EE 3101 ELECTRONICS I LABORATORY

EXPERIMENT 9 LAB MANUAL

APPLICATIONS OF IC BUILDING BLOCKS

OBJECTIVES

In this experiment you will

- Explore the use of a popular IC chip and its applications.
- Become more familiar with application notes.
- Learn how new applications are developed for special-function IC's.

LAB NOTEBOOKS

The format of lab notebooks should be such that the information can be used to reproduce the lab, including what values were used in a circuit, why the values were used, how the values were determined, and any results and observations made. This lab manual will be used as a guide for what calculations need to be made, what values need to be recorded, and various other questions. The lab notebook does not need to repeat everything from the manual verbatim, but it does need to include enough information for a 3rd party to be able to use the notebook to obtain the same observations and answers. In the following numbered sections there are **bolded words and/or lines**. These bolded words and/or lines are statements and/or questions that the lab TA will be looking for an answer either in the lab preliminary, or lab notebook.

INTRODUCTION

In actual practice, op-amps and special-purpose integrated circuit modules are often used rather than design all of our circuit with discrete components. This is for reasons of *economy*. By using IC "building blocks," design and development time is saved (and its associated cost), as well as physical space or volume needed for the circuit.

There are hundreds of thousands of these special-purpose IC chips to choose from. To get started, this experiment will explore one of the most-popular integrated circuits of all time: the 555 timer. In this experiment the design of several applications that are very important will be performed.

PRELIMINARY

Look up the data sheet for the LM 555 Timer: www.national.com/ds/LM/LM555.pdf. Most important will be the first pages that introduce the chip as well as the pin connection diagram for the 8-pin DIP on page 2. The application section begins on page 7 of the data sheet. Read about the monostable and astable multivibrator and make sure to understand them. A thorough explanation is given in your textbook.

1. **Design a monostable multivibrator (Figure 1) (one-shot) that will deliver a pulse of approximately 10 seconds when triggered.** The nomograph of *Figure 3 in the data sheet (page 7)* as a guideline for choosing either R_A or C. Use the formula given or the nomograph to determine value of the other component. The circuit should look like the one below. Note that a bypass capacitor is used for the power supply and a resistor R_B should be used if the value of capacitance is large ($\geq$ 10 μF). This will limit the capacitor discharge current when it is shorted by the internal transistor connected to pin 7.

2. **Design an astable multivibrator (Figure 2) that will generate a negative-going pulse approximately 100 μs, approximately every 1 ms.** Use a 1 μF capacitor for *C*. Calculate the value needed for R_B and then, R_A. The circuit is shown below in Figure 2.

EXPERIMENT

Part A – Monostable Multivibrator

1. Build the monostable multivibrator circuit shown in Figure 1. Apply power and check to see that the circuit works. Use the oscilloscope probe on the output (pin 3) to see the output go HIGH for 10 seconds, and then return to the LOW state **(save the shape of the resulting pulse showing on oscilloscope screen)**. **Show the TA the operating circuit.** This circuit can be used to generate time delays from about 10 μs to several hours. Even longer times (days!) can be generated with additional circuitry.

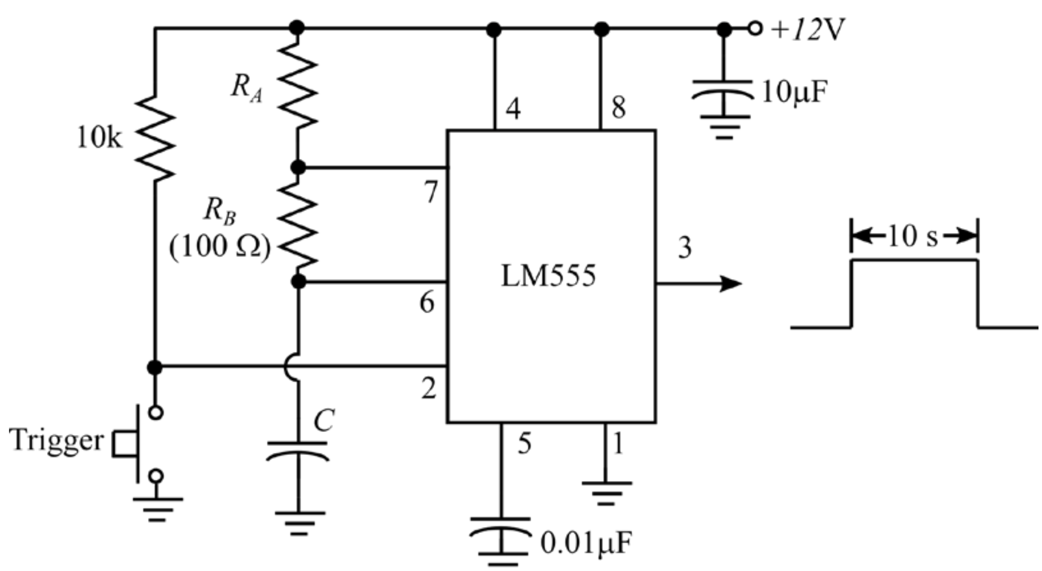

Figure 1: Monostable multivibrator.

Part B – Astable Multivibrator

1. Build the astable multivibrator circuit shown in Figure 2. Apply power and observe the output **(save the shape of the resulting square wave showing on oscilloscope screen)**. **Show the TA the operating circuit.**

Q1. How close is the waveform to calculated parameters?

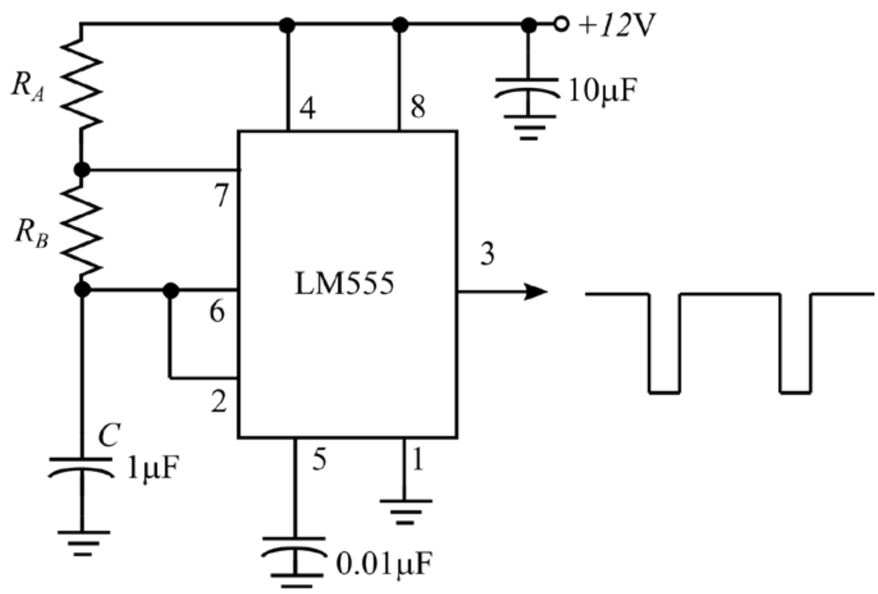

Figure 2: Astable multivibrator.

2. To demonstrate the superiority of this chip's design, <u>carefully</u> vary the power supply voltage between 6 volts and 15 volts **(comment on your observation)**. The output frequency and duty cycle should remain fairly constant, even though the output amplitude will change. This is due to the precision voltage divider network in the 555 to determine the switching thresholds.

3. With the scope probe, observe the waveform across the timing capacitor *C*. There should be a sawtooth waveform **(save the oscilloscope screen for both capacitor voltage and output voltage)**. This circuit can be changed so that the sawtooth becomes a linear ramp. This is just one of the many possibilities with this versatile IC chip.

FURTHER EXPLORATION

Depending on time remaining, use the remaining lab time to experiment with some of the other applications. The pulse-width modulation circuit of shown in *Figure 8 of the datasheet* is a very useful circuit. Apply a variable dc voltage to pin 5 to observe the pulse-width change or supply a low-level sine wave or square wave as well. If the output is low pass filtered, there should be a crude sine wave. PWM switching is used extensively in power electronic motor controls and sine wave inverters.

Another important circuit is the linear ramp generator shown in *Figure 12 of the datasheet*. For this one, you will need to bias the transistor so that it will provide a constant current to charge C. The same astable multivibrator used previously, can be used. Use a 2N3906 PNP device for the current source transistor. Noting that since

$$I = C\frac{\Delta V}{\Delta T}$$

a linear ramp should be seen at pin 6. Note, however, that the constant-current source must be designed so that it will not saturate and will supply a constant current over the required range of Vc.

Another circuit for experimentation is the frequency-to-voltage converter shown in Figure 3. This can be used to make a tachometer. The op-amp functions as a zero-crossing detector, triggering the one-shot at the beginning of each input cycle. The output pulses are averaged by an RC low-pass filter, so that the meter reading corresponds to frequency. With an oscilloscope here instead of the microammeter and resistor, look at the *average* voltage to confirm that it works. Vary the input frequency around 500 Hz to see if there is a linear relationship between frequency and average output voltage.

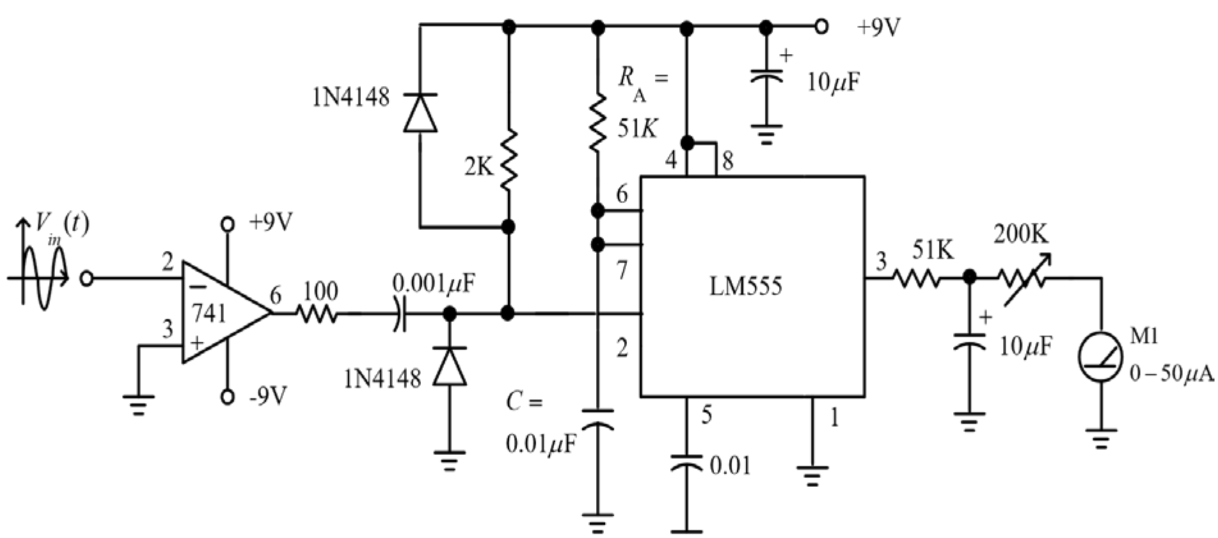

Figure 3: Frequency-to-voltage converter.

COMMENTARY

For nearly 25 years, the 555 timer IC was the largest-selling chip in the world! Entire books have been written about the chip, entailing hundreds of applications. It can be used in many consumer and hobby applications, as well as commercial applications with caution.

Designer's Tip: Always use a suitable bypass capacitor at the power supply pin (8) and make sure that you have a good solid ground, especially when using this circuit with digital ICs. Reason: When C is shorted by the internal transistor, there is a large "current dump" through the transistor and through ground pin 1. This can cause the ground pin to jump above ground for perhaps only a few microseconds. This may be just enough to fool the digital gate connected to output pin 3. Many problems can be solved by supplying a good solid ground and a suitable bypass capacitor.