that can distinguish between signals propagating in opposite directions in the coax or waveguide. The 'accessories' for return loss measurements (see tables) perform this function. All of them have a 'through' path through which the forward-going signal passes, and some form of 'reflection arm' or port which lets us 'tap off' and measure the reflected signal from the device under test.

Before we can make the return loss measurement a calibration must be performed. To do this we terminate the measurement port at the end of the 'through' path with something that reflects all the microwave signal back into the reflection arm. Components that do this are short circuits and open circuits. In coax systems it is possible to use a short circuit or an open circuit on its own for the calibration, or we can measure both and calculate the resulting calibration data by taking the average. In waveguide systems it is not possible to make a satisfactory open circuit termination that reflects all the signal, so only short circuit calibrations are performed. A similar effect to the short / open calibration in coax can be obtained in waveguide using a short and 'offset' short.

Table 3 shows the relationship between the medium, accessories and path calibration types allowed in return loss measurements. For example, if the medium is coax cable, measurements can be made using a Fault Locator, Autotester or bridge. In either case, the permitted types of path calibration are 'Short & Open', 'Short' or 'Open'. If the medium is waveguide, the available accessories are a single coupler or a twin coupler.

MEDIUM	ACCESSORIES	CALIBRATION
Coax	Fault Locator (624x Series)	Short & Open
		Short
		Open
	Autotester	Short & Open
		Short
		Open
	Bridge	Short & Open
		Short
		Open
Waveguide	Single Coupler	Short
		Short & Offset
		Short
	Twin Couplers	Short
		Short & Offset short

Table 3

Defaults are indicated in Table 3 using shading. Thus if coax is selected, the default accessory is the fault locator and the default calibration is Short & Open

The remaining parameters that may be set up are given in Table 4. These are independent of each other.

PARAMETER	DEFAULT
Format	dB
Start Frequency	10 MHz
Stop Frequency	3 GHz
Source Power Level	0 dBm
Number of Points	401
Sweep Mode	Auto
Operator Set Sweep Time	1 s

Table 4

Insertion Loss Measurements

When we make an insertion loss measurement we are trying to find out to what degree a signal is attenuated by a device or system as it passes through that system.

Table 5 shows the allowed relationship between the medium and accessories in insertion loss measurements. The calibration type is 'Through' in all cases.

MEDIUM	ACCESSORIES	CALIBRATION
Coax	Fault Locator + Detector	Through
	Autotester + Detector	Through
	Single Detector	Through
Waveguide	Fault Locator + Detector	Through
	Single Coupler	Through
	Single Detector	Through

Table 5

The remaining parameters that may be set up are given in Table 6. These are independent of each other.

PARAMETER	DEFAULT
Start Frequency	10 MHz
Stop Frequency	3 GHz
Source Power Level	0 dBm
Number of Points	401
Sweep Mode	Auto
Operator Set Sweep Time	1 s

Table 6

Fault Location Measurements

Fault location measurements allow faults to be found in transmission lines.

Faults in transmission lines reveal themselves as a change in the characteristic impedance at the location of the fault. For example if a coaxial cable is pinched at some point, its internal geometry will change at that point and so, therefore, will its impedance.

Changes in impedance give rise to a mismatch in the transmission line, and this results in energy being reflected back towards the source. The 6800 is able to calculate the distance to the fault by measuring and analysing the complex waveform seen at the 'driven' end of the transmission line that results from the vector sum of the incident signal and reflections from the fault.

Table 7 shows the allowed relationship between the medium and accessories in fault location measurements. The calibration type is 'Fault Location' in all cases.

MEDIUM	ACCESSORIES	CALIBRATION
Coax	Fault Locator	Fault Location
	Divider + Detector	Fault Location
Waveguide	Fault Locator	Fault Location
	Divider + Detector	Fault Location

Table 7

The remaining parameters that may be set up are given in Table 8.

It is useful to keep track of the source start and stop frequencies, even though the normal method of setting up the measurement is through the range and centre frequencies. Start and stop are therefore displayed and updated in response to changes of range, centre or relative velocity. It is not possible to change start and stop directly.

The operator may select the transmission line parameters from the transmission line database. When the database is in use, the most recent selection is displayed and the operator is prevented from changing the relative velocity or waveguide cut-off frequency or attenuation, as these parameters are obtained from the database. However the values of these parameters will continue to be displayed.

PARAMETER	DEFAULT
Distance Units	Metres
Range	100 m
Centre Frequency	1.5 GHz
Relative Velocity [2]	1.0
Attenuation	0 dB/m
Waveguide cut-off [3]	1 GHz
Number of Points	401

Table 8

[2] The relative velocity is the ratio of the speed of propagation of the wave in the transmission medium to that in free space. Since it is not a constant for dispersive media, this parameter is unselectable if the medium is waveguide.

[3] The lower operating frequency limit of the waveguide. This parameter is used in calculating the 'warped' sweep needed to overcome measurement inaccuracies caused by dispersion. This parameter is unselectable if the medium is coax.

Single Ended Insertion Loss Measurements

Single ended insertion loss measurements are used when it is not convenient or possible to connect a detector to the far end of the transmission line under test. A set-up similar to a return loss measurement is used, except that the transmission line is terminated with a short circuit rather than a load.

If we assume that the transmission line termination reflects all the energy back into the transmission line and that the directional device (bridge, fault locator or coupler) has been calibrated, then the trace observed will correspond to the insertion loss of the transmission line as it transmits energy forward to the reflective termination and back.

A single-ended insertion loss calibration is identical to a return loss calibration except the calibration data is marked with a flag to inform the measurement processing software that the resulting measurement must be divided by two to take account of the fact that the measurement represents the attenuation experienced by the signal during two passes through the transmission line.

Table 9 shows the allowed relationship between the medium, accessories and path calibration types allowed in single-ended insertion loss measurements.

MEDIUM	ACCESSORIES	CALIBRATION
Coax	Fault Locator (624x Series)	Single Ended Short & Open
		Single Ended Short
		Single Ended Open
	Autotester	Single Ended Short & Open
		Single Ended Short
		Single Ended Open
	Bridge	Single Ended Short & Open
		Single Ended Short
		Single Ended Open
Waveguide	Single Coupler	Single Ended Short
		Single Ended Short & Offset Short
	Twin Couplers	Single Ended Short
		Single Ended Short & Offset short

Table 9

Defaults are indicated in Table 9 using shading, e.g. if coax is selected, the default accessory is the fault locator and the default calibration is Short & Open.

The remaining parameters that may be set up are given in Table 10. These are independent of each other.

PARAMETER	DEFAULT
Start Frequency	10 MHz
Stop Frequency	3 GHz
Source Power Level	0 dBm
Number of Points	401
Sweep Mode	Auto
Operator Set Sweep Time	1 s

Table 10

Return Loss/VSWR & Fault Location Measurements

Simultaneous return loss and fault location measurements can be made in coax using a 624x Series Fault Locator. Table 11 shows the allowed relationship between the medium, accessories and path calibration types.

MEDIUM	ACCESSORIES	CALIBRATION
Coax	Fault Locator (624x Series)	Short & Open + Fault Location
		Short + Fault Location
		Open + Fault Location

Table 11

The remaining parameters that may be set up are given in Table 12. These are independent of each other.

PARAMETER	DEFAULT
Return Loss / VSWR	
Format	dB
Start Frequency	10 MHz
Stop Frequency	3 GHz
Source Power Level	0 dBm
Number of Points	401
Sweep Mode	Auto
Operator Set Sweep Time	1 s
Fault Location	
Format	dB
Distance Units	Metres
Range	100 m
Centre Frequency	1.5 GHz
Relative Velocity [4]	1.0
Attenuation	0 dB / m
Number of Points	401

Table 12

[4] The relative velocity is the ratio of the speed of propagation of the wave in the transmission medium to that in free space. Since it is not a constant for dispersive media, this parameter is unselectable if the medium is waveguide.

Return Loss/VSWR & Insertion Loss Measurements

Simultaneous return loss / VSWR and insertion loss measurements can be made in a single channel. Table 13 shows the allowed relationship between the medium, accessories and path calibration types.

MEDIUM	ACCESSORIES	CALIBRATION
Coax	Fault Locator (624x Series) + Detector	Short & Open + Through
		Short + Through
		Open + Through
	Autotester + Detector	Short & Open + Through
		Short + Through
		Open + Through
Waveguide	Single Coupler	Short + Through
		Short & Offset Short + Through
	Twin Couplers	Short + Through
		Short & Offset Short + Through

Table 13

The remaining parameters that may be set up are given in Table 14. These are independent of each other and, apart from the format, are common to both measurements.

PARAMETER	DEFAULT
Format (Return Loss)	dB
Start Frequency	10 MHz
Stop Frequency	3 GHz
Source Power Level	0 dBm
Number of Points	401
Sweep Mode	Auto
Operator Set Sweep Time	1 s

Table 14

Calibration

Table 15 summarises the requirements for calibration. Different path cal stores are used depending on the type of measurement. This allows the operator to switch from one

measurement to another without necessarily having to repeat the calibration procedure.

The procedure is as follows:

1. the calibration diagram is displayed together with
2. a prompt to connect the equipment as shown in the diagram and...
3. ...a prompt to connect the calibration piece.
4. the application awaits confirmation from the operator [*Calibrate*]
5. instrument is calibrated.
6. in the case of Short & Open calibrations, for example, the procedure is then repeated for the second (e.g. Open) calibration.

MEASUREMENT	***MEDIUM***	***ACCESSORIES***	***CALIBRATION TYPE***
Return Loss / VSWR	Coax	Fault Locator	Short & Open Short Open
		Autotester	Short & Open Short Open
		Bridge	Short & Open Short Open
	Waveguide	Single Coupler	Short Short & Offset Short
		Twin Couplers	Short Short & Offset Short
Insertion Loss	Coax	Fault Locator plus Detector	Through
		Autotester plus Detector	Through
		Single Detector	Through
	Waveguide	Fault Locator plus Detector	Through
		Single Coupler	Through
		Single Detector	Through
Fault Location	Coax	Fault Locator	Fault Location
		Divider & Detector	Fault Location
	Waveguide	Fault Locator	Fault Location
		Divider & Detector	Fault Location
Single Ended Insertion Loss	Coax	Fault Locator	SE Short & Open SE Short SE Open
		Autotester	SE Short & Open SE Short SE Open
		Bridge	SE Short & Open SE Short SE Open
	Waveguide	Single Coupler	SE Short SE Short & Offset Short
		Twin Couplers	SE Short SE Short & Offset Short
Return Loss/VSWR & Fault Location	Coax	Fault Locator	Short & Open + Fault Location Short + Fault Location Open + Fault Location
Return Loss/VSWR & Insertion Loss	Coax	Fault Locator (624x Series) & Detector	Short & Open +Through Short + Through Open + Through
		Autotester & Detector	Short & Open +Through Short + Through Open + Through
	Waveguide	Single Coupler	Short & O/Short + Through Short + Through
		Twin Couplers	Short & O/Short + Through Short + Through

Table 15

Connecting the Device Under Test

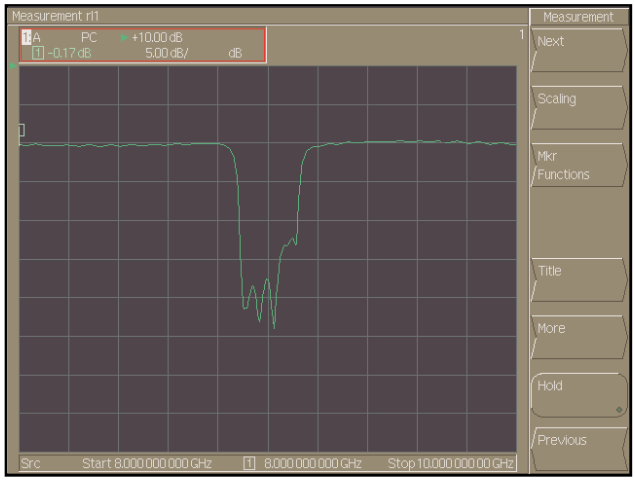
Pressing [*Next*] gives the Equipment Connection Details. The screen shows the connection to the device under test. Press [*Next*] to remove the diagram to allow the operator to see and interact with the measurement.

Measurement Manipulation

The measurement manipulation screen allows the operator to view the measurement and make a limited number of adjustments. See Table 16.

RETURN LOSS / VSWR or INSERTION LOSS (Including SINGLE ENDED)	***FAULT LOCATION***
Change display scaling parameters	Change display scaling parameters (including Autoscale)
Change between VSWR and dB format (RL only)	Change between VSWR and dB format
Set Active Marker Position	Set Active Marker Position
Set active marker to maximum	Set active marker to maximum
Set active marker to minimum	Next peak right
	Next peak left
	Identify Peaks
	'Zoom' functions

Table 16



In the case of the dual measurements the front panel keys may be used to select one of the pair of measurements for manipulation.

[SELECT MEAS] for Return Loss/VSWR & Insertion Loss.

[SWITCH CHANNEL] for Return Loss/VSWR & Fault Location.

[*Scaling*] allows scale, ref level and position to be changed.

[*Mkr Functions*] to set the marker to max or min, or to position the active marker using the rotary control.

[*Title*] allows the trace to be given a title.

[*More*] enables Averaging and Smoothing to be implemented. It also allows the supervisor to enable or disable the display of the X-axis annotation using [*Show X-axis*].

[*Next*] leads to a screen concerned with saving and printing the measurement trace.

Saving and Printing the Measurement

The purpose of this screen is to allow the operator to save and/or print the measurement and optional description. The basic options are described in Table 17.

Required Function	*Purpose*
New Measurement	Return to the measurement type selection screen
Save Trace	Allows operator to save the active trace to a file
Spreadsheet (CSV) Format	To allow the trace to be saved in spreadsheet format as well as binary format [5]
Enter User Text	Allows operator to enter up to 250 characters of text (e.g. Operator Name, Date, Test Description etc). This text will be printed with a Trace Print, and saved with a saved trace file
Print	Initiate print
Abort Print	Abort a print in progress
Previous	Return to the measurement manipulation screen

Table 17

In the case of the dual measurements - Return Loss/VSWR & Fault Location and Return Loss/VSWR & Insertion Loss - the front panel **[SWITCH CHANNEL]** or **[SELECT MEAS]** keys may be used to select one of the pair of measurements, e.g. for saving the trace.

Pressing the [*New Measurement*] key from this screen returns the application to the Select Measurement Type screen. At this point, any changes to the measurement configuration that may have been made by the supervisor or operator (e.g. medium, accessories etc) are saved in the relevant settings file for the current measurement.

[5] Binary files can only be displayed on another 6800 whereas .CSV files can be imported into any spreadsheet.

OPERATOR MODE

To use the application in Operator Mode the following keypresses should be used:

[RUN APPS] Use the softkey Up and Down arrows to select 'Guided Scalar Measurements'

[*Run*]

The **Welcome** screen is displayed (when not bypassed), showing the title of the application, its part number and its software release number.

Press [*Next*] to move to the…

Select Measurement Type Screen

The application displays a list of pre-defined measurement types from which the operator can select using the arrows.

Press [*Next*] to move to the……

Select Measurement Screen

The application displays a measurement or a list of measurements (based on the measurement type chosen in the Select Measurement Type Screen) from which the operator can select.

The subsequent screens guide the operator through calibration and measurement.

See the sections on **Measurement Manipulation** and **Saving and Printing the Measurement** under **Supervisor Mode.**

IFR, 10200 West York Street, Wichita, Kansas
67215-8999, USA. E-mail: info@ifrsys.com
Tel: +1 316 522 4981 Toll Free USA: 1 800 835 2352 Fax: +1 316 522 1360

IFR, Longacres House, Norton Green Road, Stevenage, Herts
SG1 2BA, United Kingdom. E-mail: info@ifrsys.com
Tel: +44 (0) 1438 742200 Freephone UK: 0800 282 388 Fax: +44 (0) 1438 727601