Relaxation Oscillator and One-Shot Using 555 Timer

Physics 116B Lab 11

Rev. 2, January, 2003

Introduction

In this experiment you will use an FET version of a 555 timer (TLC555) to

- make a relaxation oscillator (astable multivibrator)
- use the circuit with a thermistor as the timing resistor to make a digital thermometer of sorts (example of telemetry and analog-to-digital conversion) and
- make a one-shot circuit (monostable multivibrator or timer).

Relaxation Oscillator

Wire the circuit shown in Fig. 1. *Note: black dots indicate connections. Lines crossing at right angles without black dots are not connected.* Be sure to use a capacitor with a 10% tolerance for the 0.047 μF timing capacitor. Use a 10 kΩ resistor for the timing resistor initially. Note that the output is connected to the trigger and threshold inputs through the timing resistor. Examine the circuit and convince yourself that the trigger/threshold level will vary between 1/3 and 2/3 of the supply voltage as the output switches from 0 V to a voltage close to the supply voltage and back. Observe (and copy in your report) the waveforms on the trigger/threshold node and on the output. Record the actual transition voltages at the trigger/threshold input and the high state output voltage. From these measurements and your analysis of the circuit, estimate the period of oscillation. Measure the oscillation frequency using the frequency counter in the Tektronix function generator and compare with what you expect.

Digital Thermometer

Now replace the 10 kΩ timing resistor with the thermistor. This is a semiconductor device whose resistance varies with temperature in a known way. The oscillator frequency readout will now be a measure of the thermistor temperature. You will observe the frequency to increase if you press the thermistor between your fingers. Based on the supplied resistance vs. temperature chart, make a chart of expected oscillator frequency for temperatures between 0 and 50 degrees Celsius (in 5 degree steps). If the frequency were read into a computer, it would be simple to convert it to Celsius for display or recording.

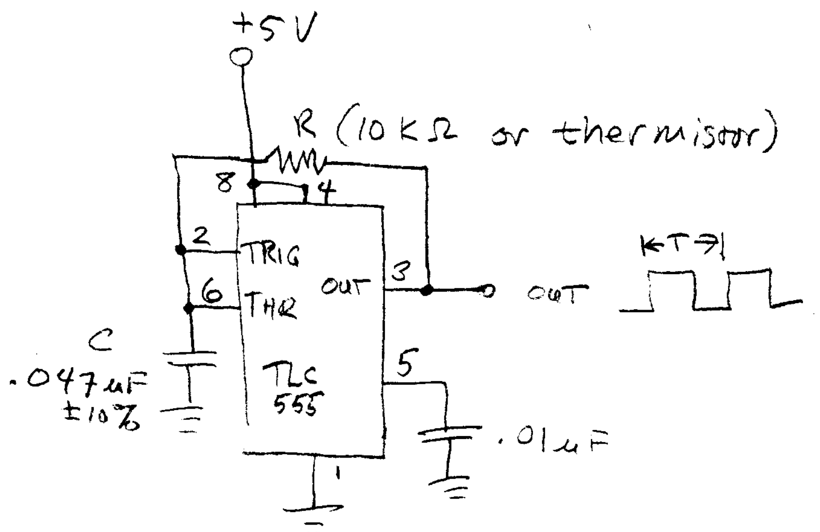
One-Shot

This circuit (Fig. 2) produces a pulse of known length following a short trigger. The transistor RC circuit is used to invert and stretch the input pulse to provide an appropriate trigger for the timer.

Use the pulse generator to produce a 5 V input pulse of approximately 10 μs width at a spacing of 100 ms. Observe the pulse on the trigger input of the timer and sketch it to include in your report. Observe the operation of the timer circuit for timing resistances of 100 kΩ and 1.0 MΩ. Measure the periods. Analyze the operation of the circuit and compare the measured periods from what you expect from the analysis.

Temperature in celsius	Kilohms
-50°	329.2
-45°	247.5
-40°	188.4
-35°	144.0
-30°	111.3
-25°	86.39
-20°	67.74
-15°	53.39
-10°	42.45
-5°	33.89
0°	27.28
5°	22.05
10°	17.96
15°	14.68
20°	12.09
25°	10.00
30°	8.313
35°	6.941
40°	5.828
45°	4.912
50°	4.161
55°	3.537
60°	3.021
65°	2.589
70°	2.229
75°	1.924
80°	1.669
85°	1.451
90°	1.366
95°	1.108
100°	.9735
105°	.8575
110°	7579

Thermistor resistance



Relaxation Oscillator

Figure 1: Relaxation oscillator diagram with thermistor resistance chart.

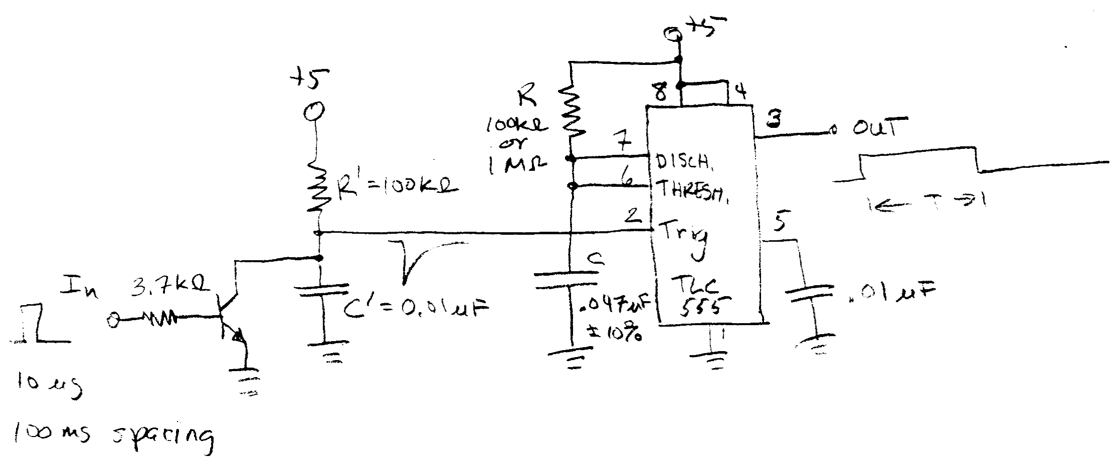


Figure 2: One-shot (timer) circuit.

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TECHNICAL DATA

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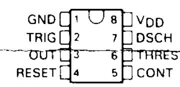
TLC555 Timer

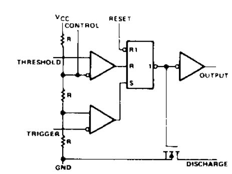
Features

- Very Low Power Consumption . . . 1 mW Typ at V_{DD} = 5 V
- Capable of Very High-Speed Operation . . . Typically 2 mHz in Astable Mode
- Complementary CMOS output Capable of Swinging Rail-to-Rail
- High Output-Current Capability
  . . . Sink 100 mA Typ
  . . . Source 10 mA Typ
- Output Fully CMOS-, TTL-, and MOS-Compatible
- Low Supply Current Reduces Spikes During Output Transitions
- High Impedance Inputs. . . . 10^{12} Ω Typ
- Single-Supply Operation from 2 to 18 volts
- Functionally Interchangable with the NE555; has Same Pinout

(TOP VIEW)



functional block diagram



Reset can override Trigger, which can override Threshold

Description

The TLC555 is a monolithic timing circuit fabricated using the LinCMOS* process. Due to its high-impedance inputs (typically 10^{12} Ω), it is capable of producing accurate time delays and oscillations while using less expensive, smaller timing capacitors than the NE555. Like the NE555, the TLC555 achieves both monostable (using one resistor and one capacitor) and astable (using two resistors and one capacitor) operation. In addition, 50% duty cycle astable operation is possible using only a single resistor and one capacitor. Operates at frequencies up to 2 MHz and is fully compatible with CMOS, TTL, and MOS logic. It also provides very low power consumption (typically 1 mW at V_{DD} = 5V) over a wide range of supply voltages ranging from 2 volts to 18 volts.

Like the NE555, the threshold and trigger levels are normally two-thirds and one-third respectively of V_{DD}. These levels can be altered by use of the control voltage terminal. When the trigger input falls below trigger level, the flip-flop is set and the output goes high. If the trigger input is above the trigger level and the threshold input is above the threshold level, the flip-flop is reset and the output is low. The reset input can override all other inputs and can be used to initiate a new timing cycle. When the reset input goes low, the flip-flop is reset and the output goes low. Whenever the output is low, a low impedance path is provided between the discharge terminal and ground.

While the complementary CMOS output is capable of sinking over 100mA and sourcing over 10 mA, the TLC555 exhibits greatly reduced supply current spikes during output transitions. This minimizes the need for the large decoupling capacitors required by the NE555.

LinCMOS is a trademark for a silicon-gate IC process by Texas Instruments.

FUNCTION TABLE

RESET	TRIGGER VOLTAGE†	THRESHOLD VOLTAGE†	OUTPUT	DISCHARGE SWITCH
Low	Irrelevant	Irrelevant	Low	On
High	< 1/3 V_{DD}	Irrelevant	High	Off
High	> 1/3 V_{DD}	> 2/3 V_{DD}	Low	On
High	> 1/3 V_{DD}	< 2/3 V_{DD}	As previously established	

†Voltages levels shown are nominal.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V_{DD} (see Note 1) . . . . 18 V
Input voltage range (any input) . . . . −0.3 V to 18 V
Continuous total dissipation at (or below) 25°C free-air temperature . . . . 600 mW
Operating free-air temperature range . . . . 0°C to 70°C
Storage temperature range . . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from the case for 10 seconds . . . . 260°C

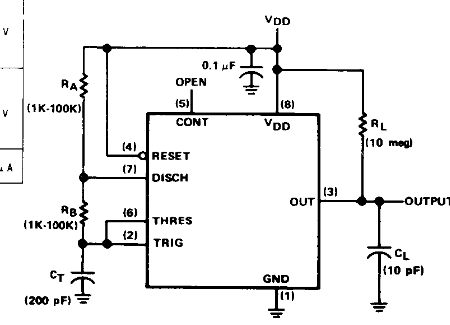
NOTES: 1. All voltage values, are with respect to network ground terminal.

electrical characteristics at 25°C free-air temperature, V_{DD} = 5 V to 15 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS		MIN TYP MAX	UNIT
Threshold voltage level as a percentage of supply voltage			66 7%	
Threshold current	V_{DD} = 5 V		10	pA
Trigger voltage level as a percentage of supply voltage			33 3%	
Trigger current	V_{DD} = 5 V		10	pA
Reset voltage level			0 7	V
Reset current	V_{DD} = 5 V		−10	pA
Control voltage (open-circuit) as a percentage of supply voltage			66 7%	
Low-level output voltage	V_{DD} = 15 V	I_{OL} = 10 mA	0.1	V
		I_{OL} = 50 MA	0.5	
		I_{OL} = 100 mA	1	
	V_{DD} = 5 V	I_{OL} = 5 mA	0.1	
		I_{OL} = 8 mA	0 16	
High-level output voltage	V_{DD} = 15 V	I_{OH} = −1 mA	14.8	V
		I_{OH} = −5 mA	14	
		I_{OH} = −10 mA	12.7	
	V_{DD} = 5 V	I_{OH} = −2 mA	4	
		I_{OH} = −1 mA	4.5	
Supply Current	V_{DD} = 15 V		360	μ A
	V_{DD} = 5 V		170	

Operating Characteristics, V_{DD} = 5V

PARAMETER	TEST CONDITIONS	MIN TYP MAX	UNIT
Initial error of timing interval	V_{DD} = 5 V to 15 V. R_A = R_B = 1 kΩ to 100 kΩ. C_T = 0.1 μF. See Figure 1	1%	% V
Supply voltage sensitivity of timing interval		0.1	
Output pulse rise time	V_{DD} = 5 V. C_L = 10 pF R_L = 10 MΩ.	20	ns
Output pulse fall time		20	
Maximum frequency in astable mode	R_A = 470 Ω. R_B = 200 Ω. C_T = 200 pF	2.1	MHz



Typical Application (Astable operation)

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Figure 3: TLC555 specifications.