Journal of Engineering Research and Reports

15(2): 28-42, 2020; Article no.JERR.59355
ISSN: 2582-2926

Design and Implementation of a Smart & Portable Wireless FM Transmitter for Wide Range Communication

Deborsi Basu[1*] and Abhishek Bhowmik[1]

[1]Department of Electronics and Communication Engineering, Heritage Institute of Technology, Kolkata, West Bengal, India.

Authors' contributions

This work was carried out in collaboration between both authors. Author DB designed the study, managed the literature searches, built the analytical model, performed the experimental analysis, executed the simulations and wrote the first draft of the manuscript. Author AB managed the analyses of the study and collected experimental data. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2020/v15i217142
Editor(s):
(1) Dr. Pierre-Olivier Logerais, Université Paris-Est Créteil, France.
Reviewers:
(1) Eid Rehman, Foundation University, Pakistan.
(2) Tommi Hariyadi, Indonesia University of Education, Indonesia.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59355

Original Research Article

Received 24 May 2020
Accepted 29 July 2020
Published 07 August 2020

ABSTRACT

The evolution of smart technologies makes end users to choose portable, cost-effective and reliable devices for their daily life usage. The optimum service and superior quality of any such devices are always remain the centers of attraction for any customer. The advent of new technologies gives the smart FM transmitters also a unique shape. Depending on the dynamic requirements, the customer needs always changes with time. Keeping this fundamental issue in mind, in this work, we have designed and implemented a smart FM transmitter model keeping the key features in mind. Its small size, long battery life, and easy portability make it very useful to be used in day to day life. It has the potential of real-time noise cancellation features to get the optimum sound quality at the receiver end. The Digital Frequency Modulation Scheme has been used here to boost the signal strength for long-range communication. The used components are very cost-effective and reliable for prolonged use. The test case has given high-quality sound reception at the receiving end from the source end using our model. This smart transmitter section model has been found to be very effective for the future digital communication system. The specific

**Corresponding author: Email: deborsibasu2015@gmail.com;*

station catching ability and low tone scanning capability make it superior to other existing similar kinds of devices. It can be used at home, or institutional premises, or any other distant trials for effective information exchange.

Keywords: Frequency modulation; digital communication; transmitter; receiver; noise cancellation; fm transmitter.

1. INTRODUCTION

The industry revolution 4.0 gives technological growth a massive height, and as a result, we are expecting all devices to be digital in nature in the near future [1-3]. Digitization makes our life easy and secure. We are always looking toward technology with simple and cost-effective applications. The up-gradation of wireless communication technology also changes the way the devices appear. The Digital Modulation schemes are being used for effective long-distance communication to transfer information from one place to another. The end-users want to enjoy these smart communicating devices with upgraded modulation schemes in a way that must suit their daily life activity. It has been seen that smart products with easy accessibility, low cost, high power efficiency, and high reliability gets higher demands with respect to other existing products. Keeping this fundamental requirement of the end-user in mind, we have aimed to develop a unique prototype of wireless FM transmitter, which can be used to develop smart communicating devices. The concept used here is simple and straightforward, which uses the FM schemes to generate modulated signals and transmit them at a satisfactory distance with HD sound quality.

The fundamental task of an FM transmitter circuit is to modulate and amplify FM signals for long-distance communication using a single transistor circuitry [4-5]. Frequency Modulation (FM) is performed by modulating the carrier wave frequency depending upon the variation of the message signal, which carries adequate information [6]. Generally, the radio frequency used by FM transmitter is in the range of VHF (Very High Frequency) that is 87.5 to 108.0 MHz. Our smart transmitter prototype model accomplishes the most excellent range with minimum power requirement. The performance and working of the wireless audio transmitter circuit depend on the induction coil and variable capacitor. The basic components required for the FM transmitter are: antenna, RF amplifier, modulator, audio pre-amplifier, and microphone. Two distinct frequency components are there inside an FM signal and they are: the carrier frequency, and the other one is the baseband frequency which is used to modulate the latter one. The FM signal is the resultant of these two signal components. The oscillator produces RF signals inside an FM transistor. The minimal power supply required is 9V to run the electronics and electrical components of the circuit, which includes: capacitor, inductor coil, resistor, trimmer capacitor, Mic, antenna, and transmitter sections. The sound signals have been analyzed using the microphone, which has a capacitive sensor inside. Depending upon the variation of air pressure on the capacitor, it generates AC signals. The transistor of 2N3904 is used to create the oscillating tank circuit having a tank circuit, a variable capacitor, and an inducing coil. An NPN general-purpose transistor has been used for amplification using that tank circuit. Whenever current passes through the inducting coil and the variable capacitor, the tank circuit matches the resonating frequency of the incoming AC signal of the FM modulation.

In order to generate the carrier waves at radio frequency, the FM transmitter needs a stable oscillator. The tank circuit stores the required energy for oscillation using its LC modules. The input audio signal, which is coming from the Mic, passes through the base of the transistor and modulates the LC tank circuit carrier frequency in the form of FM. The tuning of the circuit is done by varying the capacity of the variable capacitor to cover the FM range with fine modifications. Finally, the modulated FM signal has been radiated by the transmitting antenna at the range of FM frequency band and the antenna used here is nothing but simple copper wire of 20 cm long and 24 gauge. So, in this work, we have used the following specification along with our adaptive noise cancellation and sound amplification process to produce the smart transmitter module. The length of the antenna used here is significant enough with 25-27 inches long copper wire to produce noiseless transmission for a significant amount of distance.

2. RELATED WORKS

The first-ever idea of FM was coined by Edwin Amstrong in 1933, who gave the idea of Practical

Frequency Modulation Transmission, which was less vulnerable to noise with respect to AM [7]. It is almost a century now since the first-ever transmitter was launched in the market. With the technological revolution the all the transmitting devices change their shapes, sizes, and operating principals. The smart digitized FM transmitter is also one of them. Todays' smart devices like speakers, HD recorders, smart phones, cameras, and many other electronic gadgets are using Smart Transceiver Sections. The transmitter and receiver units are having a wide range of applications in all the spheres of the communication world. In A. Shrivastava [8] has implemented a low range FM transmitter device with a limited range of coverage with low power amplifier units. In M. Ahmed et al. [9] have proposed a joint receiver and transmitter section at 90 MHz of range. The frequency fluctuations are limited and always near to the central frequency always. The frequency away from the central frequency created a distortion in their case. However, in Bakare et al. [10] have presented a comprehensive investigation of the RF Signal Strength of Love FM Transmitter in Port Harcourt, Nigeria. The Signal measurement was carried out at different locations with the aid of a GPS band scanner. A maximum distance of 6 km was chosen with respect to the North, South, East, and West of the Transmitter. In R. Singh et al. [11] have given a simple prototype of a wireless FM transmitter. The frequency of operations has been chosen the FM range and the operating principle has been explained suitably with proper schematics. Few works also have used similar system models [12-14], but still, they all face the noise at the output signals, and the quality of the output signal degrades for that. The range of communication is always an issue, and researches are still ongoing in long-range communication. Producing a cost-effective signal transmitter is also one of the challenging tasks.

Thus, keeping the restrictions in our mind in our work, we have targeted to implement a smart and cost-effective wireless FM transmitter for long-range of communication with noise immune system. The output here almost covers 2 km of the range provided the surrounding medium is less noisy. With increasing distance, the quality of the signal deteriorates, but the effective range of communication is still 200-300 meters with sufficient clarity and noise suppression. The next sections will elaborate on our system prototype, fundamentals of Frequency Modulation techniques, circuit construction, result evaluation, and finally, it will be concluded with some futuristic scopes of improvements.

3. ADVANCED FREQUENCY MODULATION

Frequency Modulation or FM is a technique to modulate the carrier wave in accordance with the baseband or message signal that contains vital information. The variation of the carrier frequency is independent of the carrier amplitude, which remains unaffected. FM can be classified under the Angle Modulation technique. Its Frequency Modulation Index gives the percentage of deviation of the modulated signal with respect to the un modulated signal. The modulation index can also indicate the amount of changes inside the carrier frequency.

$$h = \frac{\Delta f}{f_m} = \frac{f_\Delta \, |x_m(t)|}{f_m}$$

where, the modulating signal is represented by $x_m(t)$, f_m is the maximum frequency component present inside $x_m(t)$, and Δf is the highest frequency deviation i.e. the maximum deviation of the instantaneous frequency from the fundamental carrier frequency signal. The frequency modulation index can be defined as the ratio of the peak frequency deviation to the standard frequency of the modulating wave.

An FM signal is called Narrow Band FM signal if h << 1, and its bandwidth is approximately $2f_m$.

Similarly, for h >> 1, the signal is termed as Wide Band FM with a bandwidth of $2\Delta f$ (approximately). While wideband FM uses more bandwidth, it can improve the signal-to-noise ratio significantly.

The Family Radio Service uses Narrow Band FM technique. The carrier signal can only deviate around 2.5 kHz above and below of the central carrier frequency. This also has a limited bandwidth of 3.5 kHz. Narrow Band FM is used mostly for short distance communication, and it is not used intensively in advanced technologies. FM Broadcasting uses Wideband FM signal. Here, music and voice are transmitted with up to 20 kHz of bandwidth, and 75 kHz of allowed frequency deviation.

3.1 Process of Frequency Modulation

The frequency modulation scheme has been explained in Fig. 1 along with its frequency domain representation (Fig. 2). A message signal with frequency of operation f_m is modulated with a carrier signal with steady state frequency f_c. where, $f_c >> f_m$. The time domain representation contains three fundamental frequency components: f_c, $f_c + f_m$ & $f_c - f_m$. The same can be seen in the frequency domain analysis as well. Theoretically an FM signal spans plus infinity to minus infinity in frequency domain. So, all such harmonics can be seen as the sidebands of the modulated signals. As the harmonics do not contain significant voltage, and power, they can be filtered out using suitable limiter circuits explained in the next sections. The time and frequency domain representations of a simple FM signal are shown in this section for easy understanding of our proposed procedure and system model analysis which have been elaborated in the following sections.

3.2 Necessity for Frequency Modulation

Dimension of the Antenna: Inside a basic transceiver unit, the free space transmission occurs from the transmitter end to the receiver end. The antenna dimension has been kept in order of the magnitude of the operating wavelength of the transmitted signal.

$$L = \lambda = u / \vartheta = (3 * 10^8 \text{ m/sec}) / \vartheta \text{ Hz}$$

The range of the Speech Signal frequency is in between 20 Hz and 20 kHz. Now, considering a frequency of 20 kHz which has been transmitted through a free space channel:

$$\text{Antenna Length} = (3 * 10^8) / (20 * 10^3) = 15000\text{m} = 15\text{km}$$

The dimension of the antenna or antenna length is coming to be very costly and infeasible. Use of High Frequency Carrier Wave can effectively reduce the antenna size and make it feasible for installation.

Communication through Wireless Media: The modulation schemes are very useful for transmitting information signals over large distance wirelessly. The wired telephones are now replaced with cordless phones and most importantly everyone now is connected by the mobile phones. The standard of human living upgrades to a smart level due to incorporation of modulation techniques.

Interference and Noise Reduction: Nowadays the air is all covered up with signals. Most of them are information signals. It is extremely necessary to segregate those signals for an effective communication. The baseband signals are modulated by carrier signals that shift their fundamental frequency of operation to upper bands. With a range of carrier frequencies significant separation, and frequency gap have been maintained between two successive bands to avoid interference. That is necessary to avoid the noise signals and only transmit the message signals.

3.3 Advantage and Disadvantage of FM

3.3.1 Advantages

Noise reduction: Noise reduction is one of the major advantages of frequency modulation technique. Signals at higher frequency range are less affected by noise, and their noise resistive capacity is also high. Most noises are related to the amplitude of the signals. So, signals are passed through a limiter to vary the frequency only, and limit the unnecessary amplitude variations.

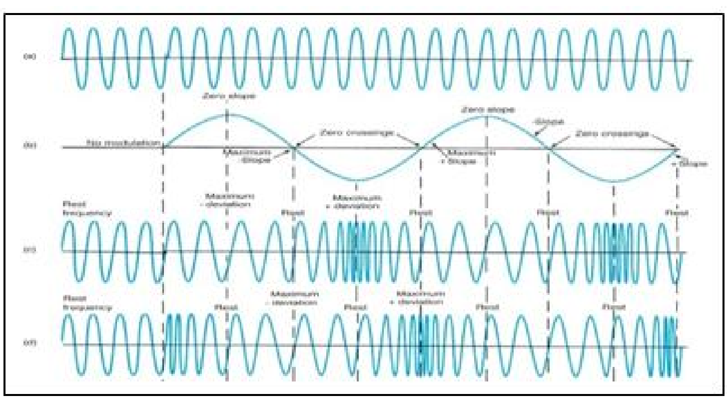

Fig. 1. The FM signal generation

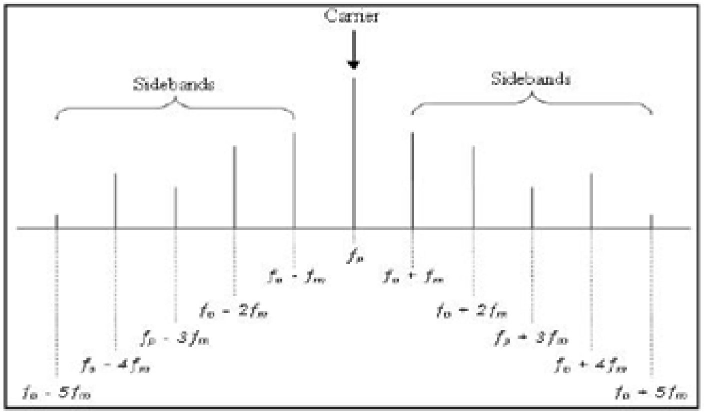

Fig. 2. The FM frequency spectrum

Resilient to signal strength variations: The amplitude of message signals is absolutely independent of its frequency modulation. The use of FM is ideal for mobile communication where the steady amplitude signal level has to be maintained. The signal level is sufficiently high that provides proper signal transmission over a longer distance. Amplitude noise is tough to remove so in FM there is no such kind of noise resides.

Linear Amplifiers are not required at the transmitter end: Only frequency variations are done so no such amplifiers are required at the transmitter side. It makes the model cost effective and economical.

High transmission power efficiency compares to other methods: The use of non-linear amplifiers, e.g. class C, etc. improves the energy efficiency. Linear amplifiers are inherently inefficient, and not used here as well.

3.3.2 Disadvantages

Complicated Demodulators: Designing the demodulator units at the receiver end is a bit complex job but now the recent smart reverse convolution techniques make this job easier to implement [15]. Though, the techniques make the demodulation costly as well compare to AM (Amplitude Modulation) demodulation technique where simple diode detectors are used [16]. Low cost broadcast receiver market is only struggling with this issue but on a large-scale scenario this problem is considered to be the major one.

Low data spectral efficiency: Advanced Quadrature AM, and Phase Modulation schemes have better data transmission, and spectral efficiency than Digital FM. That is why the PSK or QAM techniques are more preferable than FM techniques here.

Large Bandwidth Consumption*:* Wideband FM theoretically extends to infinity. So, to filter out unnecessary side bands proper frequency limiter circuit is used that causes some unwanted distortion in the signal.

3.4 Methods of FM Generation

3.4.1 The direct method or parameter variation method [17]

In this method the carrier frequency varies depending on the input message signal. A VCO (Voltage-Controlled Oscillator) unit is used (shown in Fig. 3), and the output frequency of the VCO varies with respect to the voltage of the input signal. A shunt voltage varactor is used inside the tuned circuit which performs the conversion operation to produce proper output. In FM generation using Reactance Modulator, the VCO is implemented using by using a sinusoidal oscillator with a tuned circuit having a high value of Q. The reactance of the device is varied proportional to the modulating signal voltage.

In the Varactor Diode method (shown Fig. 4), in the varactor diode is connected in shunt with the tuned circuit of the carrier oscillator.

3.4.1.1 The drawbacks of direct FM generation

- The instability of the central carrier frequency of VCO causes it to drift away.

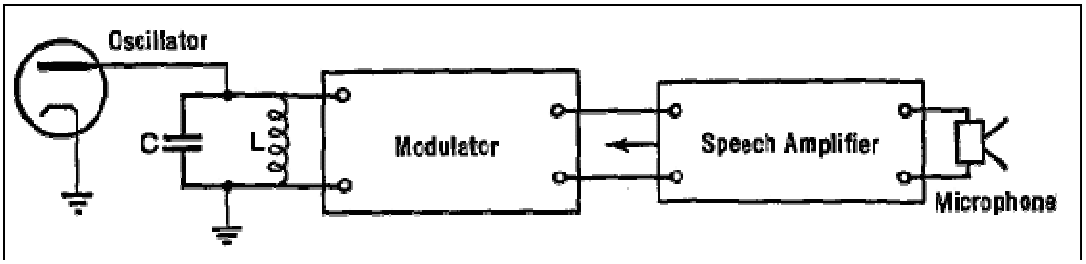

Fig. 3. The direct method of FM generation circuit

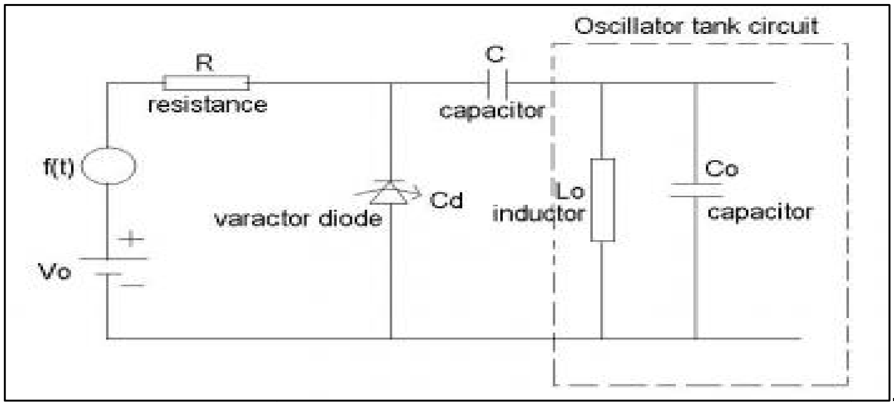

Fig. 4. Varactor diode FM modulator

- The Frequency stabilization capacity of Crystal Oscillator is very high but it cannot be used in Direct FM.
- The circuit complexity increases if Feedback Frequency Stabilization is used inside.
- The commercial FM needs a frequency deviation of 75 kHz where the deviation of Direct FM is only about 5 kHz. That makes it insignificant for commercial utilization.

3.4.1.2 Armstrong method or indirect method

- Initially, the Crystal Oscillator circuit is used to obtain NBFM via a NBPM signal as shown in Fig. 5.
- Thereafter, frequency multiplier is used to scale up the carrier frequency, and the frequency deviation depending on the requirement. Mixers can be used to concatenate multiple multipliers together. Mixer cannot affect the frequency deviation; it only changes the carrier frequency.
- The commercial FM requires indirect FM because it can produce stable carrier frequency which is extremely necessary for commercial FM broadcasting.

3.5 FM Modulators

3.5.1 Slope detector [18]

- The fundamental frequency of operation is slightly offset from the carrier frequency of the signal with which the oscillator circuit is tuned.
- The slope of the tuned circuit moves up and down following the frequency variation of the FM signal. The amplitude of the signal varies in line with the modulated carrier frequency variation. Both types of parametric variations can be seen at this stage like amplitude variation as well as frequency variation.
- A simple diode circuit is used at the final stage to demodulate the AM signal. This keeps the FM unaltered only the AM signal gets demodulated.
- The major disadvantage of this technique is that both amplitude and frequency variations can be seen at the output of the incoming message signal. However, the AM has been further tackled by using a limiter before the final detector circuit as shown in Fig. 6.

3.5.2 Zero crossing detector

- The frequency of operation of an FM signal can be evaluated by means of its wavelength.
- The Zero crossing is used to determine the fundamental wavelength of the FM signal.
- A ZC Detector generates a pulse at the zero-crossing of the respective signal.
- A low pass filter is used to pass the signal, and at last the signal is DC-blocked.
- A typical ZC Detector circuit has been shown in the form of a block diagram in Fig. 7.

3.5.3 Phase discriminator or foster seeley discriminator [19-20]

- The principle operation of a Foster Seely Discriminator depends on the difference in phase between signals. The phased signals are generated by connection a capacitor to the primary side of the transformer, and same is taken to the centre tap of the respective transformer. This has the ability to generate signals having phase separation of 90 degrees.

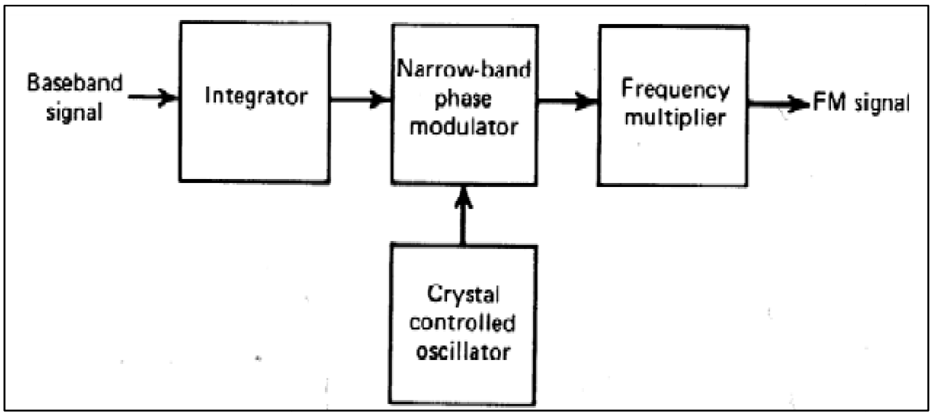

Fig. 5. Indirect method of generation

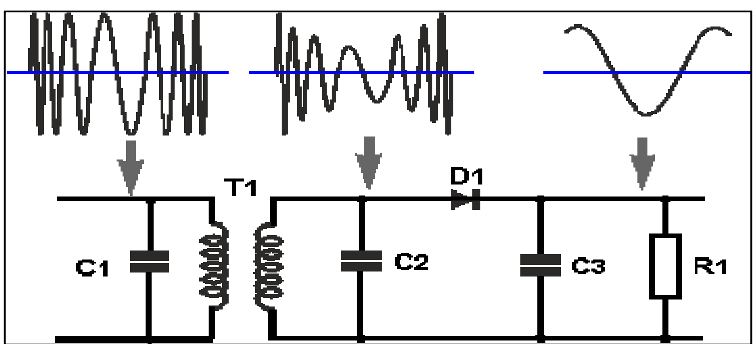

Fig. 6. Circuit diagram of slope detector

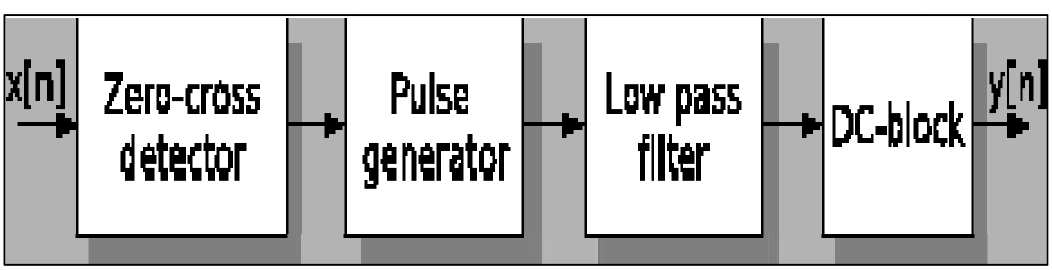

Fig. 7. Zero crossing detector

- An un-modulated carrier signal has been applied at the centre frequency of the circuit. Both the diodes start conducting the signal to generate equal but opposite voltages across their loads respectively. Whenever the carrier frequency goes from one side of the centre frequency to the other violating the balance condition, the diode of that side starts conducting more than the later. The resulting voltage across the resister of that diode becomes higher than that of the other resister. This results a modulated output signal generation for the corresponding input signal.
- Fig. 8 shows a standard Foster-Seely Discriminator circuit. Here, the C1 and C2 capacitors are used for the filtering function to ensure that no RF signals must appear at the output.
- The significance of this type of detection for FM signal is very high, and this has been used at a large scale for a broad range of applications.

4. BLOCK DIAGRAM OF SYSTEM MODEL

4.1 Circuit Diagram

The circuit diagram of a three-stage single ended Class A power amplifier is shown above. In the first stage, R2 and R4 are the biasing resistors. They form a voltage divider network which supplies the base of the transistor with a voltage 0.7V higher than the *negative maximum amplitude swing* of the input signal. This is the reason behind the transistor being ON irrespective of the input signal amplitude. Capacitor C_1 is the input decoupling capacitor which removes the DC components present in the input signal. If C_1 is not there, and there are DC components in the input signal, these DC components will be directly coupled to the base of the transistor and will surely alter the biasing conditions. The tank circuit is used to balance the impedance across the collector. R5 is the emitter resistance. Their value is so selected that the collector current is in the desired level and the operating point is placed at the center of the load line under zero signal condition. Placing operating point as close as possible to the center of load line is very essential for the distortion free operation of the amplifier. C_5 is the coupling capacitor which connects the two stages (stage 1 & 2) together. Its function is to block passage of DC components from first stage to the second stage. C_4 is the emitter by-pass capacitor whose function is to by-pass the AC components in the emitter current while amplifier is operating. The simplest explanation is that, the additional voltage drop across R_5 will get added to the base-emitter voltage and this means additional forward voltage is required to forward bias the transistor. Stage 2 and 3 follows similar structure just like stage 1. The two tank capacitor units are used for fine tuning the output signal and minimizing the signal distortions.

C_{15} is the output coupling capacitor which couples the output to the load (loud speaker). C_{15} blocks the DC components of the third stage from entering to the output device. The Coupling

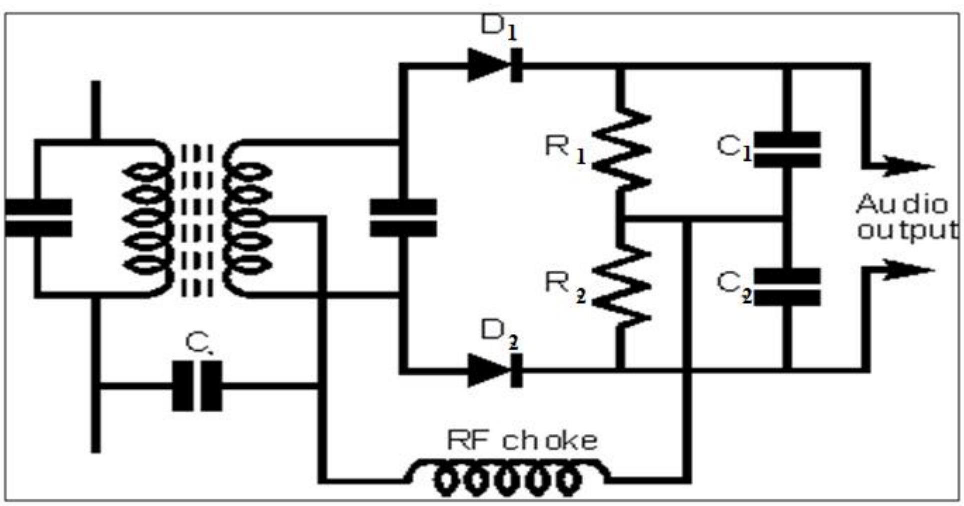

Fig. 8. Foster-seeley FM detector circuit

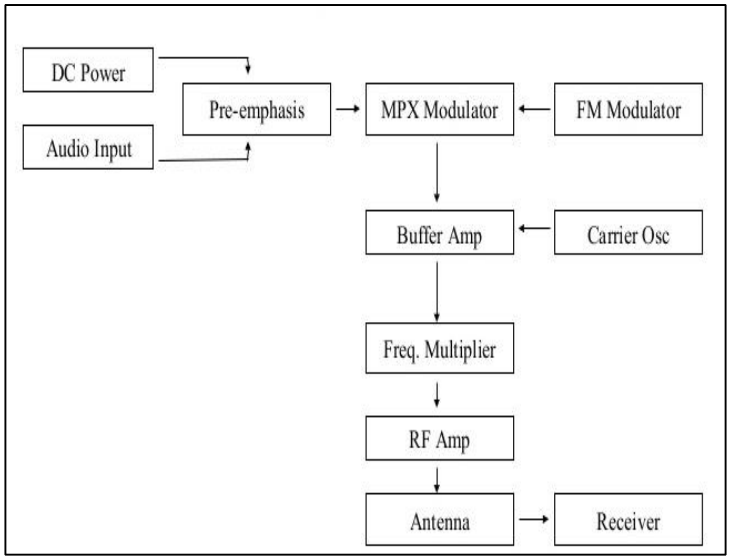

Fig. 9. Flow diagram of the FM transmitter operating principle

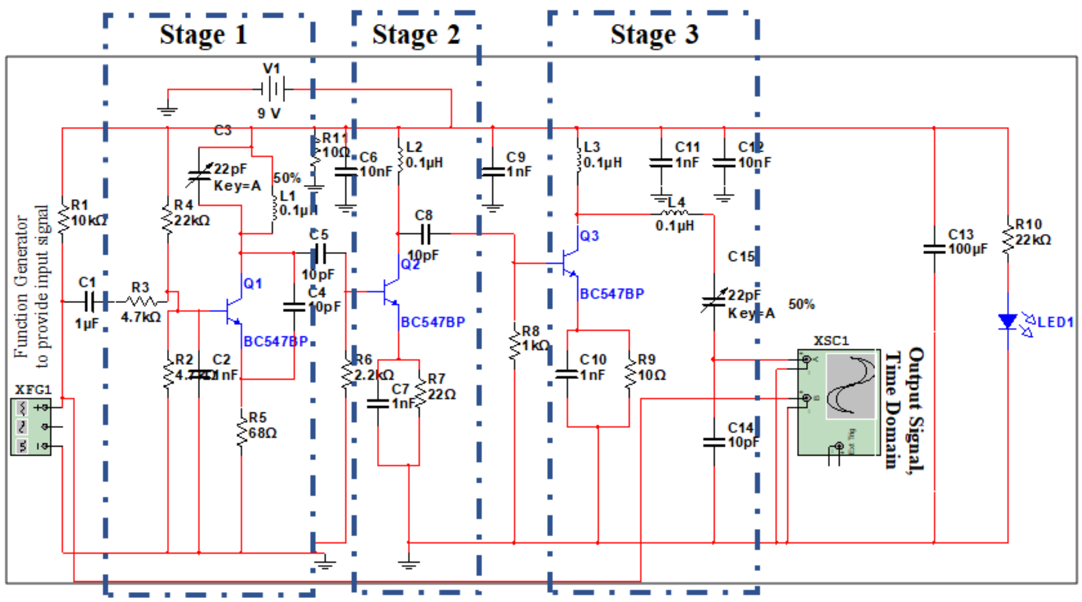

Fig. 10. Circuit diagram of wireless FM transmitter realised using multisim simulator

capacitor C_{15}, C_8 and C_5 all degrades the low frequency response of the amplifier. This is because these capacitors form high pass filters in conjunction with the input impedance of succeeding stages resulting in the attenuation of low frequency components.

4.1.1 Hardware model

The FM transmitter prototype has been demonstrated in Fig. 10 along with its Hardware counterpart as shown in Fig. 11. The simulation model has been done using NI Multisim Student Edition 14. The input and output configurations are checked with suitable parametric input. The performance of our hardware model is also checked with the frequency analyzer, digital oscilloscope, and frequency meter. In a test case analysis, we have transmitted an audio signal at the input of the microphone unit of the circuit and use a mobile phone as a receiving unit placed at distance of 100 meters from the transmitter unit.

We have received a clear audio reception of the signal at the receiving end. The carrier frequency has been kept inside the standard FM range. The receiver has been tuned at the same frequency of the transmitter unit to get the audio output. The entire demonstration has been recorded and the same will be uploaded in the social media site in future after proper license agreements and authorized permission from our institution.

4.2 Circuit Operation

Our FM transmitter circuit consists of three distinct stages.

> Stage I: Audio pre-amplifier and FM Modulator.
> Stage II and III: RF power amplifier stages which sequentially boost the RF Power in the FM band for the received audio.

The electret Microphone is used to catch the audio from its surroundings and pass it to the transmitter unit. The signal caught by the Mic. is applied as an input to the first transistor stage. Here, the audio amplification has been done. Due to the applied base voltage, the junction capacitance of the transistor varies. The audio signal causes the junction capacitance to modulate from the first stage which also is the main reason of the frequency variation of the oscillator circuit. The frequency oscillator circuit is connected using the Hartley Configuration [21]. The output modulated signal coming from the oscillator unit is then applied as an input to the next state. Furthermore, two stages of amplification have been used here to boost the output signal for long distance communication. The final stage consists of a RC unit for unwanted noise cancellation. Only the signal with higher amplitude passes through it, and the low power noise signals are filtered out. This stage generates the effective long-distance noise free transmission of our test case. Figs. 10 and 11 demonstrates our circuit in the simulation and hardware platforms respectively. The basic components used for designing the circuit can be found in [22-24].

5. RESULTS AND DISCUSSION

In this section a test case is shown. A set of input was given to the circuit designed in the simulation platform, and the corresponding output was generated accordingly. We have tested for various sets of input parameters, and one of such cases is detailed here.

5.1 Input

Input Specification: A Signal (Defined waveform e.g. Sinusoidal Wave) in the audio-frequency range 20Hz to 20 kHz is provided as input.

The test case input frequency of the modulating signal is 2 kHz.

Input through Function Generator is given by Fig. 13.

5.2 Output

The output signal has been demonstrated at the Digital Oscilloscope. The same is shown in the Fig. 14.

The output as seen in the Digital Oscilloscope:

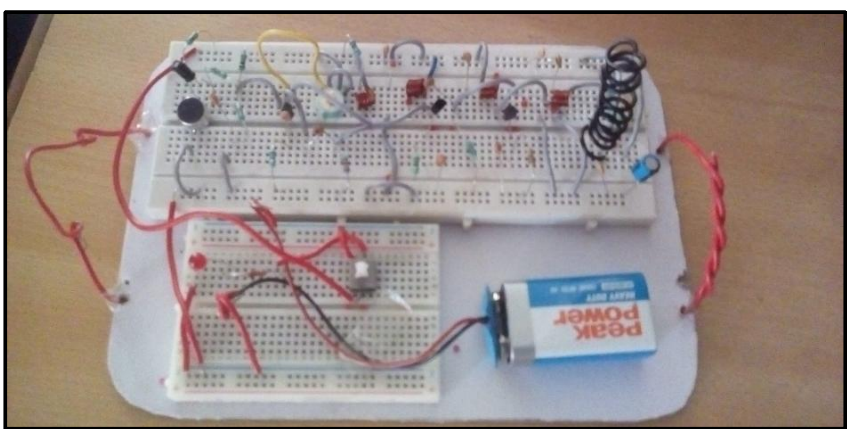

Fig. 11. The FM transmitter circuit that is designed

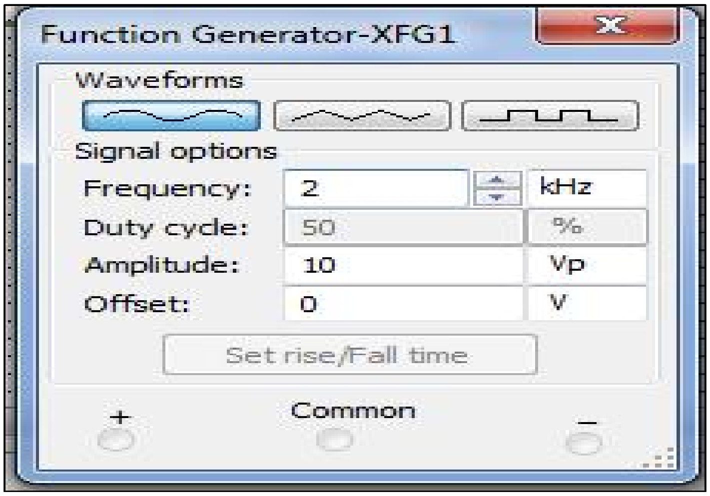

Fig. 12. The input simulation parameter for the modulating signal

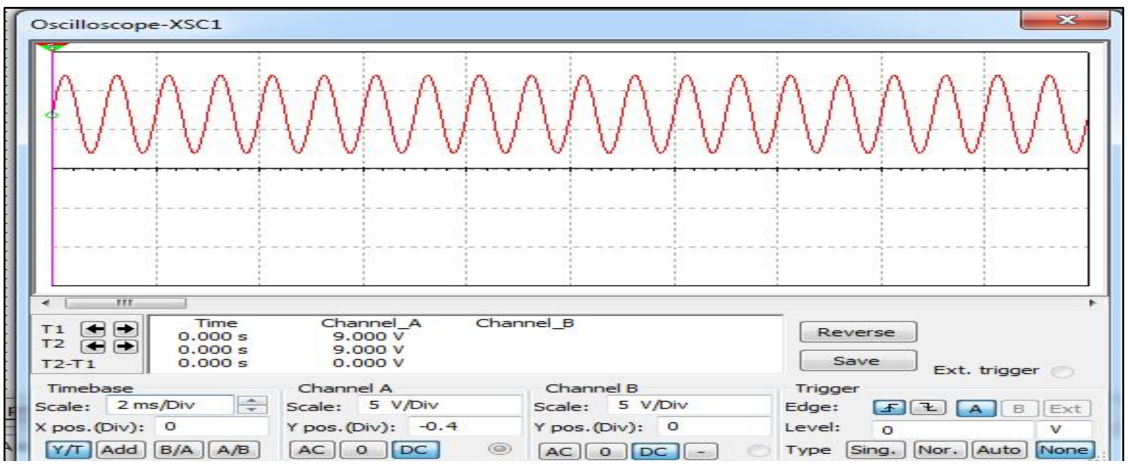

Fig. 13. The input waveform capture by the oscilloscope

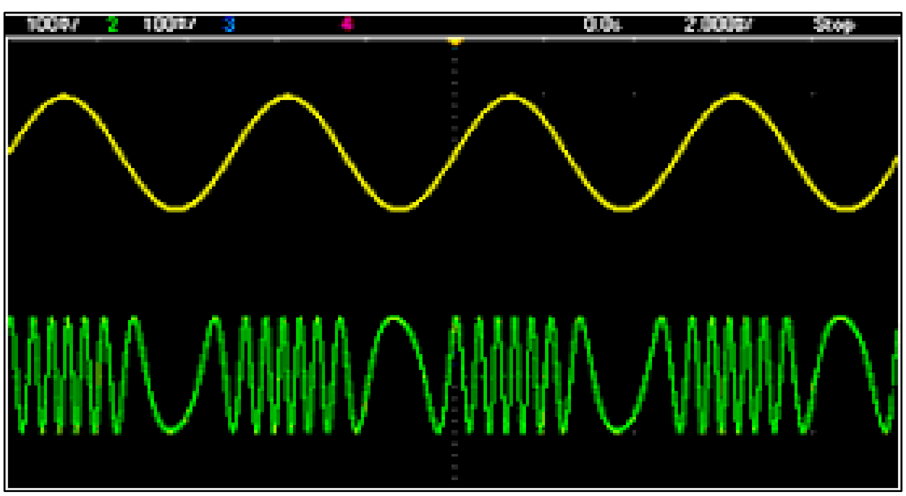

Fig. 14. The FM modulated signal (green) and message signal (yellow) using digital oscilloscope (simulation output)

In this section, a comparative result analysis is being done using both the software and hardware models. Figs. 12, 13 and 14 are used to show the MULTISIM specifications of the modulating sinusoidal signal along with its waveform. The time domain representation is displayed in Fig. 14. Similarly, the hardware model is also tuned using proper specification to generate the FM signal. The frequency domain representation is shown in Fig. 15 using Digital Frequency Analyzer.

The circuit is fine to work as a mini FM transmitter which can successfully transmit audio frequency in the FM range (88MHz – 108MHz).

- This has a fine capability to transmit the signal within the 200m range by default, which can be extended up to 3 km by varying the trimmer capacitor of range.
- As the base carrier frequency can also be changed so any suitable frequency can be picked within the FM range.
- It can be used to transmit information in a local sector effectively that can save the time of communication.

A simulation-based test case output is shown in the Fig. 16. We have calculated signal strengths at different noise levels.

The noiseless condition is considered to be the quiet environment with absence of noisy resources. We increase the distortion levels to check the nature of received signal strength. The crowded case gives highest distortion in the signal and the corresponding range is low as well. Our proposed model is capable enough to provide a clear and high-quality signal for a distance of 2-3 km. The practical case is not

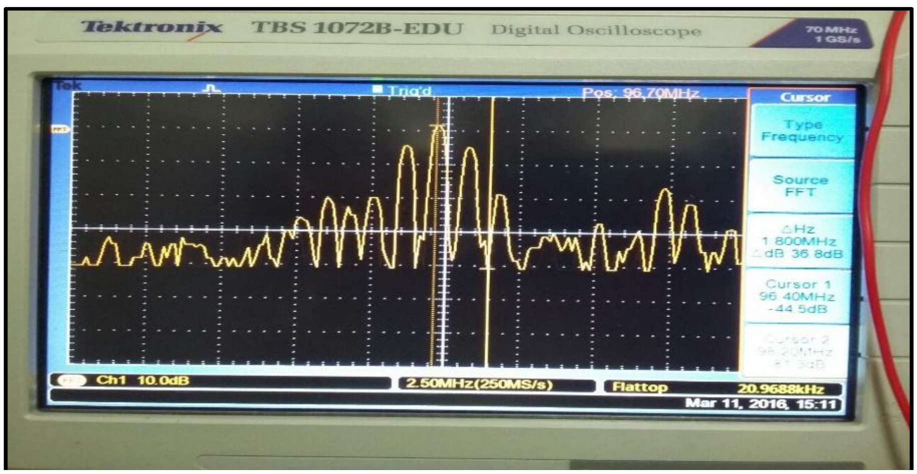

Fig. 15. The FM output captured using frequency analyzer (tuned at center frequency of practical test case)

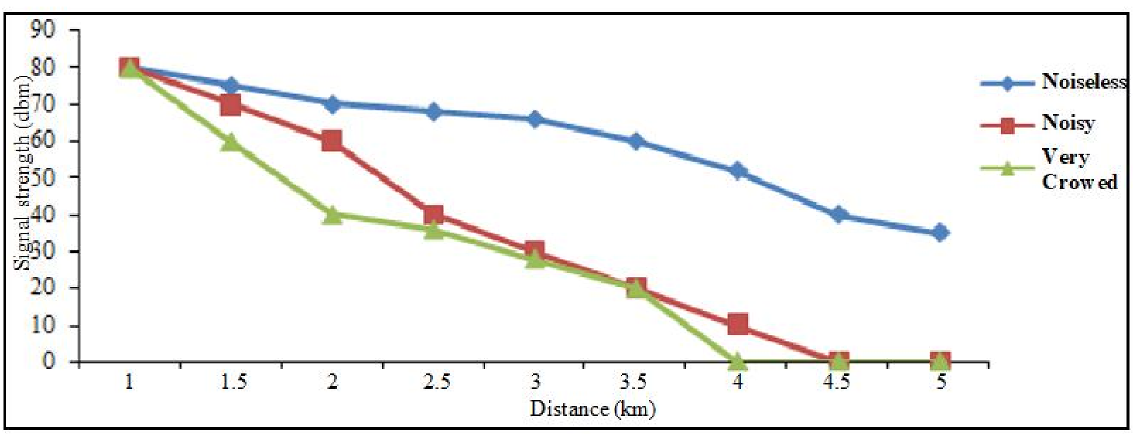

Fig. 16. Distance vs signal strength analysis for different noise levels

exactly equal to the simulation result as the chances of getting noiseless environment is very difficult. The simulation result is near to the practical one and that also validate our model performance.

6. CONCLUSIONS

This prototype is meant for the wireless transmission of Frequency Modulated signal from one place to another with a limited but wide distance separation. This entire setup is checked under a fixed local region without hampering the general standard FM stations available in our common communication networks. As no licensed band has been allocated here, so the trial frequency has been kept at some intermediate frequency between the FM band region and that can be manually set with the help of the trimmer capacitor depending upon the user requirements. Since RF circuits are highly prone to noise, special care has been taken to suppress any such noise by including high-frequency capacitive filters. While tuning the transmitter with any FM radio, the absolutely silent spot is at the frequency of the transmitter. Alternatively, one can put the FM radio at a particular frequency and then start tuning the transmitter and stop it when a clear reception is heard. The detailed test case analysis has proven the effective application of our model, and in the future, it would be helpful to design smart broadcasting elements.

7. FUTURE WORKS

The sound catching ability can be improved by using condenser microphone of better quality, as the carrier frequency will be modulated by the modulating input audio signal, so better the quality of sound provided to the circuit through the Mic, better will be the quality of Frequency Modulated signal at the output. This will make the clarity of our received signal much better. Even if the volume intensity of the input signal is low, a smart Mic can catch and transmit it properly. Some more stages of an audio amplifier and power amplifier can be incorporated for a better quality of FM transmission. As we know, if the receiver's distance from the transmitter increases, the receiving sound quality deteriorates, resulting in interference with the adjacent channel and loss of information. But to keep the circuit simple and easy to use, a few stages of the amplifier have been used. Proper tuning is always a problem for the circuit as the frequency can shift from its base level. For that, we can use a fixed valued ceramic capacitor in the tank circuit, and the value of the capacitor should be calculated in such a way that the base carrier frequency should stay between the FM range, and it should not interfere with any other channel. We will be looking into these improvements in future works.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ACKNOWLEDGEMENTS

We are indebted to the Department of Electronics and Communication of Heritage Institute of Technology, Kolkata, to fund our project and provide every necessary apparatus at our disposal. The entire project work and testing have been conducted in the Analog Circuit and RF & Microwave Communication Laboratories of HIT-Kolkata. We would like to thank all the lab assistants and technicians for their collaborative help and support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Marr Bernard. Why Everyone Must Get Ready For The 4th Industrial Revolution. Forbes.
   Retrieved 14 February 2018.
2. Mike Moore 05. What is Industry 4.0? Everything you need to know. Tech Radar; 2019.
   Retrieved 27 May 2020.
3. Schwab Klaus. The Fourth Industrial Revolution; 2015.
   Retrieved 15 January 2019.

4. Valipour M Hadi, Homayounpour M Mehdi, Mehralian M Amin. Automatic digital modulation recognition in presence of noise using SVM and PSO. 6th International Symposium on Telecommunications (IST). 2012; 378–382. ISBN 978-1-4673-2073-3

   DOI: 10.1109/ISTEL.2012.6483016

5. Dobre Octavia A, Ali Abdi, Yeheskel Bar-Ness, Wei Su. Communications, IET. Survey of automatic modulation classification techniques: Classical approaches and new trends. IET Communications. 2007;1(2):137–156.

   DOI: 10.1049/iet-com:20050176

6. Ke-Lin Du, Swamy MNS. Wireless communication systems: From RF Subsystems to 4G Enabling Technologies. Cambridge University Press. 2010;188.

   ISBN 978-0-521-11403-5.

7. Erickson Don V. Armstrong's fight for FM broadcasting: one man vs big business and bureaucracy, University of Alabama Press; 1973, ISBN 0-8173-4818-2.

8. Shrivastava, Abhishek. Design and development of low-range frequency modulated signal (F.M.) transmitter. BIBECHANA. 2017;15:30.

   DOI: 10.3126/bibechana.v15i0.18279

9. Ahmed Mostak, Das S, Mojid, M. Design of a FM transmitter and receiver operates at 90 MHz green global foundation. Institutional Engineering and Technology (IET) © Design Of A Fm Transmitter And Receiver Opetates At 90 Mhz. 2016;16-24.

10. Bakare Bodunrin, Nwakpang F, Desire A. Propagation analysis of radio frequency (RF) signal of love FM transmitter in Port Harcourt, Nigeria. 2019;14:5-12.

    DOI: 10.9790/2834-1402010512

11. Ranjana Singh, Nidhi. Design and working of fm transmitter. International Journal Of Advance Research In Science And Engineering-IJARSE. 2013;2(10), ISSN-2319-8354(E).

12. Islam MM, Hossain T, Akman W, Sultan MZ, Kabir H. simulation and analysis of signal transmission through SMF and DCF for wireless communication. Institutional Engineering and Technology. 2015;5(1): 30-35.

13. Ogbuanya TC, Sule Abu, Bakare J. The design and construction of a frequency modulated (fm) transmitter with output capacity of 10 watts and range above 4km. International Journal of Applied Engineering Research. 2017;12(18):7516-7523, ISSN 0973-4562© Research India Publications.

    Available:http://www.ripublication.com 7516

14. Ryu, Jeong-Tak Ryu, Kyung Ki Kim. Mini-FM Transmitter with a Built-In Antenna and a Built-In Storage Battery. Embedded and Multimedia Computing Technology and Service, Springer Netherlands. 2012;567-574.

15. Horbatyi IV. Research on properties of devices for shaping and processing of signals based on amplitude modulation of many components. Radioelectronics and Communications Systems, Springer. 61(10);467-476

16. Moore BCJ, Mariathasan S, Sęk AP. Effects of age and hearing loss on the discrimination of amplitude and frequency modulation for 2- and 10-hz rates. Trends in Hearing; 2019.

    Available:https://doi.org/10.1177/23312165 19853963

17. Masoud Arablu, Sajad Kafashi, Stuart T Smith. Synchronous radio-frequency FM signal generator using directdigital synthesizers. Review of Scientific Instruments. (89)4.

    Available:https://doi.org/10.1063/1.502632 1

18. Zhang Yining, et al. A 1.8 mW 2Mb/s chirp-UWB transceiver with burst-mode transmission and slope-based detection. 2016 IEEE International Symposium on Radio-Frequency Integration Technology (RFIT). IEEE; 2016.

19. Dowling Jack F. Alarms intrusion detection systems. Handbook of Loss Prevention and Crime Prevention. Butterworth-Heinemann. 2020;223-237.

20. Nair Kartik. All Digital FM Demodulator. Diss. Virginia Tech; 2019.

21. Park, Joonhong, et al. A Fully-Differential Complementary Hartley VCO in 0.18$\mu $ m CMOS Technology. IEEE Microwave and Wireless Components Letters. 2010; 20(2):91-93.

22. Wang Liyong. Fm transmitter for car. U.S. Patent Application No. 16/509,520.

23. Musa A, Paul BS. Design of an FM Transmitter Powered By Piezoelectric Energy. IEEE International Smart Cities Conference (ISC2). IEEE; 2019.

24. Kamimura Tatsuya. Frequency modulation circuit, FM-CW radar, and high-speed modulation radar. U.S. 2019;10: 393,861.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59355