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High Fidelity FM Transmitter

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FM broadcasting is radio broadcasting using frequency modulation technology. In order to attain high-fidelity broadcast of music and speech, all audio frequencies up to 15kHz must be transmitted. The high fidelity FM transmitter presented here achieves that using simple and readily available components. Its output frequency is locked to 96MHz using the phase-locked loop (PLL) approach.

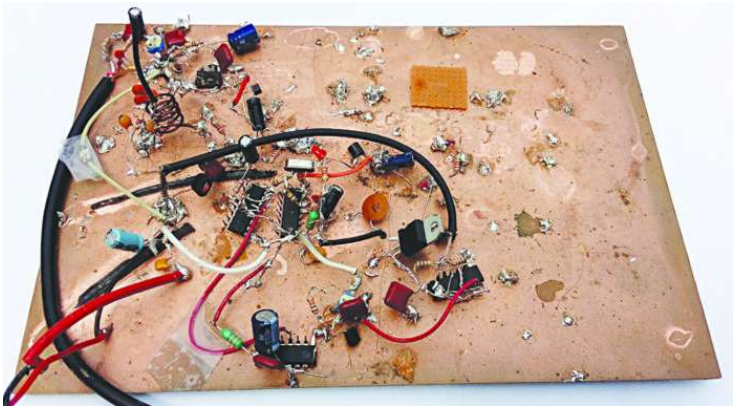

Fig. 1: Author's prototype wired on a copper clad sheet

Circuit and working

The author's prototype of the high fidelity FM transmitter circuit wired on a copper clad sheet is shown in Fig. 1. Block diagram and circuit are shown in Figs 2 and 3, respectively. The circuit is built around dual D-type positive-edge-triggered flip-flop 74AC74 (IC1), ripple-carry binary counter CD4060 (IC3 and IC5), low-power audio amplifier LM386 (IC6), phase-locked loop CD4046 (IC4), 5V voltage regulator 7805 (IC2) and a few other components.

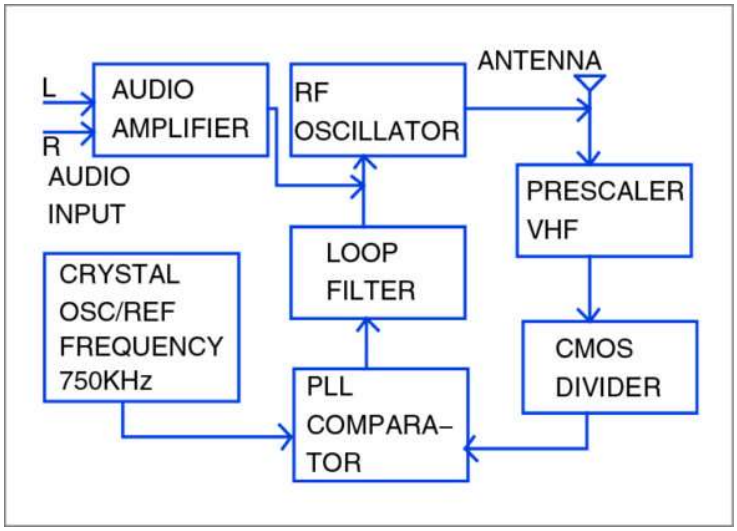

Fig. 2: Block diagram of the high fidelity FM transmitter

Transistor T1 along with resistors R1, R2 and R3, capacitors C2 and C5, coil L1, trimmer capacitor VC1, and varactor diode D1 forms a voltage-controlled oscillator (VCO) in Pierce configuration. IC1 acts as a VHF prescaler and divides the oscillator frequency by a factor of 4. Low-level RF output is taken via half-turn tap off L1 and fed to pin 3 of IC1 via C3 and to antenna via C4. The 24MHz (96MHz/4) output from the prescaler is further divided by 32 by binary counter IC3. This signal is available at its pin 5 (Q5).

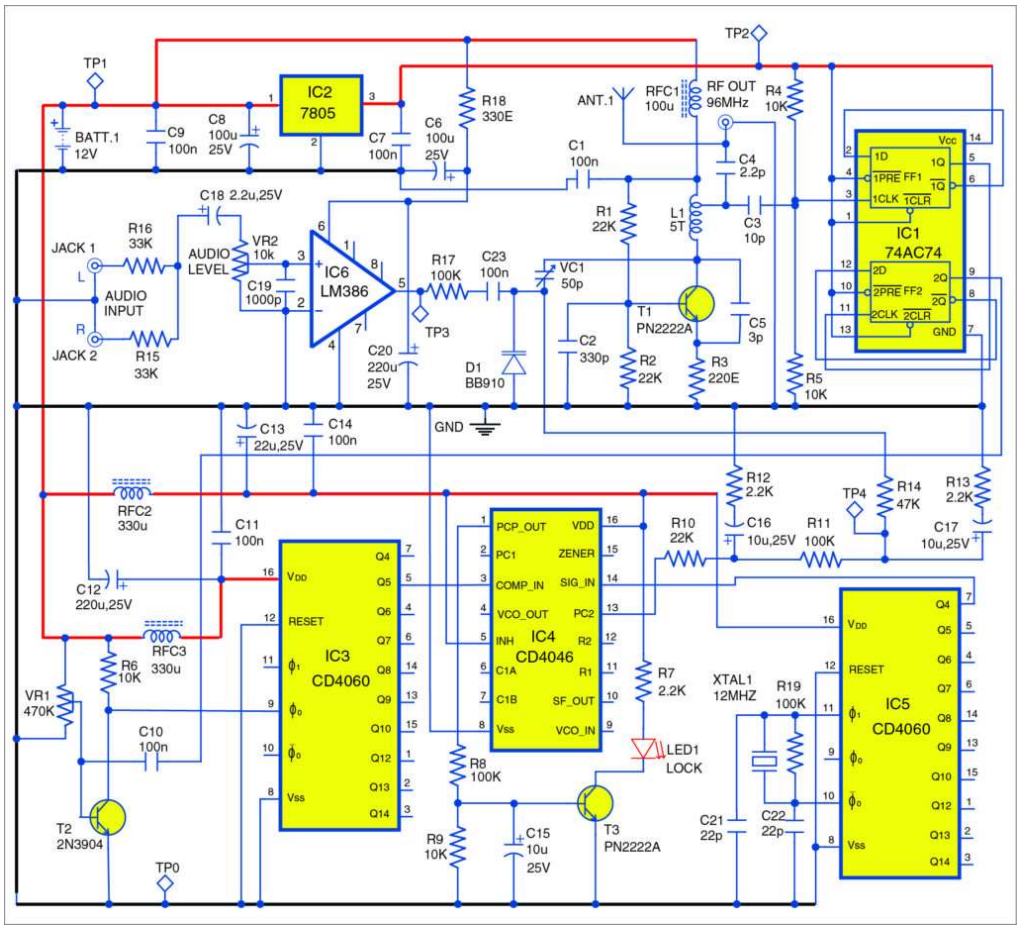

Fig. 3: Circuit of the high fidelity FM transmitter

IC5 is used as a reference oscillator for the PLL, which generates a stable frequency of 750kHz at its pin 7. IC4 compares the two 750kHz signals presented to its pins 3 and 14, then decides the greatest frequency. The result is available at its pin 13, which switches between 12V and 0V.

Pin 13 of IC4 is coupled to a long time-constant filter formed by R10 and C16. C16 charges to the average DC voltage and so provides a control voltage to the transmitter's oscillator frequency control circuit, and varactor diode via R11 and R14. R13 and C17 form another filter.

Both filters have damping resistors, R12 and R13, to reduce the control loop's gain. Without these resistors the control circuit would over correct a frequency error, causing a larger and opposite frequency error.

Test Points

Test point	Details
TP0	0V (GND)
TP1	12V
TP2	5V
TP3	Amplified audio signal
TP4	3.6V-4.2V
RF OUT	96MHz
LED1	'On' when frequency is locked

The error signal from pin 13 of IC4 is filtered and coupled back to the varactor diode to correct the frequency. In effect, the oscillator is stabilised and referenced to a 12MHz crystal, giving the crystal stability. The oscillator, however, can still be modulated to ±75kHz (wide-band frequency modulation) with an audio signal. This would have been impossible if a crystal directly controlled the oscillator.

When the transmitter is initially switched on, allow a couple of seconds for the frequency to settle. This is a little annoying, but it allows the transmitter modulating frequency to be as low as 10Hz.

The stereo audio input is taken from audio jacks JACK1 and JACK2 and combined in R15 and R16. VR2 is audio-level control. The amplified audio frequency (AF) from IC6 is fed to the varactor diode via R17 and C23 for frequency modulation of the RF signal.

Connect a piece of wire (78cm long) to the RF output as an antenna. You may use an external RF amplifier at RF output to amplify the signal to 1W level.

PARTS LIST

Semiconductors:

IC1	- 74AC74 dual D-type flip-flop with preset and clear
IC2	- 7805, 5V regulator
IC3, IC5	- CD4060 ripple-carry binary counter
IC4	- CD4046 phase-locked loop
IC6	- LM386 low-power audio amplifier
LED1	- 5mm LED
D1	- BB910 varactor diode
T1, T3	- PN2222A npn transistor
T2	- 2N3904 npn transistor

Resistors (all 1/4-watt, ±5% carbon):

R1, R2, R10	- 22-kilo-ohm
R3	- 220-ohm
R4, R5, R6, R9	- 10-kilo-ohm
R7, R12, R13	- 2.2-kilo-ohm
R8, R11, R17, R19	- 100-kilo-ohm
R14	- 47-kilo-ohm
R15, R16	- 33-kilo-ohm
R18	- 330-ohm
VR1	- 470-kilo-ohm potmeter
VR2	- 10-kilo-ohm potmeter

Capacitors:

C1, C7, C9-C11, C14, C23	- 100nF ceramic disk
C2	- 330pF ceramic disk
C3	- 10pF ceramic disk
C4	- 2.2pF ceramic disk
C5	- 3pF ceramic disk
C6, C8	- 100µF, 25V electrolytic
C12, C20	- 220µF, 25V electrolytic
C13	- 22µF, 25V electrolytic
C15-C17	- 10µF, 25V electrolytic
C18	- 2.2µF, 25V electrolytic
C19	- 1000pF ceramic disk
C21, C22	- 22pF ceramic disk
VC1	- 50pF trimmer

Miscellaneous:

RFC1	- 100µH, 2-hole balun ferrite core
RFC2, RFC3	- 330µH readymade axial inductor
L1	- 5T 20 SWG 8mm dia. air core spread over 1.2 or 1.5cm. Tap at 1/2T from V+
JACK1, JACK2	- Audio input jacks
XTAL1	- 12MHz crystal oscillator
BATT.1	- 12V battery or 12V DC power supply
ANT.1	- 78cm single-strand wire as antenna

Construction and testing

PCB layout of the high fidelity FM transmitter is shown in Fig. 4 and its components layout in Fig. 5. House the transmitter in a small plastic box. Keep all leads as short as possible. Use good-quality

shielded cable for input audio connections. 12V DC regulated hum-free power supply is recommended.

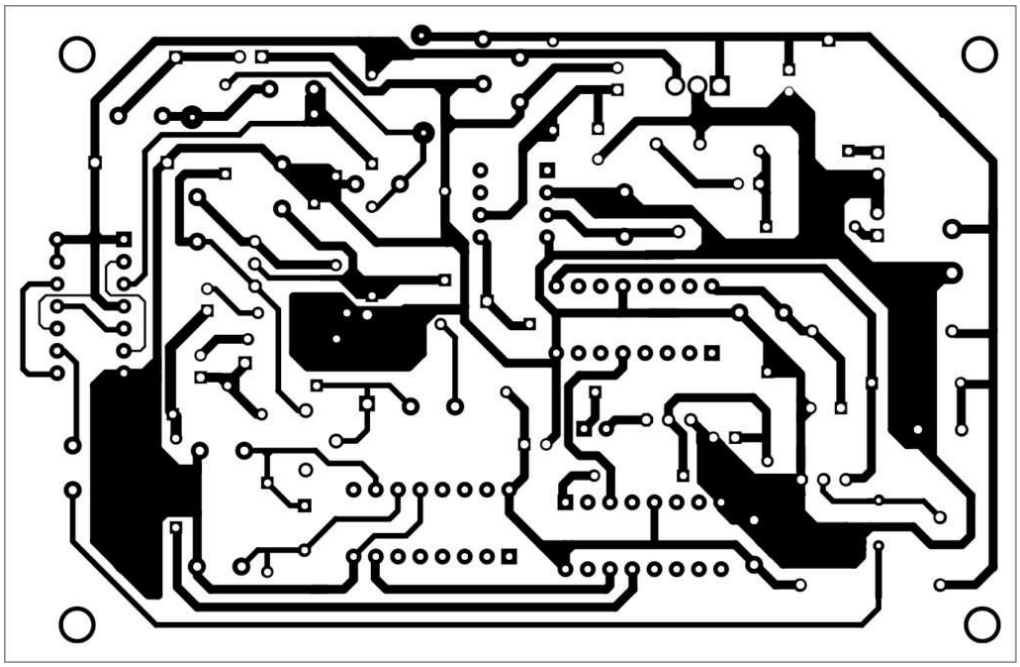

Fig. 4: PCB layout of the high fidelity FM transmitter

The operating frequency of the transmitter is 96MHz. Set VR2 to minimum and adjust VC1 for a reading of 3.6V to 4.2V at test point TP4. VR1 is biasing control for transistor T2 and should be set in the middle position. LED1 should light up to indicate a frequency lock at 96MHz. Feed audio signal at JACK1 or JACK2. This signal will be transmitted at 96MHz via antenna ANT.1. Tune the FM receiver to 96MHz. You should be able to hear the transmitted signal in your FM receiver. You can also use your mobile phone if it has inbuilt FM receiver.

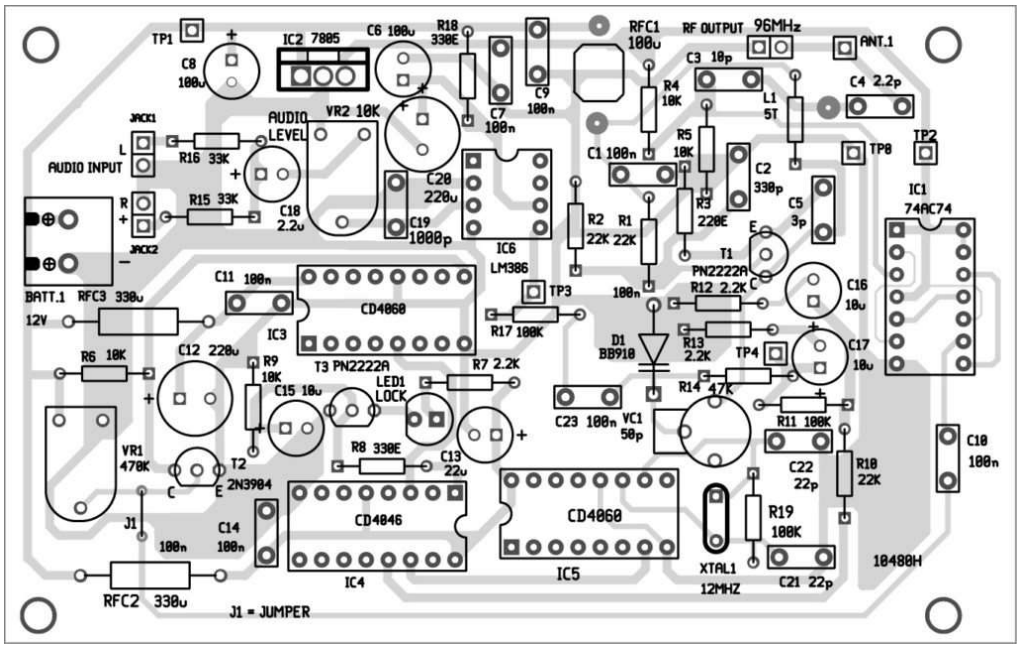

Fig 5. Component layout of the PCB given above

Vary VR1, VR2 and VC1 for adjustment. For test points and troubleshooting, refer to test points table.

Download PCB and component layout PDFs: **click here**