Secured Communication using Programmable Devices for IOT Applications

Nanda Kishore Holla, Siva Yellampalli

Abstract: ***This technical paper illustrates about the implementation of a system to have secured communication between the devices used in IOT applications. The proposed method use Transmitter and Receiver designed with Programmable Modulator & Demodulator which work on Software Defined Radio (SDR) technology. At Internet of Things (IOT) environment, output from the devices are captured and transformed into a required frequency just before modulation and transmission. At the receiver, the signal is demodulated and reconditioned to process it further.***

Index Terms: *ATSC, IOT, SDR, QAM, QPSK*

I. INTRODUCTION

Sensors, Processors, Gateway & Application are building blocks of IOT. There are various methods available to communicate between sensors and processor or processor and gateway. Proposed method is to use a programmable Transmitter and Receiver to communicate between sensors and processors or between processor and gateway. The communication is through modulated RF signal. Secured communication between devices is one of the most important requirements in IOT application, which is addressed by means of custom modulation.

Many communication technologies like Wi-Fi, Bluetooth, ZigBee and 2G/3G/4G cellular, are in use for the IOT application. Depending on the application and the required factors such as range, data requirements, security, power demands and battery life, different technologies are being used. Each technology has its own merits and demerits and engineers need to select the communication technologies based upon the requirements or an application. Secured communication between the sensor and receiver is very much essential in many applications.

In the proposed approach, programmable Modulator and Demodulator are used in the system architecture, which work on Software Define Radio Technology (SDR) [1]. In this method, it is possible to select the required modulation method Symbol rate and Frequency of operation depending on the application. The one to one communication between Transmitter and Receiver is possible to adapt required security.

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II. METHODOLOGY

The aim is to design a Trans-receiver system using Software Defined Radio (SDR) based Programmable Modulators and Demodulator to establish point to point secured communication between the devices and adapting the system for IOT environment.

A. Transmitter Design

In this section we discuss about the Transmitter system design, which consists of programmable Modulator, IQ Modulator, Filter & Power amplifier connected to antenna. The top level architecture of the Transmitter block is shown in Figure 1.

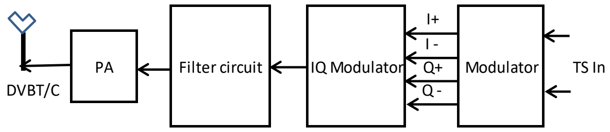

Figure 1: Block diagram of Transmitter architecture

B. Programmable Modulator

Programmable Modulator process transport stream and gives out I & Q signal. The modulator work on Software Defined Radio (SDR) based technology. Different types of modulation can be programmed such as QAM, ATSC, QPSK etc. Software defined radio (SDR) technology enables many waveforms to be processed by a single hardware platform by simply changing its programming.[2],[3]

- The parameters need to be defined for the modulators are:
- Type of modulation
- Frequency of transmission
- Symbol rate

The output from the Modulator is processed at IQ Modulator or the Frequency up converter. The programming is controlled through IIC. Modulator is to be connected to USB Controller & required software need to be downloaded into the device. Architecture of SDR Modulator consists of DSP Encoder, Modulator and Signal conditioners, which gives out IQ signal. The programmability brings the flexibility to get different types of signals.

C. IQ Modulator or Frequency up converter

The output from the Modulator is a differential signal called as I & Q, which is processed at IQ Modulator or Frequency up converter, as it up converts the signal to place in the band of 50 MHz to 1000 MHz.

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It consists of Amplifiers, Mixers & Oscillator and the operation is controllable through IIC [4]. If the analog output to be processed, then it is to be first up converted to Low IF range of about 5 to 10 MHz and then should be converted in to digital Transport stream using Programmable Modulator.

D. Harmonics suppression Filter

Third harmonics generated during frequency up conversion process need to be suppressed before amplifying the signal. The Filter bank is designed with set of 3 to 4 Filters [5]. Depending on the frequency of operation, the Filter will be switched ON. For example, Filter 1 works up to 100 MHz, Filter 2 works up to 200 MHz and Filter 3 works up to 350 MHz input and suppress the Third harmonics by 30 db minimum [6]. Since the desired frequency of operation is 50 to 1000 MHz, no need to use filters above 350MHz, as the third harmonics falls above 1000 MHz for the input signal of 350MHz [7].

E. Amplifier

Wide band general purpose amplifier is used to get typical 10 d B gain for the frequency of 50 to 1000 MHz. Generally, to transmit the signal over air, DVBT signal is used with antenna connected to amplifier. Depending on application and the signal level requirement, the gain of the ampler can be varied.

F. Receiver Design

Receiving system architecture consists of Tuner, RF Programmable Demodulator & Decoder as shown in Figure 2. Tuner gives out Intermediate frequency (IF) & processed further at Programmable Demodulator [8]. Depending on the type of signal, Frequency and the symbol rate, demodulation process is carried out, selecting the appropriate program. The demodulator gives out digital Transport stream or analog CVBS and SIF, which will be handled by decoder.

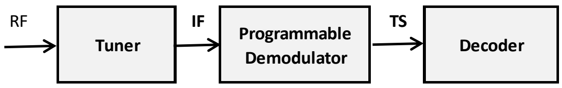

Figure 2: Receiver architecture

G. Tuner

Tuner will receive RF and convert it in to Intermediate Frequency or IF. The frequency of operation can be 50 MHz to 1000 MHz. The Tuning operation is controlled through IIC data. Any silicon Tuner can be used for this purpose [9]. While selecting the Tuner, the critical parameters need to be considered are, Power Gain, IF Rejection, Image Rejection, and Noise Figure etc., [10]. If the frequency of operation need to be extended up to 2.5 GHz, with DVBS Modulation scheme, then DVBS Tuner need to be used. The Modulator and Demodulator are capable to perform DVBS modulation and demodulation process with relevant software.

H. Programmable Demodulator

The output from the Tuner may be a balance IF or Unbalance IF, depending on the architecture of the Tuner, which will be processed at SDR based Programmable Demodulator. Its operation is controlled through IIC and program need to be selected depending on the type of demodulation. Suppose if the input signal DVBC, then the QAM demodulation process to be implemented. This process is exactly the opposite process what is been implemented in Programmable Modulator.

Hence the parameters need to be set for Demodulation process will depend on the parameters used for Modulation process. Otherwise, received signal cannot be detected and processed further. Critical parameters like Signal frequency, Modulation type and symbol rate have to be exactly match with the similar parameters set at Transmitter. Required software need to be downloaded into the demodulator through USB port. The output from the Programmable Demodulator is a Digital Transport Stream, which will be decoded and analyzed in next stages.

I. Decoder

Commercially available Decoder can be integrated with Demodulator. The digital Transport stream from the Demodulator is further processed at Decoder to get the original Transmitted Signal. Decoder output to be used for any signal analysis if required.

J. Adapting the Trans receiver for IOT environment

The designed Transmitter and Receiver systems can be adapted for IOT environment. If the system is to be used for IOT applications, then output from the sensors or processor are to be converted in to analog or digital signal using Signal conditioner block as shown in Figure 3. If multiple sensors outputs are to be handled, then the processor to be used along with the sensors, which is optional and required depending on the applications.

Figure 3: Transmitter for IOT applications

The conditioned signal is digital transport stream, which is handled by SDR Modulator embedded inside the Transmitter block. The transmitted RF is received by the receiver which consists of Tuner and demodulator as shown in Figure 4. The Demodulator output is handled by Signal conditioner which gives out signal as per the user requirement to activate or control any device as per the requirement and it can be connected to the analyzer depending on the application.

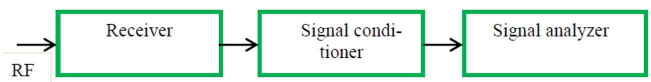

Figure 4: Receiver for IOT applications

III. RESULTS

The performance of Transmitter and Receiver system is evaluated with different types of signal and for the frequency of 50 to 900 MHz operation range.

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Critical parameters of the Transmitter are:

- MER (Modulation Error Ratio) and BER (Bit Error Ratio)
- Output level from the Amplifier

Critical Parameters for the receivers are:

- Power Gain
- Image Rejection and IF rejection
- Noise Figure

Target specifications are:

- Tuner Power Gain : Better than 80 dB
- Tuner IF rejection : Better than 60 dB
- Tuner Image Rejection : Better than 60 dB
- Noise Figure : Less than 8 dB
- MER : Better than 30 dB
- BER : Less than10.0 E-06
- Output level : Better than -10 dBm

The Transmitter and Receiver system are fabricated and Programmable devises are programmed with required software. The critical parameters measured for the Transmitter are shown in Table 1 and Table 2 which meet the target specification.

Table1: Receiver section Parameter measurement

Frequency. [MHz]	Power. Gain [dB]	Image Rejection [dB]	IF Rejection [dB]	Noise Figure [dB]
50	90	65	65	5.5
200	89	70	>70	6.0
500	92	68	>70	6.5
850	91	67	>70	6.0

Table 2: Transmitter section measurement

Signal DVBC		MER [dB]	BER	Output [dB m]	
64 QAM,	50 MHz	37.2	2.0 E - 06	- 5.0.	
128 QAM	100 MHz	38.4	3.0 E - 06	- 8.0.	
256 QAM	200 MHz	37.4	3.0 E - 06	- 6.0.	
256 QAM	800 MHz	38.2	2..0 E- 06	- 5.0.	

The communication between the Transmitter and Receiver are checked for various signal frequencies, Symbol rate and the different types of modulation. It is confirmed that the one to one communication is possible between the Transmitter and the Receiver, only if Frequency, Symbol rate and Signal Modulation match each other. The operation range of about 10 meters is achieved with signal output level of – 5 to 0 dBm. The system performance is checked at IOT environment controlling some of the device operations.

IV. CONCLUSION

Programmable devices which work on SDR based technology can be used for Trans-receiver applications. It brings flexibility to select the frequency and modulation type required for communication depending on the available device and an application environment. The SDR based system can easily adaptable to use in IOT applications by integration of signal conditioners. The frequency of operation ranges from 50 to 900 MHz and it can be programmable based on the application requirements. The designed system meets the required industry standards and can be used for commercial and military applications

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