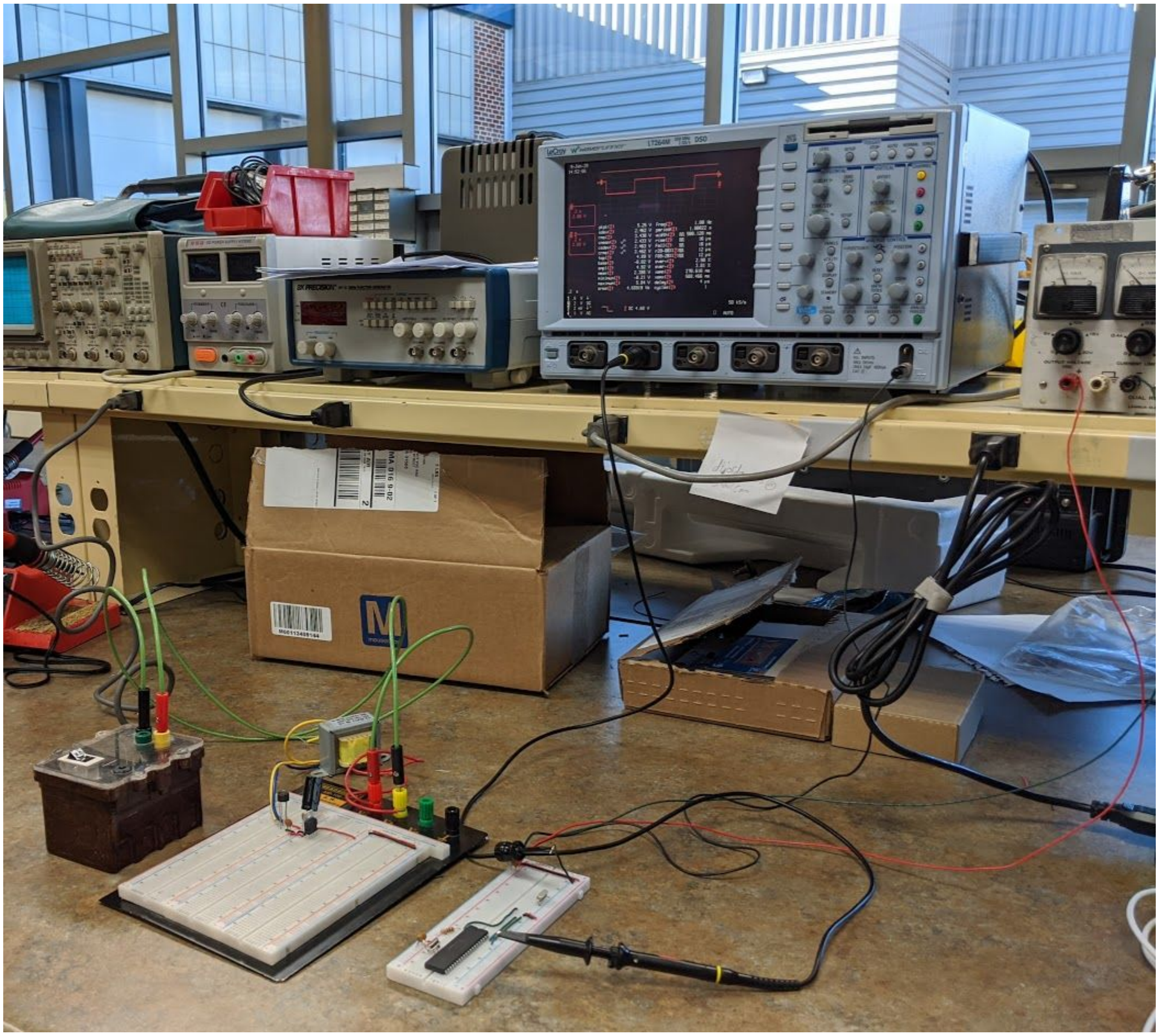
Experiment 42

5 Volt power supply



By: Thomas Buckley, Aidan O'Leary, Josh Pinoos

1/6/2020-1/10/2020

Objective: Build a 5-volt power supply outputting at 1 pulse per second.

Materials:

- 1 - PIC16F877A Microcontroller (Pin Datasheet on Page 6)
- 1 - PicKit 2
- 1 - 10:1 Step-Down Transformer
- 1 - Schmitt Trigger (7414N) (Pin Datasheet on Page 6)
- 1 - 5 Volt Voltage Regulator (7805) (Pin Datasheet on Page 7)
- 1 - Zener Diode
- 1 - Bridge Rectifier
- 1 - 20 MHz Crystal Oscillator
- 1 - 300 Ω Resistor
- 2 - 1000 Ω Resistor
- 3 - .1uf Disc Capacitor
- 1 - 1,000uf Electrolytic Capacitor

Procedure:

1. First, a circuit design was created as a backup option, shown on multisim in *Figure 1*. The circuit uses a Schmitt trigger that would take a rectified sine wave and convert it to a 5 volt 60hz square wave that was only positive as it only output the positive side of the wave and when it wasn't positive the Schmitt trigger would output a low positive signal. An oscilloscope measurement of both the input and output of the trigger is shown in *Figure 2*, the sine wave is the input and the square wave is the output. This operation of the Schmitt trigger, called its transfer function, is shown in *Figure 4*. Before going to the Schmitt trigger a Zener diode would filter out the negative side of the sine wave. We then connected this 5 Volt DC 60hz square wave to a DIV10 chip, and then the output of that was connected to a DIV6 chip effectively outputting a 1hz square wave.

Figure 1

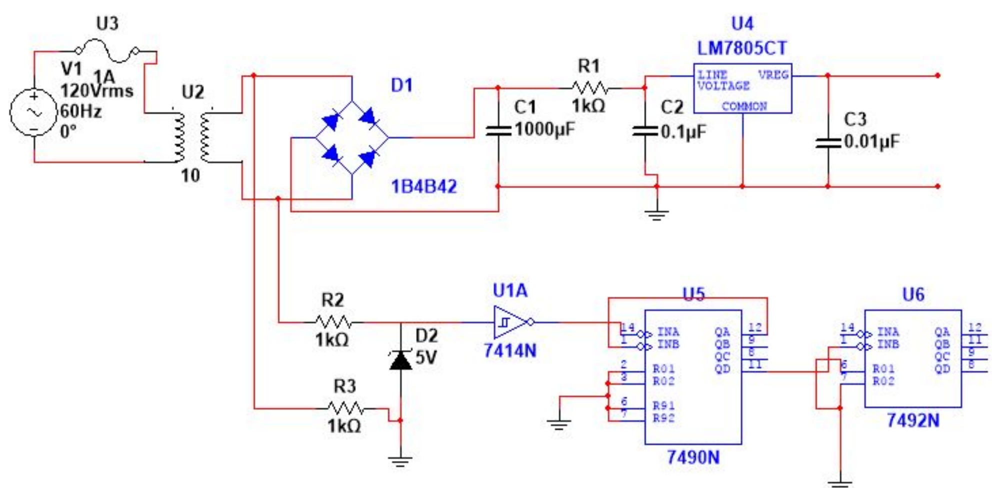


Figure 2

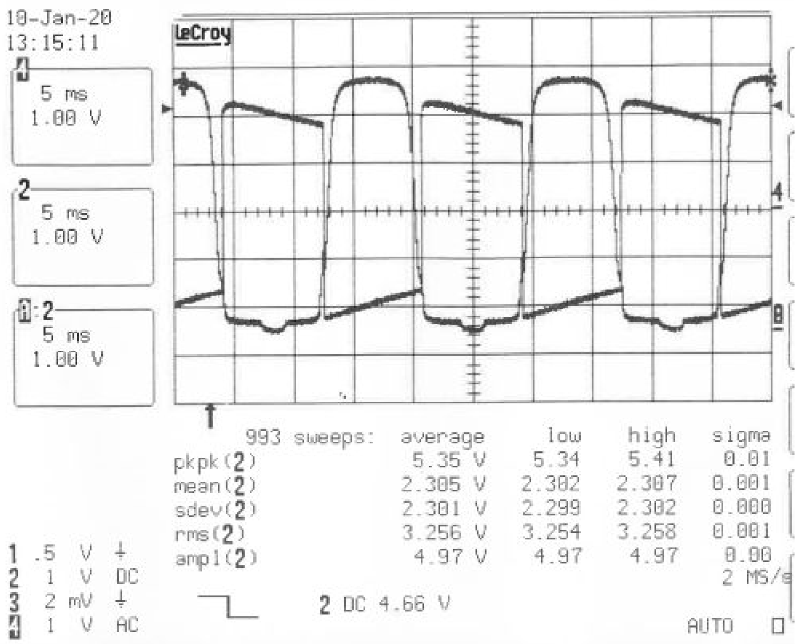
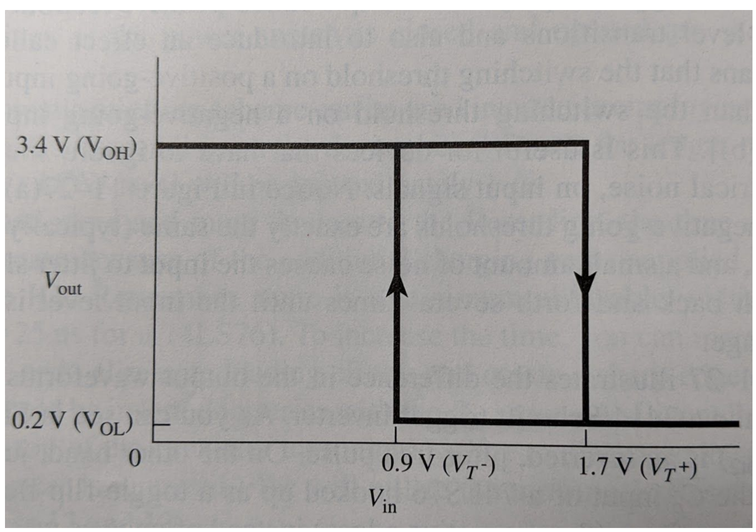


Figure 3



2. To begin this experiment using our design a prototype was created in multisim as shown in *Figure 4*. The circuit uses a step-down transformer to take a 120 volt AC sine wave down to 12.6 V AC. Once the voltage is stepped down a bridge rectifier refines the sine-wave and this wave is sent to a capacitor bank that smooths the AC wave. This is sent through a 5 Volt regulator to ensure that the supply outputs a very stable 5 volt supply. The outputted supply was breadboarded, ensuring that we used a breakout box for safety, and the oscilloscope measurement of the output of our 5-volt power supply before the microcontroller is shown in *Figure 5.*

Figure 4

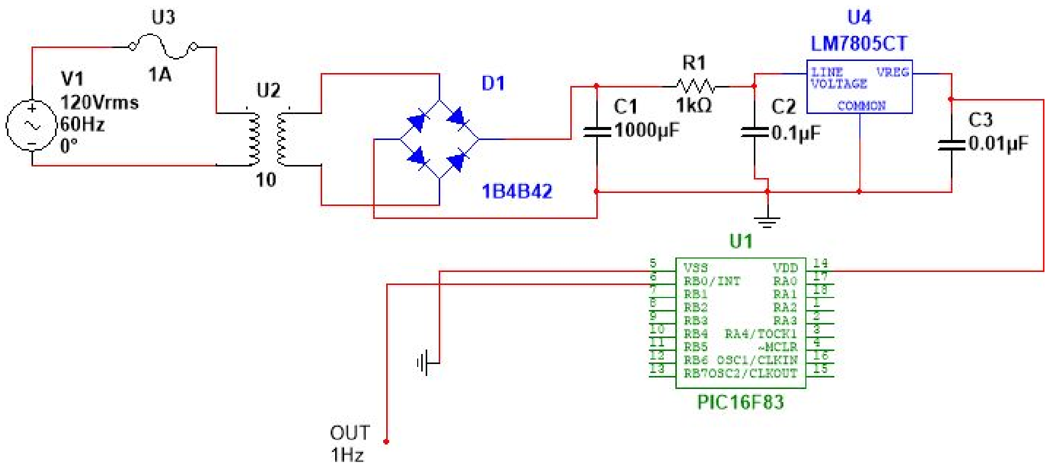
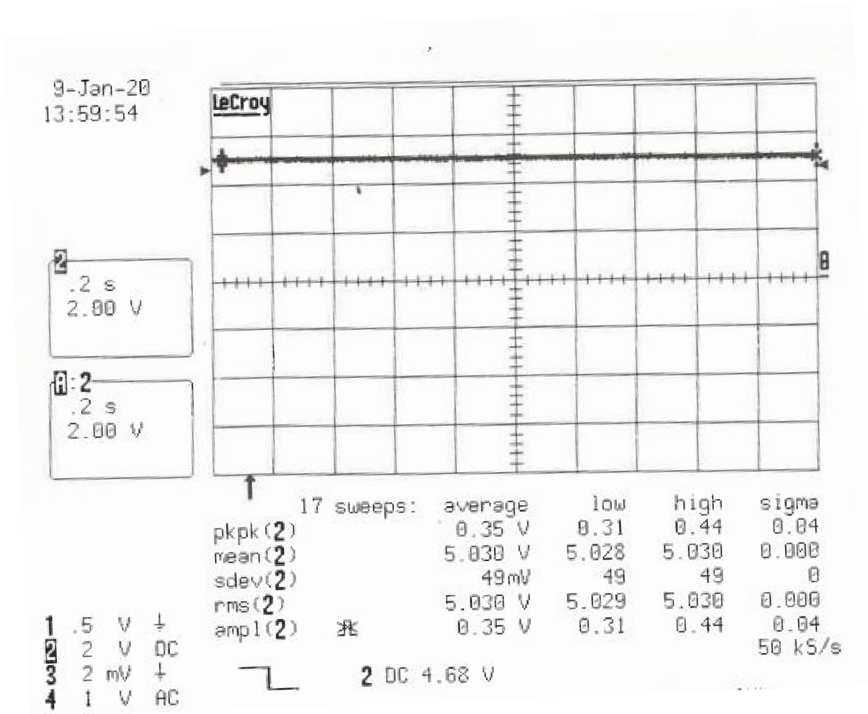


Figure 5



3. We then decided to use a PIC16F877A microcontroller to perform the pulsation as we can make it very accurate using an external crystal oscillator and also this chip has many GPIO pins that we can use in the future to expand our project. This program was created by calculating the time required per compute cycle on the microcontroller based on the 20mhz external oscillator, and then writing helper methods that waste precisely enough cycles to add up to the required delay, which in this case is a delay of half a second. The main loop program that was burnt to the microcontroller is shown in *Figure 6*. The program contains a delay helper method is shown in *Figure 7*. Both of these code snippets are written in assembly.

Figure 6

```
repeat
        movlw 0xFF              ;Move '0b11111111' to PORTB register
        movwf PORTB             ;PORTB ports should now read high
        Call DelayHalfs         ; call subroutine for half second delay
        Call Delay1ms           ; tuning
        movlw 0x00              ; Move '0b00000000' to PORTB register
        movwf PORTB             ; All LED at PORTB should be dimmed now
        Call DelayHalfs         ; call subroutine for half second delay
        Call Delay1ms           ; tuning
        goto repeat             ; goback to 'repeat' infinite loop
```

Figure 7

```
DelayHalfs
        banksel CountHalfs
        movlw H'32'
        movwf CountHalfs
RHalfs
        call Delay10ms
        decfsz CountHalfs
        goto RHalfs
        return
```

4. We then assembled the microcontroller on a breadboard and connected it to our microcontroller programmer, the PicKit 2. This circuit is shown in *Figure 8*. We measured the precision of this circuit and tuned the helper methods using an oscilloscope, and the measured period and frequency are demonstrated in the oscilloscope image pictured in *Figure 9*.

Figure 8

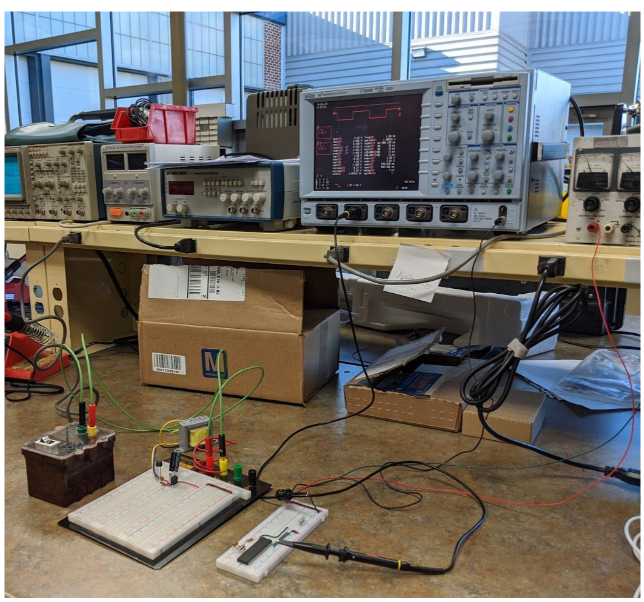
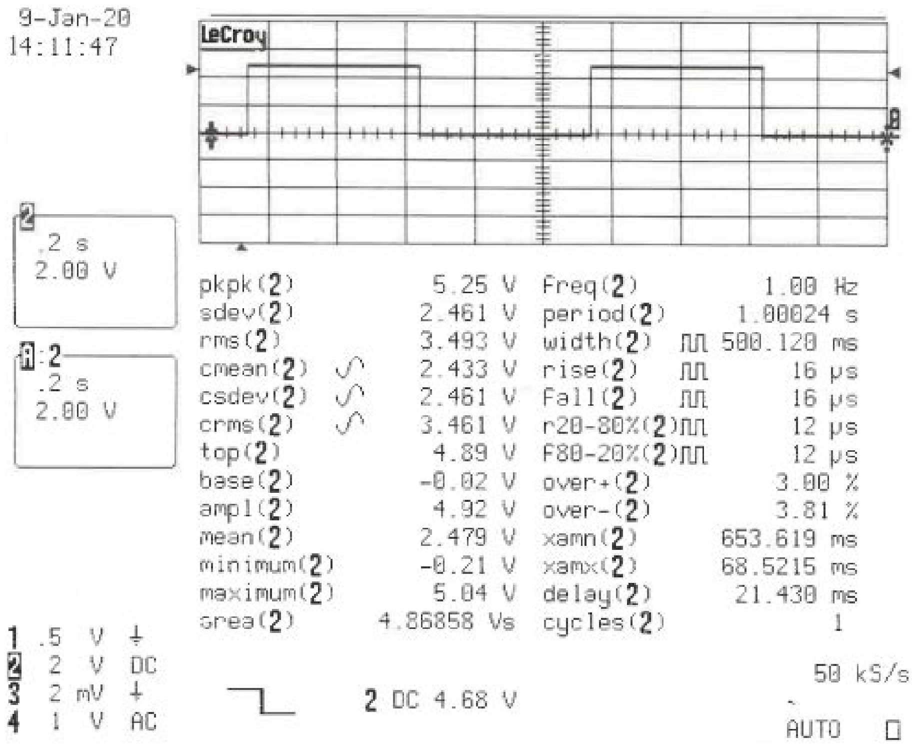


Figure 9



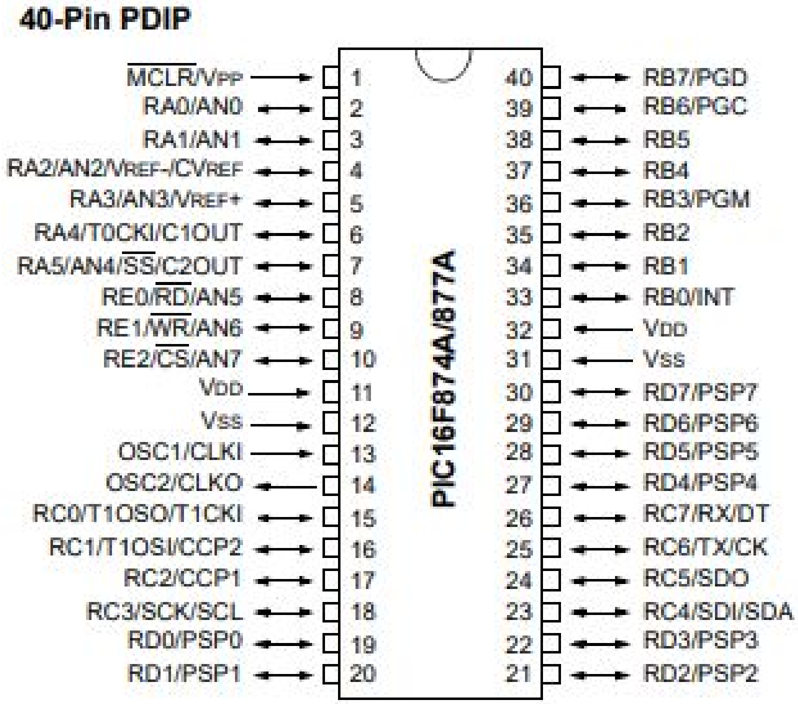
Discussion:

While building the voltage supply a design was created that used a microcontroller to control the output of the circuit which we had an issue with the code at first using a larger microcontroller chip. We eventually got the larger microcontroller to work but before that, we switched over to a smaller chip to make sure we could complete the project. The microcontroller that we used can be built on to complete more complex operations in later labs which why we choose to use it in the lab instead of a Schmitt trigger and Zener diode with dividers. We had no problems with the power supply section of the circuit.

Conclusion:

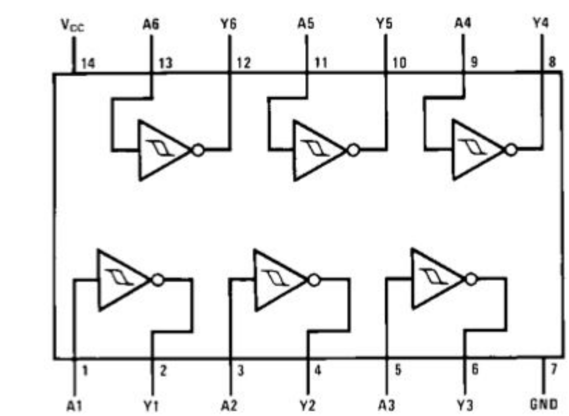
A Zener diode and a Schmitt trigger can be used to convert a rectified sine wave to a clean square wave using the Zener diode to cut off the negative part of the wave and a hysteresis, or more simply two thresholds, one that triggers on the rising edge of a wave and one that triggers on the falling edge of a wave. A 60 Hz signal sent through a Zener diode and Schmitt trigger can be converted to a 1 pulse per second signal using DIV chips, which have internal JK flip-flips to create a ripple counter and effectively divide the frequency as each JK is added. A wall outlet is usable not only for powering the circuit but also to provide a 60 Hz frequency for timing, but it can also be used to avoid errors from dirty input signals.

PIC16F877A Microcontroller Pinouts



Schmitt Trigger Pinouts

Connection Diagram



Function Table

$Y = \overline{A}$

Input	Output
A	**Y**
L	H
H	L

H = HIGH Logic Level
L = LOW Logic Level

Voltage Regulator Pinouts

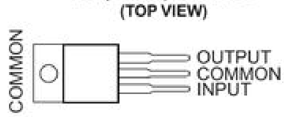
TEXAS INSTRUMENTS
www.ti.com

TL780 SERIES
POSITIVE-VOLTAGE REGULATORS
SLVS055M–APRIL 1981–REVISED OCTOBER 2006

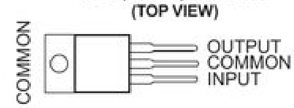
FEATURES

- ±1% Output Tolerance at 25°C
- ±2% Output Tolerance Over Full Operating Range
- Thermal Shutdown
- Internal Short-Circuit Current Limiting
- Pinout Identical to µA7800 Series
- Improved Version of µA7800 Series

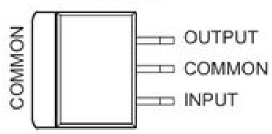
KC (TO-220) PACKAGE
(TOP VIEW)



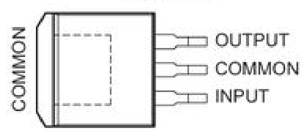
KCS (TO-220) PACKAGE
(TOP VIEW)



KTE PACKAGE
(TOP VIEW)



KTT (TO-263) PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

Each fixed-voltage precision regulator in the TL780 series is capable of supplying 1.5 A of load current. A unique temperature-compensation technique, coupled with an internally trimmed band-gap reference, has resulted in improved accuracy when compared to other three-terminal regulators. Advanced layout techniques provide excellent line, load, and thermal regulation. The internal current-limiting and thermal-shutdown features essentially make the devices immune to overload.

ORDERING INFORMATION

T_J	V_O TYP (V)	PACKAGE(1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 125°C	5	PowerFLEX™ – KTE	Reel of 2000	TL780-05CKTER	TL780-05C
		TO-220 – KC	Tube of 50	TL780-05CKC	TL780-05C
		TO-220, short shoulder – KCS	Tube of 20	TL780-05KCS	TL780-05
		TO-263 – KTT	Reel of 500	TL780-05CKTTR	TL780-05C
	12	TO-220 – KC	Tube of 50	TL780-12CKC	TL780-12C
		TO-220, short shoulder – KCS	Tube of 20	TL780-12KCS	TL780-12
	15	TO-220 – KC	Tube of 50	TL780-15CKC	TL780-15C
		TO-220, short shoulder – KCS	Tube of 20	TL780-15KCS	TL780-15

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.