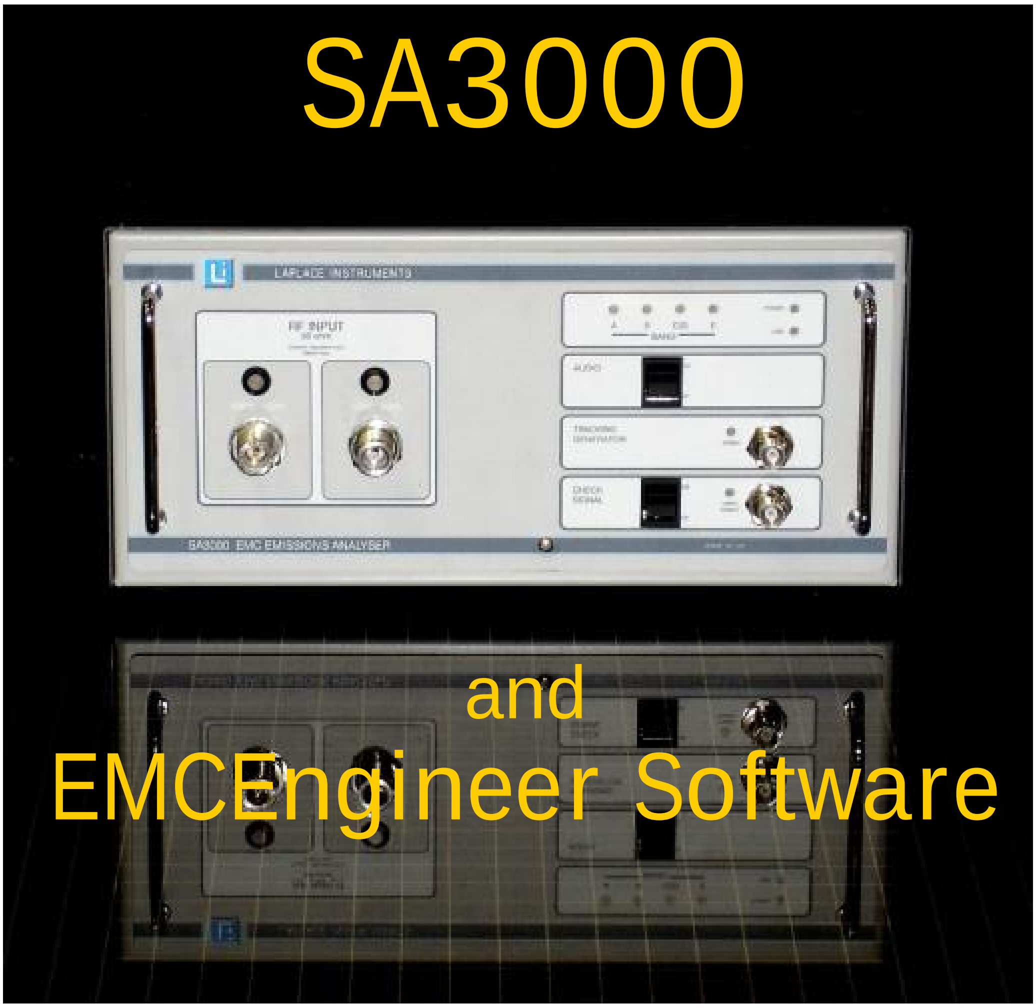
SA3000

and

EMCEngineer Software



USER NOTES

Version 2.0
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INDEX

SA3000 EMC Analyser

Chapter 1 Introduction

The SA3000 EMC analyser is specifically designed to provide a powerful tool for the measurement of EMC emissions as required by European and international standards. Where appropriate, this analyser meets the requirements of CISPR16 and FCC standards.

The analyser is intended for use with the 'EMCEngineer' software package supplied with each unit. This software is an integral part of the analyser and provides all the control and much of the data processing functions. In this manual, reference to the 'analyser' implies both the hardware (analyser) and the PC software.

Some of the features included with the analyser are unique and specifically intended to assist in the measurement of emissions where conditions are problematic. Careful study of the relevant sections of this manual will therefore be of benefit to the user.

Key features

- Coverage of all EMC compliance frequency range up to 3GHz.
- Simultaneous measurements and display of all three CISPR detectors
- Instant zoom, no need to re-scan.
- Up to 20 'marked' frequencies with bargraph and tabular display of results in near real time.
- Auto peak tracking capability.
- Ambient cancellation processing.
- Limits for most common standards included.
- Automatic correction for antenna distance
- Windows software package compatible with all current versions of Windows.
- Output data can be printed direct or exported to other Windows applications
- Automatic calibration of test sites (when used with ERS reference source)
- Dwell time and frequency step adjustable under an 'Advanced Setting' menu
- Optional 200Hz RBW filter for compliant band A measurements.

In particular, the SA3000 is designed for ease of use by engineers and technicians who need to obtain EMC compliance measurements with the minimum of complexity and with minimal resources.

Chapter 2 Analyser overview

The SA3000 is designed to cover all the requirements for EMC emission measurements in the frequency range 10KHz – 3GHz. It is therefore fitted with:

Detectors: Peak
Quasi-peak
Average

RBW: 200Hz (option -A)
9KHz
120KHz
1MHz

The user can choose to sweep the desired spectrum with either the peak detector (for quick scanning), a quick scan with just the QP and Average detectors, or all three detectors running and displaying results in parallel. This last mode provides a slow but accurate result.

Scan frequency resolution of between 2 and 4 samples (depending on range) per RBW to ensure that no detail of the spectrum is lost.

Basic sensitivity of 20dBuV and up to 30dB attenuation.

To aid measurement, the system (SA3000 and EMCEngineer software) will:

Apply standard and user entered correction (calibration) data for antennas and other input devices such as test cells and LISNs.

Show relevant limits including any entered by the user.

Output results in standard format for transfer to other Windows applications.

Directly produce hardcopy on standard printers.

Instantly zoom to any part of the scanned range.

Mark up to 20 frequencies and display the levels at these markers in near real time.

2.1 The Analyser hardware

Connections

Power:	Standard IEC inlet. 110/240V autosensing. 50/60Hz
Fuse:	2A anti-surge (T)
Power:	22W 42VA (at 230V, 50Hz)
USB:	Standard USB interface.

Front panel

RF Input	N type	10KHz – 1GHz
RF Input	N type	1GHz – 3GHz
Check signal	BNC	Output, 10MHz, 50dBuV
TG output	BNC	Output, 50dBuV (if fitted)

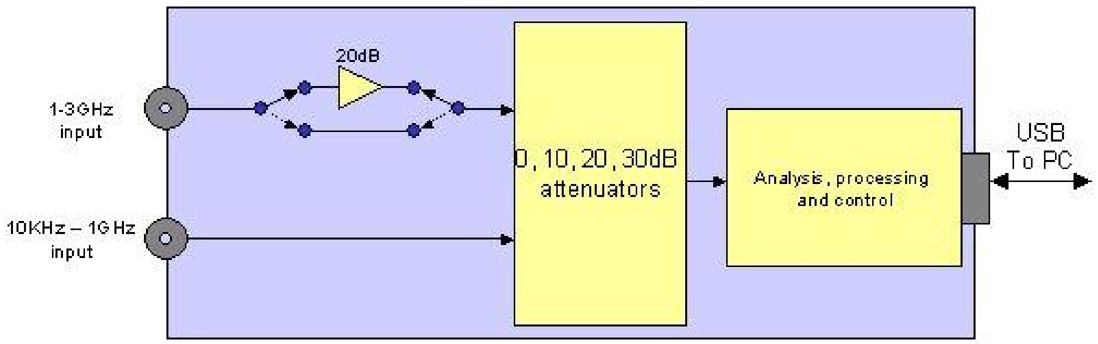
Controls

Power	ON/OFF	Rear panel
Audio control	Low/Off/High	Front panel
Check signal	On/Off	Front panel

Indications

- Power on
- USB active
- Band selection (A, B, C/D, E)
- Input connector selected
- Tracking generator on
- Check signal on

Figure 1 Basic input configuration.



It can be seen from the diagram that the analyser has four switched attenuator settings, and a 20dB pre-amplifier in the high frequency input circuit. Both the attenuators and the amplifier are controlled by the EMCEngineer software.
The SA1020 pre-amplifier is available externally to provide 20dB gain in the 10KHz – 1GHz band if required.

2.2 EMCEngineer Software

This software is specifically developed to be used with the SA3000 EMC analyser. It will also drive the RF9xx series of pre-selectors and will interface to the LaplaCell range of test cells via any RFx000 synthesisers.

PC hardware requirements:
It is recommended that the host PC should have a minimum clock speed of 1.5GHz and a USB2 port. Note that the analyser makes intensive use of this port and hence the need for a relatively high spec PC.

Operating system: Windows XP, NT, 2000 or Vista

Licence

This software is licenced for use by any user purchasing the SA3000 EMC analyser from Laplace Instruments Ltd (the supplier), or any distributor appointed by the supplier. This licence pemits the user to install the software on any PC for purposes allied to the use of the SA3000 analyser within the purchaser's organisation. However, it must not be distributed, sold or loaned to any other person or organisation.

Chapter 3 Quick start procedure.

3.1 Quick summary

The logical sequence to making EMC measurements is……

- Power up the SA3000.
- Connect the analyser to the PC via the USB port.
- Connect the RF input to the relevant devices.
- Run the EMCEngineer software and ensure that it shows ‘Connected’.
- Set the operating frequency range. (Options shown lower screen).
- Choose the detector(s) to be used. (Detector menu).
- Use ‘Input’ menu to select input device.
- Use ‘Limits’ menu to select the appropriate limit.
- Select the appropriate gain/attenuation settings. (LHS of screen)
- Click S/Sweep or Run.

3.2 The Quick steps….

- Connect to PC

  The analyser uses a standard USB interface to the PC. The software install program should load the necessary drivers for the USB connection to the PC (see Appendix 1). On running the software, connection to the analyser should be automatic. If the status display indicates ‘Not connected’, check that the USB cable is installed, that the analyser is switched on and use the ‘Connect’ button to make the connection. Note that if the problem persists, some PCs may need to have a USB hub connected in between the PC and the analyser in order to connect properly.

- Connect input

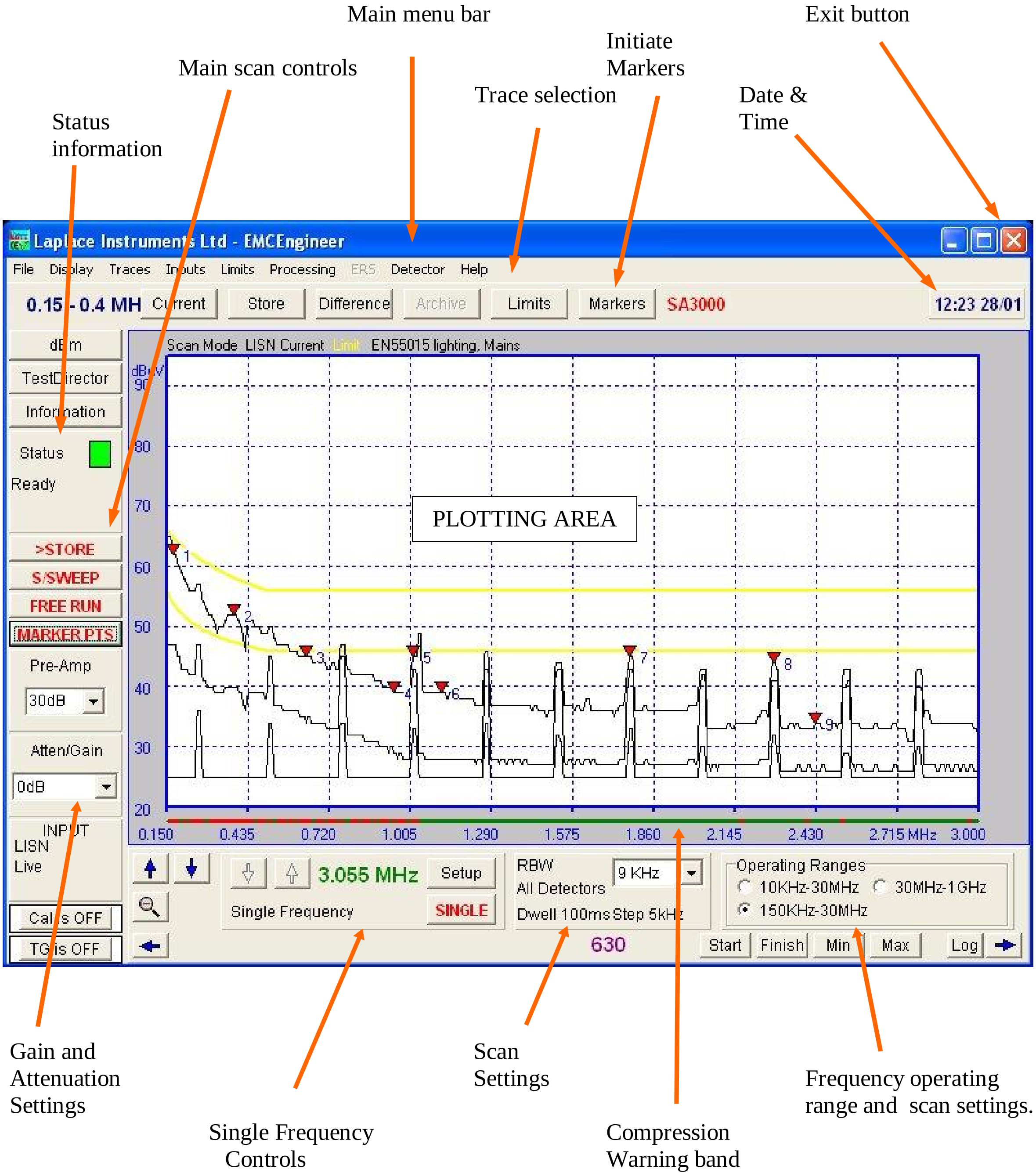
  Connect the RF input to an appropriate device or signal source. Note that there are two inputs, the left hand input is for signals below 1GHz and the right hand input is for 1GHz—3GHz.

  CARE: the analyser is a very sensitive instrument. Full scale is 0.1V, so DO NOT connect direct to any signal source (such as a signal generator) without first ensuring that its output level is well below full scale on the analyser. Although the inputs are protected, the level of protection is limited due to the need to retain full bandwidth to over 3GHz. This limits the rating of protection diodes that can be used.

Chapter 4   Main screen and controls

4.1.   The user interface, menu system and controls are all based on standard Windows conventions. Pull down menus, radio buttons and <alt> key shortcuts are all available in standard formats.

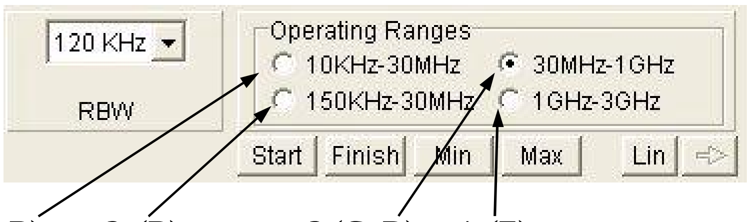
The main elements of the screen display are shown in Figure 2:



Note that there are three window sizes available, so that the appropriate size can be selected to match the screen size of your PC. See *Display…Size*. There are minor changes in the lay-out of each screen size. The size shown above is the 'Regular' version.

4.2. Frequency ranges

The frequency operating ranges are matched to the bands specified by EMC Standards.



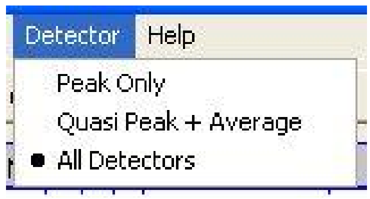
Range button…. 1 (A+B) ….. 2 (B) …… 3 (C+D) ... 4 (E)

Each range automatically selects the correct RBW and frequency step size. Selecting the range has the effect of 'greying out' input devices in the Input menu that would be inappropriate.

Range button	Start Frequency	Finish Frequency	Band	Function	RBW	Step Frequency
1	10KHz	150KHz	A	Conducted	200Hz	100Hz
1 and 2	150KHz	30MHz	B	Conducted	9KHz	5KHz
3	30MHz	300MHz	C	Radiated	120KHz	50KHz
	300MHz	1000MHz	D	Radiated	120KHz	50KHz
4	1000MHz	3000MHz	E	Radiated	1MHz	500KHz

Table 1. Operating ranges

4.3 Detector



Choose the detector(s) to be used under the '*Detector*' menu. There are three choices…….

Table 2. Detectors

Selection	Description	Notes
Peak only	Conventional peak detector. Not specified by most EMC standards except above 1GHz. Note that if implusive signals present with a repetition rate below 100Hz, the resultant scan will only intermittently reach the correct amplitude. See Advanced Settings for increased dwell times for lower rep. rate signals,	Useful for quick pre-compliance scans
Quasi-Peak + Average	QP and Average detectors running in parallel. The detectors are not discharged between steps. This is not so important for broadband spectra, but will lead to distorted narrowband peaks. Average detector readings of narrowband signals should not be used in this mode. Not suitable for Band C/D measurements.	Faster than option 3 below. Perfect for broadband emissions
All detectors	All three detectors running in parallel. All are discharged between steps. Dwell time at each step increased to ensure detector response time requirements are met.	Slower scanning, but accurate.

The normal strategy would be to use *Peak only* at first to obtain the fastest results. Only if results are close to, or above the limit line(s) would it be necessary to invoke the other detectors.

A plot of only the peak detector result is adequate for compliance purposes, provided that it shows the levels are below the limits after allowing for measurement uncertainty.

Where the Peak result is over or close to the limit, the Quasi-Peak and (if required) the average detectors will need to be used. Note that this rule does not apply to the 1GHz—3GHz band, where Peak detector only is specified by the standards. The SA3000 is able to measure and plot all three detectors simultaneously if the *All detectors* option is selected on the *Detectors* menu. A third option (*QP and Ave*) is available which scans at the same quick rate as the Peak detector. This option is good for preliminary investigations but should only be used for broadband signals in bands A or B.

4.4 Input devices

Select the input device…

The view shows the input selections available for Bands C and D.

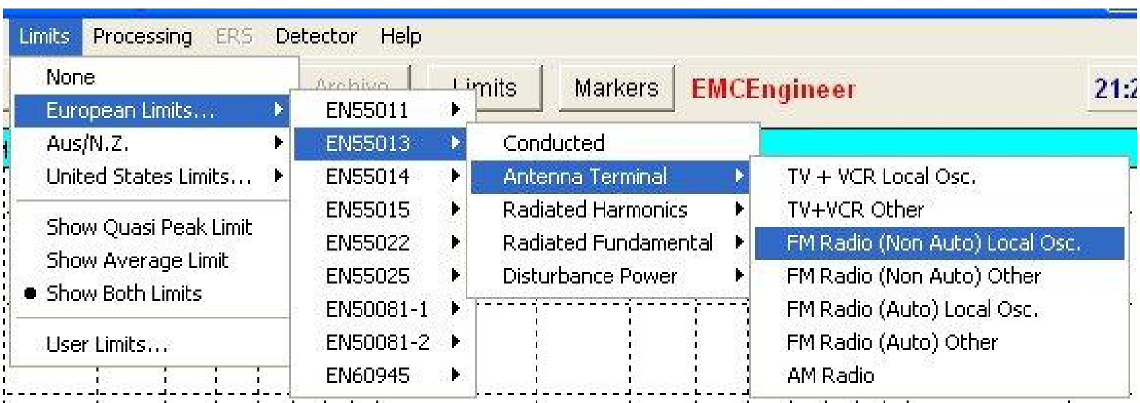
Devices that are not relevant to this band are ‘greyed out’.

Direct and *RF100* simply measure the signal at the input connector without any correction. The other options all apply the relevant correction, calibration or antenna factors to the input levels so that amplitudes are shown in their proper units. Note that because LaplaCells are all individually calibrated, the relevant cell file must first be loaded using the *Create LaplaceCell File option.* Selecting this option will open a new data entry window in which the cell serial number is entered. Actual calibration file will be provided with the cell and must be copied from the CD provided to the ‘c:/ Program Files/Laplace Instruments Ltd/EMCEngineer/’ directory

Third party devices can have their calibration data entered under the ‘*Create User Antenna….*’ Option.

4.5 Limits

Select the limit to be shown.

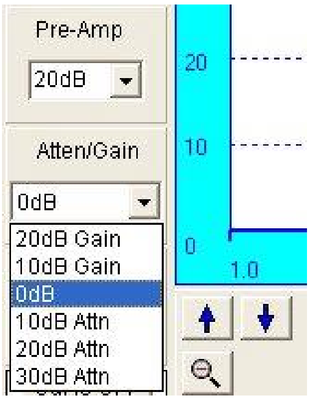


The above shows the options available for the EN55013 standard. Note that FCC and Australian/New Zealand limits are also available. In addition, the user can enter their own limits.

Note that the limit lines will NOT be displayed unless a calibrated input device has been selected.

Where the standard indicates two limits (Quasi-peak and Average) both limits are shown on the screen. Note that the upper limit is always the Quasi-Peak and the lower limit is the Average. In order to be compliant, the entire QP result must be below the QP limit AND the entire Average result must be below the Average limit. Alternatively, if the Peak result is below all limit lines, then the product is compliant in respect of this measurement.

If preferred, either limit line can be switched off so that only one limit is shown.



4.6 Attenuator

Select the appropriate gain/attenuation settings.

The ‘**Pre-Amp’** setting refers to any external pre-amp connected between the input device and the input connector on the analyser.

Atten/Gain settings refer to the internal configuration in the SA3000. The 20dB and 10dB gain settings will only appear if the frequency range is set above 1GHz. (see figure 1).

These are critical settings. Read section 5.3 in order to ensure appropriate settings are used.

If the *RF200 antenna* is selected (input menu) the Pre-Amp setting will default to 20dB. (The RF200 antenna is calibrated with an SA1020 connected at the antenna). Setting these parameters correctly is an important step. The aim must be to achieve maximum sensitivity without suffering compression (See next section). Choice of the best settings will generally become apparent with experience with using the analyser in each application.

The analyser is now ready to take spectra. Use the **S/Sweep** or **Free RUN** buttons. **S/Sweep** will take one sweep of the range, whilst **Free Run** will continually sweep until either **STOP** or **CANCEL** are clicked.

STOP will cause the sweep to end when it reaches the end of its current sweep.

CANCEL will stop immediately.

Chapter 5 The EMC Analyser

These analysers are similar to oscilloscopes in some regards. Whilst an oscilloscope takes instantaneous measurements of the magnitude (voltage) of an input signal and plots them against time, a spectrum analyser takes instantaneous measurements of the magnitude of the frequency components of an input signal and plots them against frequency. The oscilloscope is said to work in the time domain, and the analyser is said to work in the frequency domain.

5.1 Spectral types

The 2 domains are linked. In some respects one is the inverse of the other. For example, a spike (transient) in the time domain equates to a smooth curve in the frequency domain. This 'smooth' spectrum is termed a broadband spectrum. Conversely, a spike in the frequency domain (a narrowband spectrum) equates to a continuous time domain signal, in fact a continuous sine wave as you would obtain from a signal generator. Many real signals are a combination of both types. Understanding how the time and frequency domains are linked can significantly help in the interpretation of results. Many sources of RF interference are 'impulsive', that is the appear as a series of spikes when viewed in the time domain, which implies that the frequency spectrum will be broadband. This is especially true when measuring conducted emissions as many types of circuit specifically produce impulsive noise. These include light dimmers, power control circuits, commutators, invertors and some switching power supplies. A key factor to be aware of is that the energy in a signal is related to the area under the spectral curve. It is obvious that a broadband spectrum contains far more energy than any narrowband signals, even if the maximum height of the broadband line is well below the peak height of the narrowband signal.

5.2 The Spectrum Analyser

EMC analysers are very specialised. The characteristics and performance are fully defined in the standard CISPR16-1. This international standard is the recognised document which defines most EMC test equipment. To understand the implications for the operation of an EMC analyser, we need to understand how the analyser operates.

The basic configuration of the analyser as shown in Fig 3.

The critical item is the Mixer. This device must cope with the full range of amplitude and frequency of the input signal. Devices that follow the Mixer are 'protected' by filters and other devices and so do not have such a critical effect on performance.
Mixers has, like any active device, an input to output characteristic that has a linear operating range. For accurate results, the mixer must be kept within this linear operating range. This is its linear dynamic range and this dictates the dynamic range of the analyser. For the SA3000 this range is 70dB. The main purpose of the input amplifiers and attenuators is to 'adjust' the incoming signal to a level that fits within the dynamic range of the mixer.
If this range is exceeded, the linear input to output characteristic is lost and we are in 'Compression', a technical term for 'overload'. Compression causes distortion of the output spectrum (as plotted on the screen), and this distortion can be substantial.

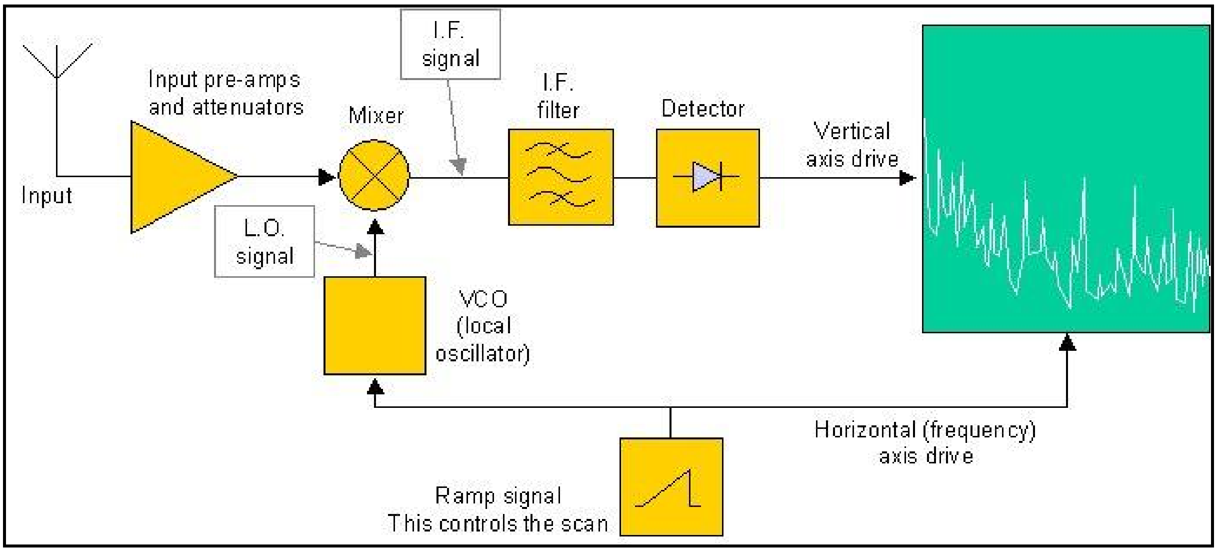


Figure 3 EMC analyser block diagram.

Figure 4 graphically shows what happens. The top view shows an actual spectrum of a type typical of what can be expected from power controllers when measuring conducted emissions. This spectrum is generally broadband and has high levels at low frequency. The second view shows what happens if we set the attenuation too low. The high level energy at low frequency cannot be accommodated by the mixer and distorts the whole spectrum, producing the red result which shows several peaks well over the limit.

The lower view shows the attenuator correctly set, producing a 'true' result. This emphasises one problem… that of viewing low level signals in the presence of high levels of unwanted signals. The best solution to this scenario is to use a 'pre-selector' in front of the analyser, such as the RF910 or RF915, or to use the RF800, a 150KHz—30MHz band pass filter.

Pre-selectors split the frequency span into a series of small bands, and allow only one band through to the analyser at a time. This makes the signal more 'mixer friendly' and avoids the compression problem.

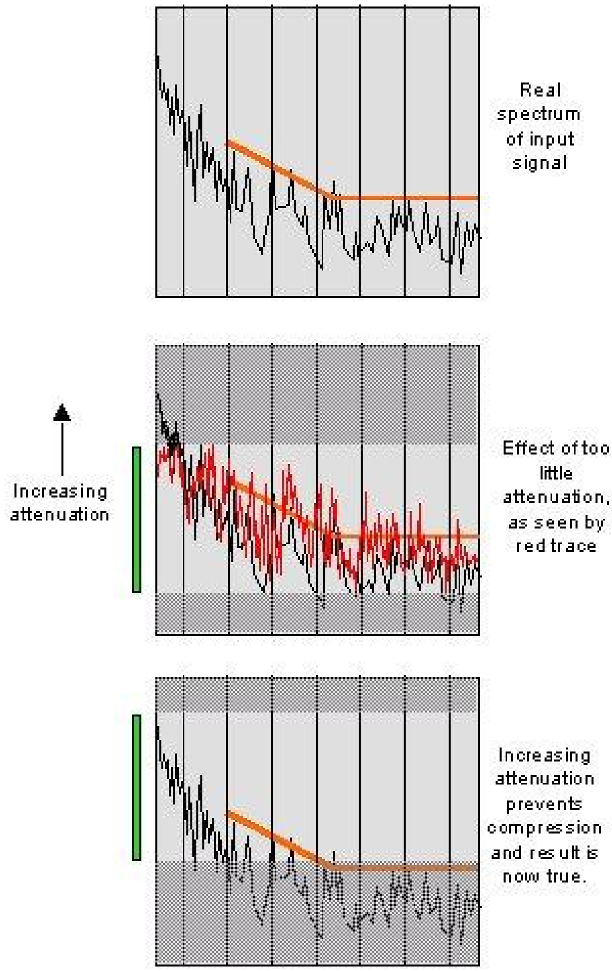


Figure 4 Dynamic range issues

In fact, the standards specify the use of a ‘Receiver’ for EMC measurements. A receiver is an EMC analyser with a pre-selector built-in.
The SA3000 system does provide a warning system which detects compression conditions. This causes the Status indicator to turn red and for the ‘compression warning’ band to switch from green to red. Unfortunately, it is impossible to arrange a system in which this warning system can be anything but an indicator that compression may be present. (this is because the level at which compression occurs is a function not only of amplitude, but spectral type too). So it is recommended that if the compression warning band and indicator shows red (even if intermittently), compression should be checked manually.

5.3 Setting the input gain/attenuation.

If the input is a low level signal, we can use gain either the internal amplifier or an external amplifier) to increase the level so that the signal spectrum appears at a reasonable level on the screen. If we apply too much gain, compression will occur. If the input is a strong signal, we use attenuation to reduce its level, to appear at a reasonable level on the screen and to avoid compression. The key aim is to have the strongest signal that just avoids compression. The procedure to achieve this desirable situation is as follows:

1. Set attenuator to 30dB (max) and sweep the analyser. The resulting trace may generally be a line across the bottom of the screen.
2. Use **>STORE** to obtain the red store trace.
3. Reduce the attenuation by 10dB and sweep again.
4. If the peaks on the black (current) and red traces are essentially the same (apart from the base line which will have moved down 10dB), then compression is NOT present on either trace and you can go back and repeat steps 2 to 4. If a significant difference does occur, then compression has set in and you should go back one 10dB step and use that setting.

5.4 RBW (Resolution Bandwidth)

The RBW determines the degree to which an analyser can resolve closely spaced frequencies. For example, if the RBW is 9KHz, and two signals are only 7KHz apart, they will appear on the display as one peak and cannot be resolved to show that there are actually two signals present. If the RBW could be changed to 2KHz, then the two signals would appear as two distinct peaks. A key point is that the RBW does not affect the measured amplitude of narrowband signals, but does affect the measured amplitude of broadband signals. In the narrowband case, it can be assumed that all the energy in a signal is ‘seen’ by the analyser even if using a small RBW. Increasing the RBW does not increase the amount of energy seen by the analyser. However, with broadband signals, the wider the RBW, the more energy is seen by the analyser and the higher the plotted amplitude. CISPR16 defines precisely what RBWs to use for EMC measurements.

5.5 Frequency step size

Modern analysers do not sweep in a continuous manner. They 'step' through the required frequency span, stopping at each frequency step to take the measurement before jumping to the next frequency.
The RBW can be thought of as the width of a window through which we observe the frequency spectrum of the incoming signal at each step. If this window is 9KHz wide, and we step in 25KHz increments, then there will be a 16KHz wide gap between each step that we do not measure. This is not good practice! It is important to be able to measure all frequency components in the signal if we are to ensure that no 'peaks' are missed. Therefore, it is normal practice to take at least 2 steps per RBW to ensure that the scan is thoroughly covered.
Table 3 shows the implications of this rule.

Band	RBW	Step size	Start frequency	End frequency	No. of steps
A	200Hz	100Hz	10KHz	150KHz	1400
B	9KHz	5KHz	150KHz	30MHz	6000
C/D	120KHz	50KHz	30MHz	1000MHz	19400
E	1MHz	500KHz	1000MHz	3000MHz	2000

There are lots of steps!

Scanning rate and speed

The key factor in determining the speed at which we scan is the time needed to take each measurement at each step. In band C/D there are 19,400 steps, so every millisecond required for the measurement will add almost 20 seconds to the time taken for a full scan. The analyser uses about 2 milliseconds to move from one step to the next, during which time the analyser is blind. Then we add the time allowed to take the measurement which depends on…

(a) which detector(s) are selected.
(b) the detector time constants.
(c) how long we wait for the detector to settle.

5.6 Detectors

The detector is the part of the analyser that actually measures the signal.
CISPR16 specifies three type of detector, Peak, Quasi-peak and Average. The definitions are shown in fig 5, together with a plot of how they respond to an impulsive signal. In the diagram, the incoming impulsive signal is shown in black and the detector response is in red.
Peak is simple.. but note that between each measurement step, the peak holding capacitor

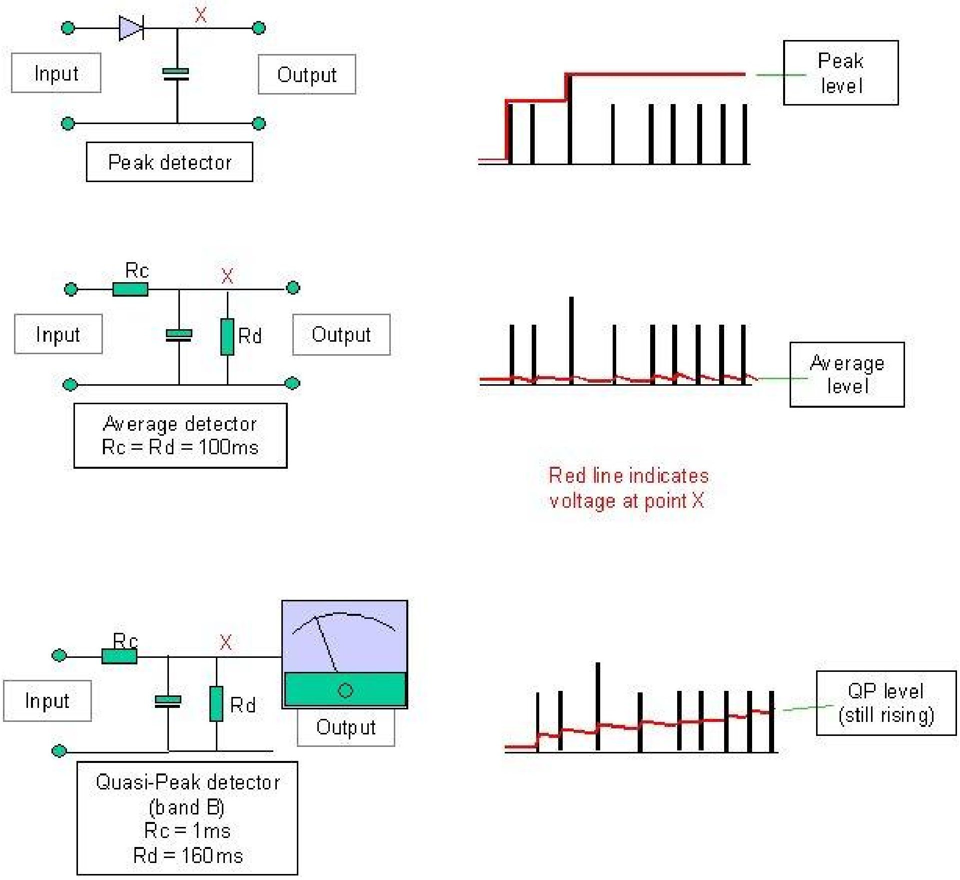


Figure 5 Detector specification and characteristics

should be discharged.

Average is also straightforward, but note that with impulsive signals, the resultant level will be generally very low because the duty cycle of impulsive signals is usually very low. Average detectors are normally used as a measure of modulated narrowband signals such as broadcast transmitters.

Quasi-peak detectors have been developed to provide a measure of the subjective level of interference, and is very dependent on the impulse repetition rate. Note that the characteristic time constants result in a generally slow rise of the QP value to the final value. This means that the analyser must dwell for a significant period at each frequency step in order to reach a final value.

For example, in the case of band B, CISPR16 gives a maximum sweep rate of 200sec/MHz which equates to a time per step of 1 second and an overall sweep time of 1 hour, 40 minutes.

The three detectors installed in the SA3000 comply with CISPR16 and have calibrated characteristics which include the rise and fall time constants as specified by EMC requirements. These time constants are as shown in Table 4

Each detector includes a discharge (reset) switch under software control. The peak detector is reset after every frequency step, but the QP and average detectors are only reset after each step in the 'Slow' mode. This mode allows time at each step for the detectors to rise to the final value before they are sampled. In 'fast' mode, the QP and Ave detectors are not reset.

Band	Frequency	QP Rise time constant	QP Fall time constant	Average time constant (Rise & fall)	Default Sample time (msec)	
		(msec)	(msec)	(msec)	Peak/Quick	Slow
A	10 KHz – 150KHz	45	500	100	12	250
B	150KHz – 30MHz	1	160	100	12	50
C/D	30MHz – 1GHz	1	550	100	5	10
E	1GHz – 3GHz	Peak detector only			5	5

Table 4 CISPR16 Detector time constants.

This will give a reasonable measure of any broadband spectrum, but the QP detector will show a 'tail' after any narrowband peak, and the Average detector will not respond to narrowband peaks due to its slow rise time. This fast mode permits a quick evaluation of the situation before to highlight any problem frequencies for more detailed evaluation using the 'slow' mode.
When a selection is made under the '*Detector*' menu, the relevant traces are automatically selected ON (see '*Traces*' menu).

5.7 Optimising operation

5.7.1 Use of the Peak detector.

It is common practice to 'pre-scan' the emissions as a first step using the peak detector. It is accepted that if the 'peak detector' gives a scan that is below the relevant QP and Average limits, then the product is deemed compliant and no further testing is required. (Peak, by definition, always produces the highest result). The Peak detector has an almost immediate response so we can afford to substantially reduce the dwell time. We can make the pragmatic decision to assume that a common repetition rate for impulsive emissions will be 100Hz (as produced by many circuits connected to the a.c. mains supply, which draw power every 1/2 cycle), so we need to dwell for something slightly more than 10msec. The default dwell time for the 'Peak' only detector setting in band B is therefore 12 msec. This produces a complete scan in band B in just 84 seconds. This can be changed under the advanced settings menu described in section 5.8.
In practice, signals which require the long dwell times specified by CISPR16 are those impulsive signals that have a low repetition rate (<50Hz). These are rarely encountered. So instead of the 800msec suggested by CISPR, the default dwell time is set to the lower figure of 50msec which equates to a complete scan in band B in just over 5 minutes. Longer dwell times are available under the '*Advanced settings*' options.

5.7.2 Use of Zoom

By restricting the frequency span, the scan will take less time. For example, when measuring conducted emissions using the Peak detector pre-scan, a common result is that levels can be close to, or over the limits at lower frequencies (150KHz—1MHz), but well below the limits for the rest of the scan up to 30MHz. In this case, only the range 150KHz—1MHz needs to be fully evaluated with the QP and Average detectors. This span has 213 steps rather than the 6000 and is consequently completed far more quickly.

5.7.3 Use of Markers

Some spectra may have specific frequencies of interest. The SA3000 provides the capability for the user to attach up to 20 '**Markers**' at these frequencies. The analyser can then perform measurements at just these frequencies and report the results in a tabular or bargraph format. Because there are relatively few steps involved (maximum 20), the results are provided in virtually 'real time' and can be plotted in a easily observed graphical format (bargraph). The dwell time is selectable in the ***advanced settings*** menu. All three detectors can be measured simultaneously and any two viewed together on the bargraph display.

5.7.4 Single frequency mode

If these is a particular problem at a certain frequency, the analyser can be set to monitor this one frequency exclusively. The measurement is continuous, and the frequency is not changed or stepped, so there are no dwell time issues. The results are plotted in real time in chart recorder fashion, against a horizontal timebase. This is very helpful in tasks such as …

- adjustment of product orientation or operating mode for worst case emissions
- Testing various 'fixes' to solve an emissions problem.
- Effect of moving cables.

5.7.5 Frequency step size.

By default, the analyser will step approximately twice every bandwidth (RBW). This ensures that no detail of the spectrum is missed. This is clearly important if any narrowband components are present in the signal. If however, the signal is essentially all broadband in characteristic, then (by definition), change in the spectrum occurs gradually against frequency. In this case we can afford to take larger steps in frequency. The software permits the step size to be changed from the default 2 per RBW, to 1 per RBW or 0.2 per RBW. This latter selection results in a considerably faster sweep time, whilst still giving a true measure of the spectrum, <u>provided it is broadband only</u>.

5.7.6 Recommendations

In general….

For broadband signals… changing the steps/RBW will have no significant effect on the result, but can reduce scan time to $^{1}/_{10}$th the default time, but consideration should be given to increasing the dwell time. As a check, sweep with the default dwell time, store the result and then do another sweep with increased dwell time. If the two results are the same, the shorter dwell time is OK, if not, check again with the longest dwell time.

For narrowband signals, the steps/RBW must be left at the default settings but the dwell time could be reduced and left set to the shortest times.

Advanced settings

This feature allows the user to adjust the fundamental parameters which control the operation of the analyser.

To view or change these settings, select *Processing…. Advanced Settings.*

The screen shown below will be presented. This shows the current settings, and will allow you to make changes.

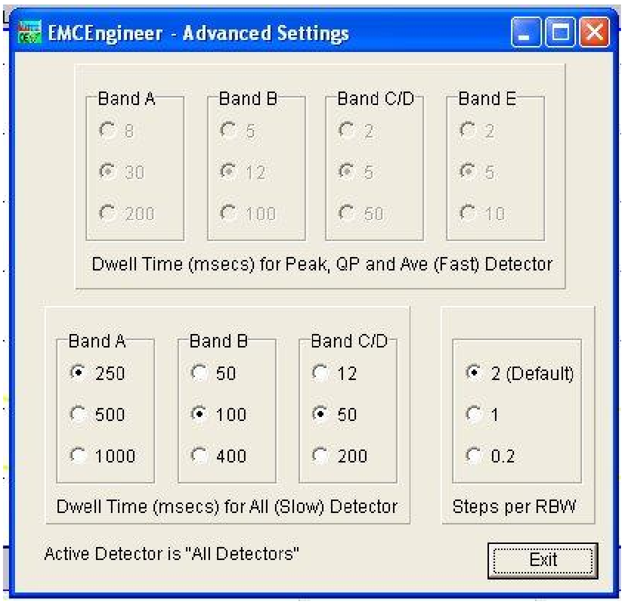


Figure 6 Advanced settings menu

Dwell time

The dwell time settings are divided into 2 groups, one for the ‘All’ detector mode, and one for the Pk and QP+Ave modes. For each detector mode there is a separate setting for each band, A—D.

The default settings will generally provide a good compromise between sweep time and accuracy, but the previous section indicated situations in which alternatives could be worth trying.

Steps/RBW

By reducing the number of steps, scan times can be reduced. BUT spectral information will be lost. If the signal has a purely broadband characteristic, the 0.2 steps/scan will deliver the complete and accurate spectrum, and complete the scan in appoximately one tenth of the time taken for the default setting. Any narrowband peaks are however, likely to be lost.

Band	**Step (KHz)**	**Slow settings for ALL detectors**						**Fast settings for Pk or QP+Ave**					
		Default dwell time		**Optional dwell times**				**Default dwell time**		**Optional dwell times**			
		Time (ms)	Full scan (mins)	Time (ms)	Full scan (mins)	Time (ms)	Full scan (mins)	Time (ms)	Full scan (mins)	Time (ms)	Full scan (mins)	Time (ms)	Full scan (mins)
A	0.1	250	6	500	12	1000	24	8	<1	30	1	200	6
B	5	100	18	50	8	400	72	12	2.5	12	<1	100	12
C/D	50	50	18	12	5	200	72	5	2.5	5	1.5	50	15
E	1000	N/A	-	N/A	-	N/A	-	2		5		1-	

Chapter 6 Results— Presentation and analysis

6.1 Trace organisation

There are up to 5 sets of traces that can be shown on screen. These are:

Name	Origin	Default Colour
Current	Most recent scan	Black
Store	Copied from current using >Store button	Red
Difference	Current—Store. Two formats, see Processing… Difference trace (Section…..)	Yellow
Archive	Trace loaded from disk	Violet
Limits	Selected from 'Limits' menu	Yellow

Table 6 Trace organisation

Generally, **current** is the 'working' trace, the most recent scan. **Store** is commonly used to store ambient (background) results with the EUT switched off. The **difference** trace is calculated from the above two traces (**Current-Ambient).** This calculation is NOT the simple difference, it takes into account the fact that the scaling and values are logarithmic so must convert them to linear values first before subtracting, the convert back to log (dB) values.

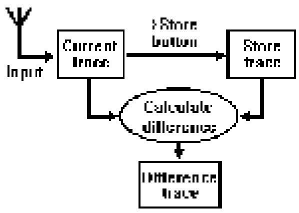


Figure 7
Derivation of Difference trace.

Each set of traces (with the exception of Limits) can display all three detectors (Pk, QP and Ave) results. These three lines will be of the same colour, but should always follow the vertical sequence Peak (highest), QP then average (lowest).

The *Display* Menu provides control of which traces are displayed. Across the top of the Plotting Area are buttons which switch trace sets ON and OFF.

6.2 Analysing the results.

Once a scan is completed, the data that has been acquired will be at full resolution. This may represent up to 20,000 samples, far too many to display given the limited number of pixels across the plotting area. This means that each pixel may represent many samples. The software is designed such that each pixel represents the highest level within each group of samples, thus ensuring that no peaks are missed.

This strategy of acquiring data at full resolution means that zooming can be done instantaneously, and no there is no need to take additional scans.
The above strategy applies regardless of the number of detectors used.

On-screen controls

Functions that relate to the analysis of the scan data are all available by right-clicking the mouse. This causes an pop-up window to appear in the plotting area.

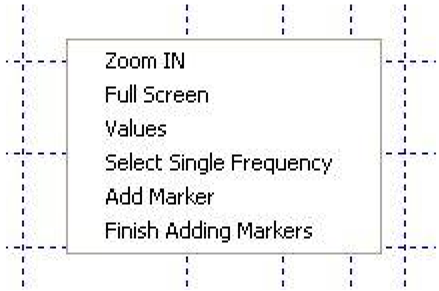


Figure 8
Pop-up window

6.2.1 Zooming

There are two methods for zooming. You can use the **start/ Finish** buttons to type in the required values, or use 'on-screen' cursor control as follows…

Right click the mouse anywhere on the plotting area to show the Pop-up window. Highlight '*Zoom IN*' and click. The selection window will disappear. To indicate the start frequency of the zoomed section of the spectrum, move the cursor towards the left hand edge of the plotting area, press and hold the left mouse button down (a vertical line will appear), and move the line to the frequency at which the zoomed section will start. Release the mouse button.
If the end frequency of the zoomed section is to be selected, repeat the procedure, selecting '*Zoom IN*' again. move the cursor to the right side of the plotting area, hold the mouse button down and move it left towards the required stop frequency.

To zoom back out to the full scan, click on '*Full Screen*' or use the 

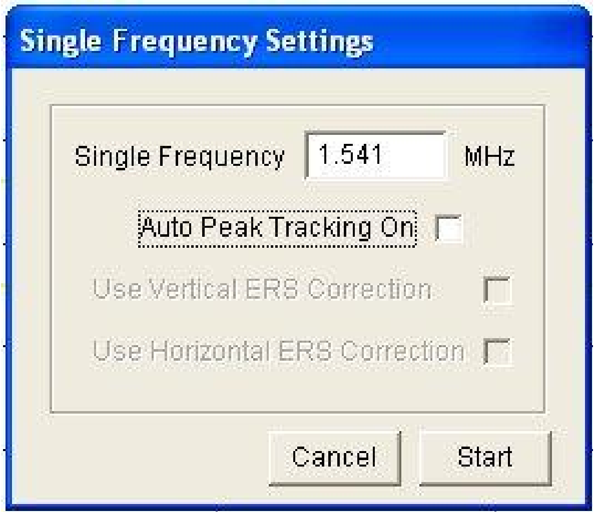
button.

6.2.2 Values… allows the user to select a frequency and measure all the data at that frequency. To use this feature, select '*values*' in the pop-up window and use the the mouse to drag the cursor to the desired frequency. On releasing the mouse a 'Values' window will appear displaying all the data (readings) at that frequency. The values will automatically update after each scan. The cursor can be moved to a new frequency by selecting '*move*' in the values window and repeating the cursor dragging procedure.

6.2.3 Single frequency mode.

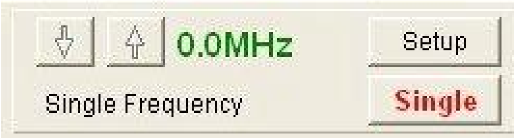
This mode enables the analyser to measure and plot the signal against time, acting similar to a chart recorder. This is very useful for to monitoring a specific emission frequency whilst adjusting EUT variables such as mode of operation, motor speed, orientation, cable positioning and/or measure the effect of modifications in real-time.
To enter single frequency mode, select '*Select Single Frequency*' in the pop-up window, hold the mouse button down and position the vertical line at the frequency to be monitored.
A window will appear which will allow you to change options related to the way in which Single Frequency mode is run:

- change the selected frequency if required.



- Enable a peak tracking mode. This will only work if the emission to be monitored is a narrowband peak. By selecting this mode, the analyser will always lock onto the maximum local peak and will stay with it if the peak moves or drifts.

Click **START SF** and the results from the selected detectors will plot across the screen against a horizontal timebase which will indicate the current time (as set by the PC). These results are plotted in real time, so any change to the levels can be observed as they occur.



The frequency can be 'fine tuned' using the **UP** or **DOWN** buttons in the single frequency control area.

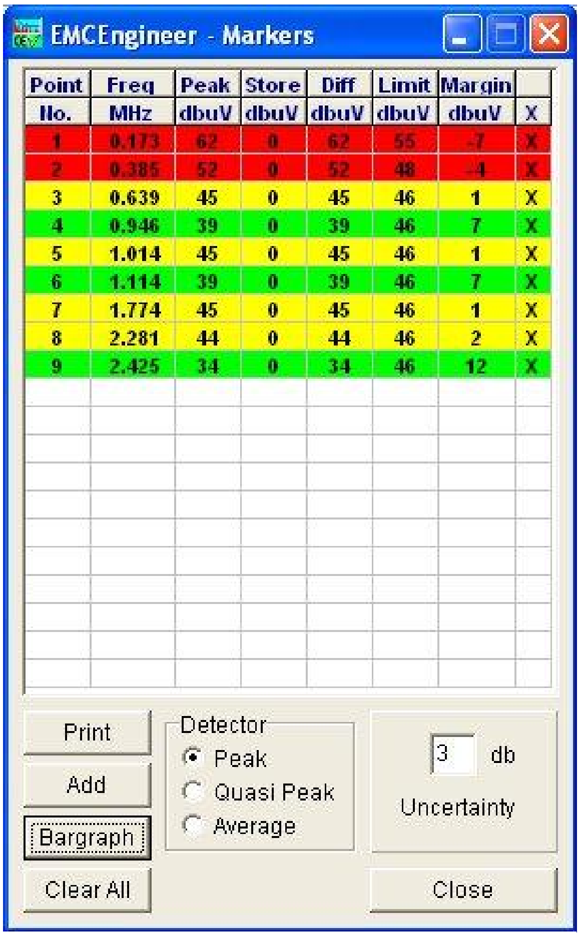
To change or exit this mode, click on **STOP**. You can then either click the **Setup** button in the Single Frequency control area to change the single frequency parameters, or use the Pan buttons to look at past results, or click **Scan** to return to the scan.

6.2.4 Marker Modes

Up to 20 'Markers' can be added to the scan. The data related to each marker frequency can be displayed in either tabular or bargraph formats. The analyser is then able to run in 'Marker Points' mode (**MARKER PTS**) which will update the values in the Marker results window in near real time. (but not the whole span).

To place markers on the scan, you can either ….

Click on '*Add Marker'* in the selection window. Place the cursor on the plotting area and press and hold the left mouse button. Move the vertical line to the intended marker location. A dot(s) moves with the current trace to help lo-



Point No.	Freq MHz	Peak dbuV	Store dbuV	Diff dbuV	Limit dbuV	Margin dbuV	X
1	0.173	62	0	62	55	-7	X
2	0.385	52	0	52	48	-4	X
3	0.639	45	0	45	46	1	X
4	0.946	39	0	39	46	7	X
5	1.014	45	0	45	46	1	X
6	1.114	39	0	39	46	7	X
7	1.774	45	0	45	46	1	X
8	2.281	44	0	44	46	2	X
9	2.425	34	0	34	46	12	X

Figure 9 Tabular marker window

cate the correct position. Release the mouse button when the dot is in the correct location. Several markers can be added in this way (up to 20). When you have finished adding markers, right click on the plotting area to bring back the selection window and click on '*Finish Adding Markers*'.

Alternatively, just click on the button at the top RH side of the screen. This will cause the marker results window to appear…

There are two windows available. One will display the results in a bargraph format, the other in tabular format. (figs 9 and 10).

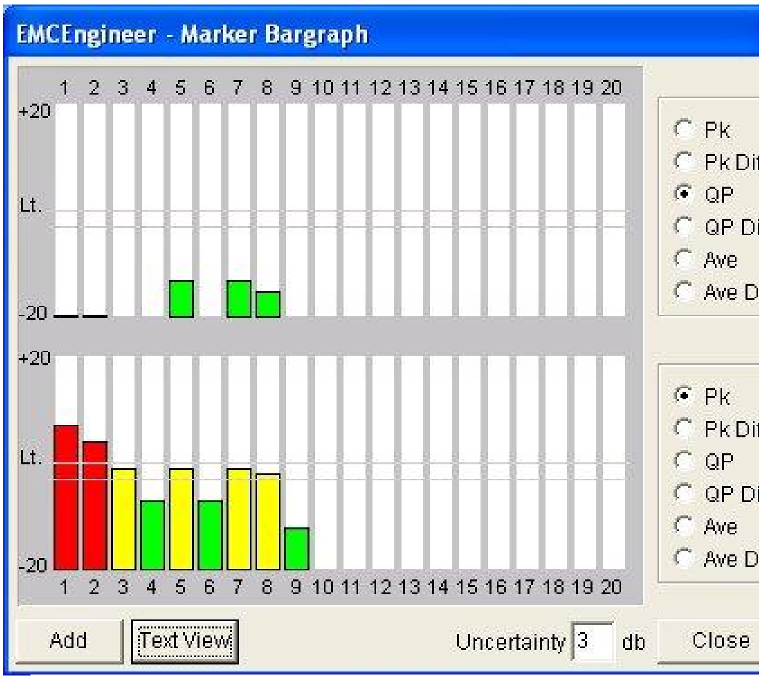


Figure 10   Bargraph marker window

Buttons at the bottom of each window will switch from one screen to the other.
To add a marker to the trace, click on the '**Add**' button in either window.
Use the cursor as explained above to locate a marker.
Note that markers are always arranged in the table and bargraph view in frequency order, not in the order in which they have been selected.
Individual markers can be cleared by clicking on the column headed **X** in the tabular window. All markers can be cleared using the '**Clear All'** button.

There are two rows of bargraphs, and an array of trace buttons to select which trace is to be used for each row. This enables any two measurements of each marker to be displayed.
The vertical scaling is + and – 20dB, normalised to the limit level at the marked frequency.
The bar is coloured red if over the limit, yellow if under or within the marginal value of the limit, and green if the level is below the marginal value. the marginal value can be input as a measure of the measurement uncertainty.
The fields in the tabular display are also coloured according to the above rules.
If no limit is selected, then the bargraph scaling is set to display a 40dB range with the lower end of the vertical axis set to the same as shown on the scan.

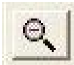
When 

is clicked, the active fields and the bargraph levels will track the incoming levels in near real time. The 'radio' buttons on the Right hand side of each bargraph display selects what result to show. So, for example, QuasiPeak can be shown on one display and Average results on the other.

The Print button produces a tabular printout of all active detector readings.

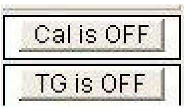
6.2.5 Secondary controls

Shift the vertical axis up or down in 10dB steps.



Zoom out in 50% steps.

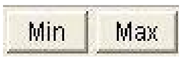
When zoomed in, Pan left or when range is 30MHz – 1000MHz change range to 30MHz – 300MHz or if in Single Frequency mode, pans back through the previous results.



Switch calibrate signal on/off.

Switch tracking generator on/off (if fitted).

Enter start and finish frequencies for zoomed spectrum.



Change to minimum span, starting at the current start frequency.
Change to full range (Zoom out fully).

Alternate between linear frequency and logarithmic frequency axis.

Switch between dBm and dBuV vertical scaling.

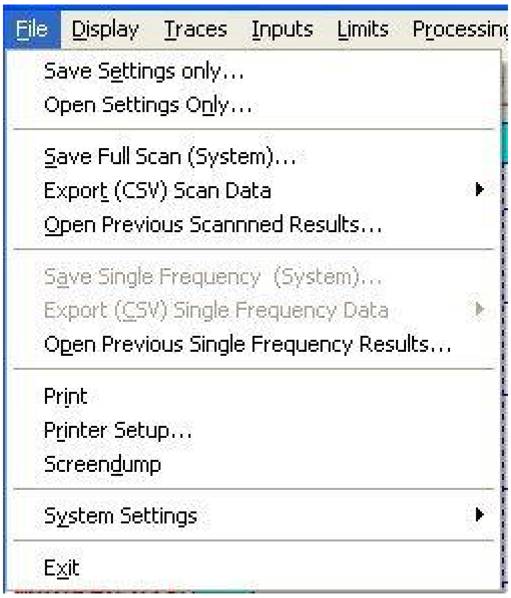
A guide to the standards and explanations of test requirements.

A summary of the analyser mode, setup and settings, including input correction data, ERS correction data and limit lines.

Chapter 7 Software Reference

7.1 Main Menus

7.1.1 File:



Save Settings Only…. and
Open Settings Only
…. will store and retrieve settings. Results are not saved.

Save Full Scan (System)…. stores all the data in a compact format that can be opened at a later date by the EMCengineer software. This format is not suitable for export to other applications.
Data stored includes:
All analyser settings
Title and notes
Date and Time
Frequency vs amplitude for both the Current and Store traces.

Export (CSV) Scan Data saves the results in standard CSV format for export to other applications (such as Excel). This format can produce large files!
Two options are offered, either the full scan data is saved, or just that part of the data that is currently displayed in the plotting area. This means that you can just save the data related to a zoomed section of the scan, rather than all the data. It can produce much smaller files.

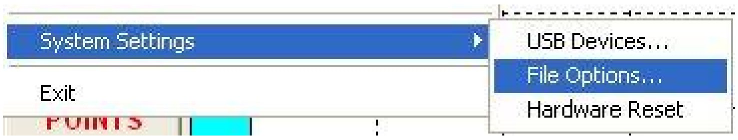
Open Previous Scanned Results….
Will load results that have been stored to file. Options are provided .
On selecting this item, an Import file Options screen is presented. This allows the user to make choices about each stored result (Current and Store). Each may be displayed on screen either as a Current, Store or Archive trace. This allows any current and/or store result already on screen to be retained and not overwritten. If both results are selected to be shown by the same trace, an error message is displayed.
Screen settings can be either left as currently displayed, or changed to those that were saved previously.
If ERS correction data was included with the file, this may be invoked.

The next group of options relate to single frequency results. Note that until a single frequency mode has been run, the *Save and Export* options are greyed out.

Print and *Printer Setup* are standard Windows functions, fully implemented in the EMCengineer software.

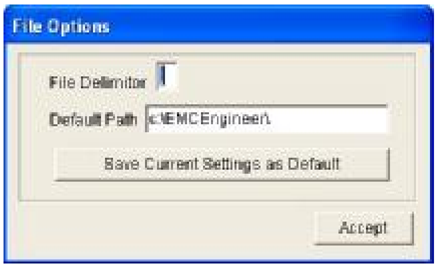
Screendump sends a copy of the EMCEngineer window to the default printer.

System Settings



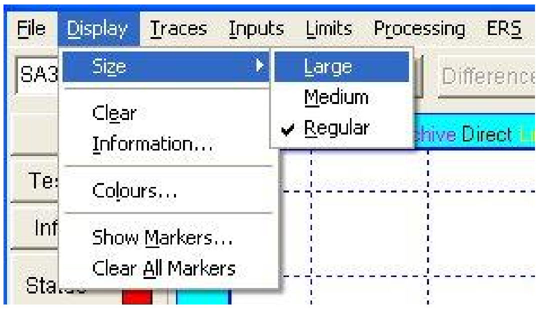
USB Devices…. will list the USB devices that are connected, together with their 'Handle', 'description', Serial number' and H/ware issue. This is a standard windows feature that can help debugging in cases where connection to the analyser is not made.

File options allows you to select the file delimiter for the CSV files and set the default path for the saved results.



7.1.2 File… Display…

Three window sizes are available to suit all commonly available PC displays. All show the same information, although the layout may vary slightly. The screen images shown in this manual are taken from the regular size display.



Size…

Size	Window size (Pixels)	Grid size (plotting area) (Pixels)
Large	1280 x 900	1100 x 640
Medium	1024 x 710	850 x 490
Small	800 x 580	630 x 350

Clear. Resets all the data in memory (Current trace, Stored trace, Archive trace).

Information…. Opens a window to show a summary of the analyser setup and settings. Also allows notes to be entered related to the test. See section ….

Colours….. Allows the user to change the trace and background colours of the plotting area.

Show and *Clear Markers….* Opens or deletes the marker windows.

7.1.3 Traces

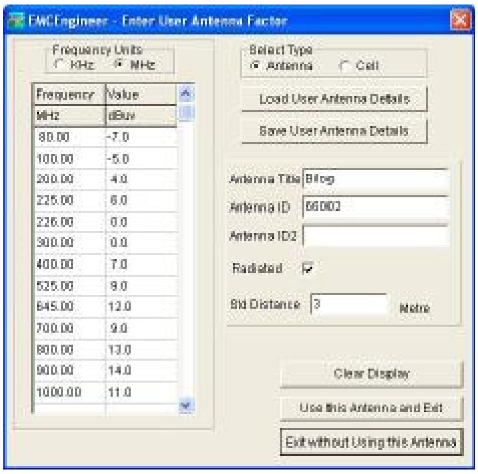
Displays a list of all possible traces, and allows each to be turned on or off. This list automatically switches on the relevant traces to match the detectors in use.

7.1.4 Inputs…

Select input device.

Note that devices that are not appropriate to the current frequency range are greyed out and not available. Selecting any item automatically loads the antenna factor or insertion loss data and applies it to the incoming signal.

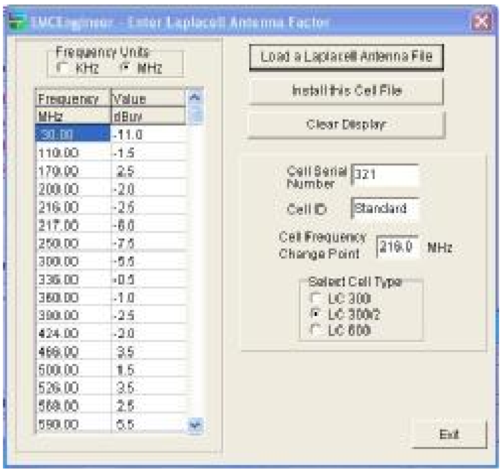
If a radiated emissions antenna is selected (RF200, RF230) a pop-up window appears in which the EUT – Antenna distance is entered. This distance is used to calculate the limit level according to formula specified by the standards.
If a pre-selector is connected (RF915 or RF910) this item will appear on the list and by default will be selected ON.



If other devices are used, the calibration data can be entered using the *Create User Antenna File, or Create Laplacell File* options.

This graphic shows how the data is entered for antennas. Up to 255 data points can be added. The software will automatically apply interpolation between the data points. The interpolation can be linear against linear frequency, or linear against log frequency.

Each antenna can be given a title and identification references. This data will appear I the lower left hand corner of the main screen when the antenna is selected.



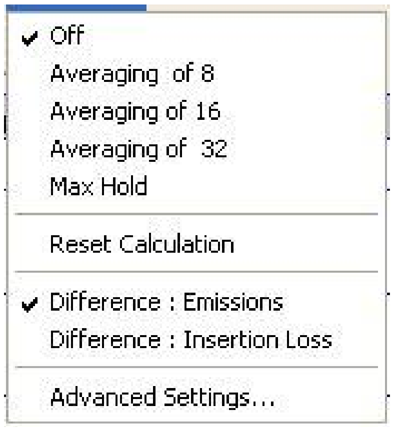
Existing user antennas can be selected on this screen. If '*Create LaplaCell'* is selected, the Window allows you to first Load a file (which would have been supplied with the cell) so that you can see the details, then to *Install this Cell file*. This file is then ready to be selected in the pull down menu shown at the top of this page.

7.5 Limits…

See section 4.5

Select Limit by standard.
EU, Aus/NZ and FCC limits are available. Other limits can be entered by the user under the *User Limits* item. This opens a window very similar to that shown above for the *User Antenna* entry.

7.6 Processing



This applies post processing activities to the scans.

Averaging and *Max Hold* are functions that apply to the current traces as they are acquired. Averaging takes a set of scans (8, 16 or 32) and at each frequency point, calculates the average result. This is particularly useful for producing a relatively stable ambient result that can be stored and then used to create the difference trace without being affected by significant fluctuations in the ambient.

Max Hold can be used for a similar purpose to the above averaging technique. It can offer a quicker solution and works well in some circumstances where the ambient is relatively stable and does not suffer from momentary high noise inputs.

The *Difference options* refer to the way in which the difference trace can be used and how the difference is calculated.

Emissions is selected (and is the default) when using the difference trace to show EUT emissions in the presence of ambient signals.

Insertion loss is selected when measuring the attenuation (insertion loss) or gain of a system. Such systems may be an amplifier or a filter. The signal at the input is measured (scanned) and copied to Store trace, then the signal at the output is similarly scanned. The difference trace (insertion loss) will now be plotted against a scale on the RHS of the plotting area.

Advanced settings…. This allows the user to change the dwell time and frequency step size to optimise performance. See section 5.8 for full explanation.

7.7 ERS

This options will be added when the software is fully released. They are related to the automatic correction of OATS test sites when using the ERS reference source.

7.8 Detector

Allows the user to select the desired detector(s).
The choices are explained in section 4.3. The Peak only and QP + Ave modes offer quick results, but for compliance testing, the All (slow) mode should be used.

7.9 Exit

When the software is closed, the current status and configuration is saved to a default.stg file so that when the software is next used, the analyser will be set to the conditions that applied last time it was used. Note that not all settings are saved. For example, the attenuator settings will always default back to maximum attenuation for safety.

Chapter 8 EMC testing

8.1 System Connections:

8.1.1 Radiated emissions

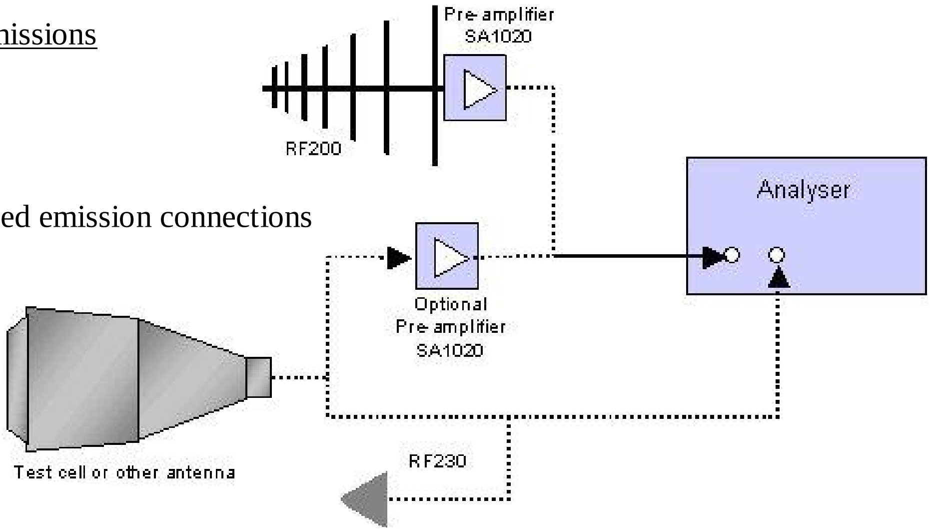


Figure 11. Radiated emission connections

The input device (antenna or test cell) is connected direct to the appropriate analyser input (under 1GHz or 1—3GHz). The RF200 antenna is always used with the SA1020 pre-amplifier and is connected to the low frequency input. Test cells and other antennas may be connected to either input as appropriate, using an SA1020 if required to provide additional gain for the low frequency input. The high frequency input is fitted with an internal 20dB pre-amplifier which can be switched in or out under software control.

8.1.2 Conducted emissions

A range of input devices may be used (LISN, PLIP, Voltage probe, current clamp etc…). These may or may not require a pre-amplifier. The important item to note is that if a pre-selector is used, the pre-amplifier is always connected after the pre-selector as shown in figure 12 Other filters such as the RF800 will always be connected in the same location as the pre-selector.

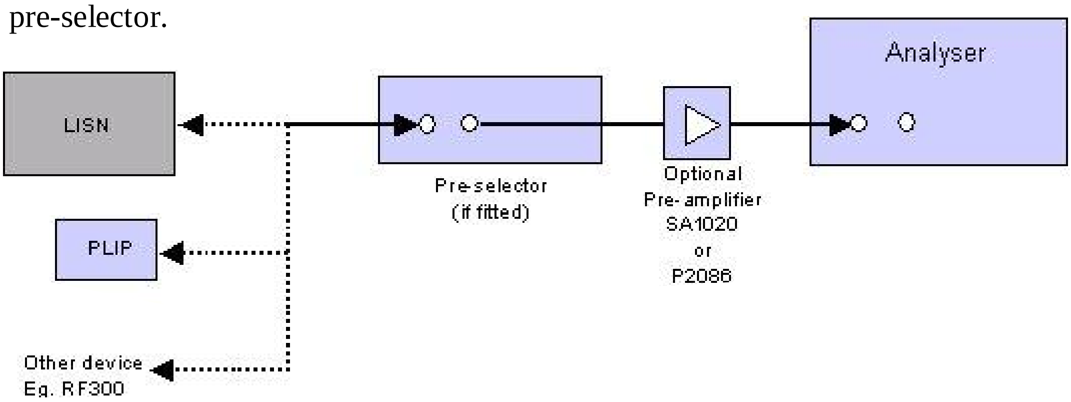
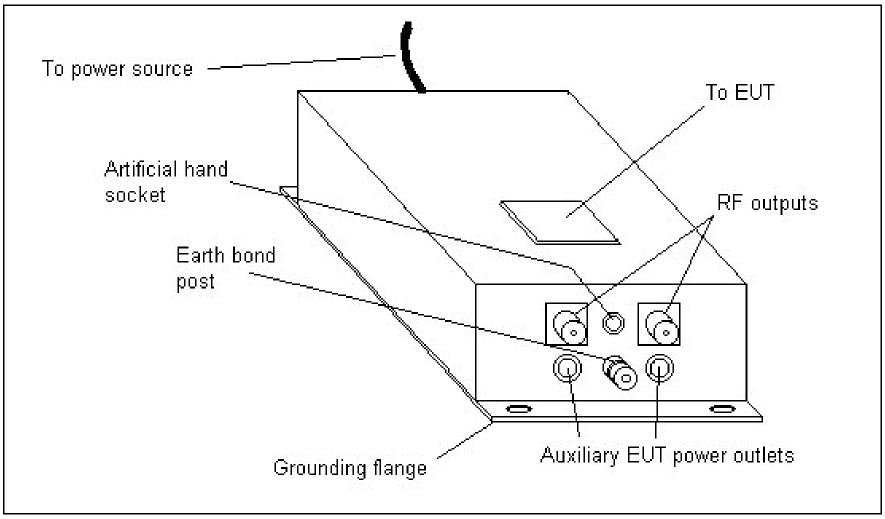


Figure 12. Conducted emission connections

8.2 Conducted emission testing

Assuming that a LISN is to be used…..Connect the LISN mains lead to the mains supply. Note that the LISN is cannot be considered a 'portable device' so should not be fitted with a standard mains plug. Ensure that the supply is NOT fitted with an RCB (Earth leakage trip). If it is, use an isolation transformer of adequate rating for the EUT, between the mains supply and the LISN.
Plug the EUT into the mains socket on the top of the LISN. Note that this socket is not switched by the LISN, so it will be live if the incoming mains is live.

Fig 13 LISN connections



1. Bolt the LISN directly to the ground plane using the holes in the flange. Alternatively connect the LISN to the ground plane with a short, thick bonding strap.
2. On the PC software, set 0.15—30MHz frequency range or 10KHz—30MHz if band A measurement is required..
3. Click on Input menu and select ....**LISN**
    1. Insertion loss… **30 dB** if using standard Cranage LISN
    2. LISN source = **live** or **neutral** (or **phase**) as required
4. Click on Detector menu and select **Detector...Peak (Fast scan)**
5. Switch analyser input **attenuator** to 30dB (see field at LHS of screen).
6. Set Pre-amp window to **0dB** and do not use pre-amp initially.
7. Connect the appropriate LISN RF output to the analyser signal input with a short BNC lead. If using a pre-selector, make this connection via the pre-selector.

In the following procedures, ***reduce attenuation*** means switching attenuation down by 10dB. This can be accomplished by a combination of the following to give an end result which equals a 10 dB reduction in attenuation (ie a 10dB increase in sensitivity)

- analyser attenuator, (30 > 20 > 10 > 0dB)
- use of pre-amplifier (which has the effect of reducing attenuation by 20dB or 30dB depending on which is used). Ensure pre-amplifier status window on screen shows correct indication.

Increase attenuation means increase attenuation by 10dB using the same facilities in reverse as listed above.
See attached flow diagram, fig 14.

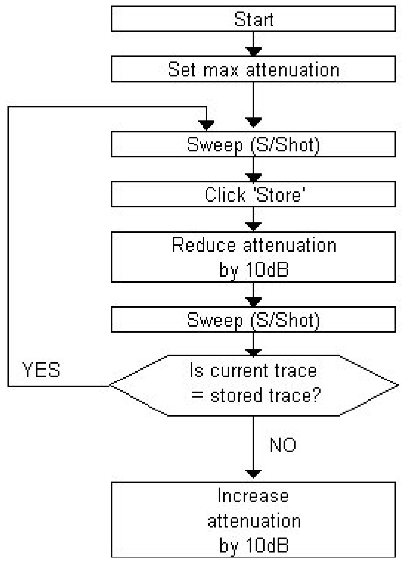


Fig 14 Setting the attenuation level

8. Click on **S/Sweep** and observe the signal on the screen.
9. Use **>STORE** button to store result ***....reduce attenuation*** (ensuring on-screen indications are correct) and click **S/Sweep** again.
10. Compare current trace with stored trace.
    If current trace is essentially the same as the stored trace at all frequencies, then repeat step 9.
    If current trace is significantly less than stored trace, ***increase attenuation*** **and go to step 11**
11. This is the best result. Make sure that the software switches match the settings on the LISN, analyser and pre-amplifier and proceed with the next stage.
12. If the signal is particularly strong, use an RF800 filter or an RF9xx series pre-selector.

Then the ‘proper’ measurements can be taken USING THE SAME SETTINGS.

Sweeping the complete range 150KHz to 30MHz with then peak detector will show any significant emissions. Remember that the peak detector will always produce the highest reading of any of the detectors. If a limit line has been selected, it will be showing the QP and average limit. The average is the lowest limit level. Only if this Peak trace shows any results close to, or above the limit, is there any need to use average or quasi-peak scanning. Average and quasi-peak detectors are slow! If only a small number of peaks require further measurement, use the single frequency or Marker mode. This enables measurement with these detectors in real time. Single frequency plots the measured level against time as the horizontal axis, just like a chart recorder. Marker mode allows up to 20 points to be measured.
If a scan is preferred rather than single frequency, set **detectors … all**. If the results show just part of the spectrum is of interest, use **zoom** to the frequency band of interest. This will enable quicker results to be obtained.

The above measurements can be refined using the advanced settings options, but ensure that the implications of this are understood first. See section 5.8

8.3 Radiated Testing

1. Connect an antenna (RF200, RF230 or test cell) to the input using the supplied long lead. If using the RF200 install the SA1020 pre-amplifier at the antenna end, mounted on the ‘platform’, using the supplied velcro pads to hold it in place. See appendix 4 for antenna assembly.
   If using the RF230, no pre-amp is necessary as the 1—3GHz input is fitted with a pre-amplifier internally.
2. If using the SA1020, install the battery. Note that the SA1020 is supplied with a battery, located in the battery compartment. Ensure this battery is unwrapped and connected to the battery leads.
3. Orientate the antenna to suit (Elements vertical for vertical polaristion, horizontal for horizontal polarisation). If using the RF200/RF230 broadband antenna, place it about 3 metres from the product and pointed towards it (‘sharp’ end forward!). Switch the pre-amplifier ON. Leave the EUT switched off.
4. Check the frequency range of the analyser. Select 30Mz—1GHz or 1—3 GHz in the frequency selection area. The horizontal axis should show the relevant range . Use log frequency axis scaling.
5. Under **Input....** menu, select the appropriate antenna. Select the **Pre-amp** to show a cross in the clear field if the pre-amp is in use. Note that selection of the RF200 broadband antenna automatically selects the pre-amplifier. Check that the **Current** trace is active. Traces are selected on/off by clicking on the trace control buttons just above the graphical trace area.. Active traces are identified by name in the space immediately above the graphical trace screen. The colour of the text identifies the colour of the trace.
6. Select **S/Sweep** The trace will build up the spectrum of the background radiation as received by the antenna, plotted as amplitude vs frequency.
7. The sensitivity of the analyser must be matched to the signal strength at the input. The idea is to reduce the **attenuator** setting to the minimum such that the compression (overload) warning just appears intermittently. With the RF230 and the 1GHz—3GHz range, select the sensitivity that avoids spurious signals appearing just above 2GHz. With the RF200, it is quite possible that even if the attenuator is set to 0dB (the most sensitive setting) the overload does not appear. This is good, it shows that the environment is relatively quiet and the analyser can be left at this most sensitive setting. If the overload is permanently flagged even with the attenuator at the 30dB setting, the background must be very strong indeed. The options then are:
   - Check for any single or group of strong peaks. If such a group appears at 86 - 106MHz, this is the FM broadcast band. The RF600 is specifically designed to overcome this problem.
   - If no one peak or group of peaks is particularly strong, try an RF700 30MHz high pass filter between the antenna and the pre-amplifier. Sometimes the problem is energy below 30MHz, outside the scan range in use and therefore not visible, but still causing the input to be overloaded.
   - Normally, one or more of the above steps will fix the problem. If however it still

persists, the location must be abnormally noisy and the source should be evident. (E.g. a plastics welding factory next door!) In this case either:

(a) use a ‘quieter’ location for EMC testing. If the product (EUT) is small, try the back garden at home!

(b) if the product is less than 60cm cube, use a test cell such as the LaplaCell300 or 600

(c) use a screened room, not normally advisable except in extreme circumstances

8. Having set the attenuator, do a single sweep (S/Sweep) to show the background spectrum. If outdoors or in a relatively unscreened indoor area, the FM transmissions between 86 - 108MHz may be clearly seen as a cluster of peaks. To confirm, check you are in **lin**(ear) frequency axis mode and use the cursor options to zoom the LH and RH edges of the spectrum display so that the start frequency is about 80MHz and the stop frequency is about 120MHz. (alternatively use **Start** and **Finish** buttons). Scan again to see the FM band in detail. Select **Min** Span and a 10MHz scan width will be selected with the start frequency unchanged from the previous setting of about 80MHz. This 10MHz scan width can be moved up or down in frequency in 2.5MHz steps by using the left or right frequency shift buttons each side of the frequency axis. Finally select **single** frequency mode and a frequency select cursor will appear. Position this line on a peak of interest and click. A selection window will appear enabling the user to select the detector type. For the moment select ‘**Instantaneous**’ and ‘**Fast’** update rate. The analyser is now set at a single frequency which can be fine tuned up and down in frequency using the single frequency **shift buttons**. Switch the audio demodulator on the front panel of the analyser into the up or down position and the signal will be demodulated and output at the internal loudspeaker. By fine tuning the signal can be clearly identified as a broadcast station. The accurate frequency of the transmission can be read off the current frequency readout display. Set the analyser back to the original settings by clicking on the **scan** button and clicking on **Max** button before continuing. This will set the frequency scan width back to 30MHz - 1000MHz.

7. The presence of emissions from a product can be crudely tested by switching the EUT on in the vicinity of the antenna. If there are any ‘heavy’ emissions, these will show up as increases in the spectral levels. In general, emissions from most products are minimal and to ‘see’ these amongst the background, a more sophisticated approach is required to null out the background.

8. Because the background is generally unstable, switch the EUT off and select **Peak hold** or Averaging from the **Processing...** menu. Use **Run** to sweep the spectrum continuously. Peak has the effect of applying a peak hold function at each frequency point across the spectrum, thus acquiring the peak level of the background emissions and the screen will eventually show a stable result. The length of time this takes depends entirely on the nature of the background at your particular location. This may vary between 10 minutes and 20 minutes. When no more changes to the result can be observed, stop the scanning by clicking on the **STOP** button

   Averaging will display the average of 8, 16.... sweeps, building up the average with each sweep and automatically stopping when the target number of sweeps has been completed.

When the above has been completed, copy this result to the STORE trace by clicking on the **>STORE** button. This action turns the Store (red) trace on and observation will confirm that it will be identical to the current (black) trace.

9. Turn the EUT on. Click either **FREE RUN** or **S/Sweep**. Remember that the analyser will still be in peak hold or average mode unless the processing is intentionally switched off. Any continuous emissions from the EUT will be shown up on the first sweep, but any discontinuous emissions from the EUT may take several sweeps for the envelope of emissions to be fully shown.

10. If using peak hold with the **RUN button**, click on the **STOP** or **CANCEL** buttons to stop the sweeping, The screen will redraw and any new signals (i.e. those from the now operating EUT) will appear as black traces above the red background (stored) trace. Use the difference trace to show the field strength of the EUT emissions. Turning both the current and stored traces off will make the difference trace easier to observe. Save to result to disk or note the approximate frequencies so that they can be examined in detail at the next step.

11. Examine the suspect peaks by ‘zooming in’ to the suspect area with the frequency select cursors. Note that the background (stored) trace is also zoomed and remains valid. However, if preferred the background can be renewed for the zoomed area by repeating the procedure with the acquisition of the background trace, copying it to the stored trace then switching the product ON to see the product emissions.

APPENDIX

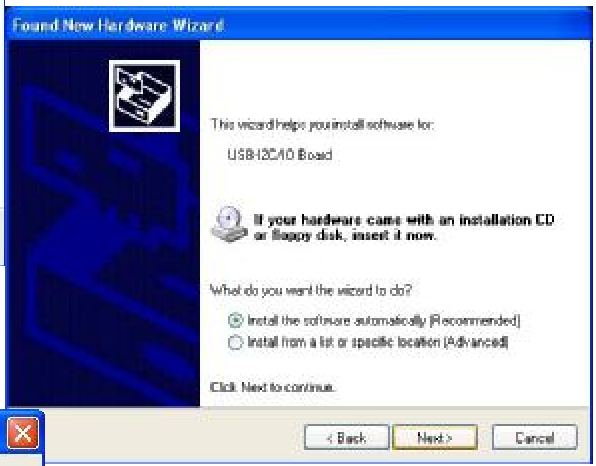
1. Software INSTALLATION
2. Safety
3. EMC compliance certificate
4. RF200 antenna
5. SA1020 pre-amplifier
6. Pre-selectors
7. Ancillaries
   - RF100
   - RF600
   - RF700
   - RF800

Appendix 1 ….. Software installation

The EMCEngineer software is supplied on a standard CD.
Load the CD on your drive and run the install.exe program. The software will automatically install into a directory on the C drive called 'emcengineer'. The files that are created include the drivers for the USB connection to the analyser. If your system includes individually calibrated items such as a LaplaCell, the calibration file(s) will need to be transferred manually into the C:\emcengineer\ directory.

When the software is installed, connect the analyser to the USB port, switch the analyser on and the PC will respond with 'Found new hardware' and initiate the New hardware Wizard.

Select the 'No, not this time' option and click 'Next'.



On the next screen, select 'Install the software automatically' option and click 'Next'.

You will need to tell the PC where the driver is located. It may default to an external drive but if you click on the pull-down menu, the top item is usually C:\emcengineer\DEVASYS304\DRV. DLL. Select this item and click OK.

You may get a driver verification window as shown here. Click 'Continue Anyway'.

That will complete the loading of the software and the USB drivers for your system.

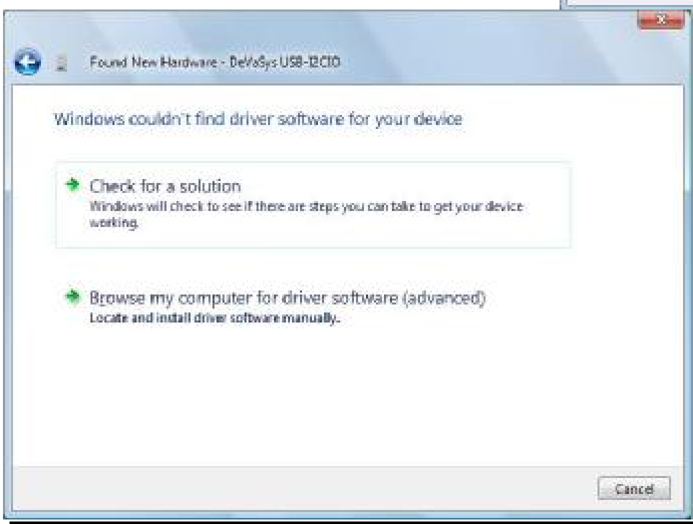
Appendix 1B   ….. Software installation (Vista)

The EMCEngineer software is supplied on a standard CD.
Load the CD on your drive and run the install.exe program. The software will automatically install into a directory on the C drive called ‘emcengineer’. The files that are created include the drivers for the USB connection to the analyser. If your system includes individually calibrated items such as a LaplaCell, the calibration file(s) will need to be transferred manually into the C:\emcengineer\   directory.

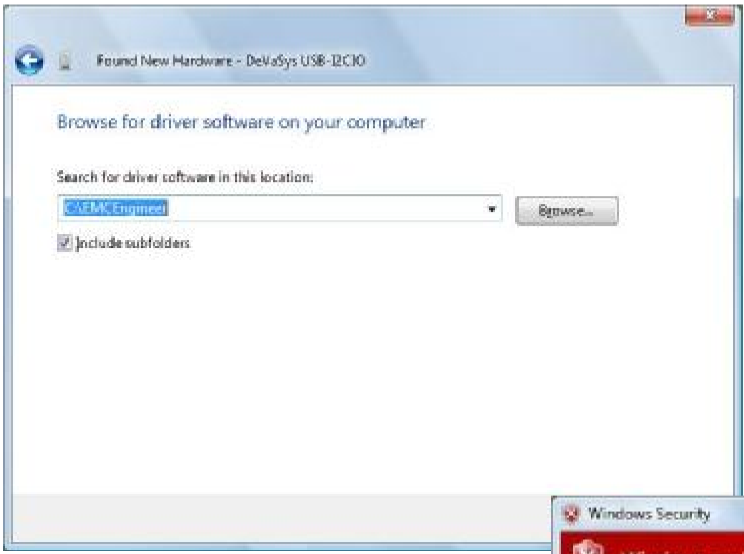
When the software is installed, connect the analyser to the USB port, switch the analyser on and the PC will respond with ‘Found new hardware’ and initiate the New hardware Wizard.

Select the top item ‘Locate and Install drive software (Recommended).

Select ‘I don’t’ have the disc. Show me other options.

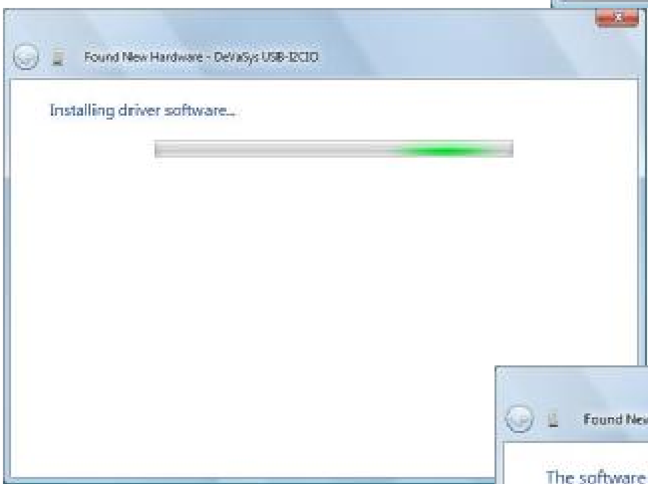


Select ‘Browse my computer for driver software (advanced).

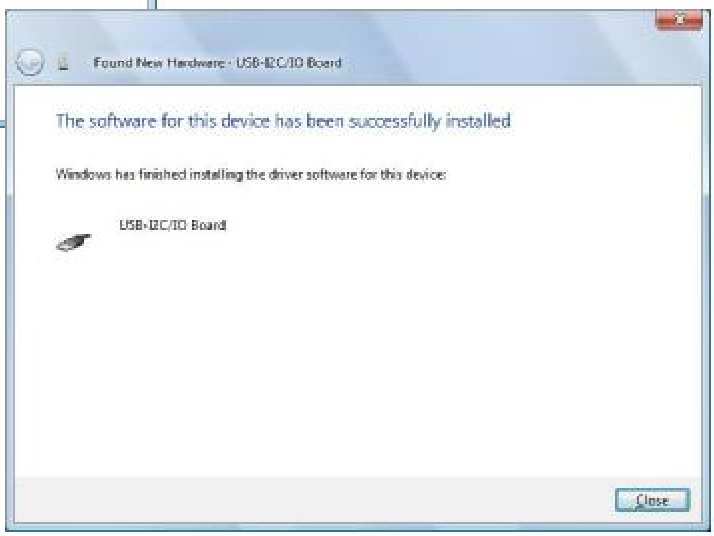


Using the Browse facility, find and select C:\EMCEngineer\ directory.

The security screen may appear. Despite what the window states, the driver software is from a verified publisherso select ‘Install this driver software anyway’.



Software should now load.



And is confirmed.

Close the window and the analyser and/or pre-selectors (if fitted) should connect.

Appendix 2 …… SAFETY

This instrument is Safety Class I according to IEC classification and has been designed to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% - 80% RH (non-condensing). It may occasionally be subjected to temperatures between +5° and -10°C without degradation of its safety. Do not operate while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to a mains supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair.

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

Do not wet the instrument when cleaning it. The following symbols are used on the instrument and in this manual:-

Caution -refer to the accompanying documentation, incorrect operation may damage the instrument.

Terminal connected to chassis ground.

Alternating current.

Appendix 3

EC Declaration of Conformity

We, Laplace Instruments Ltd
3B, Middlebrook Way
CROMER, Norfolk
NR27 9JR

declare that the

SA3000 and SA1002 EMC Analyser

meets the intent of the EMC Directive 89/336/EEC and the Low Voltage Directive 73/23/EEC. Compliance was demonstrated by conformance to the following specifications which have been listed in the Official Journal of the European Communities.

Emissions:	EN61326 (1998) Radiated, Class B
	a) EN61326 (1998) Conducted, Class B
	b) EN61326 (1998) Harmonics, referring to EN61000-3-2 (2000)
Immunity:	EN61326 (1998) Immunity Table 1, Performance B, referring to:
	a) EN61000-4-2 (1995) Electrostatic Discharge
	b) EN61000-4-3 (1997) Electromagnetic Field
	c) EN61000-4-11 (1994) Voltage Interrupt
	d) EN61000-4-4 (1995) Fast Transient
	e) EN61000-4-5 (1995) Surge
	f) EN61000-4-6 (1996) Conducted RF

EMC

Safety

EN61010-1 Installation Category II, Pollution Degree 2.

David Mawdsley
Managing Director
12th December 2007

Appendix 4

RF200 Broadband antenna

The broadband antenna will allow the user to detect and measure radiation over the frequency range 30MHz to 1GHz.
This is shipped in a ‘knocked-down’ form to ease packaging and to minimise the potential for damage in transit. Assembly is straightforward but must be done with care.
The basic design of the antenna consists of a central main beam, itself comprising two parallel aluminium sections spaced apart by insulators. Equal length pairs of aluminium alloy rods form the antenna elements, these mounted on the main beam in order of length, the shortest at the end at which the output lead is attached. An insulating block provides attachment for the stand with facilities for horizontal and vertical mounting. The non-metallic stand allows adjustment of antenna height and direction.

Antenna assembly (see fig 15)

1. The aluminium elements are secured to the central beam using M4 bolts and washers provided. An M4 hex driver is also included to facilitate assembly. These elements are mounted in equal length pairs with the shortest at the end of the central beam where the output cable is attached.
2. Alternate the element direction as shown in Fig 21, so that for each side of the central beam, the elements alternate up, down, up, down...etc. until element 9 which is out-of-sequence and is mounted same side as element 8. Element 10 is alternate to element 9 as shown in the diagram.
3. The number of elements should match the number of hole pairs along the central beam.
4. Each element is secured by the M4 bolt with one crinkle washer under the bolt head and one under the element. Tighten so that the crinkle washer is flattened, but do not overtighten and this may distort the aluminium beam.
5. A pre-drilled plastic block is supplied to form a central mounting block and pre-amp support. This is screwed to both beams using the supplied nylon screws.

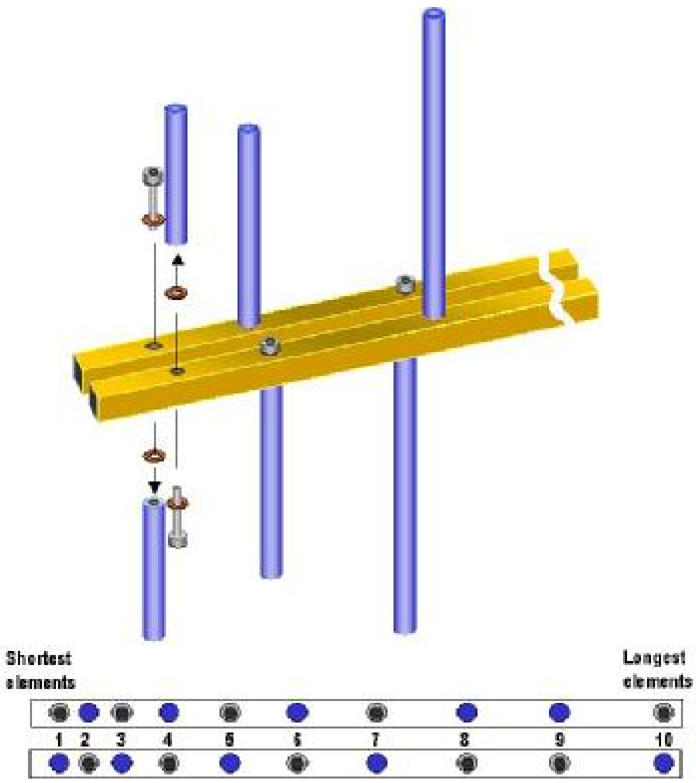


Figure 15
RF200 Antenna assembly

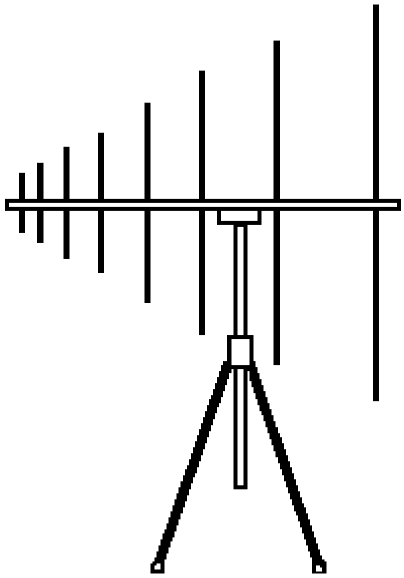


Figure 16 Stand assembly

RF200 Stand assembly

This is supplied as a central vertical support fitted with a leg attachment moulding and three legs.
The legs are a push fit into the leg attachment moulding.
The vertical support has a friction slide fit in the leg attachment moulding so that the antenna can be adjusted in height over the full length of the vertical support.

The antenna is located on the stand by locating the central support block on the top of the vertical support in either the horizontal or vertical polarisation position. Nylon bolts are provided so that the antenna can be clamped in position
If used outdoors in strong wind conditions, the stability of the antenna can be considerably increased by filling a bag with sand, soil or stones and supporting it by cord tied round the leg attachment moulding.

In use
Connect the SA1020 pre-amplifier directly to the antenna output lead and secure the pre-amp to the central pivot block with the velcro strips.
Point the antenna, sharp end forward, at the EUT. Note that the antenna is directional but full sensitivity is maintained over a wide angle either side of ‘dead ahead’. Orientate the elements to match the polarisation required (vertical or horizontal).
The height of the antenna can be changed by sliding the vertical support up or down within the leg attachment moulding. If this friction fit is too slack or tight, **slightly** adjust the nylon bolt to suit. Note that antenna height may be a critical factor in obtaining valid results.
The main feature of the polar plot of the antenna (i.e. its directional properties) is a sharp null at 90º on either side. This can be used to null out any strong background emission for in-

RF200 Antenna Factor tabular data.   These figures include the SA1020 and 5 metres co-ax cable

Freq(MHz)	A.F. (dB/m)	Freq(MHz)	A.F. (dB/m)	Freq(MHz)	A.F. (dB/m)
30	0	220	-3	460	4
40	-1	240	-2	480	5
50	-2	260	-4	500	5
60	-3	280	-5	550	6
70	-5	300	-3	600	7
80	-7	320	-2	650	8
100	-9	340	-1	700	9
120	-9	360	0	800	10
140	-8	380	1	900	11
160	-7	400	2	1000	12
180	-6	420	3		
200	-5	440	3		

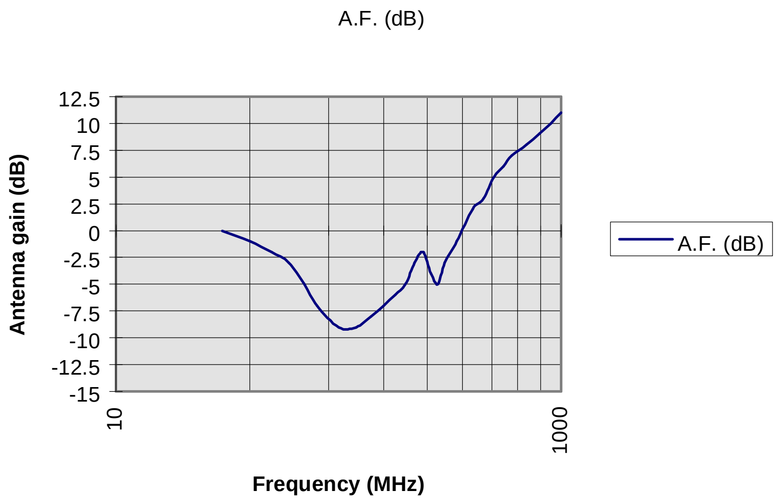
stance from an FM radio transmitter IF using a true open field site. Note that the null is very sharp and care has to be taken to find the right angle. Attenuation of up to 20dB is possible under the right conditions. In the presence of buildings etc., these emissions will be affected

by reflections and will not be unidirectional, making them impossible to null out.
When using the RF200 in conjunction with the SA3000 Windows software, the antenna factor for this antenna can be invoked in the software to give a display of field strength. See section 7.4 Note that when used in this mode, the Pre-amp YES/NO buttons on the PC screen will default to YES as the antenna factor data loaded in the software includes the effect of the pre-amplifier.

Antenna Factor
The sensitivity of any antenna will vary with frequency. i.e. it will be more sensitive at some frequencies and less sensitive at others. A plot of sensitivity vs frequency is called the Antenna Factor.
The SA3000 Windows software has the antenna factors for the RF200and RF230 broadband antennas ready installed. Selecting this item in the INPUT menu automatically applies the appropriate conversion to read out in absolute field strength.

WARNING: Although the conversion is valid, the field strength measured by the antenna is subject to your test site conditions and configuration and may be subject to gross errors. Reception of emissions radiated from the EUT depend on the test conditions, the test site, reflections, ground plane, background radiation, EUT to antenna distance etc..etc.. Be very wary about relating field strengths to limit lines unless you have some known test results to act as a reference, or use an ERS or other reference source.

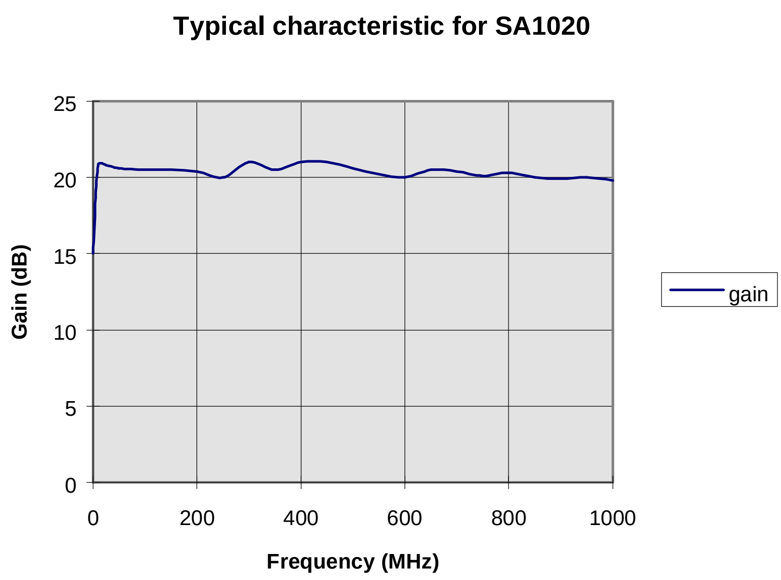
Fig 17 RF200 Antenna factor.
Note. Antenna factor includes SA1020 Pre-amplifier and 5 metres co-ax cable.



Appendix 5 SA1020 Pre-amplifier

SA1020 Pre-amplifier
Description

The SA1020 is a small self contained amplifier intended to provide in-line signal amplification for low level RF signals such as output by radio or EMC antenna and near field probes, and to provide an output suitable for RF spectrum analysers, oscilloscopes or other measurement or recording instruments.
In order to maintain high signal to noise ratio and to offer maximum operational convenience, the unit is internally battery powered with a standard PP3 battery. This may be either primary cell type, or rechargeable (e.g. NiCad).
Fig 18 Typical gain characteristic.



Note that this characteristic is included in the RF200 antenna factor curve.

Battery installation

Suitable batteries are any PP3 type such as alkaline or rechargeable types such as NiCad.
To fit the battery, push off the moulded battery cover as indicated on the rear of the SA1020. This will reveal the battery compartment and the battery connector. Ensure that the ON/OFF switch is set to OFF before connecting the battery to the connector and that the connector is correct orientation before pushing the contacts home. Check that the contacts are both fully engaged before inserting the battery in the battery compartment. Clip the battery cover back in place.

Make sure that the battery is not discharged by checking the battery voltage with a meter before fitting the battery cover. With the battery connected to the SA1020, and the unit switched ON, the battery voltage should not be less than 8V

With a fully charged battery, the amplifier should run for the following periods:

Battery type	Capacity	Duration
NiCad	110mAH	5 hour
Alkaline	200mAH	10 hour
Zinc-Air	1000mAH	50 hour

Avoid using ‘cheap’ batteries. They are a false economy!

Operation

Important notes

1. The amplifier is intended to be used with low level signals, of uV amplitude rather than Volts amplitude. The input is therefore very sensitive and , although protected, may be damaged if input voltages exceed the specified values. When used with the SA1000 analyser and to ensure linear operation, input signal amplitude should not exceed 22mV rms in the frequency range above 5KHz. For signals with frequencies below 5KHz the internal ac coupling permits higher input voltages. The slope of this characteristic is 3dB/octave which gives a max. voltage input of 2.2V at 50Hz.
2. If the input is subject to overload voltages, a diode clamping network will protect the amplifier. However, this network has limited current capacity so that the degree of protection and the overload voltage which the unit will withstand depends on the source impedance of the signal.
3. During use, monitor the condition of the battery. Low battery condition is manifested by a reduction in output signal. This occurs quite abruptly if using NiCad cells.
4. When not in use, switch the amplifier off to preserve battery life. If the unit is not to be used for any significant period, disconnect the battery. This avoids batteries being drained inadvertently.
5. Two SA1020 amplifiers may be cascaded in series. For optimum results, fit a 3dB attenuator between the two amplifiers and after the second. This gives an overall gain of nominally 35 dB.
6. Dispose of used batteries properly.

Appendix 6 Pre-Selectors

RF910 and RF915 Pre-selectors

These pre-selectors are designed to be used for band A and band B measurements with the analyser. They dramatically improve measurement integrity in instances where relatively high levels of broadband noise exist when measuring conducted emissions.
They must be connected to the RF signal coming from the source (LISN, PLIP, loop antenna) before any other part of the system (pre-amplifier or analyser). Their function is to 'pre-filter' the signal through band limiting filters. These filters are as shown in table 7

	RF910		**RF915**	
Band	Start frequency	Stop frequency	Start frequency	Stop frequency
A-1	Not fitted		10KHz	32KHz
A-2	Not fitted		32KHz	80KHz
A-3	Not fitted		80KHz	150KHz
B-1	150KHz	400KHz	150KHz	400KHz
B-2	400KHz	1MHz	400KHz	1MHz
B-3	1MHz	2MHz	1MHz	2MHz
B-4	2MHz	4MHz	2MHz	4MHz
B-5	4MHz	7MHz	4MHz	7MHz
B-6	7MHz	10MHz	7MHz	10MHz
B-7	10MHz	15MHz	10MHz	15MHz
B-8	15MHz	30MHz	15MHz	30MHz

These filters are switched by the EMCEngineer software to synchronise with the scanning of the analyser.
The effect is to substantially limit the amount of energy being input to the mixer in the analyser (see sections 5.1 and 5.2), thus avoiding the problems related to compression. The filters in the pre-selector are specified to have a small insertion loss in the pass band and this loss is compensated for by the software.

Connection
The RF910/915 pre-selectors are mains powered. They should be connected to a suitable mains supply between 100 and 240V ac, 50—60Hz.
The USB connection is made from the rear panel to the host PC running the EMCEngineer software. When first connected, the PC will request a driver to be loaded. The procedure is explained in Appendix 1.
The RF connections are as shown in figure 12 (Page 31).
When the pre-selector is switched on, it will default to 'Auto Mode'. In this mode control is transferred to the PC and the software. The software should automatically detect the presence of the pre-selector. Check under File… System Settings… USB Devices to show a table which will list the devices connected. This should include 'RF910' or 'RF915' and show the serial number.

Operation

The Pre-selector can be left in Auto Mode and operation will be entirely transparent to the user. The band indicators will show the band in use. If the analyser is to be used in other bands above 30MHz (eg… for radiated emissions), it is recommended that the pre-selector be removed from the RF circuit.

The pre-selectors can be controlled manually if required. To switch to manual mode, press the paddle switch in the channel selector section area down. After a three second delay, the Auto Mode indicator will go out. Further downward presses of the paddle switch will move the selected band downwards. Upwards presses will move the selection up the bands. If the switch is held up past the top band, Auto mode will be re-selected.

Appendix 7 Ancillaries

RF100 Near Field Probe set
Near field probes can be used for the location of emission sources and for monitoring the effectiveness of design changes, circuit improvements and screening.
They should not be used to assess emission levels as required by the legislation because this requires measurement of the far field.
Sources of radiated emissions may be current or voltage in nature. Low impedance sources will be current sources and generate magnetic fields (H field). High impedance sources generate electric fields (E field). Most electronic circuits exhibit H field radiation because the sources are allied to current flow.
The H field loop and the E field stub antenna are included in the near field probe set so that both types of sources can be traced. The output signal level of both are very dependant on proximity to the source. Generally, more than a few centimetres from the source and the output from the probes will drop to virtually zero. This makes the probes ideal for use in noisy 'laboratory' environments and for accurate pin-pointing of sources.
Some sources can be related to lengths of cable or internal wiring. Often the user will find nodes and anti-nodes (standing waves) along the length of these conductors, the E and H fields being in anti-phase. Therefore when checking conductors, it is important to check along the length of the conductor to ensure detection of a node.
Note that the level of signal picked up by the near field probe does not give any indication of the field strength in the far field. The probes respond to source intensity and do not take into account how well that source is coupled to the environment.

Filters
RF600 FM Band Filter
This filter provides a notch filter which attenuates the band of frequencies used for FM broadcast transmitters. These are often a major source of problems when using outdoor sites. The RF600 reduces the signal; strength of the band between 85MHz and 108MHz by >30dB without affecting other frequencies. It should be fitted between the antenna and the pre-amplifier. No power is required.
Locate the filter before the pre-amp on the antenna.
This filter does not need any action with the SA3000 software.

RF700 30MHz High Pass Filter
On some test sites, particularly indoors, the analyser exhibits compression when set to measure radiated emissions even if there is no apparent high signals in the spectrum. These circumstances can be caused by high levels of interference below 30MHz, and thus out of 'sight' on the high range spectrum. Fitting the RF700 will eliminate these signals and cure the problem.
Locate the filter before the pre-amp on the antenna.
This filter does not need any action with the SA3000 software.

RF800 Band B filter
Used for conducted emissions testing, in situations in which out-of-band signals are causing compression. Effective only in certain conditions but a low cost alternative to using a pre-selector. Recommended use when sensitivity needs to be improved by just 10dB before onset of compression.
Fit the filter between the transducer (LISN or probe) and the analyser or pre-amp (if fitted)
This filter does not need any action with the SA3000 software.

INDEX

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