MOBILE APPLICATION FOR RF CALIBRATION IN RADIATION MODE

S. Aruna, Dept. of ECE, AU College of Engineering, Visakhapatnam
S. Sudha Rani, DLRL, Hyderabad
Niranjan Prasad, DLRL, Hyderabad
G. Sasibhushana Rao, Dept. of ECE, AU College of Engineering, Visakhapatnam

ABSTRACT— This paper brings out the design of an application to calibrate the testing of an RF receiver consisting of an antenna and an RF amplifier in radiation mode. Due to the far field distance requirement between the transmission antenna and the receiving antenna, an application is required to compute the distance between the transmitter and the receiver. This application is built around two features: a step counter and a calculator. Step counter determines the distance between the antenna and the receiver using the number of steps taken between transmission antenna and the RF receiver. The measured distance is further used to calculate different parameters of an antenna and receiver using the calculator. Using these parameters, the receiver test setup can be calibrated by calculating the signal strength, error rate, path loss, antenna gain, power received etc., based on which the RF receiver testing can be automated.

1. INTRODUCTION

Testing an RF receiver consisting of antenna and RF frontend system is a tedious process [1]. The receivers consist of various modules such as antennas in the desired frequency band of operation, frontend receivers for downconverting to the required lower IF frequency and output display mechanism for the measured parameters. To test the receiver including the antenna in the radiation mode, the RF receiver is initially located in an isolated region, free from reflections and multipath. The transmitter used is a directional antenna, which operates in the desired frequency band of operation. The test process has to be carried out over the band of frequencies and the received power at the antenna has to be calculated. This needs to be repeated over the azimuth and performance of the receiver is measured. Before the actual testing of the receiver is carried out, the transmission setup has to be calibrated, This paper details a mobile based application developed for calibration of the test setup of the receiver by taking into consideration the various parameters involved, such as antenna gains, distance between the transmitter and the receiver antennas, frequency of operation, etc.

2. PROBLEM STATEMENT AND PROPOSED FRAMEWORK

2.1.1. Current Testing Process

The first step in the testing process is the measurement of the distance between antenna and receiver. Currently the measurement is carried out manually using measuring tapes etc.

The second step in the testing process is to measure the power received at the receiver's input using a matching antenna and using a spectrum analyser. The measurements are noted down manually or automatically. Based on the antenna gains, the path loss is used to calculate the received power and matched with the received power.

2.1.2 Proposed System

The basic block diagram of the test setup is shown in Fig. 1. The radiating antenna is fed from a signal generator and transmits a power P_t. The transmitted power is received at the RF receiver antenna through the distance D_n. This application provides a basic methodology for measurement of distances, path loss based on antenna gains, and the frequency of operation. All the equations used in this paper have been taken from [2].

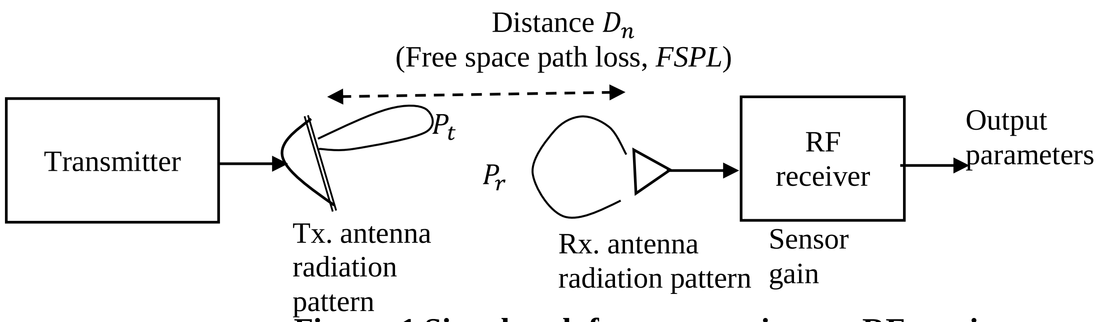

Figure. 1 Signal path from transmitter to RF receiver

The relation between the radar transmitted power and the received power at the sensors is given by

$$P_r = P_t - FSPL \qquad (1)$$

Where,

P_t is the transmitted power;

$FSPL$ is the free space path loss from the transmitter to the RF receiver given by,

$$FSPL = 20\ log_{10} D_n + 20\ log_{10} f + 20\ log_{10} \frac{4\pi}{c}\ ; \qquad (2)$$

f is the frequency of operation,
D_n is the distance,
c is the speed of light.
All the parameters in Eq. 2 have to be measured and computed.
The application incorporates measurement of all the required parameters and computes the FSPL.

The user enters the required inputs and the output is calculated and displayed on the application user interface. In addition to the required parameters for the calibration, the user is also provided with other formulas and conversion factors of interest. This application has been developed on Android Studio [3].

2.2 Realisation of the application

The following sections detail the realization of the application for estimating the various parameters.

2.2.1 Icon of the application

The icon of the application for displaying is shown in Fig. 2.

Figure 2. Icon of the application

2.2.2 Login activity

The first activity of this application is the login activity as shown in Fig. 3. One can use this application only if he or she is an authenticated user. This activity has a login text field and a password field. Only after Login and password match with the database the user is provided access to the application.

Figure 3. Login Activity

2.2.3 Menu activity

The two main features of this application are: step counter and the calculator as shown in Fig.4. This menu activity consists of two buttons and when either of the buttons is selected, respective intended activity is accessed. When the step counter button is selected, the step counter is activated and counts the number of steps to estimate the distance walked. When the calculator button is selected, various formulas to calculate the required parameters are shown.

Figure 4. Menu Activity

2.2.4 Step counter

The step counter in the application uses the gyroscope, accelerometer, GPS and other sensors to detect if the user is mobile. As the user walks, the sensor suite collects data points based its position in space, and the velocity it senses as the user moves. Based on the change in sensor it will conclude whether a step is taken or not. The aim of using the step counter is to determine the distance between the transmission antenna and the receiver as the user walks between the two locations. The number of steps between the two are logged and multiplied with the step size of the user to get the distance.

The activity consists of two buttons, start and stop. On selection of start, the counting the steps is initiated and on selection of stop the number of steps is logged and distance is displayed after multiplication with the step size of the user.

Figure 5. Step counter Activity

2.2.5 Calculator

This activity consists of many formulas to determine different parameters of the antenna and the receiver which are of general interest to the user as shown in Fig. 6.

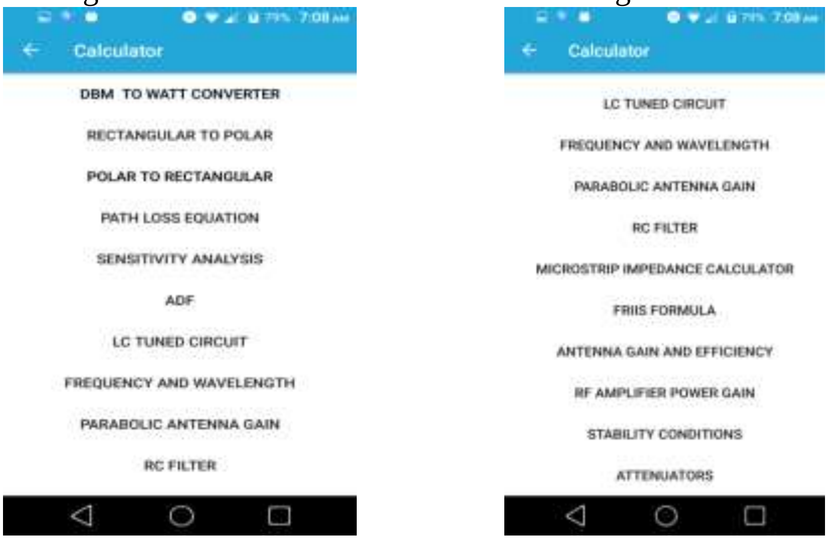

Figure 6. Calculator menu Activity

2.2.6 dBm to Watt converter

The activity for dBm to Watt converter is shown in Fig. 7. The user enters the dBm value and the application converts to Watts.

Formula:-

$$P\ (\text{watt}) = \frac{10^{\frac{P(dBm)}{10}}}{1000}\ \text{watt}$$

Example:- 25 dBm to watt

$$P\ (\text{watt}) = \frac{10^{\frac{25}{10}}}{1000} = 0.3162\ \text{watt}$$

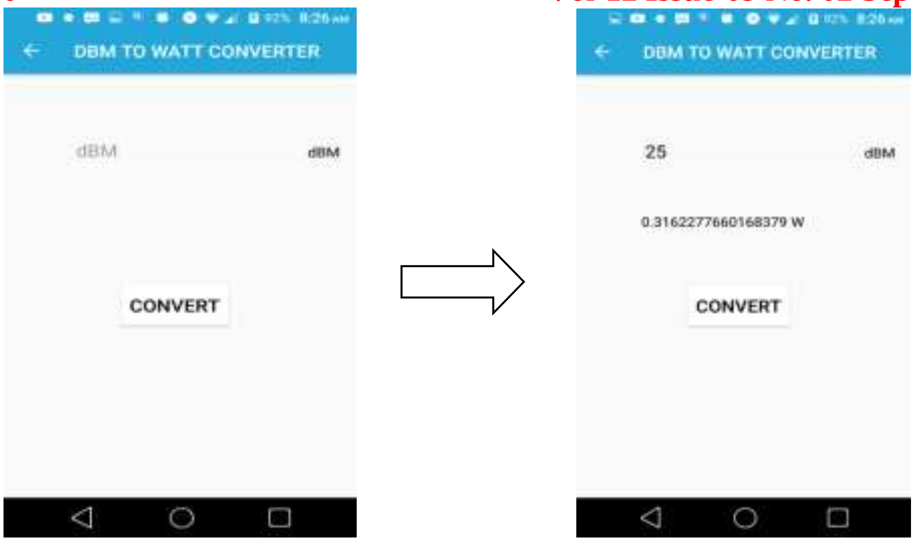

Figure 7. dBm TO WATT converter Activity

2.2.7 Path loss equation

The free space path loss, also known as FSPL is the loss in signal strength that occurs when an electromagnetic wave travels over a line of sight path in free space. In these circumstances there are no obstacles that might cause the signal to be reflected refracted, or that might cause additional attenuation. Free space path loss calculations do not include any factors relating to the transmitter power or antenna gains, which are added separately. The activity is shown in Fig. 8.

Figure 8. Path loss equation Activity

2.2.8 Parabolic antenna gain

Parabolic reflector antenna gain is one of the key parameters in the application. These types of antennas are mostly used in the radiation mode testing due to the high gain that can be obtained. The parabolic antenna gain can be calculated from a knowledge of the diameter of the reflecting surface, the wavelength of the signal, and a knowledge or estimate of the efficiency of the antenna as given in the activity of Fig.9.

$$\text{Gain } G = 10 \log_{10} k \left(\frac{\pi D}{\lambda} \right)^2$$

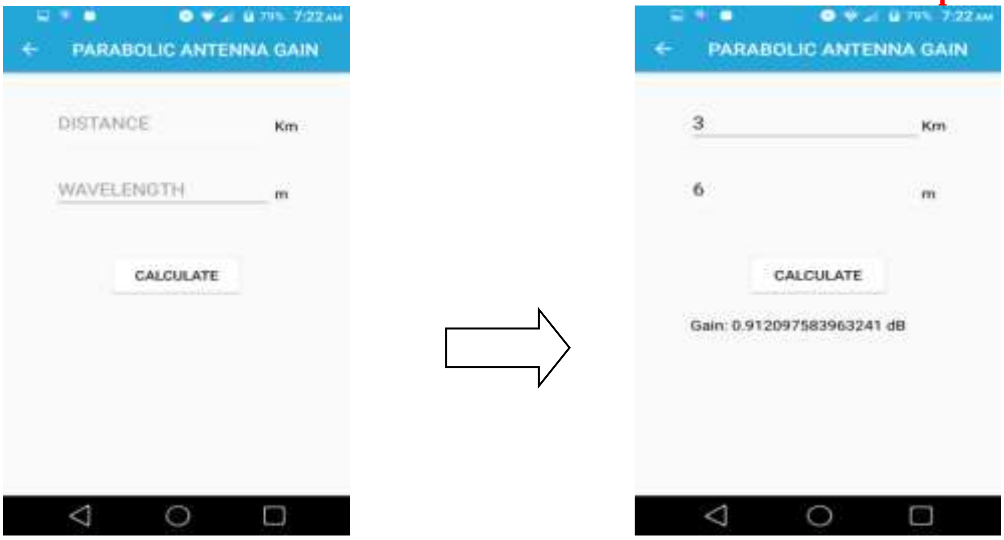

Figure 9. Parabolic Antenna Gain Activity

2.2.9 Friis formula

The activity for Friis formula is shown in Fig. 10. The FRIIS Equation is used to calculate the power received from one antenna, when transmitted from another antenna separated by distance R, frequency f and wavelength lambda

$$P_R = \frac{P_T G_T G_R \lambda^2}{(4\pi R)^2}$$

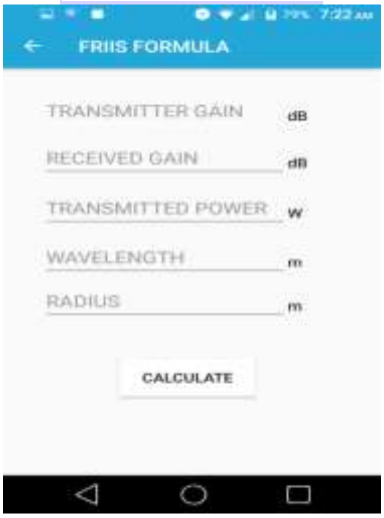

Figure 10. Friis Formula Activity

2.2.10 Antenna gain and efficiency

The efficiency of the antenna is related to the power delivered to the antenna and the power radiated from the antenna.

$$\varepsilon_R = \frac{P_{radiated}}{P_{input}}$$

Antenna gain describes how much power is transmitted in the direction of peak direction to that of an isotropic source.

$$G = \varepsilon_R D$$

The activity is shown in Fig. 11.

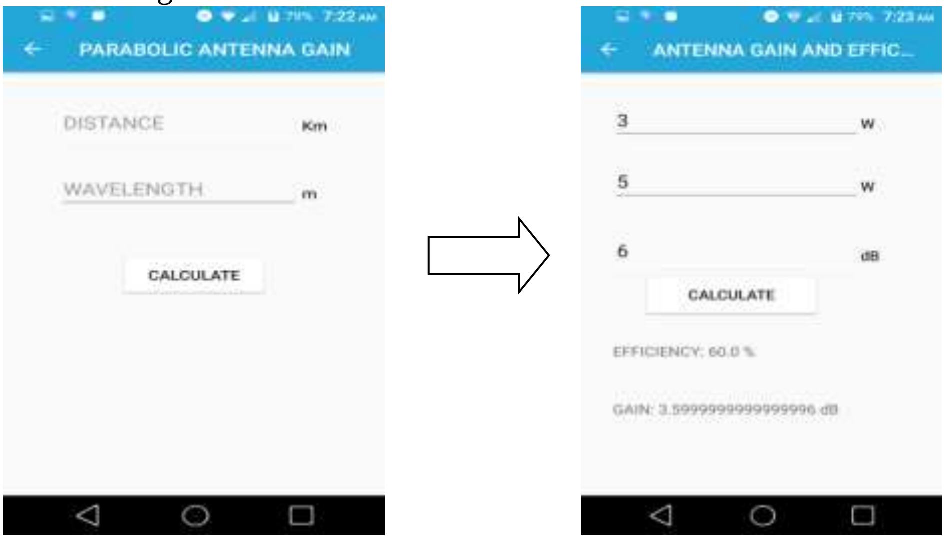

Figure 11. Parabolic Antenna Gain Activity

2.2.11 Results

The generated data during the process of testing is logged and retained in a data base, which can be accessed during the RF receiver testing. The data can also be transferred to a data file or a spread sheet for further processing and integration in to the measurements during the actual receiver testing.

CONCLUSION

In this paper, the design of an application for calibration of test setup required for RF receiver testing in radiation has been presented. The signal strength, path loss, antenna gain, power received etc., which are the major parameters of the radiation mode testing can be logged and testing can be automated. In addition to all the features required for calibration, the application also includes various calculations required for an RF engineer during day-to-day activities.

REFERENCES

[1] RF Transceiver Test Procedure | How to test RF Transceiver | measurements (rfwireless-world.com) www.rfcafe.com
[2] C.A. Balanis, " Antenna Theory: Analysis and Design", Wiley, 2016.
[3] https://developers.android.com