Data Acquisition Lab
USB-Based Capacitance Meter

Acknowledgements: Developed by Jesus Casas, Faculty of Austin Community College, Austin, Texas

Lab Summary

A capacitance meter can be constructed out of a simple RC circuit. If the R value remains constant and the C value changes, the response of the circuit is linear in nature. This lab utilizes this linear response to solve for unknown capacitance values.

Lab Goal

The objective of this lab is to construct a USB-based capacitance meter which utilizes the RC time constant upon which to solve for unknown capacitance values.

Learning Objectives

1. Construct a USB-based capacitance meter.
2. Use the linear response of the capacitance meter to solve for capacitance values.

Time Required

Approximately 2 hours

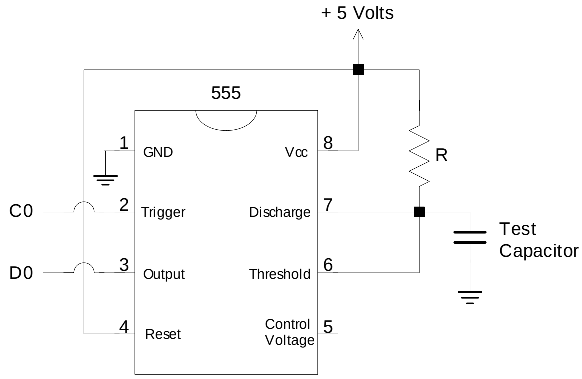
Equipment and Supplies

Part	Quantity
DLP-USB245M Module (http://www.dlpdesign.com/usb/)	1
DLL Drivers (http://www.dlpdesign.com/usb/usb245.shtml)	1
555 Timer (CMOS version)	1
10 MegOhm Resistors	2
PC with Visual Basic 6.0 installed	1
Lab Software (Visual Basic programs)	1
Capacitors (assorted values)	As needed
Capacitance Meter (to be used as a reference)	1
Protoboard	1
Wire	As needed

Lab Preparation

1. Assemble all equipment and components.
2. Read Introduction (below)
3. Review Lab Procedures (below)
4. Review the User Manual for the DLP-USB245M module and the specification sheet for the 555 timer.
5. Review RC circuits and the RC time constant.

Introduction
The heart of the capacitance meter is the following circuit.



When the 555 timer is configured in the one-shot mode, the length of the pulse generated at Pin 3 is directly proportional to the value of the timing resistor (R) and the test capacitor.

With a fixed timing resistor, the duration of the output pulse will be directly proportional to the value of the timing capacitor. If the relationship (transfer function) between capacitance and pulse length is known, then an unknown capacitance value could be tested, with the resultant pulse length being measured. This pulse length value would then be put into the transfer function and it would in turn provide a capacitance value.

Sending a "low" to Pin 2 of the 555 timer triggers the one-shot circuit and the output pulse is seen at Pin 3. A Visual Basic program will measure the pulse length and then convert it into a capacitance reading.

The fixed resistor plays a crucial part in determining the length of the output pulse. Please note that the test capacitor must charge-up through the fixed resistor. The bigger the value of the resistor, the longer the output pulse will be with any given capacitance.

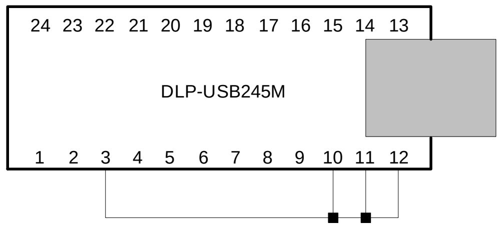
Every R value has a practical capacitance range. If the test capacitance is too small for a given R value, then the duration of the output pulse will be too small for the software to measure accurately. If the test capacitance is too large for a given R value, then the duration of the output pulse will be extremely long.

If the R value is small such as 20 kOhms, the practical capacitance range is from about 1 to 100 uF. The larger the resistance value, the smaller the capacitance than can be measured. If the R value is large such as 20 MegOhms, the practical capacitance range is from about 100 to 800 pF.

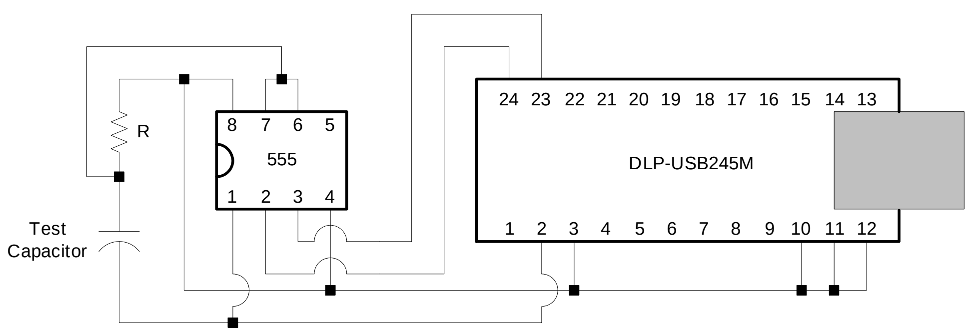
Interfacing
This lab will interface the 555 IC to the PC USB port via DLP Design's DLP-USB245M Module. This module provides an easy method of transferring data to / from a peripheral and a host at up to 8 million bits per second. The module can utilize both Virtual Com Port drivers as well as DLL drivers. This lab makes use of the DLL drivers.

Lab Procedures

1. Configure the DLP-USB245M module to work off of bus-power. Wire the module according to the following diagram. Do **not** connect to the PC's USB port yet.



2. Download the appropriate DLL version of the device drivers from either www.dlpdesign.com or www.ftdichip.com . Unzip the drivers onto a folder on the hard-drive or onto a blank floppy disk.
3. Connect the DLP-USB245M module to one of the PC's USB ports.
    a. The operating system will recognize that a new USB device has been plugged in and will prompt you for the location of the drivers.
    b. Select the folder where the DLL device drivers were stored in Step 2.
    c. Windows will then complete the installation of the device drivers.
    d. Once installed, the drivers will be automatically loaded whenever the DLP-USB245M is connected.
4. To see the USB connection tree and the USB devices that are connected to it, along with their configuration data, use USBView, which can be downloaded from www.dlpdesign.com .
5. Assemble the following circuit using an R value of 20 MegOhms. (Note: A picture of the Protoboard layout is at the end of this procedure.)



6. Connect the above circuit to the PC's USB port.
7. Run the lab software program named "Cap-USB". The software is located under the Learning Resources tab of this module titled "USB Capacitance lab software."

8. Use a capacitor, whose value is known and is close to 1 nF, as the “Test Capacitor”. Use the Cap-USB software to acquire the charge time. The time value (in seconds) is X_1 and the capacitance value (in uF) of the capacitor is Y_1. If the charge time is smaller than .2 seconds, try a slightly higher value capacitor.
9. Use a capacitor, whose value is known and is close to 1 uF, as the “Test Capacitor”. Use the Cap-USB software to acquire the charge time. The time value (in seconds) is X_2 and the capacitance value (in uF) of the capacitor is Y_2.
10. From both (X,Y) points in Steps 8 and 9, derive a linear transfer function equation of the form $y = mX + b$. Where m is the slope of the line, b is the y-intercept, X is the input in seconds, and y is the output in uF.
11. Input the slope and y-intercept derived in Step 10 into the Cap-USB software.
12. Test some unknown capacitors on the capacitance meter and then on an actual capacitance meter. Compare the results.

Note: Large value capacitors will take longer to charge than smaller value capacitors. In the case of large value capacitors, the charge time may take up to a couple of minutes.

Protoboard Layout