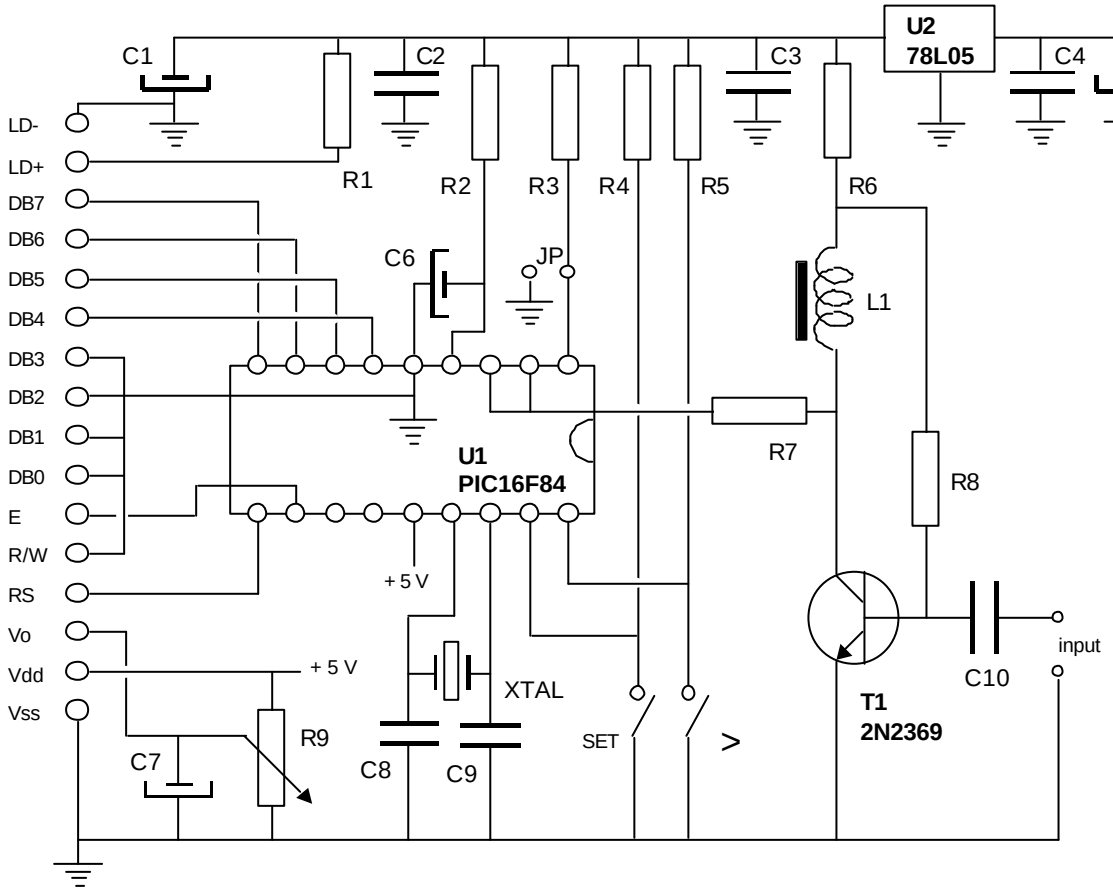
The m-counter, a PIC based programmable frequency meter

Project Overview

This project proposes a simple frequency reader specifically designed for QRP rigs, also if you may employ it also as a workbench instrument. In fact it exhibits several very interesting features, like a maximum working frequency above 40 MHz, a 10 Hz resolution, a low consumption (15 mA) and a very simple assembly. Moreover it is possible to program an IF value and mode simply by means of two push buttons.
The basic idea comes from the AN592 Microchip application note: "Frequency counter using PIC16C5x" [(1)], where you may find a simple software wich implements a frequency counter using a PIC microcontroller. I read also a couple of interesting articles concerning this matter on "QST" [(2)], and so I was encouraged to go ahead with the project. I wrote a specifically designed software to improve the counter resolution, to handle the IF mode and value by means of an operating menu, to decode and edit the read frequency on an LCD display. The result was a simple and effective device, equipped with a free software available to those who could be interested.

The electrical schematic



R1 : 22 Ω	R5 : 18 K Ω	R9 : 10 K Ω var.	C4 : 100 nF	C8 : 33 pF	U2 : 78L05 see text
R2 : 22 K Ω	R6 : 470 Ω	C1 : 10 µF	C5 : 10 µF	C9 : 33 pF see text	T1 : 2N2369
R3 : 18 K Ω	R7 : 470 Ω	C2 : 100 nF	C6 : 1 µF	C10 : 10 nF	L1 : 10 µH
R4 : 18 K Ω	R8 : 10 K Ω	C3 : 100 nF	C7 : 4.7 µF	U1 : PIC16F84	

The electrical schematic is very simple, given that most of the functions are implemented by the microprocessor. It was needed only an amplifier stage to raise the input signal level from 200-300 mV p.p. to about 3 volts p.p., so as to drive correctly the RA4 (pin 3) triggered gate of the PIC. I implemented a common emitter amplifier using a 2N2369 transistor, with a small inductance series connected to the collector load, so as to improve the frequency response at the high frequencies. So it was obtained a suitable gain from 100 KHz up to about 50 MHz, the lower limit being forced only by the C10 capacitor. The R8 value is chosen so as to obtain about 1,6-1,8 V on the transistor collector, such a value is necessary to drive correctly the PIC gate, and you may verify this voltage after completing the assembly, and before inserting the PIC on its socket.
The time base is provided from a 4 MHz, parallel resonant, microprocessor crystal, if you have at your disposal a professional frequency meter, you may tune accurately the frequency by adjusting the value of C9, which could also be replaced by a little plastic trimmer, otherwise the reading will be in any case within the quartz tolerance (typically 50 p.p.m. max).
The 78L05 regulator is well suited to feed the 15 mA required, however if you want to employ a back-lighted LCD module, it will be necessary to replace it with a 7805 model, capable to supply about 60 mA without excessive heating. On the 16 pin connector two pins are provided (15, 16) to drive the LCD LED panel. The supply voltage should be in the 8-12 volts range, and you may control the display brightness by turning the R9 trimmer, the maximum value being obtained with the cursor completely turned toward the ground.

The Software Functions

The counter works using the 8 bits internal counter (TMR0) and the 8 bits prescaler of the PIC. The prescaler cannot be read directly by means of the PIC basic instructions, therefore it is necessary to employ a trick in the software, the whole process is well described in the Microchip application note [(1)] where you may find further details. To improve the resolution I managed a third 8 bits counter, which is increased by the program when a timer overflow is detected. So it was possible to improve the overall counters capacity to 24 bits. The counting period is obtained by means of some accurate delay routines, tuned precisely using my workbench instrumentation.
Several readings / second are implemented, so as to simulate a continuous display refresh.
The counter programming is obtained using two push buttons **SET** and ">" in the following manner :

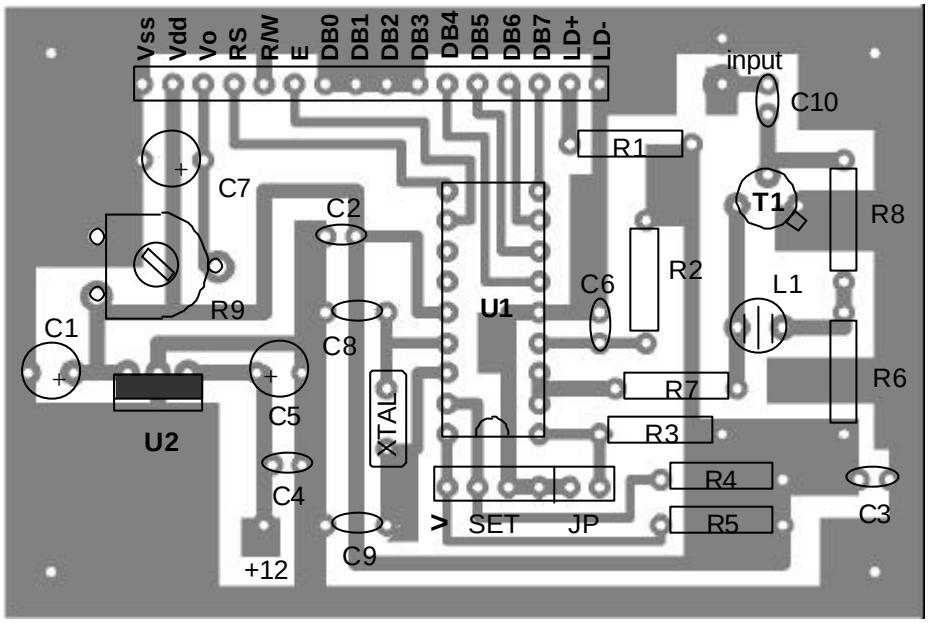
- Pressing the **SET** button a first time, the IF value will be displayed ("IFset" function) and the flashing cursor is positioned on the first digit you may modify (ten MHz), now you may modify the digit value by means of the ">" push button in the 0 - 9 range. After changing this digit you may go to the next digit by pressing again the **SET** button, and so on until you reach the last digit to the right.
- Another pressing of the **SET** button starts the "Mode set" function, and now you may choose, by means of ">" button, between the three operating modes : "VFO + IF", "IF - VFO", "VFO - IF".
- Now a new **SET** button pressing enters the "Prescaler" setting mode allowing, by means of ">" button, to select one of the provided ratios (see below)
- A last **SET** button pressure closes the menu, saves the setting parameters in the PIC EEPROM, and re-activate the frequency reading function.

Keep in mind that, when operating in the "IF - VFO" or "VFO - IF" modes, the frequency value will be displayed only if the result of the subtraction is positive.
By inserting the JP jumper the µ-counter may be connected to a prescaler, so as to enhance the frequency reading range up to 1.5 GHz.

The following settings may be chosen :

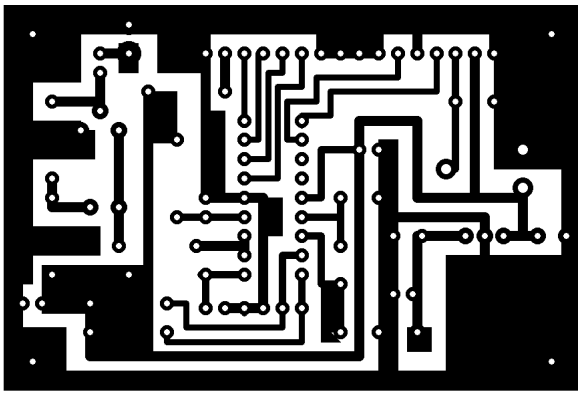
prescaler ratio	*Max frequency*	*resolution*	*Readings/sec*
10	**500 MHz**	**100 Hz**	**9**
32	**1.5 GHz**	**100 Hz**	**3**
64	**1.5 GHz**	**200 Hz**	**3**
128	**1.5 GHz**	**400 Hz**	**3**

The device assembly



The assembly is done on a single sided PC board measuring 76 x 51 mm. On the board are placed also a female 16 pin connector, 2.5 mm spacing, to match the LCD module and a male 6 pin connector to link the two push buttons and the JP jumper. The components placement is shown clearly in the picture, and the assembly is very simple, due also to the small number of parts.
The LCD module may be connected using a 14 wires flat cable (16 wires if back-lighted) or it may be inserted directly on the connector, as shown in the photo. In this case, a male connector must be soldered on the LCD, choosing a "long size" pin model, so as to leave some free space under the module, while the 7805 regulator will be folded against the board. I recommend to employ small sized components, like multi layer ceramic and tantalum capacitors, which will fit better to the PCB size, using a 7805 regulator if a back-lighted LCD is employed.
The PIC microprocessor must be inserted on a 18 pin socket, so it will be possible to extract it if some software upgrade should be needed.

The 1:1 scale PCB (76x51 mm)



The 1:1 PCB may be reproduced in several ways. I suggest to copy it on a transparent using a good quality laser photocopier, or by means of a scanner and an inkjet printer. Next you may employ a usual photo etching technique. I may provide the master in CIRCAD format to those who are interested.

Conclusions

I built several units of this device, and it always proved to be very effective and easy to assemble. By tuning accurately the oscillator, it is also possible to use it as a workbench instrument, also if it was thought mainly as a QRP complement. The power consumption is very low (about 15 mA without back-light), so you may use a common 9 V radio battery to feed it. I may provide the software, the CIRCAD master and also the programmed PIC to those who are interested in the project.
You may contact me for any question, writing to my E-mail address : francesco_morgantini@libero.it or visiting my WEB site : www.qsl.net/ik3oil.

Notes

(1) - See the AN592 application note at the WEB address :
http://www.microchip.com/1010/suppdoc/appnote/all/an592/index.htm

(2) - *A PIC based Digital Frequency Display*, by Neil Heckt, QST, May 1997
- *The Unicounter, a multipurpose frequency counter/electronic dial*, by Ron Stone KA3J, QST, Dec 2000