## TUFC Features

- Up to four FET outputs
- Up to four gate inputs
- Programmable via PC serial interface
- Firing time from 0 to 999.999 seconds in 1 ms increments
- 100 ms firing duration
- Optional crystal oscillator or resonator
- 9V input
- Separate high current firing circuit
- Flashing LED output
- 76 mm diameter circular board
- Three 6 mm diameter mounting holes

## Introduction

The TUFC timing unit and firing circuit consists of a PIC16F84A 4MHz 8–bit microcontroller with four IRLD014 FET outputs. There are also four isolated gate inputs, a LED output and a serial PC interface. The unit is powered by 9VDC. The PIC uses either a crystal or a resonator. Figure 1 shows the double–sided printed circuit board for TUFC without any components loaded.

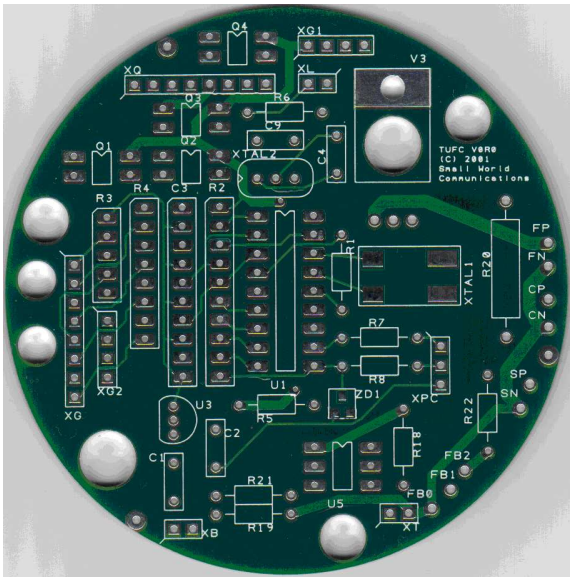


Figure 1: TUFC unloaded PCB.

## Timing Circuit

Figure 2 shows the output circuit for FET Q1 and the input circuit for gate G1. There are four identical input and output circuits. Each FET (Q1, Q2, Q3 and Q4) can be programmed to be triggered by any of the gate inputs (G1, G2, G3 or G4).

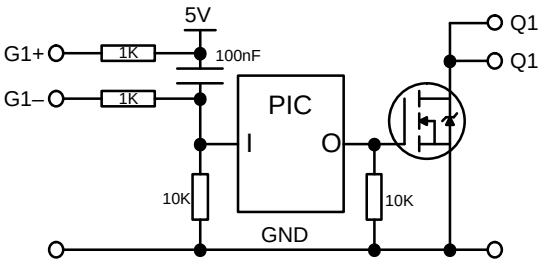


Figure 2: Gate Input and FET output.

For example, FET1 can be triggered by Gate2. When Gate 2 is shorted (G2+ and G2– connected together), the timer for FET1 starts. When the timer reaches 0, FET1 is turned on for 100 ms. Gates 1, 2, 3 and 4 are triggered when they are shorted.

Figure 2 shows the circuitry for driving an external LED and connecting to a serial PC cable. The LED anode should be connected to L+ and the LED cathode to L–. The three serial PC interface signals can be connected to either a 9 pin or 25 pin female D–type connector. For a 9 pin connector TX, RX and SG should be connected to pins 2, 3 and 5, respectively. For a 25 pin connector TX, RX and SG should be connected to pins 3, 2 and 7, respectively.

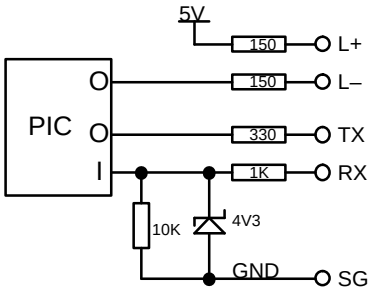


Figure 3: LED output and Serial PC interface.

When the TUFC is turned on and all the gate inputs are open, the LED will flash every 0.8 seconds after a 1.1 second initial time delay. When any of the four gates have been triggered, the LED will flash at 5 Hz. When the last FET has fired, the LED flashes every 1.6 seconds.

For safety reasons, if any of the gates are shorted at any time from 0.1 to 1.1 seconds from power–up, the TUFC goes into a fault state with the LED continuosly on. All operations are disabled, including the ability to fire the FETs and program the TUFC. To remove the fault state, the TUFC has to be powered off and the gates opened.

To program the TUFC, connect a serial cable from a PC to the TUFC. Use a serial modem interface program such as HyperTerminal (found in C:\Program Files\Accessories\HyperTerminal\ in Windows 95 or C:\Program Files\Windows NT\ in Windows XP). You may need to install this program from your Windows CDROM.

Setup the terminal at 1200 bits per second, 8 data bits, no parity, 1 stop bit and no flow control. This can be done in HyperTerminal by selecting File → Properties. In the Phone Number page for Connect using: select Direct to Com 1 or Com 2 (depending on which COM port you have connected to). Click on Configure... and set the various communications parameters.

When TUFC is switched on the following output will be produced:

```
TUFC V1.3
FET1 Time005.000 Gate1
FET2 Time010.000 Gate1
FET3 Time020.000 Gate0
FET4 Time040.000 Gate0
FET
```

This shows FET1 and FET2 are both triggered by Gate1 and will fire at 5 and 10 seconds, respectively. FET3 and FET4 have been turned off, even though a time has been programmed.

To program a FET, simply type a FET number, followed by the firing time (don't type the decimal point, it will print automatically), and then a gate (from 0 to 4). Selecting Gate0 will turn off the FET, i.e., the FET will not fire. After typing the Gate, the TUFC will program the parameters in the PIC's EEPROM and restart, redisplaying the TUFC parameters. If a non–numeric key is pressed, the programming sequence will abort and the TUFC restarts, leaving the original parameters unchanged.

Shorting gates 1, 2, 3 or 4 (if these gates are selected) will start the timer(s). Also, the serial interface will output the state of the FET's every 0.1 seconds. The output is a summation of the FET output times 1 for FET1, times 2 for FET2, times 4 for FET3 and times 8 for FET4. For example, if FET2 and FET3 are both set to fire from 10 seconds from Gate1, then the output will be 2+4 = 6 at 10 seconds. The keyboard input is disabled when a gate is triggered. This is to prevent inadvertent signals at the RX input interfering with the timer operation.

Table 1 shows the signals for the various connectors.

**Table 1: Timing circuit pin connections**

| Pin No. | Signal | Pin No. | Signal |
|---|---|---|---|
| XB.1 | B+ | XG1.1 | GND |
| XB.2 | B– | XG1.2 | GND |
| XL.1 | L+ | XG1.3 | GND |
| XL.2 | L– | XG1.4 | GND |
| XPC.1 | TX | XG2.1 | GND |
| XPC.2 | RX | XG2.2 | GND |
| XPC.3 | SG | XG2.3 | GND |
| | | XG2.4 | GND |
| XG.1 | G1+ | XQ.1 | Q1 |
| XG.2 | G1– | XQ.2 | Q1 |
| XG.3 | G2+ | XQ.3 | Q2 |
| XG.4 | G2– | XQ.4 | Q2 |
| XG.5 | G3+ | XQ.5 | Q3 |
| XG.6 | G3– | XQ.6 | Q3 |
| XG.7 | G4+ | XQ.7 | Q4 |
| XG.8 | G3– | XQ.8 | Q4 |

## Firing Circuit

A separate high–energy firing circuit is shown in Figure 4. The trigger inputs T+ and T– can be connected to one of the FET outputs, e.g., T+ to Q1 and T– to a ground. Six 9V batteries can be used to supply the three battery inputs FB0, FB1 and FB2. A safe switch can be connected to S+ and S–, a charging capacitor to C+ and C–, and a squib to F+ and F–. The resistor values shown were designed for a 27 mF, 63V capacitor.

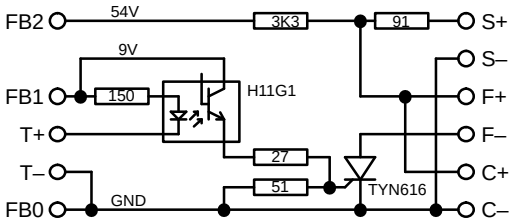


Figure 4: Firing Circuit

When the trigger input in shorted, the optocoupler is switched on. This in turn switches on the thyristor, discharging the capacitor into the squib. When the safe switch is on, the capacitor is discharged through the 91 Ohm resistor. For safe

operation, the safe switch must be on whenever the squib is connected to the circuit.

The thyristor energy $I^2t$ is given by $I_p^2RC/2$, where $I_p$ is the peak current, R is the squib resistance, and C is the capacitance. For example, with R = 0.3 Ω and the capacitor charged to 54 V, the initial anode–collector voltage is 4 V. This gives an $I_p = (54–4)/0.3 = 167$ A. With C = 27 mF, we have $I^2t = 167^2 \times 0.3 \times 0.027/2 = 112.5$ $A^2s$ which is less than the maximum value of the thyristor.

## Specifications

Supply current: 15 mA (average)
Supply voltage: 7 V (min), 30 V (max)
Input Gates: 4
Output FETs: 4
Firing Time: 0 to 999.999 s
Firing Duration: 0.1 s
Timing accuracy: ±150 ppm (crystal),
±1.1% (resonator)
Operating temperature ($T_c$): –10 C (min),
70 C (max)
FET current: 11.7 A (max)
Thyristor $I^2t$: 128 A (max, peak non–repetitive)
Serial Interface: 1200 bit/s, 8 data bits, no parity,
1 stop bit, no flow control
Board Diameter: 76.2 mm
Mounting Holes: 3
Mounting Holes Diameter: 6.1 mm
Board Centre to Mounting Hole Centre: 33.9 mm

## Ordering Information

SW–TUFC–*bxfg–n*
*b* = L for loaded board, U for unloaded board
*x* = C for crystal oscillator, R for resonator
*f* = F for firing circuit
*g* = G for high–g components
*n* = number of boards

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## Revision History

V1.04 19 May 2002. Changed gate inputs 3 and 4 to normally closed. Added startup delay.
V1.05 14 April 2011. Changed gate inputs 3 and 4 to normally open. Added fault test at startup.
V1.06 21 April 2011. Changed fault detection to be at any time from 0.1 to 1.1 seconds after powerup.
V1.07 25 September 2013. Added HyperTerminal location for Windows XP.