

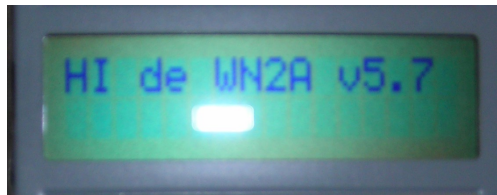
PIC16F628A BASED FREQUENCY COUNTER FOR UP TO 500MHz

THIS IS NOT INTENDED AS DETAILED PLANS FOR A CONSTRUCTION PROJECT
JUST SOME DOCUMENTATION ON A FREQUENCY COUNTER I DESIGNED AND BUILT FOR MYSELF.
ONLY FOR THE "MORE" ADVANCED BUILDER-PLEASE!

RELATED DOCUMENTS: Separate Files supporting this document:
SCHEMATIC: Schematic_FrequencyCounter_1.pdf
ASSEMBLY CODE FILE: FreqC_57.asm
HEX CODE FILE: FreqC_57.hex

FRONT VIEWS:

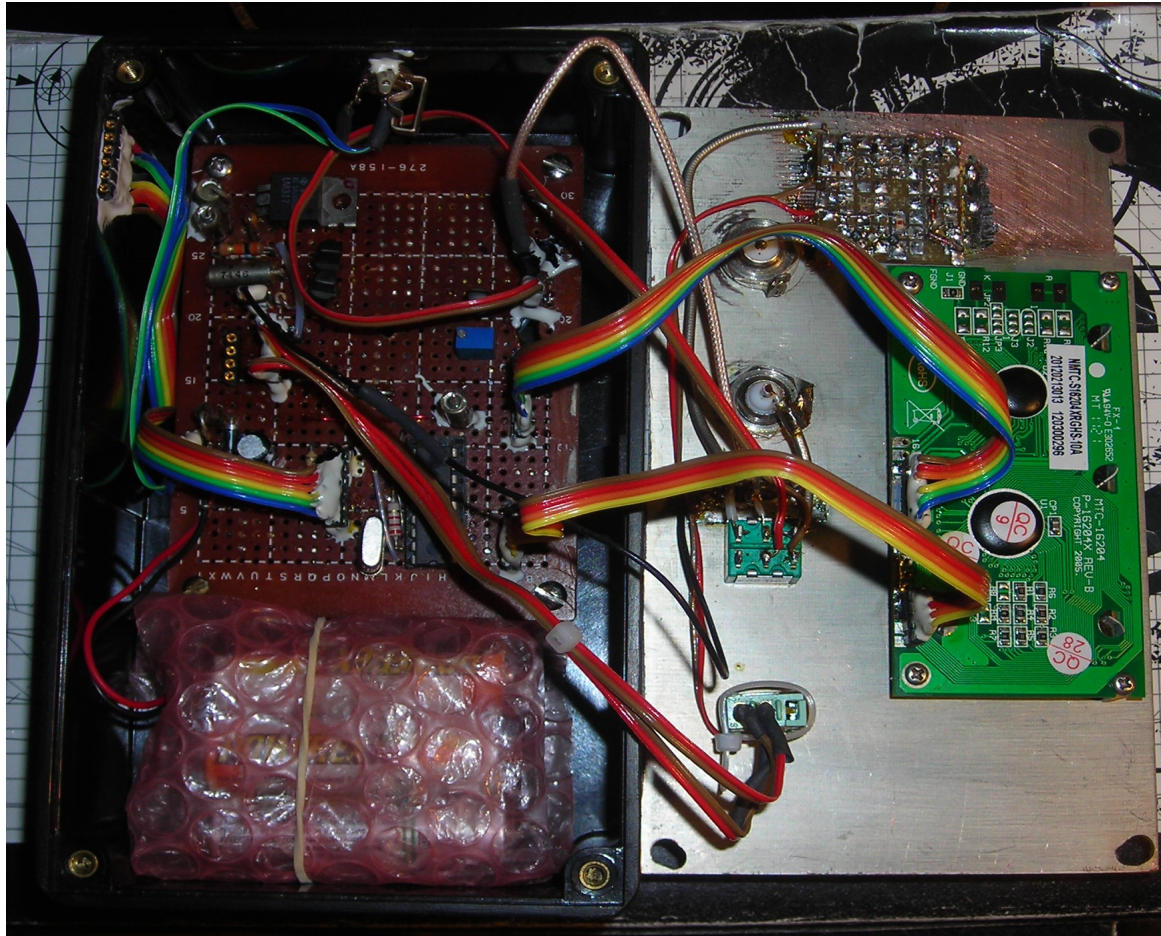
POWER-UP GREETING MESSAGE:



IN OPERATION: Measuring frequency of 30 meter CW VFO.



INTERNAL VIEW: UGH! Way too many prototype boards and interconnects. You can do much better with just one or two proper lay-out/etched PCB's (not counting LCD module). Do Not build yours this way!



GENERAL SPECIFICATIONS/GOALS: NOTE: Do Not Exceed +17dBm on any RF input

FREQ RANGE:	<1 MHz ~ 500MHz
MEASURED SENSITIVITY	5-330MHz: -35 ~ +17dBm 330-470 MHz: -30 ~ +17dBm 470-500 MHz: -15dBm ~+17dBm
DISPLAY	16 CHAR X 2 LINE LCD GRAY REFLECTIVE.
DC SUPPLY:	Frequency Counter can be powered Externally or Internally with Battery (6 X 1.2VDC NiMh AA cells). Battery can be charged from external source.
External DC requirement, counter in operation and battery charging.	+12 VDC @ <100 mA
Battery Capacity:	2300mA Hr Energizer NH15-2300 'AA' cells . ~50+ hrs.

BILL OF MATERIAL:
FOR SCHEMATIC SEE Schematic_Frequency Counter_1.pdf

REF DES.	DESCRIPTION/ PART NUMBER	NOTES:
Q1,Q2	MMBT2907A	On Semi, Fairchild
Q3	BCP53	On Semi, Fairchild,NXP
Q4.Q5,Q6	2N3415	
Q7	2N5486	ALT: 2N4416A
Q8,Q9	BFS17R	
U1	LM317	LM317K or LM317T
U2	PIC16F628A	MICROCHIP
U3,U4	MSA-0686	AVAGOTECH or MINI Circuits equiv.
U5,U6,U7,U8	74AUP1G80GW	MANF: NXP
U9	LCD DISPLAY: NMTC-S16204XRGS	MANF: MICROTIPS. SOURCE: MOUSER
D1	SCHOTTKY DIODE, GEN PURPOSE 1N5819	ALT: 1N5817,1N5818,etc
D2	1N4001	ANY SILICON RECTIFIER 500mA ~ 1 A
D3,D4	SCHOTTKY DIODE ZC5800E	ZETEX
D5,D6	1N4148	ALT: 1N916,etc
D7,D8	RF SCHOTTKY DIODE HP 5082-2826	
VR1	4.7V ZENER 1N5230B	equiv 4.7 V Zeners
Y1	QUARTZ CRYSTAL, FUND, 12.288 MHz	CTS or equiv.
C1	TRIMMER CAPACITOR, FILM, 5-27pF	
SW1	SPST TOGGLE SWITCH	E-SWITCH ST141D00 or equiv
SW2	DPDT TOGGLE SWITCH	E-SWITCH 100DP1T1B1M2QEH or equiv.
BAT1	BATTERY HOLDER : BH26AASF BATTERY: 6X 1.2V NiMh 'AA' cells.	MEMORY PROTECTION DEVICES Energizer NH15-2300 'AA' cells

OTHER COMPONENTS:

VALUE:	SPECIFICATION:
39 pF, 50 pF, 100, 680 pF	CHIP CAP, NPO 50V MIN
6.8 uF 35WV	TANTALUM AXIAL LEADED
0.1uF	CHIP CAP, X5R OR X7R 25 V MIN
0.01uF	CHIP CAP, X5R OR X7R 25 V MIN
RESISTORS (EXCEPT 47 OHMS)	CHIP RESISTORS, 5%, 0603 OR 0805 SIZE
47 OHMS	AXIAL LEADED 1/2 WATT 5%

Z1	RG-174/U or semi-rigid coax 0.141" dia. Short run approx 0.75" long.
Z2	RG-174/U approx 4-5" long

INTERCONNECTIONS:

RECEPT	SIGNAL	PLUG	# CIRCUITS
J1	EXTERNAL PWR	P1	2
J2	FRONT PANEL PWR	P2	4
J3	LCD DATA	P3	4
J4	LCD PWR/MODE	P4	6
J5	SAFETY GND	P5	2
J6	PROGRAM	P6	6
J7	PREAMP INPUT/BAND	P7	4
J8	BATTERY CLIP	P8	2
J9 BNC FEMALE	VHF INPUT	BNC MALE	RF
J10 BNC FEMALE	UHF INPUT	BNC MALE	RF
J11 3.5 mm audio mono recept.	EXT PWR	3.5 mm audio mono plug	2
J12	EXT. PROGRAM		6

Notes: J1-J7 are made from single-in-line 0.100" spacing socket strip, to required number of circuits. PCB Mounted.

P1-P7 are made from single-in-line 0.100" spacing pin strip, to required number of circuits. Cable Mounted.

All J1-J7 and P1-P7 made from TE 1-1571994-0 or equiv SIP sockets.

HARDWARE DISCUSSION: Refer to the Related Documents.

1. Credit first to Microchip AN592 by Stan D' Sousa. The gating method used in his app note was the basis of this design, except implemented in the PIC16F628A, with a few modifications. The asm file documents those items.

2. The UHF prescaler is done with low-cost MSA-0686 (alternate Minicircuits MAR-06) and low-cost 74AUP1G80GW D-Type Flip Flops from NXP. The TI version might work, but the NXP datasheet showed somewhat higher frequency capability than the TI part. For getting 500 MHz operation, this quite inexpensive.

3. The VHF preamp was done with available parts, but many good substitutes could be made, especially SMD equivalents. The reason for this circuit based on the need for a fairly wide dynamic range of signal input, and an output waveform best for the counter input. Ideally, one tries to keep the waveform square (50% duty cycle) as capable of as high in frequency as possible to give the counter (TMR0 in 16F628A) optimal conditions. Also the DC current consumption is kept low, see note 6.

4. The heart of this frequency counter is the PIC16F628A, with Timer 0 (TMR0) acting as the input counter. A software counter watches for the TMR0 overflow(s), and the gating is done with another pin (RB0) switching between input state (high-Z) which allows counting, and as an output (low-Z) which halts counting. The RC lead network to the TMR0 pin gives some enhancement to the higher frequencies ~40-50 MHz, which helps sensitivity in that frequency range. More on the 16F628A in the software discussion below.

5. Power Supply/ LDO regulator

Power is normally supplied by battery (6x 1.2 VDC NiMh 'AA' cells, nominal ~7.2 V) or external 12VDC. Regulation is required for both +5 and +3.3 Volt devices. To extend battery life, the +5 Volt regulator is a discrete LDO type, which can operate down to +6 volt. This regulator's reference is the +3.3 Volt regulator, a standard LM317. Supply monitoring is done for two purposes: a) estimated battery level and b) internal versus external power source. The battery level is done by dropping the battery voltage through a Zener diode, and voltage divider which provides a sample to the U2's comparator circuit (RA0 input), and this results in a rough estimate to battery level. The power source is determined by biasing Q1 on (when externally powered), and sensing that at U2's RA1 input. Both RA0 and RA1 application for battery level and power source sensing are multiplexed with driving the LCD module (U9).

6. UHF prescaler/ VHF Preamp power control

The Prescaler and Preamps are only enabled when the gate is open and U2 is counting. This saves quite a lot of DC power. Further, the Prescaler is only enabled on UHF operation. When either is enabled, it is done some time before the counting starts, so that UHF prescaler and VHF preamp can stabilize bias. When counting is done, both are disabled.

SOFTWARE DISCUSSION: Refer to FreqC_57.asm. Separate document.

1. TMR0 OPERATION

The TMR0 is used as the main counter with an input frequency capability of 50 MHz. To make use of this, the prescaler is set to divide by 256, and TMR0 is monitored for overflow. Overflow is then fed to register tmr0of. After gating is closed, the remaining count within the prescaler is clocked out by toggling the T0SE line which controls an exclusive-or gate.

2. GATE TIMING VHF AND UHF

The Gate timing for VHF (to 50 MHz) is 100 milliseconds, derived from the 12.288MHz clock. Since the instruction cycle is derived by dividing this clock by 4, this results in an instruction cycle = $1/(3072\text{KHz})$, then to get 100 milliseconds a software loop generates the VHF gate timing using 307,200 instruction cycles. In the same way 614,400 instruction cycles are used for UHF, resulting in a gate time of 200 milliseconds. This was needed (plus the shifting the count left 3x) to calculate the UHF frequency. The resultant count now resides in registers 0x27-0x28-0x29-0x2A (bufh-bufh-bufh-bufh) from LSB to MSB.

3. DOUBLE-DABBLE The binary count from above four registers is converted by the algorithm known as Double-Dabble. This algorithm is well documented on the internet, so the reader can get more information there.

4 LCD CONTROL The Microtips NMTC-S16204XRGs follows the same control protocol as many other LCD modules of the 16x2 type. Timing, character definition and cursor control are all defined in the software. See lines annotated in the assembly program. The program initially sends a one-line greeting message "Hi de WN2A v5.7", but the builder can easily generate his or her own customized greeting. The IC driver on the NMTC-S16204XRGs is the Samsung KS-0066 or equivalent according to Microtips. This uses commonly found parallel 4 or bit LCD data line format with a couple of control lines. Controlling the LCD with the 16F628A was rather straightforward.

PIC16F628A Programming:

1. Use MPLAB or MPASM to generate the hex file (if you are customizing the assembly code).

2a . Burn the program into the PIC16F628A using the free program IC-Prog. I have used a homemade Ludi type programmer that works very well with IC-Prog. IC Prog is made for Windows systems but also works perfect on Puppy Linux with Wine. The Ludi type programmer runs off a PC's serial port.

2b. If you have no serial port, you can use MPLAB and program with the PC's USB port. The PicKit 3 goes for about \$50 and programs directly from MPLAB. There are other similar programmers available as well, and there are FOSS projects like usbpicprog.

CALIBRATION:

Very Easy. After building unit, close it up, charge up the batteries and turn it on, let it stabilize for a minute or two. Then supply a known reference (such as 10.0000 MHz clock) that has been calibrated to a known frequency standard such as WWV. Adjust C1 for correct display reading. Done. A Full Charge was indicted by "Int:9" (on mine) and I recharge it when it goes down to "Int: 7". Your Battery Level readings may vary! It is just a coarse voltage indicator.

CONCLUSION:

This paper is not meant to be a complete construction project, just some material to document one successful effort that resulted in a useful frequency counter for me.

Have Fun- And CU on the Amateur Bands!

73, Mike, WN2A

Software Used:

LibreOffice:



Qucs Circuit Simulator



Geany Integrated Development Enviroment

