Spectrum Engineering Services

Smart Meter HAN 868MHz RF Coverage Survey Test Methodology

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Contents

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1 Introduction

This document details the test setup for the Smart Meter HAN RF 869MHz measurement campaign.

1.1 Background

A campaign of signal coverage measurements within Multiple Dwelling Unit (MDU) buildings is being carried out in support of the DECC energy supplier HAN (Home Area Network) smart meter implementation programme to enable further refining of the HAN propagation coverage model. A previous campaign was completed which focused on measurements within various house type dwellings. The requirement has been expanded to look at the propagation coverage within flats and converted multi-story buildings. Measurements are to be carried out at various MDU sites located in London, Bristol, Birmingham, Nottingham, Edinburgh and Perth as directed by DECC.

2 Test Methodology

The work involves making a series of 868MHz (862-876MHz License exempt band) signal measurements at a number of multiple dwelling unit (MDU) buildings. Signal level measurements are carried out within each MDU building by setting up a reference carrier wave (CW) transmitting source and using a spectrum analyser to measure the local signal variance (fast fade effect) at a number of location points within the MDU.

As a result of processing and analysing the measurement data from each of the MDU buildings, an 868MHz, MDU path loss model is to be derived to assist in determining the signal coverage and feasibility for installing Smart meter HAN systems in a variety of flats and apartments.

The exact location for setting up the two transmitting sources and making measurements is to be determined by DECC and its stakeholders, following a site survey at each MDU. Typically measurements will made between the ground floor (typical electrical meter location) and several locations on each floor or until the signal level become unmeasurable.

There is also the requirement to carry out signal coverage tests at the larger MDU sites and their adjoining areas to determine the propagation distance of an 868MHz signal within an urban and rural environment.

2.1 Measurements to be carried out

To simulate the typical inside and outside location of a meter, two CW signals are transmitted with one antenna located at the agreed inside building position (Tx1), and a second antenna located in an outside building position (Tx2). Tx1 and Tx2 are set to different frequencies to enable both inside and outside transmitter location measurements to be made with the spectrum analyser during a single measurement visit, thereby maximising the number of measurements carried out at each MDU site.

To capture the effect of fast fade, measurements are made by 360º rotation of the spectrum analyser antenna over a few wavelengths (a wavelength = 34.5cm at 868MHz) around a pivot point using a purpose fabricated antenna tripod with a rotating arm. The localised signal variance is recorded over a 10 second period at each measurement location to assess the median signal level due to fast fading.

DECC and its stakeholders have requested that the fast fade measurements are carried out with the analyser antenna rotated in both horizontal and vertical orientations

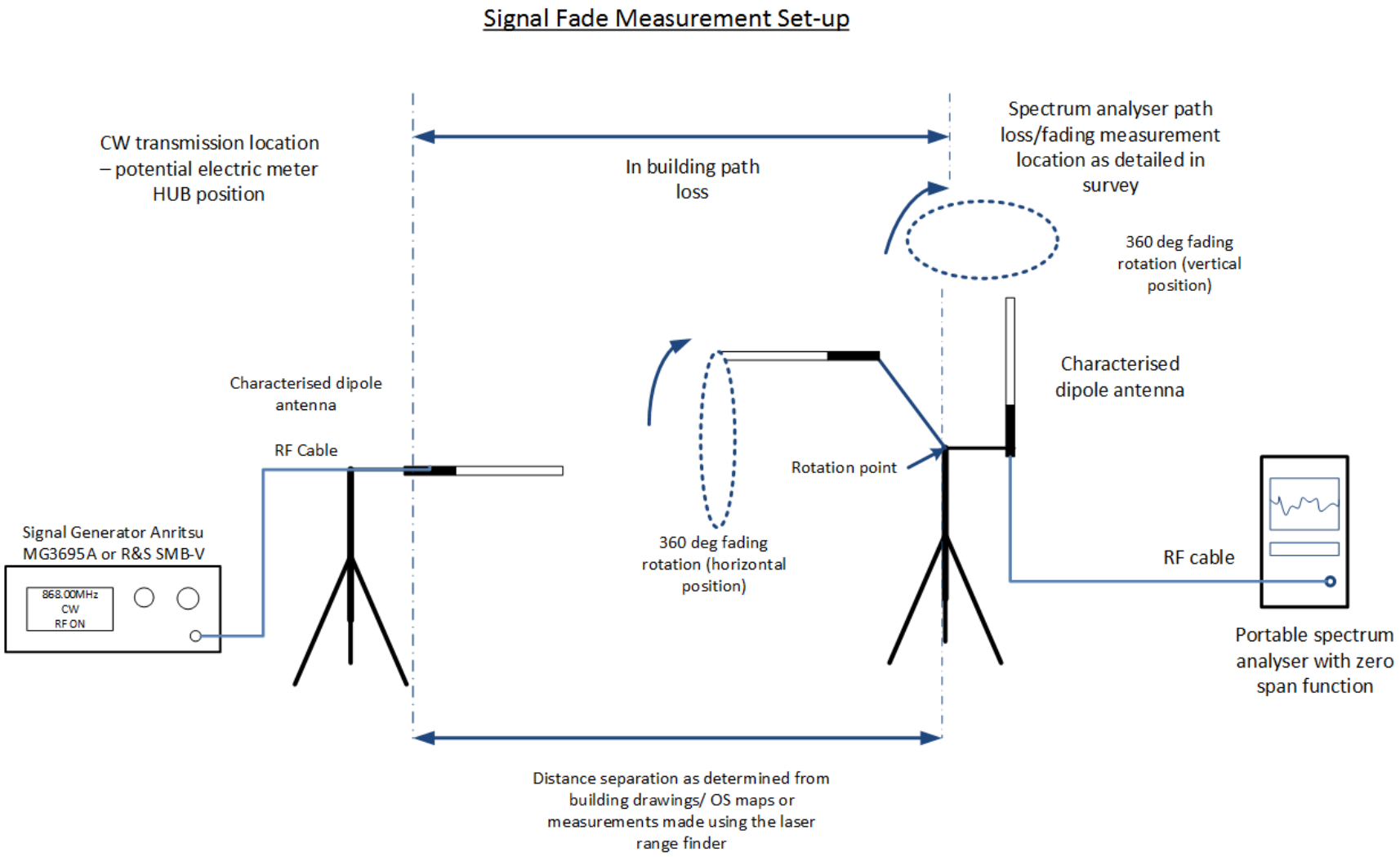
To determine the radio coverage of an 868MHz signal within an urban and rural environment, measurements are carried out using a mobile reference receiver with GPS location information, to record the signal level from a CW transmission located at a high point within the MDU. The reference receiver is walked around the MDU site and adjoining areas while the signal is recorded. This, measurement activity is carried out at the larger MDU sites as directed by DECC and stakeholders.

All measurements are to be recorded saving data files on the portable spectrum analyser and using the campaign measurement template to record the file name data/ photo files and

location drawings etc. This information is necessary and required as part of the measurement analysis.

It is necessary that each measurement location is easily identified using the photographs and sketches/ plan drawings. A measurement pack will be made up for each location to record the measurement information.

2.2 Test Measurement Setup



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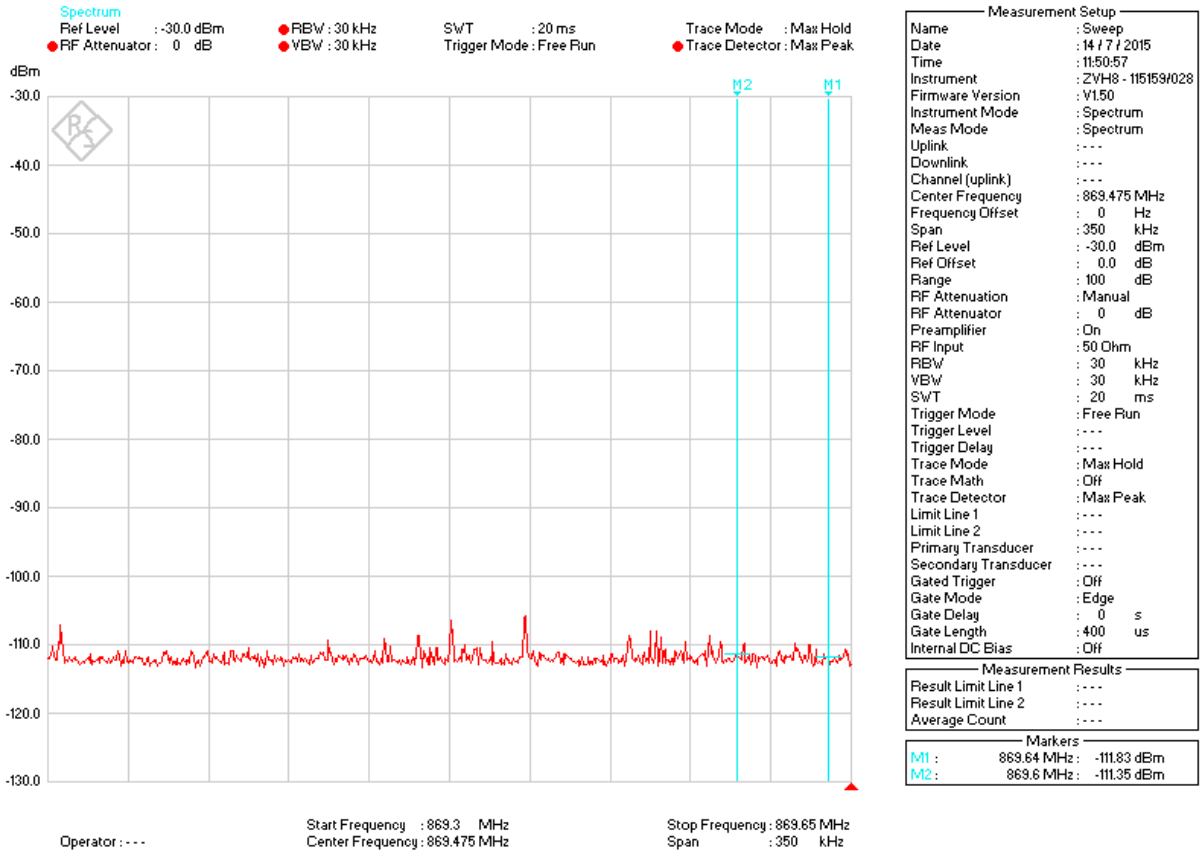
3 Test Procedure

3.1 Procedure for the Selection and Setup of Transmitters

Before setting up and transmitting the two CW measurement signals Tx1 and Tx2, a sweep of the spectrum is carried out using the spectrum analyser. This is undertaken at each MDU site to check for radio activity and RF interference in the 868MHz band.

To comply with the licence conditions, CEPT/ERC Recommendation 70-03 and the interface requirements in Ofcom document IR2030 for operating in the 868MHz band, the choice of the two CW frequencies is limited to between 869.400MHz and 869.650MHz. The two frequencies selected must be chosen to avoid interference to other services and with as large as possible frequency spacing between them.

The spectrum sweep must be saved to file and the selected two CW frequencies documented.



The above shows a typical spectrum sweep. In this example, the analyser span was set between 869.300MHz and 869.650MHz to confirm if there were any radio services operating just below 869.400MHz. The following two spot frequencies could be selected due to no other radio services being present and minimal RF noise.

Transmitter	Frequency
Tx 1	869.640 MHz
Tx 2	869.450 MHz

3.3.1 Selection of Transmit Frequencies

- Using the 868MHz antenna connect to the spectrum analyser – ZVH8
- Switch on analyser and press the pre-set button to ensure the analyser is set with the default settings
- Enter Mode

  Set to spectrum analyser (F5)
- Enter frequency/Dist. Mode.

  Set start frequency (F3) – 869.400MHz

  Set stop frequency (F4) – 869.650MHz
- Enter Sweep/BW

  Set manual RBW (Resolution Bandwidth, F1) – 30 KHz

  Confirm/set VBW (Video Bandwidth, F3) – set 30 KHz
- Enter Scale/Amp

  Enter RF, Attn/Amp/Imp (F5) –

  Set pre-amp ON

  Confirm/set RF Attn – 0dB (confirm value in upper left corner of screen

  Confirm/set Ref level - -30dBm
- Enter Trace

  Enter Trace Mode (F1)

  Set Max hold

  Confirm/set Detector (F2) – Max Peak

  Assess activity within band two select the two CW transmit frequencies (Tx1 and Tx2). - Maintain as large as possible separation between both frequencies.

  Use the Maker function (marker button) to identify the two frequencies using M1 and M2 (use marker type to select and activate M2).
- Record the screen shot using the camera button. Make a record of the file name and selected frequencies.
- Once complete, revert the analyser back to the following settings:

- Trace mode – Clear/write
- Detector – RMS

Once the two CW signals are selected, the signal generators (Tx1 and Tx2) and associated antennas are set up using the following procedure to ensure that the correct calibrated signal is radiated from each antenna.

3.3.2 Setup and Calibration of Transmitters

The main components are:

- ENI 6071-01, 7 watt UHF power amplifier (s/n: 162)
- R&S SMBV-100B signal generator (s/n: 256587)
- Anritsu MG 3695A
- 2 x 868MHz ENF900 dipole antenna (s/n: 11911 and 11883)
- 2 x nylon tripods
- 2 x antenna clamps
- Short N-N RF cable
- 2 x long (dark blue) N-N RF cables
- Mains cables etc

Note:- It is important that care is taken during the set up and calibration process to ensure that the power amplifier is not transmitting with no antenna/load connected at the output and that the spectrum analyser is not subjected to any high input power likely to cause front end damage.

The transmitter configuration comprises of:

- The SMBV-100A connected to the power amplifier to enable transmission of a 500mW (27dBm) CW signal fast fade and range test measurements (Tx1).
- The Anritsu MG 3695A is used for the second CW transmitter transmitting 100mW (20dBm) for the fast fade measurements (Tx2)

3.3.3 Tx Calibration and set up procedure

Tx 1 – SMBV-100A

- Make sure the amplifier and SMBV are powered off.
- Connect up the Power amplifier to the SMBV-100A
- Connect a short length RF cable between the RF-out of the SMBV and the RF-in of the power amp.
- Use the longest dark blue RF cable and connect to the amplifier RF output.

- Connect a 10dB pad between the spectrum analyser and the free-end of the RF cable connected to the amplifier. – **Make sure that the RF amp is off**
- Set SMBV signal generator RF output level to -40dBm. Using the curser arrows move the cursor to enable the output level adjustment of tens and units.
- Set the SMBV signal generator to the Tx1 frequency
- Press the analyser pre-set button to revert to the default settings.
- Press Freq Mode button
- Enter Centre frequency – Tx1
- Enter span – 1MHz
- Confirm/enter detector – RMS
- Change Ref level - +20dBm
- Press RF Attn/Amp (F5) Confirm set attn. +40dB
- Confirm Pre-amp OFF
- Confirm set up is OK and that all cables are terminated and that RF output from SMBV is set at -40dBm
- Switch ON Power amplifier
- Switch on SMBV RF output
- Confirm that a CW signal is being measured on the spectrum analyser.

Note: - The Analyser accounts for the internal 40dB pad so this does not need to be included in the measurement calculations.

Allowing for the 10dB pad and the gain to be provided by the antenna as stated increase the output power on the SMBV using the curser keys until the correct power is measured by the analyser.

Typically this is:

+20dBm (from antenna) – antenna gain (nominally ~2.5dB but confirm the exact value of the antenna gain for that being used) – 10dB (pad) =~ 7.5dBm on analyser.

(The loss of the RF cable is accounted for within the measurement process)

For other transmitter powers the following applies:

25mW = +14dBm (radiated)

100mW = +20dBm (radiated)

500mW = +27dBm (radiated)

- Turn RF off on the SMBV
- Switch off power amplifier

- Disconnect the spectrum analyser
- Connect the RF cable to the antenna.

Tx2– Anritsu 3695A

- Connect the shorter dark blue RF cable to the RF-out of the Anritsu.
- Using the curser keys set the RF level to 0dBm (No power amp).
- Set the frequency to Tx2.
- Connect the spectrum analyser to the dark blue RF cable free end.
- Switch on RF output.
- Confirm that signal is being measured on the spectrum analyser.
- Adjust the power on the Anritsu using the curser keys until the correct power level is measured.
- Switch off RF and disconnect spectrum analyser.

Set up the two transmitter antenna tripods and orientate the antenna to be in the horizontal plane. Position the both antenna (Tx1 and Tx2) in the agreed indoor and outdoor locations. Confirm that the antenna reference line mark is aligned and facing upwards. Connect up the signal generators.

3.3.4 Sanity Check Test for Spectrum Analysers

Prior to making any fade measurements it is necessary to check that both analysers (Team-A and Team-B) are operating as correctly and that are no measurement anomalies between both units. This is achieved by carrying out a line of sight path loss measurement with both units.

Position the receive antennas from both analysers at the same distance from one of the transmit antennas and confirm that the measured magnitude of the received signal on both analysers is the same and as expected.

1. Adjust the height of both receive antenna tripods to the same height as that of the transmit antenna.
2. Measure out the distance between the transmit antenna and the two receive antennas – typically use a distance of say 3m.
3. Set up the spectrum analysers as follows:

   Attn = 0dB
   Ref level = -40dBm
   Detection = RMS
   Pre-amp = No
   RBW = 10 KHz
   VBW = 100 KHz
   Centre frequency as CW Tx

Span 1MHz
Max hold

4. Calculate the link budget:

   Free space path loss FSL = 32.4+20log f +20log d
   Where f (MHz) and d = Km (the frequency being either Tx1 or Tx2)
   For 3m distance this is ~40.8dB.
   Therefore +20dBm – 40.8 + antenna gain (~2.5dB) – cable loss (~-0.8) = ~ -19dBm
   Confirm this is measured by both analysers and respective antenna.

5. Check that both analysers have the same parameter settings. Record the time and measurement. - Do not start taking making measurements unless satisfied with the sanity check results. The analysers should be within ~1dB of each other.

3.3.5 Measurement Procedure

To account for the multipath characteristics at a given measuring location a methodology to measure fast fade effects has been established using the purpose fabricated antenna tripod. This allows for 360º rotation of the receive antenna around a radius to capture the max and min signal strength with the antenna in either horizontal or vertical planes. Measurements are made setting the analyser to zero-span – i.e. to act as a measurement receiver (time domain).

The spectrum analyser parameters are as follows:

Zero Span
Sweep = 10secs (to allow for ~ 5 rotations of the antenna)
Attn = 0dB
Ref Level = -40dBm
No pre-amp
RBW = 10 KHz
VBW = 100 KHz
Frequency – Tx1 or Tx2 depending on which is being measured

Method

- Confirm the location for making the signal measurements is correct and as detailed in the site survey. Use the pro-forma template to add the details required for the measurements.
- Take photographs of the each measurement location and record the location, date and time photograph was taken. It is important that the measurement location can be referenced the site map and that the height from ground can also be confirmed.
- Set the analyser to zero-span and the center frequency to the Tx being measured.

- Set the analyser to single sweep/ trigger and record the signal level as the antenna is rotated. Make sure the sweep measurement is saved and that the file name is recorded on the measurement sheet.
- Measurements are made for both Tx1 and Tx2 and for horizontal and vertical antenna orientations. - Four measurements will be recorded.

Figure1 shows the typical fading measurement sweep with the varying peaks and nulls as the antenna is rotated. Figure2 illustrates the measurement setup.

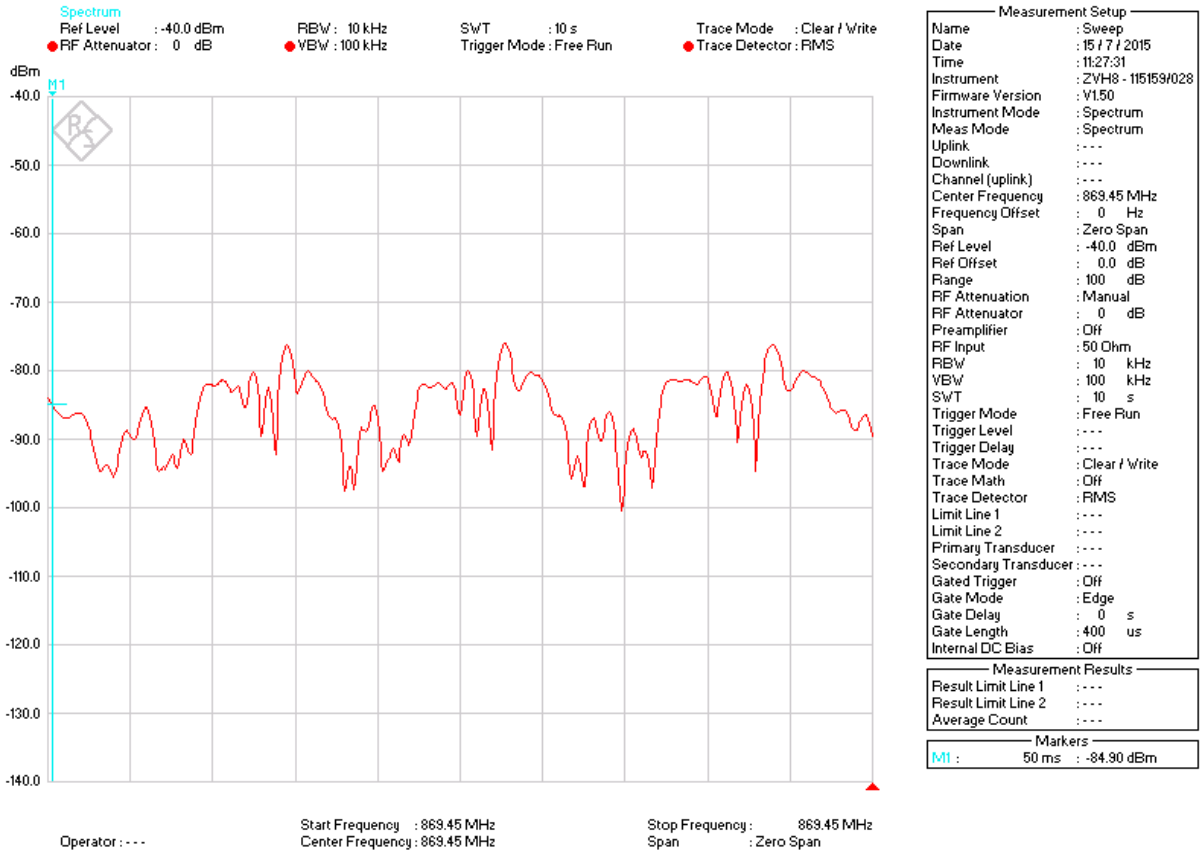


Figure 1 typical sweep measurement as the antenna is rotated

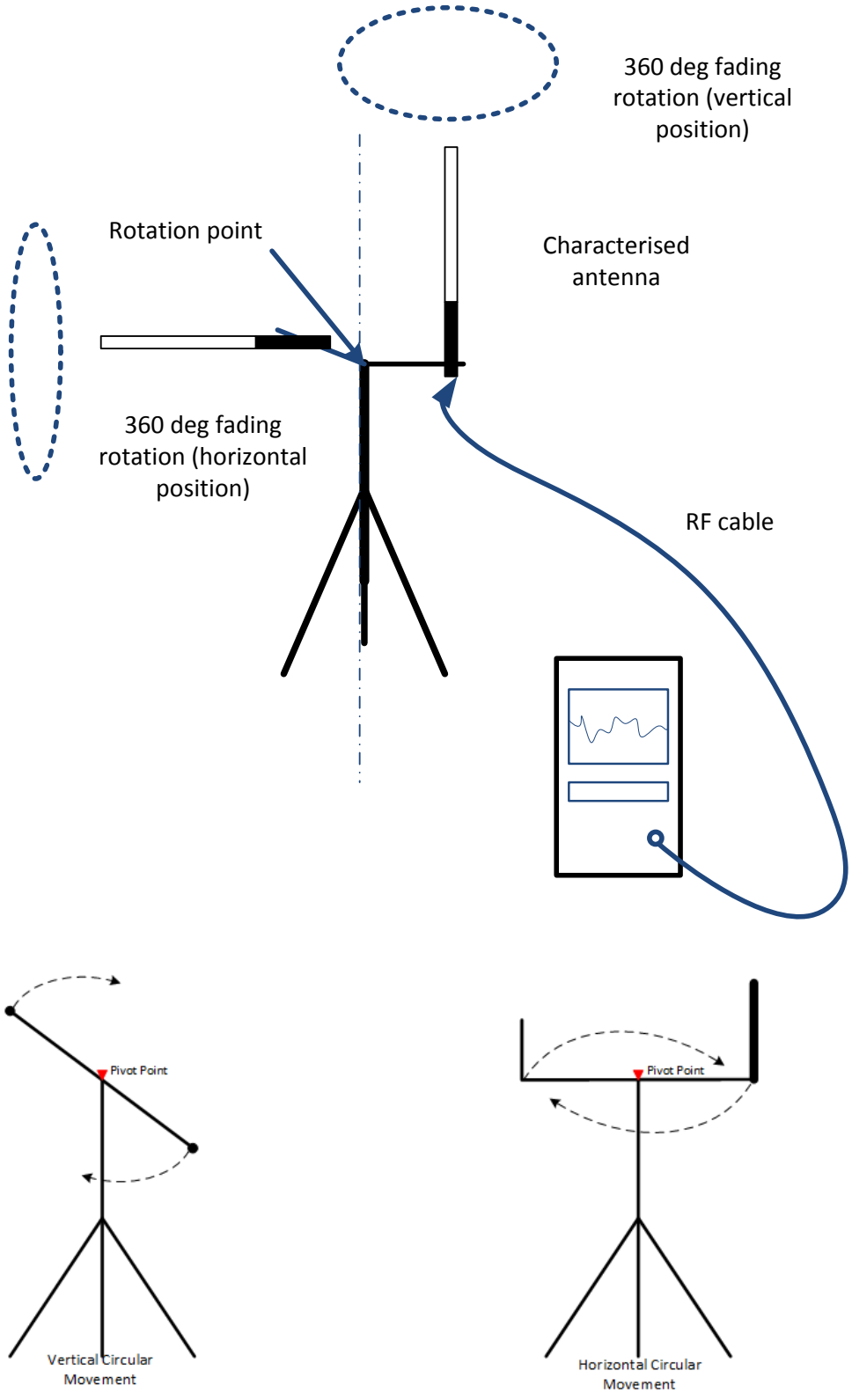


Figure 2 Fast Fading Effect Measurement Arrangement

3.3.6 Range Test Measurement Procedure

At a number of agreed sites a range test is to be carried out using the CRFS node mobile measuring receiver/data recorder and GPS logger. This is used record the signal level against a GPS location as the user walks around to generate a signal coverage map. This measurement requires the transmitter to be located at height and with the transmit antenna vertically orientated. The transmit power is set for 500mW (27dBm) radiated from the antenna.

4 Appendix A – 868MHz Channel Plan