Table of Contents

Chapter 3
Design and Analysis of Transmitters and Transceivers in Wireless Modules

3.1       Wireless Communication with Transmitters 41
3.2       Design and Construction of Transmitter Modules 41
3.2.1     Block Diagram Explanation 42
3.3       Wireless Communication with Receivers 44
3.3.1     Block Diagram Explanation 45
3.4       Wireless Communication with Transceivers 46
3.4.1     Design and Construction of Transceiver Modules 46
3.4.2     Block Diagram Explanation 47
Chapter 3

Design and Analysis of Transmitters and Transceivers in Wireless Modules

3.1 Wireless Communication with Transmitters
A radio system usually includes a source of electromagnetic wave with a planned destination for that message. A source radio is referred to as the transmitter while the destination radio is called the receiver which is designed and assembled from core components. There are many wireless transmitters and receivers available such as RF, Zigbee, Bluetooth, GT (FM), etc., which are interfaced to process the data from source to destination – as an example – the digital data transfer from the microcontroller to the receiver.

3.2 Design and Construction of Transmitter Modules
The transmitter modules like RF, RFID, GPS, etc., are constructed with Mixer or modulator, crystal oscillator, power amplifier and filter circuits. The transmitters work with the analog signals so we cannot directly interface to the digital devices like microcontrollers.
3.2.1 Block Diagram Explanation
The block diagram mainly consists of three blocks that are microcontroller block, digital to analog converter and transmitter blocks.

Microcontroller Block
This block is constructed with a microcontroller like PIC, 8051, AVR and ARM based on the requirement for controlling the application. The microcontroller is a digital device: it sends and receives only digital data like ‘0’ and ‘1s.’

Digital to Analog Converter
A digital to analog converter converts digital data into equivalent analog voltage or current. The digital to analog converter is made with Op-Amp and binary biased registers, as shown in the figure. In the circuit, the op-amp is connected in an inverting mode. The circuit diagram represents 4- digits converter.
For example, the digital device generates ‘1101’ binary value that converts to give a corresponding analog value like 13v.
**Wireless Transmitter Module**

Modulation is a process in which a modulator changes some quality of the higher-frequency carrier signal related to a lower-frequency signal, and then mixes the high-frequency signals in the modulator.

**Amplifier**

An amplifier is an electronic device that increases the signal power. There are four basic types of amplifiers such as voltage amplifier, current amplifier, conductance amplifier and power amplifier. The power amplifier is a basic amplifier that receives electrical signals and processes them to amplify.

**Band Pass Filter**

A band-pass filter is a device that passes frequencies within certain range and rejects frequencies outside the range. The main function of the band-pass filter is to limit the bandwidth of the output signal to the band allocated for transmission.
Antenna:

The antenna is an electrical device that performs two functions in communication:

For transmission of a signal, radiofrequency's electrical energy from the transmitter is converted into electromagnetic energy by the antenna and radiated into the surrounding environment (atmosphere, space, water).

For reception of a signal, electromagnetic energy imposes on the antenna is converted into radio-frequency, electrical energy and fed into the receiver."

Operation of Transmitters:
The Transmitter module is interfaced to the microcontroller with the help of a decoder. The microcontroller sends digital data to the decoder. The decoder converts the binary data into a current signal which passes through the modulator wherein high-frequency signals from the oscillator are also received. These two signals are mixed, and then passed through the amplifier. Amplifying the transmission signals through an amplifier increases the strength of the signals. The band pass filter allows the signals with two specific frequencies like 433MHz – 868 MHz to pass and reject the frequencies outside the range. The antenna radiates power in the air.

3.3 Wireless Communication with Receivers
Design and Construction of Receiver Modules:
The Receiver modules are constructed with Band-pass filter, Low-noise amplifier, Mixer, low-pass filter and an analog to digital converter. The receivers working with the analog signals such as current signals or voltages cannot be directly interfaced to the digital devices that need some external devices such as encoders.
3.3.1 Block Diagram Explanation
The block diagram mainly consists of three blocks: microcontroller, analog to digital converter and receiver blocks.

Microcontroller Block:
This block is constructed with a microcontroller like PIC, 8051, AVR and ARM depending on the requirement for controlling the application. The microcontroller is a digital device; it sends and receives only digital data like ‘0’ and ‘1s’.

Analog to Digital Converter:
We already know that analog-to-digital (ADCs) converters are the most widely used devices to translate analog signals to digital numbers so that a microcontroller can read them easily. There are many ADC converters like ADC0801, ADC0802, ADC0803, ADC0804 and ADC080. As an example, the below figure depicts an ADC0804 converter. The above ADC0804 converter is a very commonly used 8-bit analog to digital converter. It works with 0V to 5V analog input voltage. It has a single analog input and 8-digital outputs. Conversion time is yet another major factor in judging the ADC. In an ADC0804, the conversion time varies depending on the clocking signals applied to the CLK R and CLK IN pins, but it cannot be faster than 110 μs.

A Wireless Receiver Module
Low Noise Amplifier (LNA):
A Low-noise amplifier is an electronic amplifier placed at the front-end of a radio receiver circuit to amplify a week signal by capturing it from an antenna. The effect of noise from the subsequent stages of a receiver chain is reduced by the gain of the LNA. Boosting of a desired signal power while adding as little noise and distortions as possible is possible with a LNA amplifier. A good LNA has a low NF for example 1db and a large enough gain of 20db.
**Low-Pass Filter**
A low-pass filter is a filter that passes low-frequency signals and reduces the amplitude of the signals with frequencies higher than the cut of frequencies.

**Testing Procedure of Receivers**
The A receiver module is interfaced to the microcontroller with the help of an encoder. The band pass filter allows certain frequency signals sent by the transmitter. The low-noise amplifier is used for increasing the signal strength and reducing the noise. The mixer generates high frequency signal by mixing the week signal with the high frequency signal (OSC). The ADC converts the current signals into digital signals like 0 and 1s format to control the applications by the processor.

**3.4 Wireless Communication with Transceivers**
The transceivers make with both transmitter and receivers within a single chip to transmit and receive the information in both ways like video, audio, text etc. In radio transceivers, a user is able to perform a wide range of functions for both the receiver and host of signals on radio frequencies. There are various kinds of transceivers available such as RF, Bluetooth, Zigbee, Wi-Fi, GSM, etc., which are interfaced to process the data from the source to destination.

**3.4.1 Design and Construction of Transceiver Modules**
The transceiver modules are constructed with Mixer, oscillator, power amplifier, band-pass filter, low-noise amplifier and low-pass filter. The transceivers work with two signals such as analog signal (current, voltage) and digital signal (0 or 1s). The transceivers consist of inbuilt ADC and DAC units, and therefore, don't need any external devices for processing the data and converting it into digital or analog data.
3.4.2 Block Diagram Explanation

**Digital to Analog Converter**
The digital to analog converter converts digital data into equivalent analog voltage or current. The digital to analog converter has Op-Amp and binary-biased registers, as shown in the figure. In the circuit, the op-amp is connected in an inverting mode.

**Modulator:**
Modulation is a process in which a modulator changes some qualities of a higher-frequency carrier signal related to a lower-frequency signal and mixes the signals.

**Amplifier:**
An amplifier is an electronic device that increases the signal power. There are four basic types of amplifiers: voltage amplifier, current amplifier, conductance amplifier and power amplifier. The power amplifier is a basic amplifier that receives the electrical signals and processes them to amplify.

**Band-Pass Filter**
The band-pass filter is a device that passes frequencies within certain range and rejects frequencies outside the range. The main function of the band-pass filter is limiting the bandwidth of the output signal to the band allocated for transmission.

**Antenna:**
The antenna is an electrical device that does the following two functions in communication:

- For transmission of a signal, radiofrequency's electrical energy from the transmitter is converted into electromagnetic energy by the antenna and radiated into the surrounding environment (atmosphere, space, and water).
- For the reception of a signal, the electromagnetic energy imposed on the antenna is converted into radio-frequency electrical energy and fed into the receiver.
**Low Noise Amplifier (LNA)**
A Low-noise amplifier is an electronic amplifier placed at the front-end of a radio receiver circuit to amplify a week signal by capturing it from an antenna. The effect of the noise from the subsequent stages of a receiver chain is reduced by the gain of the LNA. Boosting of a desired signal power while adding as little noise and distortions as possible is possible with a LNA amplifier. A good LNA has a low NF for example 1db and a large enough gain of 20db.

**Low Pass Filter**
A low pass filter is a filter that passes low-frequency signals and reduces the amplitude of signals with the frequencies high than the cut of frequencies.

**Analog to Digital Converter**
We already know that analog-to-digital (ADCs) converters are the most widely used devices for securing information and to translate analog signals to digital numbers so that a microcontroller can read them easily. There are many ADC converters like ADC0801, ADC0802, ADC0803, ADC0804 and ADC080.

**Testing Procedure of Transceivers**
The transceivers are interfaced to the microcontrollers without requiring any help of driver ICs. The information is transmitted and received by the antenna through electromagnetic waves at certain frequencies. The transmission and reception is not possible at a time by the transceivers. The microcontroller sends the digital data and transceiver converts that digital to analog signals through ADC which is then send to the air by the microwave antennas. This data received by the other transceiver controls the application or load.