Frequency Synthesis for Low Power TV Transmitter

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Abstract— This paper illustrates the frequency synthesis technique which can be used for the very low power TV transmission. The idea behind the frequency synthesis is to use the low power TV transmission method usually 50 W using an integrated voltage controlled oscillator. Such transmitters can be established solely for community education and managed by existing schools as additional support for children and support for adult education in the rural India. The availability of the channel for the signal transmission is to be controlled using the white space detection techniques like cognitive radio, etc. Currently 85% of the TV band in the 470-698 MHz range is not used in the heart of urban Delhi, and as much as 95% are unused in rural areas. At any point in time, the largest contiguous TV white space varies between 66 MHz to 136 MHz in an urban location, and between 51 MHz and 242 MHz in a rural location. This shift of channel was achieved using IR remote controlled microcontroller based control system.[1][2].

Key words: VLPT (Very Low Power Transmitter), Frequency Synthesis, Frequency Mixer

I. INTRODUCTION

The VCO based frequency synthesizer (FS) uses the integrated VCO IC-ML12149 for the synthesis of the different frequencies in the 174-698 MHz frequency band.

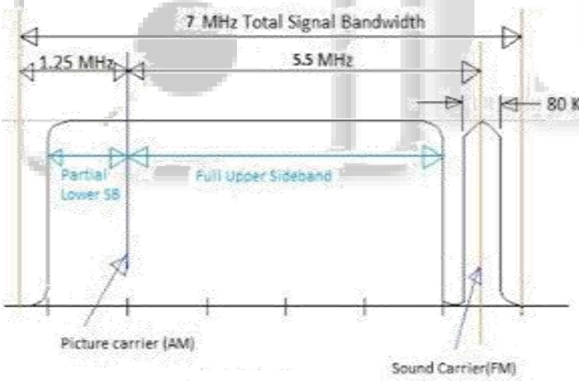

Fig. 1 TV signal spectrum in VHF band channel

Following figure shows the block diagram of the Project. There is the control system to control the channel frequency of the synthesizer using the IR remote control. This IR remote control can be used to shift between the channels. As shown in the above figure there will be eight channels in the VHF frequency band. These channel selection will be controlled from the control system of the synthesizer. Following figure shows the complete description of the control system. There will be an IR remote having eight keys to shift between the channels. An IR module will receive the IR signal and will convert the signal to the Decoder. Decoder converts the signal which can be utilized by the microcontroller and will perform the corresponding control action.

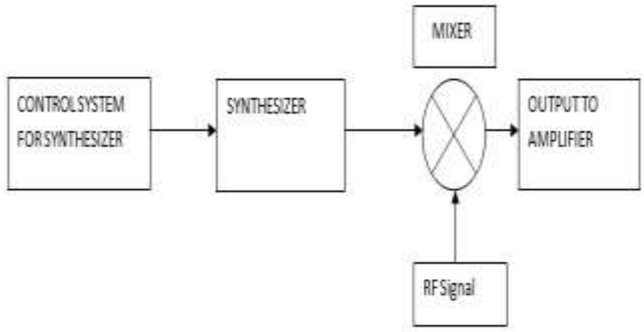

Fig. 2 Block diagram of the proposed frequency Synthesizer and mixer

The control system is used to remotely control the output of the frequency synthesizer. The output of the control system is nothing but the 8 different voltages that are needed for the VCO to generate the specific carrier frequency at the output. The mixer is used to shift the low frequency RF signal to any of the vacant channel in the VHF band. As there are 8 different output frequencies at the output of the synthesizer, the RF signal can be up-converted to any of the above channel frequencies.

II. DESIGN OF SYNTHESIZER

Following schematic shows the circuit diagram of the synthesizer. The circuit consist of the IC ML12149 which is nothing but the Voltage controlled oscillator and buffer IC. Which is fabricated to operate till 1.34 GHz frequency, Which covers our band of TV signal transmission, That is Band-III of VHF band for the TV signal transmission. The IC is driven using a designed tank circuit. The ML12149 is intended for applications requiring high frequency signal generation up to 1300 MHz. An external tank circuit is used to determine the desired frequency of operation [4][5]. The VCO is realized using an emmiter–coupled pair topology. The device is specified to operate over a voltage supply range of 0 to 5V. It has a typical current consumption of 15 mA at 3.0 V which makes it attractive for battery operated handheld systems.

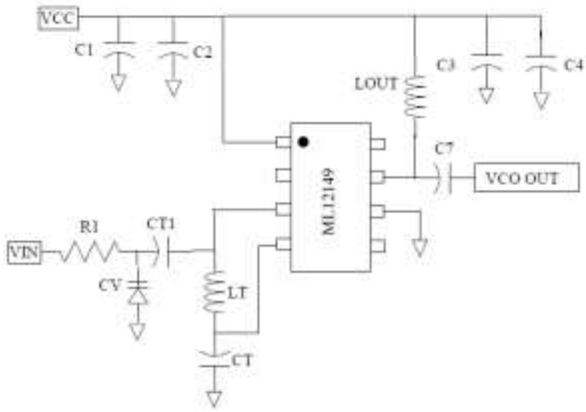

Fig. 3 Circuit schematic of synthesizer using ML-12149

The device has three high frequency outputs which make it attractive for transceiver applications.[4]

External components required for the ML12149 are:

1) Tank circuit (LC network)
2) Inductor/capacitor to provide the termination for the open collector outputs
3) Adequate supply voltage bypassing.

III. THE TANK CIRCUIT DESIGN

The tank circuit designed consists of a high–Q inductor and varactor diode components. Such that the preferred tank configuration circuit allows the user to tune the VCO across the full supply range available. VCO performance such as center frequency, tuning voltage sensitivity, and noise characteristics are dependent on particular components and configuration of the VCO tank circuit. The most important component is the varactor diode as it is the component that changes its capacitance value depending on the reverse voltage applied. MA393 was found to be the perfect match for the circuit.[3]

The tank circuit, in its simplest form, is realized as an LC circuit which determines the VCO operating frequency. This is described in Equation 1

$$fo = \frac{1}{2\sqrt{LC}} \quad (3.1)$$

In the practical case, the capacitor is replaced with a varactor diode whose capacitance changes with the voltage applied, thus changing the resonant frequency at which the VCO tank operates. The capacitive component in Equation 1 also needs to include the input capacitance of the device and other circuit and parasitic elements.

The inductor is realized as a surface mount chip. In addition, the lead inductance and board inductance and capacitance also have an impact on the final operating point. The output of the frequency synthesizer can be then applied to the frequency mixer to up-convert the signal to specific band. An integrated frequency mixer IC ADE-1L is best suited and compatible to the designed circuit.

IV. ANALYSIS OF SPECTRUM

The following table illustrates the analysis of the VHF spectrum. There are eight channels in VHF band from channel no 5 (E5) to channel no 12 (E12). The second column shows the required frequency at the synthesizer output which when applied to the frequency mixer could shift the carrier signal to specific channel in the VHF band [6]. The last column shows the corresponding voltage needed at the input of the VCO to generate these frequencies.

Sr. NO	Channel Name	Channel Band-III Frequency (MHz)	Synthesizer O/P Frequency (MHz) (Expected)	Synthesizer O/P Frequency (MHz) (Practical Result)	Frequency Offset	TANK INPUT VOLTAGE (mV)
1	Channel 5 (E5)	174-181	214.15	214.148	2KHz	250
2	Channel 6 (E6)	181-188	221.15	221.155	5KHz	378
3	Channel 7 (E7)	188-195	228.15	228.148	2KHz	502
4	Channel 8 (E8)	195-202	235.15	235.156	6KHz	625
5	Channel 9 (E9)	202-209	242.15	242.147	3KHz	746
6	Channel 10 (E10)	209-216	249.15	249.156	2KHz	857
7	Channel 11 (E11)	216-223	256.15	256.145	5KHz	972
8	Channel 12 (E12)	223-230	263.15	263.158	8KHz	1082

Table 1: Analysis of the Vhf Spectrum

V. PHASE NOISE ANALYSIS

Phase noise is the most critical aspect in any of the frequency generating circuit. The phase noise describes the power of the noise compared to the carrier power expressed in the ratio of decibel (dBc/Hz). The bandwidth of both carrier and noise signal used to compare is essentially 1Hz.

Channel No.	Carrier	@1KHz (dBc/Hz)	@10KHz (dBc/Hz)	@100KHz (dBc/Hz)	@ 1 MHz (dBc/Hz)
1	214.148	-29.1425	-60.9217	-82.1691	-98.3475
2	221.155	-45.2173	-71.1322	-88.6477	-97.2858
3	228.148	-48.0154	-61.0052	-82.3410	-109.089
4	235.156	-42.1534	-75.8417	-92.1452	-115.475
5	242.147	-26.0120	-71.1289	-88.4827	-110.128
6	249.156	-52.1420	-72.0018	-93.1042	-112.107
7	256.146	-42.1789	-60.9142	-99.1425	-95.4218
8	263.158	-40.0150	-58.3123	-69.8753	-102.290

Table 2: Phase Noise Analysis

Following graph shows the plot of phase noise observed on the spectrum analyzer. It shows the optimum required phase noise performance of the frequency synthesizer circuit. The graph of only one frequency is included. The other frequencies also exhibit the similar response.

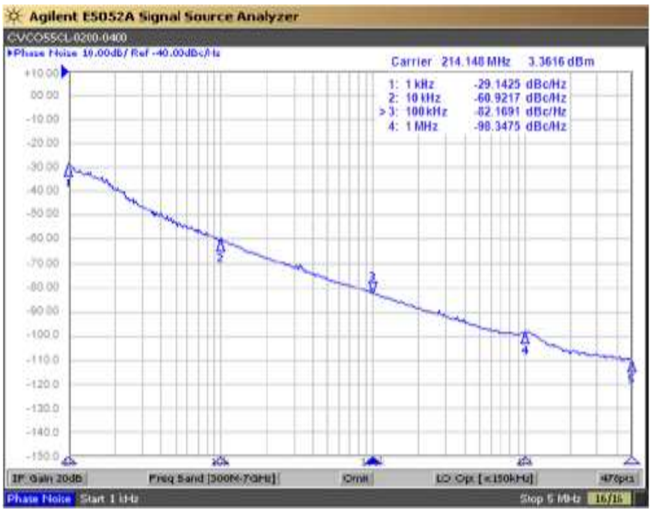

Fig. 4 Phase noise graph at carrier 214.148 MHz and 3.3616 dBm power

Following plot shows the tuning voltage curve for the synthesizer output frequency.

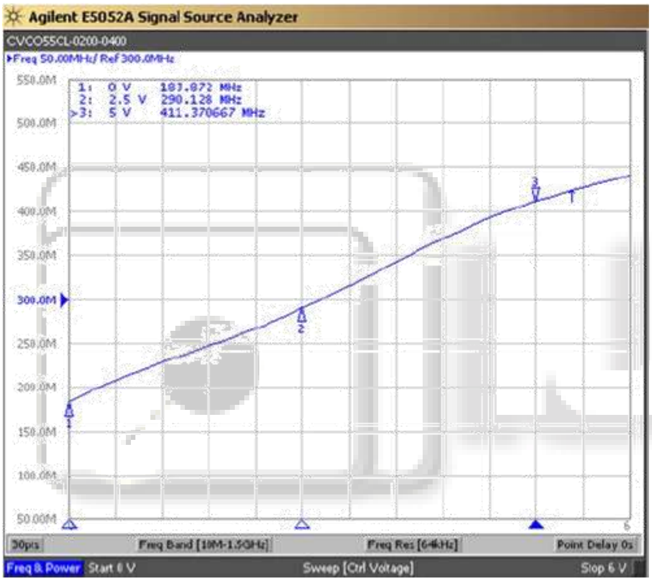

Fig. 5 Tuning voltage curve for the Synthesizer

VI. CONCLUSION

The frequency synthesizer designed using the ML-12149 VCO can provide the optimum results as specified for the transmission of the TV signal in VHF band. It is possible to achieve the system with relatively low cost and simple circuit design. The frequency synthesizer performance parameters are easily achieved within the relative tolerance. The frequency switching can be easily achieved using the microcontroller based control system. The microcontroller drives the DAC which in turn converts the stream of bits from microcontroller in to the highly stable control voltage for the VCO. The output power of the synthesizer can be controlled from -8dBm to up to +3dBm. The output of the frequency synthesizer drives the frequency mixer. The input signal to mixer other than that of frequency mixer has to be below 3dBm level. Output of the mixer provides around 6dBm power below the input power.

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