FM to AM Radio Converter (Stripboard Build)

Owing to a fast decline of medium waveband broadcasts and a continuing interest with vintage AM radios, Guy Fernando (M0OOX) presents this cost effective design for enabling FM broadcast stations to be listened to on classic vintage AM radios.

AM broadcasts in the United Kingdom and the rest of the world are in rapid decline and are likely to cease altogether by the middle of the 2020s, mainly due to higher transmitter running costs and dwindling listeners. Many countries in Europe have already closed AM broadcasts completely. Here in the UK on the long wave band (148.5 - 283.5 kHz) only BBC Radio 4 can be heard. On the medium wave band (526.5 - 1606.5 kHz) there remain a few regional and commercial stations that can be heard, but the only nationally covered stations are BBC Radio 4 and Radio 5 Live. It is however a different story on the FM band (87.5 - 108.0 MHz). At least for the foreseeable future, there remains a wider selection of FM stations including regional, community and the national BBC stations, Radio 1, Radio 2, Radio 3 and Radio 4 FM.

It is feared, with the imminent closure of the AM band countless vintage radios will become aesthetic curios or worse end up in skips - FM to AM converter to the rescue! These types of converters were widespread in the 1960s and 70s and sold mainly as AM car radio adapters, but have now disappeared into obscurity and the few that are still being manufactured are fairly costly owing to the niche market at which they are pitched. It is hoped this simple converter design described here will offer a new lease of life to AM only radios without breaking the bank.

Operation

The converter has two separate trailing wire aerials, one black for the FM reception, and one red for the AM transmission. The red wire must ideally be placed close to the AM radio or ideally connected to the AM radio's external aerial socket if a socket is available. The black wire is positioned for best FM reception. There is no requirement for a volume control on the converter, as the volume is adjusted on the AM receiver itself.

Photo 1 - The converter

The single tact switch button performs multi-function operations depending on how long it is pressed. The button can be briefly pressed, pressed for about a second, or pressed for about 10 seconds; respectively serving to seek to the next station, seek to the previous station and to store a default station in memory. During station seek and when approaching the end of the band, the seek function wraps around and starts again seeking at the beginning of the band. When a default station has been set, the converter will automatically tune to the default station on power up. The default station remains memorised, even if the batteries have been removed and changed. The converter has no power on/off switch, but it will automatically switch itself off into standby mode after 2 hours of operation to conserve battery life. Two hours was considered lengthy enough for listening to most broadcasted shows. The converter of course can be instantly switched on again while in standby mode, by pressing the button.

The Electronics

The electronics has three sections namely the PIC microcontroller, the FM receiver module, and the AM transmitter, as shown in Figure 1.

At the heart of the circuit is a PIC12F1572 PIC microcontroller, chosen for its low cost and low pin count. The author also selected a Microchip based microcontroller as he has much experience working with this microcontroller manufacturer. The PIC's primary function is to communicate with the RDA5807M receiver module using the Inter-Integrated Circuit (I^2C) serial computer bus. Port pins RA4 and RA5 are used as the clock (CLK) and data (DATA) bus lines, allowing commands to be issued and responses received. Although the maximum I^2C clock frequency for the RDA5807M is quoted at 400 kHz, it has been limited to 100 kHz so that the PIC port's internal pull up resistors can be used saving two 4.7kΩ external pull up resistors as specified by the I^2C standard. Port pin RA2 is configured as a digital output which is held low during normal operation. RA2 is taken high during standby which essentially powers down the AM transmitter section. Port pin RA0 is configured as a digital input which is normally held high by the port's internal resistor, and goes low when the button is pressed. The decoupling capacitor C1 is used to eliminate digital noise appearing on the positive rail, and must be placed as close to the PIC as possible.

The RDA5807M FM receiver module is a near baseband FM receiver with a low digital IF and audio DSP core. It has a built in synthesized local oscillator and so requires no setup or alignment which radically simplifies the setup of the converter. The mini PCB module unit was chosen in favour of the actual RDA5807 integrated circuit which is only available in SOIC package and considered too fiddly for the majority of constructors. The module also contains a 32.768 kHz crystal that forms the clock for the chip's internal synthesizer. The only other notable connections to the module are the FM antenna trailing wire (ANT), and the stereo audio output where only the left channel (L_OUT) is connected to R1 forming the input to the AM transmitter section. Even though the RDA5807M has inbuilt FM stereo and RDS decoding, these functions are of course not required and so are switched off by the firmware during initialisation.

A Colpitts oscillator forms the foundation of the AM, where L1, C4 and C5 form the basis of the tank circuit oscillating at a centre carrier frequency of around 950 kHz, with VC1 offering fine tuning about that frequency. Resistor R3 sets the base bias voltage of Q1 at around 2.4v. The audio output from the RDA5807M is fed into a simple filter network composed of R1, C2 and C3 which provide attenuation and band-pass filtering with a lower -3dB cut off frequency at 150Hz, and an upper -3dB cut off frequency at 6 kHz. This pass-band is typical of the frequency range that AM broadcast stations use, and limit the sidebands to well within the required 9 kHz AM channel spacing. The audio signal is injected into the oscillator's DC biasing point at the junction between R3, C3 and L1. This varying of the transistor bias voltage has the effect of changing the oscillator gain causing the carrier to be amplitude modulated by the audio signal. The RFC L2 provides a large reactance at the oscillator frequency and a low resistance at DC to help start and sustain oscillation. The output of the oscillator is fed from the Q1 emitter and coupled to the AM aerial via C7 which provides a reactance of around 1kΩ to limit the loading of Q1, delivering about 1mW of RF power.

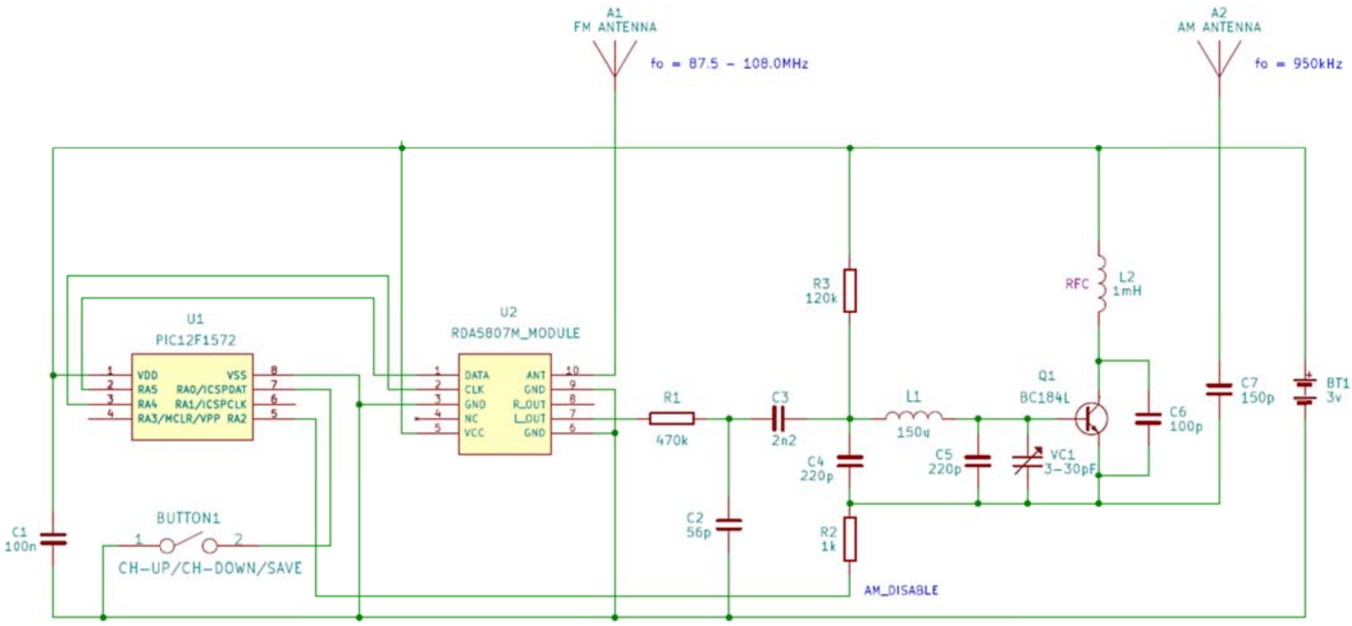

Figure 1 - Schematic Diagram

Parts List

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R1             470kΩ ¼W
R2             1kΩ ¼W
R3             120kΩ ¼W

C1             100nF
C2             56pF
C3             2.2nF
C4             220pF
C5             220pF
C6             100pF
C7             150pF

VC1            3-30pF variable trimmer

L1             150uH
L2             1mH

Q1             BC184L NPN transistor (BC184, BC184B, BC184C & BC184K use a different pinout)
U1             PIC12F1572 (Available pre-programmed, see http://www.i4cy.com/m0oox/fm2am)
U2             RDA5807M FM receiver module

BUTTON1        12mm x 12mm momentary tactile push button for CH-UP/CH-DOWN/SAVE
BT1            2 off. 1.5v AA batteries

Stripboard     Copper stripboard (veroboard) 10 x 34 holes, 0.1" pitch
Button Cap     12mm x 12mm momentary tactile push button cap
IC Socket      8-pin low profile DIP
Veropins       4 off. Vero part 18-1658
Screws         2 off. M2 x 5mm pan head self-tapper

Wire           40cm red insulated stranded 7/0.2mm 1000V PVC Ø1.2mm
               40cm black insulated stranded 7/0.2mm 1000V PVC Ø1.2mm
               15cm single core insulated 33SWG Ø0.25mm
               15cm tinned copper un-insulated 22SWG Ø0.71mm

Enclosure      OKW Part# A9052118, Soft Case L
               OKW Part# A9152219, Intermediate Ring
               OKW Part# A9152010, Set of Battery Clips
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Construction

A fine tipped soldering iron should be used to avoid damaging the board and components. The circuit is constructed on stripboard (veroboard) with the component positions placed as shown in Figure 2. The copper tracks are shown in the figure, but are actually on the underside of the board.

1. Cut a piece of stripboard so that it has 34 strips by 10 holes wide. Using Figure 2 as a reference. Begin by soldering the discrete components, resistors R1 – R3, capacitors C1 – C7, VC1, inductors L1, L2.

2. Insert transistor Q1 and the IC socket for U1 onto the board, observing their correct orientation before soldering.

3. Solder ten fine short tinned wires to the RDA5807M FM receiver module edge so that the module can be soldered to sit a few millimetres above the board. (The wires will require a little bending as the connections on the module have a slightly finer pitch than the stripboard's 0.1" spacing.)

4. Solder the five thin flying insulated wires shown in blue, and then the eight un-insulated tinned wires shown in dark grey.

5. Solder in the four veropins at the points on the board where the battery and antenna leads connect.

6. Insert the button from the underside of the board and solder the switch contacts to the stripboard copper tracks as shown.

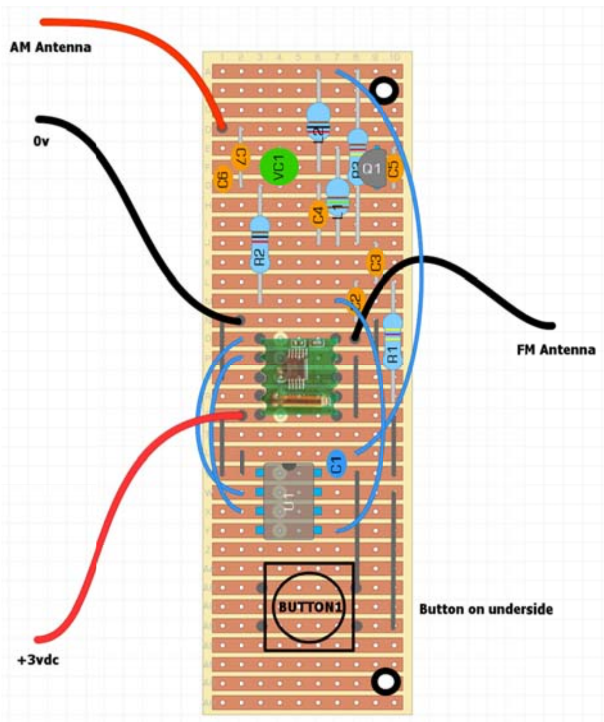

Figure 2 - Stripboard layout

7. Using an appropriate tool or drill-bit, cut the copper tracks between pins of both U1 and U2. There are nine cuts in total and are the only tracks that require cutting on the board.

8. Insert the pre-programmed PIC into the DIP socket, ensuring that the semi-circular notch on the IC is correctly oriented into the socket, while throughout observing precautions for handling static sensitive devices.

9. Three holes require drilling in the enclosure. First the button hole is drilled through the enclosure top cover. To accurately assess the position of this hole, offer the board up to the enclosure top cover where it is to be mounted, and mark the centre position of the switch. Drill a hole sufficiently large to allow operation of the button typically 8mm. Next drill two 1mm holes through the "intermediate ring" part of the enclosure for the antenna wires. Cut two 30cm antenna wires (one red, one black) and thread them through the 1mm holes as shown in Photo 3.

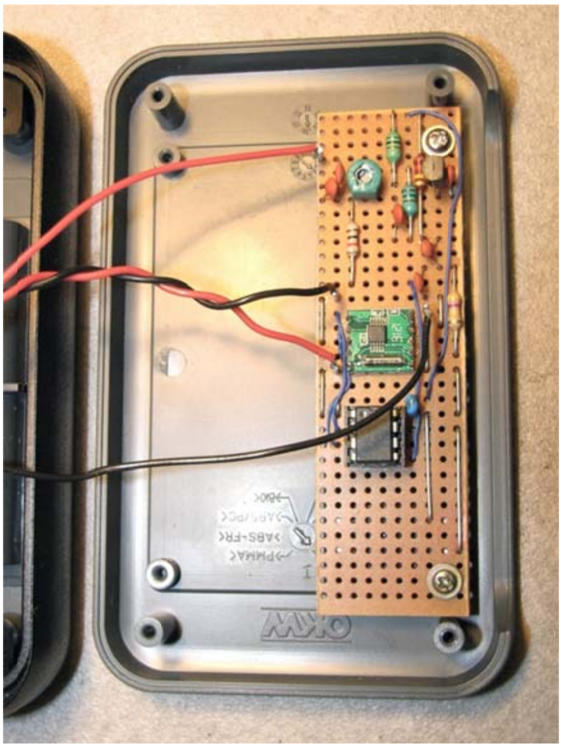

Photo 2 - Close up of the stripboard construction

10. Offer the board up to the enclosure top cover standoffs to accurately verify the self-tapper mounting screws drill-hole positions. Carefully drill two 2mm holes, top right and bottom right of the board. Fit the board to the enclosure front cover using the two self-tapping screws.

11. Push the metal battery clips into position in the battery compartment part of the enclosure.

12. Using the remainder of the red and black wires, strip the ends then solder them connecting the battery terminals to the

+3vdc and 0v board veropins. Connect by stripping and soldering the red AM antenna and black FM antenna wires to the appropriate remaining veropins on the board.

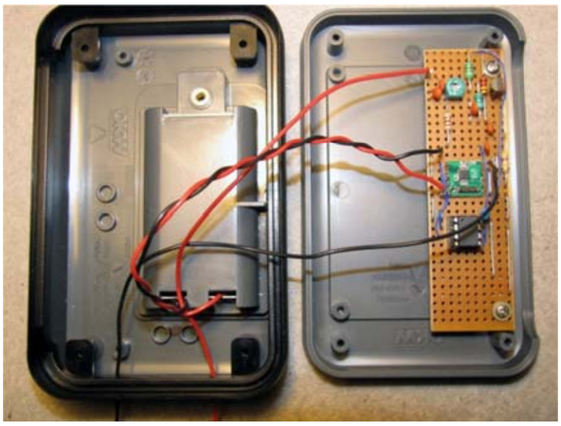

Photo 3 - Completed construction showing wiring

The Firmware

Programming a blank microcontroller with the firmware requires specialised software and programmer equipment that most readers will not have access to. For this reason a pre-programmed PIC12F1572 PIC microcontroller can be obtained from the author's website at:

http://www.i4cy.com/m0oox/fm2am

The firmware tasks programmed into the PIC include:

1. Issuing commands to the RDA5708M FM receiver chip via the I^2C bus. On power up, the PIC issues a command to initially set the receiver chip to monophonic, with flat frequency response, 75µs de-emphasis and RDS turned off. The converter will then tune to the first station it finds. Depending on how the button is pressed the PIC will issue a command to either seek to the next station, the previous station or save the current station as the default station.

2. Controlling power modes. The converter during normal operation consumes 20mA, but by controlling the AM_DISABLE line and placing the PIC into low power mode this sets the converter into standby mode reducing the current consumption to only 20uA. This should be more than sufficient giving a theoretical 15 years of standby operation using a standard set of 2700mAH AA batteries.

3. Checking when and for how long the switch is pressed. A software timer is used to determine this.

4. Saving a default broadcast station to the non-volatile PIC flash memory. PIC flash memory will retain the saved channel for many years even without batteries.

Alignment and Testing

Switch on the AM radio and tune to around 950 kHz or closest to that frequency where a broadcast station is not found. Insert two AA batteries into the converter. Position the red AM antenna next to the AM radio then straighten the black FM antenna and position it away from the AM radio. Briefly press the button on the converter, and after a short period an FM station should be heard coming from the AM receiver. The trimmer capacitor VC1 may require adjusting to fine tune the converter frequency to that of the desired position on the AM radio's tuning dial. This completes the alignment procedure. Finally screw the enclosure together using the remaining hardware supplied with the enclosure. Operating the converter is simple, and is described near the beginning of the article.

Happy listening!