

# FSM

The screenshot shows the FSM software interface with the following sections:

- Scenario:** Location: Ainslie, ACT; Environment: Residential; Tester: Owen Duffy; Antenna: 7MHz dipole; Factor (dB/m): -11.75; Feedline: 22m RG6; Loss (dB): 0.6; Attenuator (dB): 20.0; AGC Threshold (dB): 20; Receiver: R5000 Cat: 21/06/05; Rx bandwidth (Hz): 1980; Rx Noise Figure (dB): 14.6; Frequency (MHz): 7.100; Samples (k): 8.
- Measurements:**

	Sound card	Receiver	External
Avg (V)	0.00046	0.01158	0.04725
RMS (V)	0.00052	0.01279	0.05357
QP (V)	0.00085	0.02028	0.10875
Pk (V)	0.00125	0.02781	0.17864
QP/RMS (dB)	4.30	4.00	6.15
Pk/RMS (dB)	7.63	6.75	10.46
- Calculated results:**

	Rx (dBm)	FS (dBuV/m)	Normalised FS (dBuV/m)
Avg	-94.7	0.5	-32.4
RMS	-93.6	1.6	-31.3
QP	-87.5	7.8	-25.2
Pk	-83.2	12.1	-20.9
- Notes:** (Empty text area)
- Buttons:** Step 1: measure sound card noise; Step 2: measure receiver noise; Step 3: measure external noise; Record TSV.
- Timer:** 05:55:55

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## Overview

FSM is a software application that extends a conventional SSB receiver to allow measurement and calculation of field strength of radio signals or interference.

FSM is a software implementation of the technique described by Ed Hare of the ARRL in "Manual Testing of Field-Strength Levels Using Conventional Receivers" dated August 2004 (located at [www.arrl.org/~ehare/aria/ARIA\\_MANUAL\\_TESTING.pdf](http://www.arrl.org/~ehare/aria/ARIA_MANUAL_TESTING.pdf) using Google). The algorithm used in FSM V1.11 and later is different, but the concept is similar.

The technique depends on the fact that the audio output power of an SSB receiver is linearly related to the RF input power (including the equivalent internal noise power) up to the onset of AGC action, which is typically a little more than 20dB above the equivalent receiver input noise power. By using a known external attenuator to keep measured signals within this linear range, relative measurements can be made of the receiver audio output power and absolute results calculated by factoring in the attenuator, receiver equivalent internal noise power, and other scenario variables.

Effectively, the SSB receiver is used as a linear down converter, to translate a narrow RF spectrum segment of interest to audio frequencies, and to analyse the audio output of the receiver using FSM. You could think of the combination as a multiple conversion super-heterodyne receiver where the last IF is at audio frequencies.

FSM has the capability to sample the audio for a defined period (default is 8K samples or about 372mS) and calculates summary statistics; the relative DC offset, RMS, Quasi-peak and Peak voltages. Measurements made in this way of the internal noise of the sound card connection, the receiver internal noise, and the external signal, along with measurements or estimates of the test environment are used to calculate the received power and electric field strength of the external signal, noise or interference.

## Configuration

### Hardware

**Figure 1: Block diagram of the FSM hardware configuration**

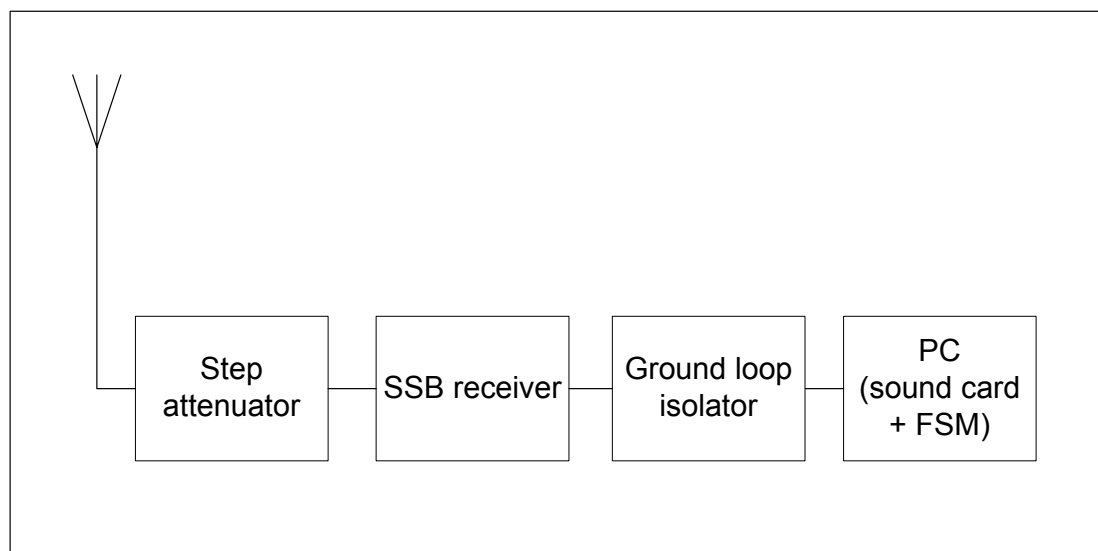
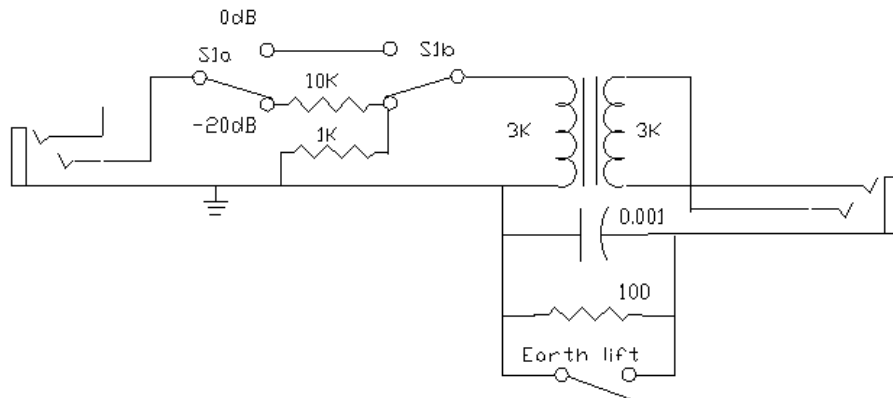


Figure 1 is a block diagram of the hardware configuration used to make measurements with FSM.

The attenuator is needed to reduce measured noise / interference so that it is below the AGC threshold. If your location is fairly quiet, you may get away with just 10dB or 20dB, but noisier locations or high level interference or strong signals will require 30dB or 40dB, perhaps a little more with a high gain antenna, perhaps a little less with an insensitive receiver. If the attenuator cannot be adjusted to more than 80dB, a 50Ω termination will also be required when measuring the receiver internal noise.

The ground isolator is to minimise noise and hum because of ground loops created in the test setup. It may not be necessary, but if the Step 1 results are high, a ground isolator may resolve the problem. An example design for a Passive DI Box is at [www.vk1od.net/FM/DI.htm](http://www.vk1od.net/FM/DI.htm).)

**Figure 2: Circuit of passive DI box.**



## Software

### FSM

FSM is a software application that extends a conventional SSB receiver to allow measurement and calculation of field strength of radio signals or interference.

FSM should run on Win98SE, ME, 2000 and XP. It has been tested extensively Win 2000 and Win98SE.

FSM will create files (eg the saved results) in the current working directory. You may want to edit properties for the shortcut that you use to start FSM to set a different "Start in" directory for more convenient access to the files.

FSM saves its current settings in a profile file. The default profile is FSM.fsm in the current working directory. An alternate profile on the command line by using the positional argument <ProfileName>. (Command line options can be set on the properties sheet for shortcuts). File menu options allow saving the settings to a new file, and for opening a profile file and reading its settings. FSM automatically saves the current settings in the current profile when you close FSM or when you open a new profile. You could use this facility to create different profiles for a number of projects, for example you may create a profile for each combination of frequency / antenna / receiver etc that you wish to measure. You could create separate icons each specifying the relevant profile file on the command line for convenience in starting FSM. The ProfileName appears in the title bar to assist automation.

FSM can be associated with .fsm files so that double clicking a .fsm file or a shortcut to an .fsm file will start FSM using that profile.

Go to menu "Options / Associate .fsm files" and click it to set the association up.

Once the association is created, profile files (.fsm) are a very convenient way of starting FSM with a particular measurement configuration.

### DPLOT

Dplot is a commercial third party graphing application with an emphasis on scientific and engineering applications.

FSM has an interface to Dplot for visual display of the measured noise samples. Dplot can do a FFT on the wave samples for a spectrum plot of the measured interval. (For optimal FFT results, check the FSM menu option " Option / Measurement interval as samples" to set the FSM Measurement Interval as samples.)

Dplot is not necessary to FSM, FSM works just fine without Dplot.

A free lite version of Dplot called DplotJr is available.

Dplot and DplotJr are available from [www.dplot.com](http://www.dplot.com).

## Visual Basic

FSM is written in Microsoft's Visual Basic 6.0 (VB6). The FSM distribution package does not include some files (known as the VB6 Runtime Files) needed for VB6 applications. Many, possibly most, people will already have VB6 Runtime Files installed on their PC and will not need to download them. If FSM cannot find the VB6 Runtime Files when it starts, it will tell you, and you will need to download and install them.

Runtime files for Visual Basic 6.0 are available at no charge from Microsoft at Visual Basic Run-time Files, choose the runtime for Visual Basic 6.0 with the latest Service Pack applied (SP6 at the time of writing this document).

## Calibration

The technique described in this document can deliver valid measurement data without using laboratory measuring instruments of traceable calibration. To deliver useful measurement data, some key parameters of the test scenario must be known or measured, and it is the uncertainty of those parameters that will contribute mostly to the total measurement error.

The key parameters of the test scenario are:

- attenuation at each step of the step attenuator;
- Receiver Noise Figure;
- receiver effective noise bandwidth;
- antenna gain (dBi) or Antenna Factor (dB/m);
- other RF losses (eg feedline); and
- receiver AGC threshold.

## Attenuator

The attenuator does not need to be of particular steps, but the steps need to be no more than about 10dB, and the attenuation of each step needs to be accurately known, the error directly contributes to error in the results. An error of less than 2dB should be acceptable, so a homemade attenuator should be acceptable if calibrated with a known signal generator or noise source. FSM may be useful in the attenuator calibration / checking procedure.

## Receiver Noise Figure

Receiver Noise Figure is the ratio of the signal to noise ratio at the receiver input to the signal to noise ratio at the receiver output. The equivalent internal receiver noise power at the receiver input terminals is a function of the receiver Noise Figure.

Receiver Noise Figure is best determined by measurement, but could be estimated from the receiver specifications if it is believed to be in good working order.

## FSM Receiver Noise Figure Calibration feature

FSM has a feature for convenient calibration of the Receiver Noise Figure value.

You need one of:

- an SSG;
- a noise source of known noise power density specified in dBm/Hz; or
- a noise source known Excess Noise Ratio (ENR) specified in dB.

You may also need an RF attenuator with the noise source.

Connect up as per a normal measurement, except connect the source via the attenuator to the radio.

It is wise to set the measurement interval to at least 2 seconds (or equivalent number of samples) to obtain adequate resolution for the calibration process.

Run Steps 1 to 3 as usual.

Plug in a number for the Receiver Noise Figure, it doesn't matter what it is, so long as the FSM can calculate the receive "RMS Rx (dBm)" level (even if it is wrong).

Put the attenuator setting into "Attenuator" box in FSM, and an estimate of cable losses etc into the "Loss" box in FSM, and the receiver Effective Noise Bandwidth in the Rx Bandwidth box.

Go to menu option "Edit / CalibrateRx", select the source type you have used, enter the level and click OK. FSM will calculate the correction to the Rx Noise Figure value and update the "Receiver Noise Figure" box on the main FSM form. The calculated results should now show the correct "RMS Rx (dBm)". This calibration procedure uses the use the "Attenuator", "Loss" and Rx Bandwidth settings, be sure that they are correct for the calibration setup.

## Estimating Receiver Noise Figure from specification or sensitivity test

Noise Figure can be calculated from a sensitivity specification and receiver Effective Noise Bandwidth. A calculator at <http://www.vk1od.net/sc/RxSensitivityCalc.htm> will perform the conversion.

## Estimating Receiver Noise Figure from evaluation reports

The ARRL has evaluated many receivers and commonly publishes a figure for the Minimum Discernable Signal (MDS). Noise Figure can be calculated from MDS and receiver Effective Noise Bandwidth. A calculator at <http://www.vk1od.net/sc/RxSensitivityCalc.htm> will perform the conversion.

## Bandwidth

Receiver effective noise bandwidth (ENB) is the bandwidth of an idealised pass band that has in-band gain equal to the actual gain at 1KHz equivalent, and the total noise power passed is the same as the actual filter. It is unlikely to be the same as the quoted filter bandwidth determined from the -6dB points, and is likely to be around 20% or 1dB lower. Errors in the ENB will affect all "noise" metrics calculated from "sensitivity" measures, and all "sensitivity" metrics calculated from "noise" measures. For more information see <http://www.vk1od.net/fsm/MeasurefBw.htm>.

The receiver bandwidth is important to the normalised 1Hz results and is best measured. The IF filter is the dominant determinant of the end-to-end frequency response of an SSB receiver.

## Antenna Gain

Antenna Gain is an important factor in calculating field strength given the calculated voltage at the attenuator / receiver input terminals. Not only is it an important factor, but it is also a most difficult factor to correctly estimate.

If the noise is from a point source, then the antenna gain should be the gain in the direction of the source. For example, if the noise or signal was from a source at some distance in a particular direction and peaked clearly on rotating a beam, then it is appropriate to point the beam for maximum signal and use the beam's gain as the antenna gain.

If the noise is not from any dominant direction, the antenna gain is the average antenna gain, which does not take account of the antenna's directivity, but integrates and averages the antenna's gain in all directions. Even for a highly directive antenna, the average gain will be less than a lossless isotropic radiator, less to the extent of losses such as conductor losses and losses in amplitude of ground reflected waves. For example, if you were measuring the general background noise level with a half wave dipole, NEC models indicate the average gain will be somewhere about -1dBi.

(If that doesn't seem to make sense, a directional antenna such as a Yagi increases the strength of the noise received on its main lobe and decreases the strength of noise received from other directions. The effect when the noise source is evenly distributed in all directions, is that the increase in noise on the main lobe is offset by a reduction in noise from other directions, and the net effect of the directivity of the antenna is insignificant to the total received noise power.)

The Antenna Gain should account for antenna efficiency, ie losses in antenna conductors or ground system should be included in the Antenna Gain.

## Antenna Factor

Antenna Factor is the ratio of the electric field strength to voltage at the terminals of the antenna, and is expressed in dB/m. Menu option "Options / Antenna Factor" can be checked to allow specification of the antenna performance as an Antenna Factor.

## Loss

Loss includes all other losses between the antenna terminals and the receiver, including mismatch losses, ATU losses, feedline losses, balun losses.

Antennas that are not impedance matched to the transmission line and receiver (eg a short whip antenna) may have quite substantial losses that are not accurately known. Such configurations are not suitable for FSM measurements because of the lack of certainty of those losses.

In most cases, Losses will be an allowance for feedline losses and possibly a balun.

See the RF Transmission Line Loss Calculator at [www.vk1od.net/tl/tllc.php](http://www.vk1od.net/tl/tllc.php) for a handy calculator for transmission line losses for most popular transmission lines.

## AGC threshold

The measurement technique calls for the receiver to have a fixed gain, so AGC must not operate to reduce the gain during any measurements. This step aims to measure or estimate the AGC threshold. If the AGC threshold is much less than 20dB, it will be difficult to make measurements with a 10dB step attenuator, a 5dB step may be needed.

This procedure determines the AGC threshold by measuring the point of onset of gain compression.

Setup to measure the sensitivity of the receiver and connect FSM to the receiver output. Temporarily relax the measurement limits in FSM by un-checking the menu option "Options/Measurement limits enabled". Having measured the sensitivity, and calibrated FSM's Receiver Noise Figure value, increase the signal generator in steps, rerunning FSM Step 3 each time until the Received power (dBm) RMS" does not linearly track the generator output. Note this signal level and subtract the Receiver Noise Floor to obtain the AGC threshold wrt Receiver Noise Floor. (The receiver noise floor can be determine from the Noise Figure and Effective Noise Bandwidth using the calculator at <http://www.vk1od.net/sc/RxSensitivityCalc.htm> ). It will probably be in the range of 20dB to 25dB above the Receiver Noise Floor.

If you are unable to perform this measurement, assume that the AGC threshold is 20dB above the receiver noise floor with pre-amp OFF, but beware of any S-meter deflection during FSM measurements, it is a warning of possible gain compression that will cause errors in the measurements and results.

Hint: FSM usually enforces limits on measurements to, amongst other things, reduce the risk of AGC gain compression. When determining the AGC threshold, it may be of benefit to temporarily disable those limits. The limits may be relaxed for diagnostic purposes by un-checking the menu option "Options/Measurement limits enabled", but results cannot be saved or sent, and must not be quoted as valid measurements.

Note that a receiver's AGC threshold wrt the receiver noise floor may be lower with a pre-amp operating. The preferred configuration for FSM measurements in that case may be with the pre-amp off.

FSM allows the user to set the AGC threshold that is used for enforcement of limits to reduce the risk of AGC gain compression causing errors in measurements.

Some receivers may allow the AGC to be disabled. This may (but not necessarily) increase the useful measurement range for FSM, but the range must be determined by test. For example, with AGC OFF, a TS2000 suffers overload and clipping at about the same input level that would result in AGC gain compression. Operating with AGC OFF might seem to be a good idea, but the visual indication (S-meter deflection) of gain reduction / limiting is lost.

## Procedure

### Setting up

Setting up involves connecting equipment up, and configuring the receiver, sound card settings, and FSM in preparation for the measurements.

The measurements are conducted in three steps that must be performed in sequence to obtain the results. Values in most of the yellow "Scenario" input boxes may be changed at any time, and the results will be recalculated when the Enter key is hit, or focus is moved from the box being edited. Most results depend on completion of Step 3.

Any of the Steps 1 to 3 can be rerun, but all subsequent steps will also need to be rerun. (If a step is rerun, FSM will automatically erase the results of subsequent steps.)



## Step 1 - Measure Sound Card Noise

This function measures the internal noise of the sound card.

Subsequent calculations will subtract the sound card internal relative noise power from the measured signal levels to obtain a measurement of the relative receiver internal noise and the relative external noise. The measurement should normally be a very low value, well less than one tenth of a percent of the maximum level that the sound card can accommodate without clipping. In the relative scale used to display the measured values, the sound-card input level should generally be less than 0.001. High values will be displayed in orange text to warn of the possible impact on the quality of calculated results.

If the value is too high, it will limit the dynamic range of the measurement. In that case, there could be external noise getting into the test fixture. It may also be necessary to adjust the sound card using the Mixer controls in Windows.

Measured values should always display in black text. If any values display in orange text, it is a warning that accuracy may be compromised, and any values displayed in red are showstoppers, they prevent subsequent calculations or steps.

**Figure 3: Screen shot at completion of Step 1.**

The screenshot shows the FSM - R.5000-7MHz - v1.0.13 software interface. The Scenario configuration panel on the left includes fields for Location (Ainslie, ACT), Environment (Residential), Tester (Owen Duffy), Antenna (7MHz dipole), Factor (dB/m) (-11.75), Feedline (22m RG6), Loss (dB) (0.6), Attenuator (dB) (0.0), AGC Threshold (dB) (20), Receiver (R5000 Cal: 21/06/05), Rx bandwidth (Hz) (1980), Rx Noise Figure (dB) (14.6), Frequency (MHz) (7.100), and Samples (k) (8). The Measurements table on the right shows values for Sound card, Receiver, and External noise. The Calculated results table shows values for Rx (dBm), FS (dBuV/m), and Normalised FS (dBuV/m). The control panel at the bottom right includes buttons for Step 1: measure sound card noise, Step 2: measure receiver noise, Step 3: measure external noise, and Record TSV. A timer at the bottom right displays 05:48:40.

	Sound card	Receiver	External
Avg (V)	0.00046		
RMS (V)	0.00052		
QP (V)	0.00085		
Pk (V)	0.00125		
QP/RMS (dB)	4.30		
Pk/RMS (dB)	7.63		

	Rx (dBm)	FS (dBuV/m)	Normalised FS (dBuV/m)
Avg			
RMS			
QP			
Pk			

This is a screen shot after Step 1 has been run.

The values for "Test conditions" are not important until Step 3 is run, indeed the Attenuator may need to be tweaked and its setting reflected in the FSM form.

Figure 4: Wave plot at completion of Step 1.

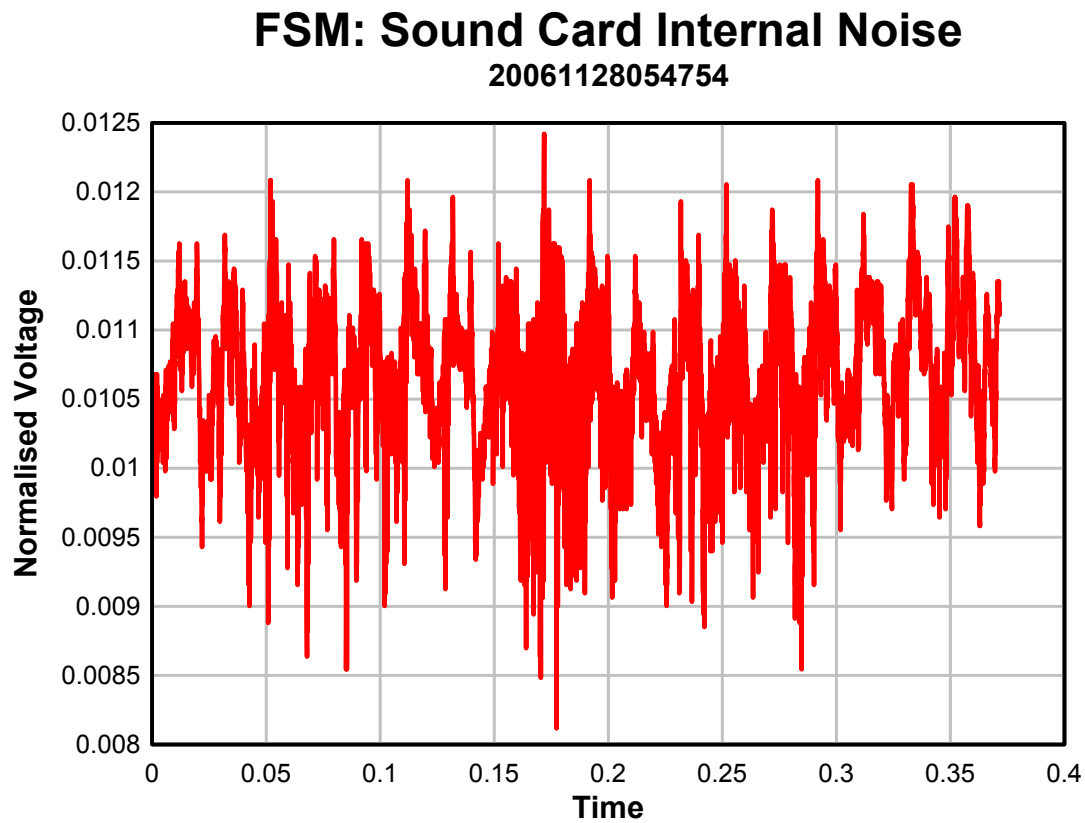


Figure 4 is a plot of the wav file of the sound card internal noise.

In fact what is being measured also includes any noise or hum induced in the cable from the receiver to the sound card. The receiver to sound card connection used a ground isolator; levels without a ground isolator were 20dB higher.

(The plot can be created only if you have DPLOT installed.)

## Step 2 - Measure Receiver Noise

This function measures the receiver internal noise by measuring the receiver audio output with the input terminated.

This is must be done with the receiver input terminated in 50 ohms, which can be achieved with either a dummy load or the step attenuator set to a sufficiently high attenuation so that the noise output of the receiver does not change with changes in attenuation. The relative output voltage is directly related to the equivalent internal receiver noise power at the receiver input terminals plus the noise power from the termination and serves as a benchmark for measurement of the external noise or interference in Step 3

Figure 5: Screen shot at completion of Step 2.

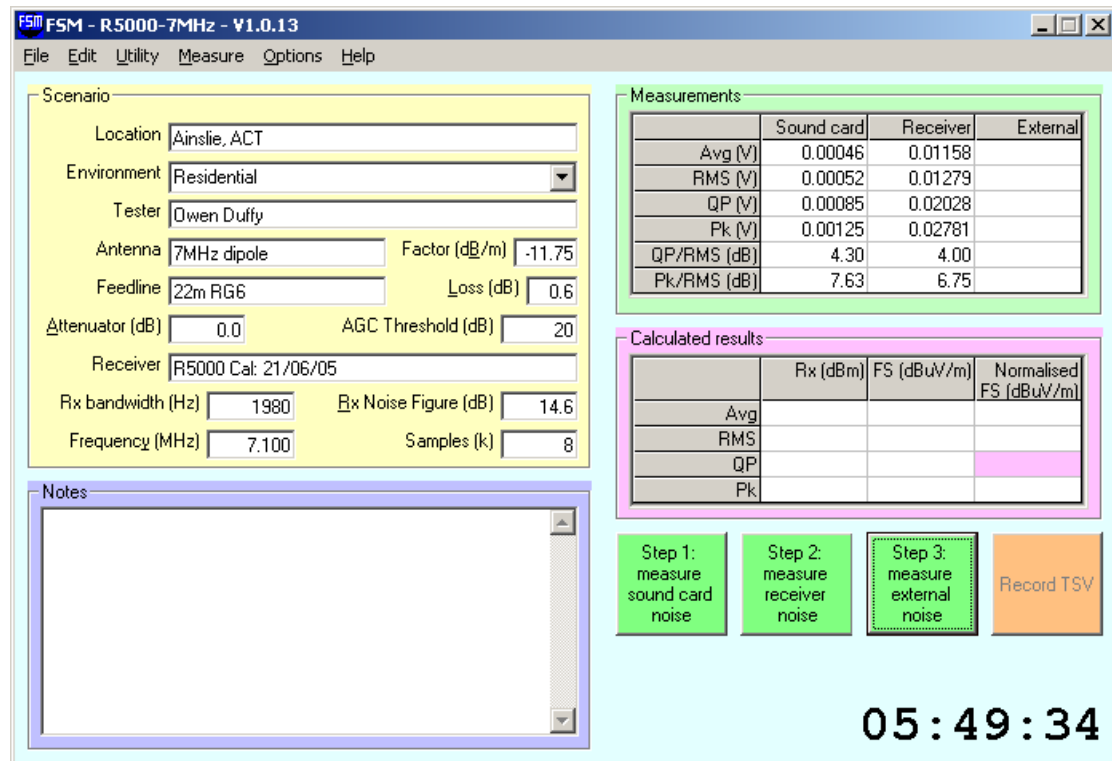


Figure 5 is a screen shot after Step 2 has been run.

Figure 6: Wave plot at completion of Step 2.

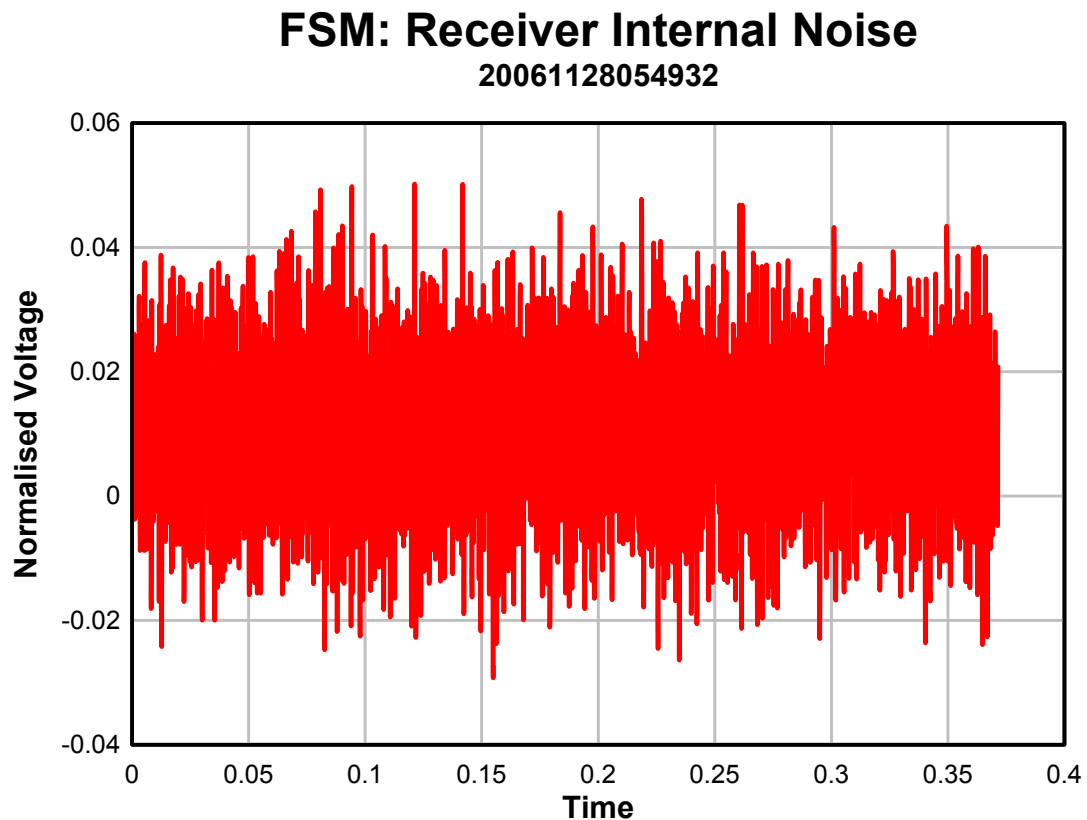


Figure 6 is a plot of the wav file of the receiver internal noise (and includes the sound card internal noise).

The reported normalised RMS voltage was 0.01279 and the Peak was 0.02781. (Note that the reported Peak voltage is the instantaneous peak divided by square root of 2.)

(The plot can be created only if you have DPLOT installed.)

### Step 3 - Measure External Noise

This function measures the receiver output with external noise or interference present.

The sound-card noise measurement is subtracted from this measurement to calculate the actual received signal level.

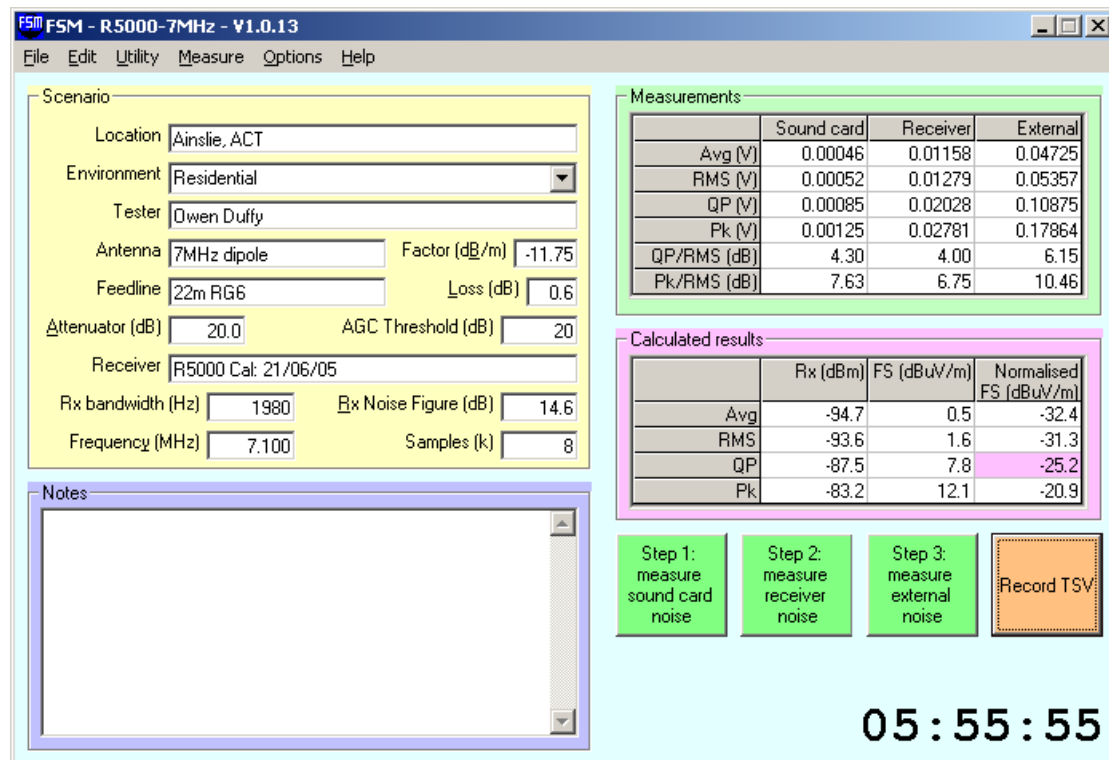
If the measured value is too high, it will limit the dynamic range of the measurement, and may result in error in measurement of the peak factor.

The program detects digital clipping and will display the Peak value in red text if digital clipping occurred. Some sound cards may clip in the analogue stages prior to the A/D converter, it is best to ensure that the Peak voltage value is never greater than 0.5.

Note, if you change the audio gain settings of the receiver, or sound card, you MUST go back to Step 1.

If the S-meter indicates above zero, it is a warning sign that AGC may be operating which will cause errors in the result. Increase the attenuation so that the maximum attenuation that results in a measurable increase in receiver noise over the measurement in Step 2. Don't forget to enter the correct attenuation value into FSM.

Figure 7: Screen shot at completion of Step 3.

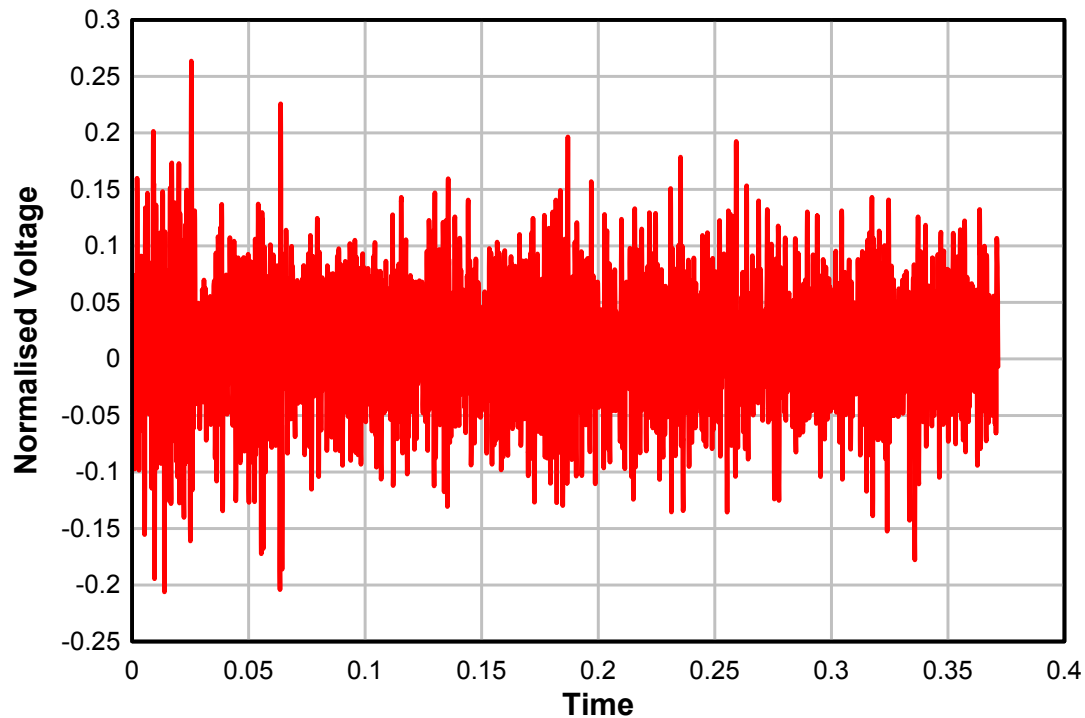


This is a screen shot after Step 3 has been run.

Figure 8: Wave plot at completion of Step 3.

## FSM: External Noise

20061128055549



This is a plot of the wav file of the external noise (and includes the receiver and sound card internal noise).

The reported normalised RMS voltage was 0.05357 and the Peak was 0.17864.

(The plot can be created only if you have DPLOTT installed.)

### Procedure checklist

Step	Checklist
0	<ul style="list-style-type: none"> <li>• connect equipment up;</li> <li>• turn receiver power on and connect antenna, select USB, set IF bandwidth to normal (IF shift centred, bandpass controls in standard position, noise reduction (noise blanker, DSP noise reduction) off, attenuator / preamp set to the standard position for specification sensitivity / MDS calibration, RF gain max, squelch open, AGC off or fast;</li> <li>• tune receiver to a strong carrier and adjust for a beat note of about 1KHz;</li> <li>• start FSM</li> <li>• setup adjust the sound card record source and level for the maximum without risk of clipping, click the Step 1 button in FSM to measure the level and adjust the sound card level controls so that the Step 1 peak voltage does not exceed 0.1, and ensure there is no clipping in the analogue stages. (you should not need to adjust the audio level again in</li> </ul>

Step	Checklist
	later steps, but if you do, you must restart at Step 1.
1	<ul style="list-style-type: none"> <li>• turn the receiver power off;</li> <li>• click the Step 1 button in FSM to measure the noise internal to the sound card and its connection to the receiver;</li> <li>• if the measurements are all black, proceed to the next step, otherwise resolve the problem.</li> </ul>
2	<ul style="list-style-type: none"> <li>• turn the receiver power on;</li> <li>• adjust the attenuator for sufficient attenuation so that the noise level does not change from step to step OR connect a known 50 ohm termination to the receiver in place of the antenna;</li> <li>• click the Step 2 button in FSM to measure the noise internal to the receiver (including the sound card internal noise);</li> <li>• if the measurements are all black, proceed to the next step, otherwise resolve the problem.</li> </ul>
3	<ul style="list-style-type: none"> <li>• if termination installed, remove the receiver input termination and reconnect the antenna + attenuator;</li> <li>• reduce the attenuation from maximum until you perceive a slight increase in audio output;</li> <li>• click the Step 3 button in FSM to measure the external noise / interference (including the receiver internal noise and sound card internal noise);</li> <li>• if the measurements are all black, proceed to the next step, otherwise resolve the problem.</li> </ul>
4	<ul style="list-style-type: none"> <li>• save the output.</li> </ul>

## Results

FSM takes a short Wave recording of the receiver audio output in each of Steps 1 to 3, and calculates the DC offset, Average, RMS, Quasi-peak and Peak values from the (half wave rectified) Wave samples. The Quasi-peak calculation uses a software emulation of the CISPR 16-1 QP detector. The ratios of Quasi-peak to RMS ("QP/RMS factor") and Peak to RMS ("RMS/RMS factor") in dB are also calculated. The default Wave sample rate is 22.05KHz, supporting audio bandwidth up to 11Khz.

Step 3 then calculates the:

- relative audio power as a result of receiver internal noise by deducting the relative audio power measured in Step 1 from the relative audio power measured in Step 2;
- relative audio power as a result of external noise / interference / signal by deducting the relative audio power measured in Step 1 from the relative audio power measured in Step 3;
- The Y factor from the net audio output power from Step 2 and Step 3.

- Input RMS power in dBm from the Y factor, receiver NF, and Attenuator and Loss values;
- Avg received power by adding an Avg/RMS factor to the RMS received power;
- QP received power by adding the QP/RMS factor to the RMS received power;
- Peak received power by adding the Peak/RMS factor to the RMS received power;
- Avg, RMS, QP, and Peak Field Strength by adding the Antenna Factor + 106.99dB to the respective received power measurements;
- normalised Avg, RMS, QP, and Peak Field Strength in 1Hz bandwidth by adding a factor of  $10 \cdot \log(1) - 10 \cdot \log(\text{Bandwidth})$ .

The Normalised QP Field Strength is a sound comparative figure, incorporating a fairer measure of interference impact than RMS measurements, and corrected to a common bandwidth with acceptable errors.

## Output

FSM displays calculated results on the main form.

Additionally, results can be save to file, transferred electronically, or passed to other applications. The following table lists the ways in which an observation may be saved or transferred.

Output contents / format	Menu path
Text file containing one observation	File / Save text file
Text file containing multiple observations, one record per observation	File / Record TSV
Wave file of measurement recording	File / Save wave file
Email text file containing one observation	File / Send text file
Electronic transfer of observation (by email or online transaction)	File / Transfer results
Wave samples	File / Export wave to DPLOT
Text file containing one observation	Edit / Copy text results to clipboard
Wave samples	Edit / Copy wave samples to clipboard

## Errors

### Scenario parameters

Errors in Receiver Noise Figure, Attenuator and Loss fields flow directly into all calculated results.

Errors in Receiver Frequency, Antenna Gain / Antenna Factor flow directly into all calculated Field Strength results.

Error in Bandwidth affects all calculated Normalised Field Strength results.

## Audio measurement

Errors in audio measurement will affect all calculated results. Overload of the linear audio stages will cause error in all measured and calculated results.

FSM requires sufficient increase in measured audio levels from Step 1 to Step 2 to Step 3 to ensure reasonable accuracy in calculations, and will not calculate results in those conditions are not met. FSM will detect and alert digital clipping.

FSM alerts some sub-optimal situations with pop-up message boxes and highlighted measurement text (as described in troubleshooting).

(FSM contains an option for relaxed limits for diagnostic purposes, but it will not save or send any results calculated in that mode.)

Provided that no audio overload occurs in the linear stages of the receiver, sound card connection and sound card, the imposition by FSM of limits as described above reduces computational error from sub-optimal audio levels.

## Antenna data file

FSM has the capability to import a file of Frequency / AntennaFactor pairs, and to automatically calculate a cubic spline interpolation for the frequency entered in the main form. The menu options to load and unload an antenna data file are on the File menu.

When an antenna data file is loaded:

- FSM's Antenna Gain /Antenna Factor field will be set to Antenna Factor and editing will be disabled;
- Antenna Factor will be automatically calculated after completion of change to the Frequency field.

Be aware that the automated calculation will not only perform an interpolation, but antenna data will be extrapolated for frequencies outside the range of the antenna data file. This extrapolation should be used with care.

The format of the antenna data file is tab-delimited records with up to 100 Frequency and Antenna Factor pairs. Records beginning with #, and empty records are ignored. A record beginning with "#\* " may be used to supply an antenna description of up to 30 characters to FSM. The name of the antenna data file is stored in the profile, and the file will be automatically loaded on subsequent invocation of FSM (unless unloaded).

### An example antenna data file

```
#
#* 0.5m square loop, 6m RG58C/U
#
#Freq      AF
3.600      38.217
5.091      37.102
7.200      36.417
10.182     36.038
14.400     35.846
20.365     35.748
28.800     35.660
```



## Troubleshooting

FSM checks the values entered and measured for validity. In the case of measured values, display in orange or red colour alerts a problem with the measurement itself or relative to other measurements. Detection of problems may prevent progression to subsequent measurement steps until the problem is resolved.

If you encounter problems, make sure that the menu option "Options / Verbose" is checked so that you get all error alerts.

Remember, any change in audio level setup between the receiver detector and FSM invalidates the calibration procedure and requires restarting the measurement procedure from Step 1.

Criteria	Alert	Hint
<b>Step 1 Peak voltage &gt; 0.7</b>	CRITICAL: Step 1 Peak voltage text colour displays red.	Resolve excessive sound card internal noise / audio cabling noise / hum loop (consider ground isolator). Re-run Step 1
<b>Step 1 RMS voltage &gt; 0.001</b>	WARNING: Step 1 RMS voltage text colour displays orange.	Resolve excessive audio level. Re-run Step 1
<b>Step 1 Peak voltage &gt; 10 * Step 1 RMS</b>	WARNING: Step 1 RMS voltage text colour displays orange.	Resolve excessive peak level, possibly caused by soundcard transient effects. Re-run Step 1
<b>Step 2 Peak voltage &gt; 0.7</b>	CRITICAL: Step 2 Peak voltage text colour displays red.	Resolve excessive audio level. Re-run Step 1
<b>Step 2 RMS voltage = 0</b>	CRITICAL: Step 2 RMS voltage text colour displays red.	Increase audio level from receiver relative to sound card internal noise. Re-run Step 1
<b>Calculated Step 2 RMS power increase is negative.</b>	CRITICAL: Step 3 RMS voltage text colour displays red.	Adjust audio levels so that RMS voltage increases significantly from Step1 to Step 2. Re-run Step 1
<b>Step 3 Peak voltage &gt; 0.7</b>	CRITICAL: Step 3 Peak voltage text colour displays red.	Resolve excessive audio level. Re-run Step 1
<b>Step 2 RMS voltage &gt; AGC threshold</b>	CRITICAL: Step 2 RMS voltage text colour displays red.	Increase RF attenuation, rerun Step 2.  Decrease audio level from receiver relative to sound card internal noise. Re-run Step 1
<b>Step 3 RMS voltage &gt; AGC threshold</b>	CRITICAL: Step 3 RMS voltage text colour displays red.	Increase RF attenuation, rerun Step 3.  Decrease audio level from receiver relative to sound card internal noise. Re-run Step 1
<b>Calculated Step 3 RMS power increase is negative.</b>	CRITICAL: Step 3 RMS voltage text colour displays red.	Adjust audio levels so that RMS voltage increases significantly from Step 2 to Step 3. Re-run Step 1

The limits described in this table are to ensure validity and accuracy of calculations. The limits may be relaxed for diagnostic purposes by un-checking the menu option "Options / Measurement limits enabled", but results cannot be saved or sent and must not be quoted as valid measurements.

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## **Version**

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