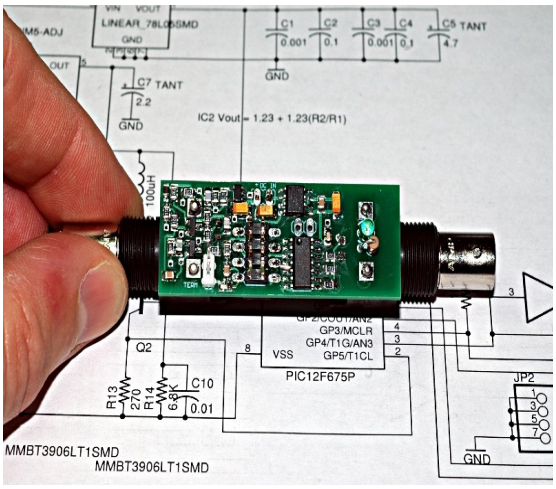
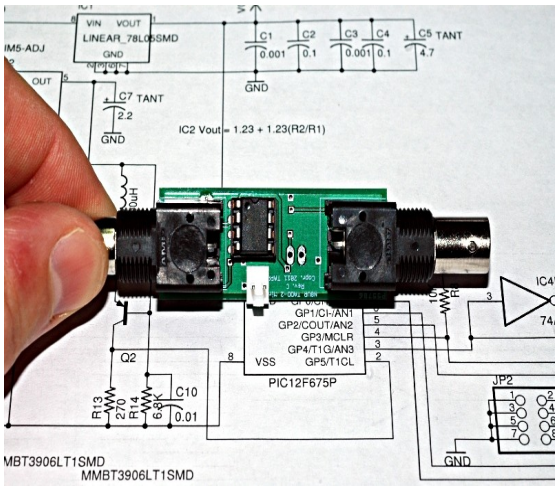
TADD-2 Mini Installation and Operation Manual

PPS Divider
Revised: 22 May 2015





Introduction

The TADD-2 Mini (or "T2-Mini") is a frequency divider that accepts signals in the 100 kHz to 20 MHz range and generates a pulse-per-second ("PPS") or other low rate digital output. Its primary purpose is to provide a low-jitter PPS output from a frequency standard; this PPS signal can be used for various timing measurements. It may also be used, with a simple modification, as a sine-to-square-wave converter, producing a TTL square wave replica of the input signal.

The outstanding characteristic of the T2-Mini is its small size -- the circuit board is only 0.75 by 2.0 inches. However, it is also designed to be very versatile and offer flexibility in use. The primary output is a low impedance source capable of driving coax lines with at least 3 volts into a 50 ohm load. The input and primary output use BNC connectors. The divider can be synchronized to an external signal (for example, to sync it to the PPS signal from a GPS receiver). Three LEDs indicate sync status as well as PPS activity. The input circuit works with signals as low as -20 dBm.

The T2-Mini accepts from 9 to 15 VDC power input. Current drain will depend on the output loads, but is typically in the range of 20 to 50 milliamps.

Use of a PIC as the divider allows extremely low jitter. Tests using various high-resolution measurement systems all show the jitter to at or near the measurement noise floor; that is, as low as 1 picosecond.

Circuit Description

The T2-Mini schematic is included at the end of this document. The circuit consists of four main sections: (a) power supply; (b) input circuit; (c) PIC chip; and (d) output circuit.

Power Supply

The power supply includes two voltage regulators. A 78L05 provides power for the PIC chip and the output driver chip. An LP2980 ultra-low dropout regulator provides approximately 9.17 volts to drive the input circuit. While the noise of this regulator is not optimum, it has a dropout voltage of only about 40mv at the current used in this circuit, and importantly has a similarly low drop when the input voltage falls below the regulated point.

The design tradeoff is that the input shaping circuit ideally wants Vcc of 10 volts to create a full 5 volt swing to drive the PIC chip. However, we'd like the T2-Mini to be able to operate from a 9 volt battery to make a self-contained unit. That's not a problem. While not ideal, 9V is sufficient to generate a reliable, low jitter signal to clock the PIC chip.

However, what happens when the battery starts to run down? The low dropout of the LM2980 allows graceful operation as the voltage drops below the regulation point, and minimal power is wasted as heat. Experiments indicate that the PIC will keep clocking, although perhaps with increased jitter, when the input drops to about 7.5 volts. So, using this regulator provides good performance when operating from typical shack voltage, but also the opportunity for reasonable performance from a 9 volt battery.

Input Circuit

The purpose of the input circuit is to convert the RF input signal into a low-jitter square wave that can drive the PIC clock input. The circuit is closely based on the one published by Wenzel at http://www.wenzel.com/documents/waveform.html, with modifications suggested by Bruce Griffiths and Ulrich Bangert. The revised circuit works with inputs as low as -20dBm.

PIC Circuit

Not much to say here: it's a 12F675 PIC chip, and they don't require much in the way of life support. As discussed below, pin 4 is pulled high via a 10K resistor to Vcc because unlike the other I/O pins, this one does not have internal pullup or pulldown capability.

Output Circuit

The output of the PIC drives a 74AC04 inverter. Gate B of the chip drives gates D, E, and F, which are paralleled through 47 ohm resistors to feed the BNC output. These resistors are *not* for impedance matching; they act as current limiters and in particular prevent the possibility of one gate sinking another if their turn-on times are not precisely matched. The 47 ohm value is a compromise to provide at least 3V peak to peak output at the connector while limiting the short-circuit current draw.

Gate A of the 74AC04 goes to pads which can be configured to drive an LED, or used directly as an additional TTL-level output.

Gate C provides an inverted PPS signal.

Assembly Instructions

All the surface-mount parts are pre-installed. What remains for you to add are the connectors, headers, socket, and optionally an LED. Please read these instructions carefully all the way through **before** you pick up the soldering iron. Because of the tight spacing and the fact that components are mounted on both sides of the board, it can be very difficult to undo an assembly error. ***You have been warned!*** In the instructions below, the "top" side of the board is the side with the SMT parts.

Instructions for use as a sine-to-square converter follow the main instructions.

Ok	Procedure
	Install 8 pin header on TOP side of the board, soldering the pins on the BOTTOM side. After soldering, trim the leads as close to the board as possible.
	Install unpolarized 2-pin headers on the TOP side of the board at the "TERM" and "INV PPS" positions.
	Install 8 pin DIP socket on the BOTTOM side of the board with the notched end facing the outside of the board. If you trimmed the 8 pin header pins closely, you should be able to mount the socket flush, or nearly flush, with the board. Solder the socket pins on the TOP side of the board, using care as there are SMT parts near the mounting pads.
	Install 2 pin polarized Molex connector on the BOTTOM side of the board with the locking tab facing the outside of the board.
	You now have a choice to make about use of the AUX PPS/LED pads. See below for more information. Install the parts of your choice on the TOP side of the board. Trim any through-hole leads as close to the BOTTOM side of the board as possible.
	Mount the two BNC connectors on the BOTTOM side of the board. Be careful solding as the two signal pins are very close to SMT parts.

Sine-to-Square Converter

To use the T2-Mini as a sine-to-square wave converter, just remove the PIC chip and jumper pin 2 of the DIP socket to pin 3 of the socket. A piece of 20 or 22 solid wire can be pushed into the sockets, or you can solder a jumper between the pins on the top of the board. Keep the wire short as it is carrying an RF signal.

If you intend to use the T2-Mini exclusively as a converter, you can skip installing the socket completely, and just solder a wire between pins 2 and 3. In that case, you can also skip installing the 10 pin header, as that is not used in converter mode.

The T2-Mini output square wave has an amplitude greater than 3 volts peak-to-peak and rise time faster than 2 nanoseconds when measured with a high speed analog oscilloscope directly at the output. Using a coax cable at the output will slow the rise time, and driving a 50 ohm load will lower the output level significantly – it's much better to terminate into a TTL (4.7kohm) or high impedance load instead.

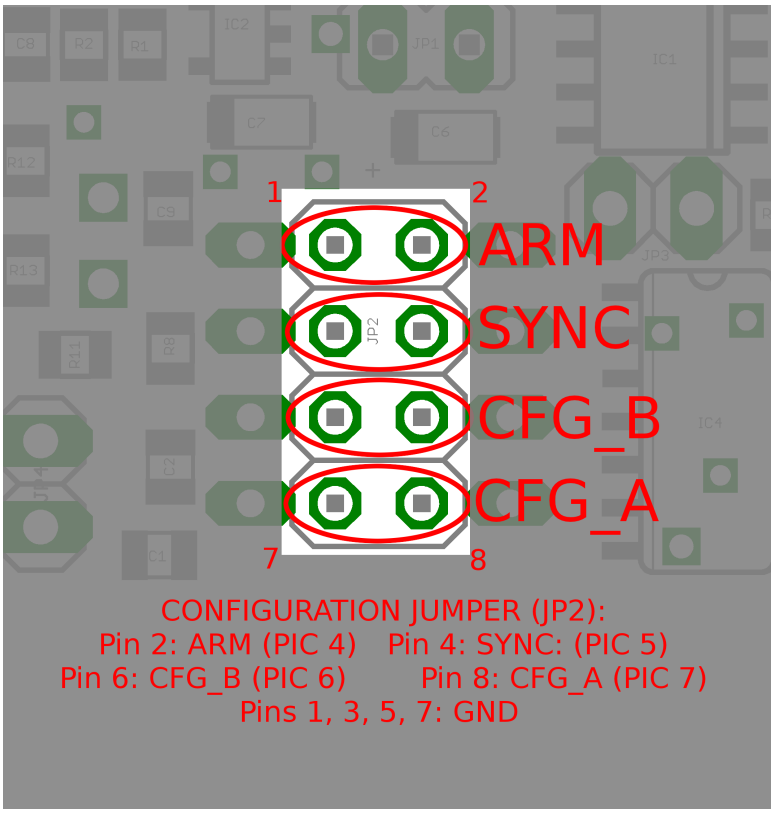
Jumper Configuration

The 12F675 PIC chip has four available I/O pins in addition to clock input, pulse output, Vcc, and ground. Those four pins are brought to an 8 pin header mounted on the bottom side of the board. The configuration jumpers **ARE NOT USED** in the sine-to-square version.

With one exception, the header pins are directly wired to the PIC I/O pins and there is no hardware constraint on the use of those pins. The exception is that PIC pin 4, “GP3/MCLR” (and header pin 2, “ARM”) is tied to Vcc through a 10K resistor (this is because the PIC can't internally set this pin to a weak pullup or pulldown). This table shows the PIC vs. header pin assignments:

PIC Pin	Signal	Header Pin	Signal
4	GP3/MCLR	2	ARM
5	GP2/COUT/AN2	4	SYNC
6	GP1/CI-/AN1	6	CFG_B
7	GP0/CI+/AN0	8	CFG_A

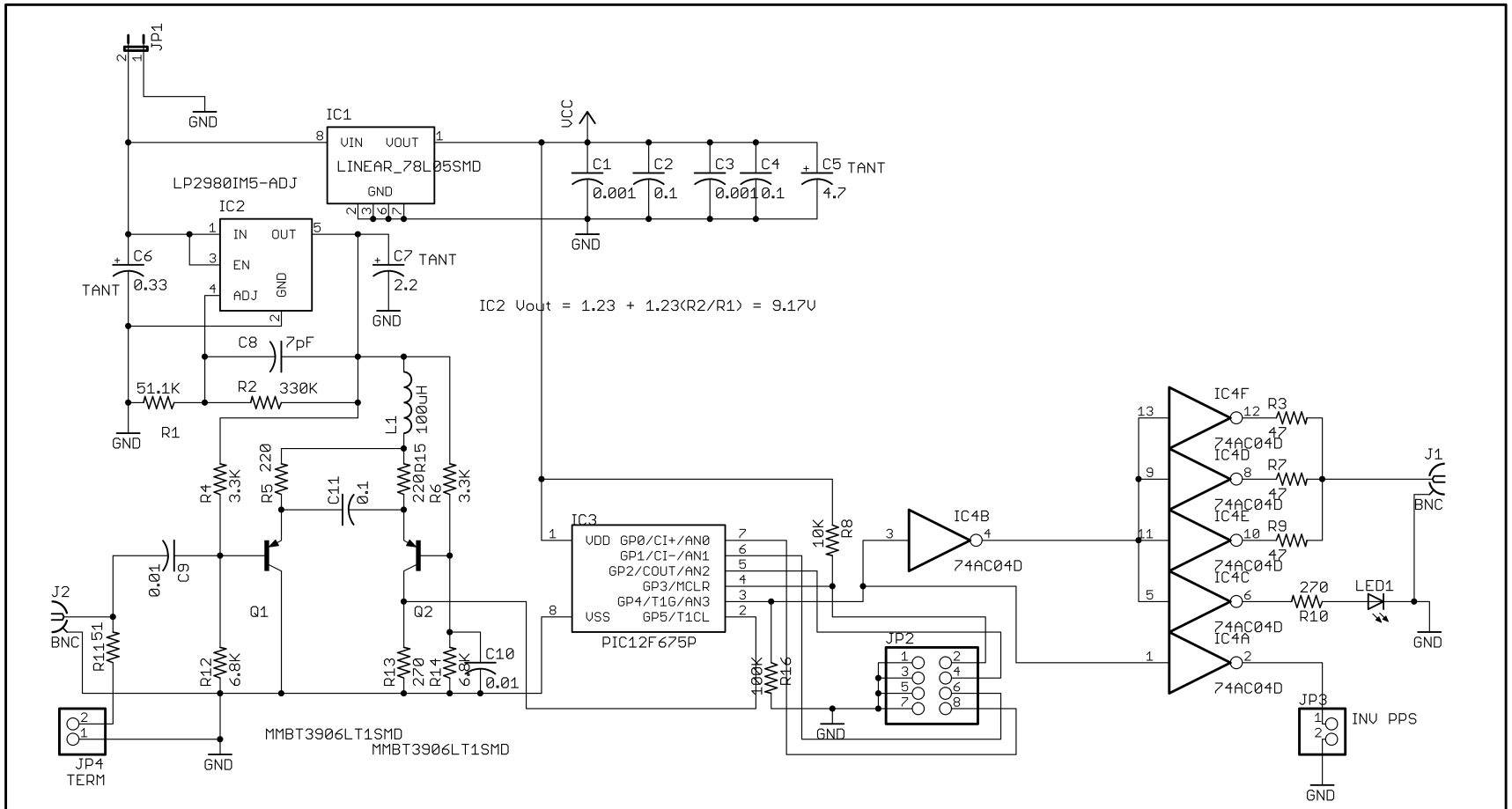
This is how the header assignments look on the board:



The firmware shipped with the T2-Mini (chip labeled “TVB PD17”) uses the CFG_A and CFG_B pins to program the input frequency (for 1 PPS output) as follows:

CFG_A	**CFG_B**	**FREQUENCY**
Open	Open	10 MHz
Closed	Open	5 MHz
Open	Closed	2.5 MHz
Closed	Closed	1 MHz

The ARM and SYNC pins allow the T2-Mini output pulse to by synchronized to an external source such as the PPS from a GPS unit. To synchronize the T2-Mini, ground the ARM pin for one second or more. The counter will reset and stop. Then apply a positive-going pulse to the SYNC pin. The counter will restart. The next output will occur 1 second after the leading edge of that pulse, with an accuracy of 4 clock cycles (e.g., 400 nanoseconds at 10 MHz; 4 microseconds at 1 MHz).



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