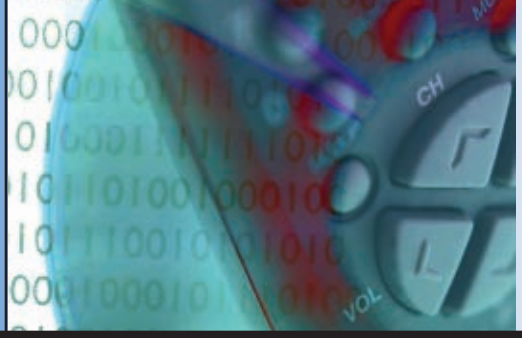
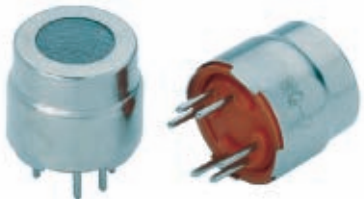


NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

THREE NEW GAS SENSORS

Parallax has just released three new gas sensors. The CO Gas Sensor (605-00007) is designed for use in gas detection equipment. The MQ-7 CO Gas Sensor can be used to detect the presence of carbon monoxide in home, automotive, or industrial settings.



- High sensitivity to carbon monoxide (CO) gas
- Stable and long life
- Simple drive circuit

The CH4 Gas Sensor (605-00008) is designed for use in gas detection equipment. The MQ-2 Methane Gas Sensor can be used to detect the presence of methane in home, automotive, or industrial settings.

- Wide detecting scope
- Stable and long life
- Simple drive circuit
- Fast response and high sensitivity

The LPG Gas Sensor (605-00009) is designed for use in gas detection equipment. The MQ-5 LPG Gas Sensor can be used to detect the presence of propane in home, automotive, or industrial settings.

- High sensitivity to propane gas
- Stable and long life
- Simple drive circuit

The price is $4.99 each with quantity discounts available.

For more information, contact:
Parallax, Inc.
Web: **www.parallax.com**

ROBOT BASIC VERSION 4

Robot BASIC Version 4.0 is now available and is the biggest upgrade to date with over 300 new commands and functions. The Window's based language still lets you create and debug your programs in a fast, easy-to-use interpreter-based IDE (which has been enhanced with external editor support and improved debugging features), but now has the option of compiling stand-alone EXE applications.

This latest release has many new visual controls (now with event-handling), making it easier to create graphical user interfaces. There is also direct support for USBmicro I/O boards and a new low-level file I/O system. Internet support includes the ability to send and receive emails plus the ability to communicate with other RobotBASIC programs anywhere in the world utilizing both TCP and UDP protocols (no additional hardware needed). RobotBASIC is a very easy language to learn. To find out more about Version 4.0, visit their website and download your free copy.

For more information, contact:
RobotBASIC
Web: **www.RobotBASIC.com**

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continued on page 64

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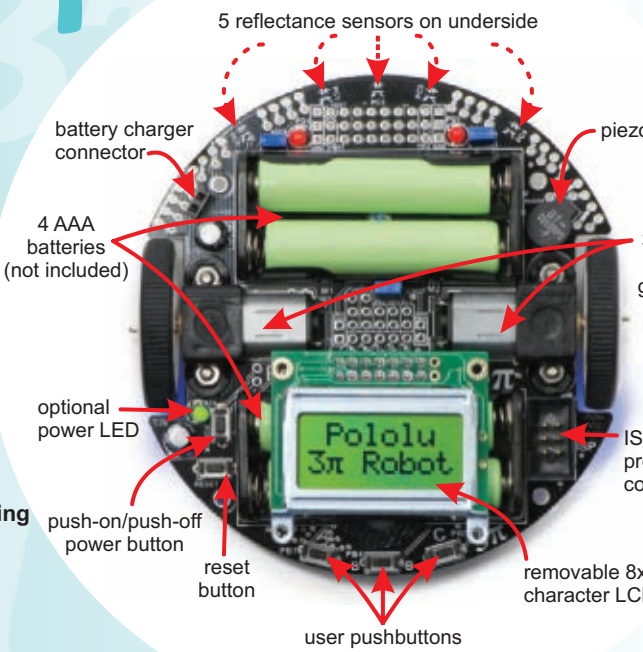

robot diameter is 3π cm (~3.7 inches)

The Pololu 3pi robot is a high-performance, compact mobile platform featuring:

* Two metal gearmotors
* Five reflectance sensors
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All peripherals are connected to an ATmega168 microcontroller running at 20 MHz, with free C-programming tools, libraries, and support for the Arduino environment.

Pololu
Robotics & Electronics
6000 S. Eastern Ave. 12D, Las Vegas, NV 89119

Find out more at www.pololu.com/3pi or by calling 1-877-7-POLOLU.

BALLISTIC CHRONOGRAPH

If you ever wanted to know the velocity of a projectile leaving your paint gun, rifle, pistol, BB gun, slingshot, or arrow then this is a project for you. This is a great project for the marksmen or hunter that loads his own shells.

By David Collins

Last year, my son bought a chronograph. I was so intrigued by his demonstration as to how it worked, that I began to gather information from the web and finally designed my own. The info obtained pertaining to IR LEDs, IR photodiodes, LCDs, EEPROMs, and RS-232 communications were most useful in the development of this project.

FEATURES

This ballistic chronograph rivals expensive units with some *very impressive features:*

- Measures velocities (ft/sec)
- Calculates the average
- Standard deviation
- Minimum and maximum velocities
- Saves data to EEPROM and displays on an LCD

There are two velocities measured for each shot as a double check confirming the measurements. The majority of chronographs on the market today only measure one velocity. Only the very expensive ($700 to $800 range) measure two velocities. This chronograph has a maximum number of shots per series of 100 and you can record a maximum of 10 series.

The *modes of operation are:*

- SHOOT — measures, displays, and saves the velocities of each shot.
- RETRIEVE — displays the shot number, series number, the two velocities of each shot along with min, max, avg, and standard deviation for the series.
- SAVE TO PC — saves all the data mentioned in RETRIEVE to a file on your PC via the PC serial port; use the HyperTerminial application to receive the data and then copy it to your file (computers w/o a serial port could use a serial to USB converter).
- DELETE A SERIES — deletes all the data in a selected series.
- DELETE ALL SERIES — deletes all data in the 10 series.

All the modes are accessed via two pushbutton switches (ENTER and END) located on the front panel. In SHOOT mode, the two velocities are displayed in big numbers and readable at greater than 10 feet. The complete design is powered by a battery pack of eight AA cells. The unit will display this voltage and beep if it is less than 7.5 volts.

THEORY OF OPERATION

This project has *two major parts:*

- The three screens
- The microcontroller (µC unit)

The screens consist of photodiodes and infrared LEDs. The heart of the chronograph is the photodiode whose reverse current is proportional to the amount of incident light. Therefore, if you reverse bias the photodiode and interrupt or diminish the amount of light as seen by the photodiode, the reverse current will decrease. The momentary decrease in reverse current develops a change in voltage across R10 (**Figure 1**). This change in voltage is very small (approximately 12 mV), so the op-amps U1A and U1B (LM224) amplify it and feed it to the comparator U1C, producing a TTL level trigger pulse which is sent to the µC for timing purposes. This trigger pulse is also sent to a monostable multivibrator U1D and illuminates the green LED for about one second. *Not having a single shot digital sampling scope, I added this during the development stage in order to have visual indication of a detected pulse.*

Screen: The term screen comes from the very early chronographs where they used a metallic screen material and sensed the change in resistance as the projectile passed through. The chronographs of today are mainly optical in design.

Therefore, when a projectile passes through the first screen, Pulse1 is generated which starts a timer in the µC. As it passes through the second screen (generating Pulse2), the number of timer ticks (the clock period) is saved as Ticks12. Likewise, as it passes through the third screen, Pulse3 saves the total number of timer ticks as Ticks13.

Knowing the time of each tick to be 1/Oscfreq and the distance between each screen (one foot), you can then calculate the velocities of the projectile in ft/sec as:

$$Velocity1to2 = \frac{D}{T} = \frac{1}{Ticks12 * \frac{1}{Oscfreq}} = \frac{Oscfreq}{Ticks12}$$

similarly $$Velocity1to3 = \frac{2 * Oscfreq}{Ticks13}$$

and $$Velocity2to3 = \frac{1}{(Ticks13 - Ticks12) * \frac{1}{Oscfreq}} = \frac{Oscfreq}{(Ticks13 - Ticks12)}$$

Theoretically, Velocity2to3 should be equal to or less than Velocity1to2 when the projectile has no positive horizontal acceleration. Therefore, if the two velocities do not meet these criteria, then you should be doubtful of the data. The majority of ballistic chronographs on the market rely on ambient sunlight to provide the source of illumination to the photodiodes. That's fine if you only use it outdoors on a not so cloudy day. This design is totally independent of the ambient light, relying only on the internal IRLEDs for the light source. In fact, it will operate in a totally dark environment.

The photodiodes D2-D5 used in this project are QSE773 and have peak sensitivity at a wavelength of 920 nm (infrared radiation). The IRLEDs D6-D9 used as the light source are QEE123, which has a peak emission wavelength of 950 nm. Each screen has four photodiodes flooded with four IRLEDs. A constant current generator U3 provides 46 mA to the string of IRLEDs, thus providing a constant infrared illumination of the photodiodes. This constant current is turned on/off by the µC only during the SHOOT mode thus saving a significant amount of the battery charge.

The µC U5 (**Figure 2**) performs the math operations, sends the data to the EEPROM U4, LCD U3, and/or the RS-232 drivers/receivers U1. These four ICs are powered by the five volt linear regulator U2. Note that the design also provides for a serial LCD[1] which can be connected to J7, although changes in the code would be required.

SOFTWARE

The BASCOM-AVR[2] complier version 1.11.9.2 was used to write the code (complete listing can be downloaded from **www.nutsvolts.com**) and program the µC. The current code uses about 75% of the available programmable Flash program memory so there is space remaining for your additions and/or modifications. An in-system programming connector J11 is available on the Chronograph_uC board for this purpose. **Figure 3** is the flow diagram of the present code.

All the data is stored in the 24LC65 EEPROM U4, which has a capacity of 8Kx8. These data are all defined as 16 bit words except Series_num and Shot_num and require two addresses. For that reason, one address is for the high eight bits and one for the low eight bits. The equations defining the used EEPROM addresses are:

Series_num addr = 500 + 600*(Series_num - 1) = 600*(Series_num) - 100

Shot_num addr = above+5*Shot_num - 4 = 600*(Series_num) + 5*Shot_num - 104

High(Velocity_1) = above + 1 = 600*(Series_num) + 5*Shot_num - 103

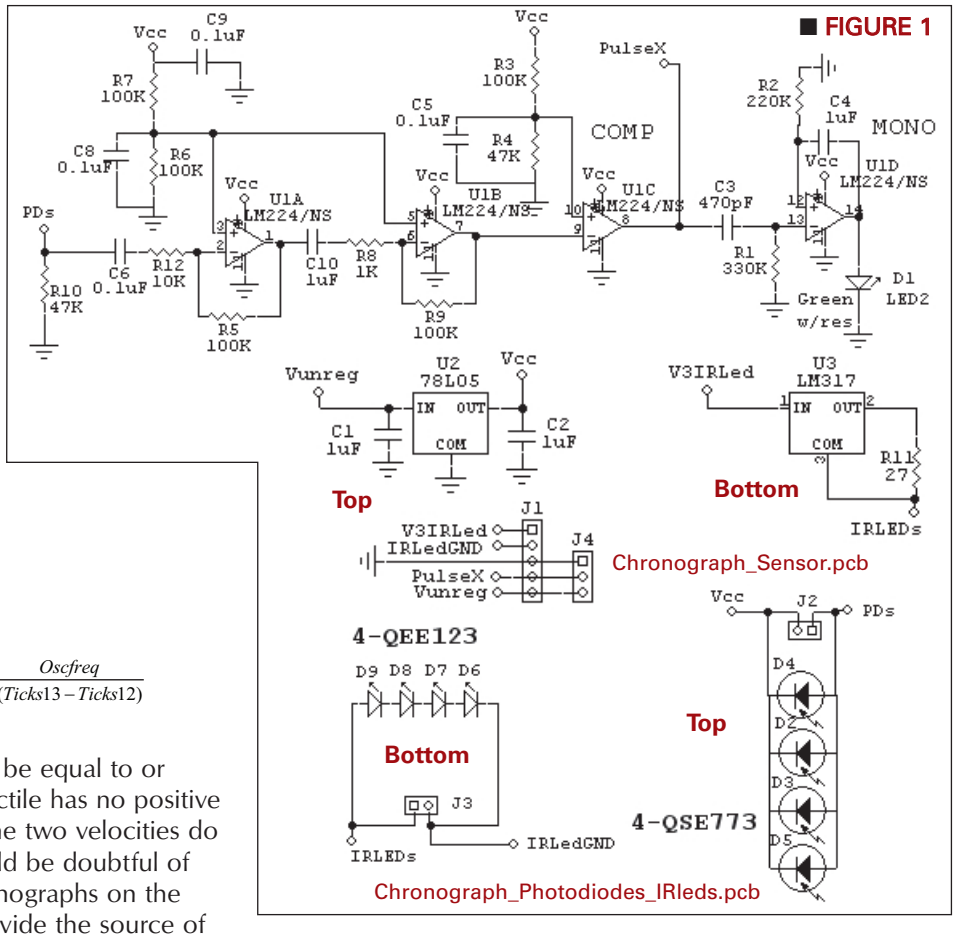
Low(Velocity_1) = above + 1 = 600*(Series_num) + 5*Shot_num - 102

High(Velocity_2) = above + 1 = 600*(Series_num) + 5*Shot_num - 101

Low(Velocity_2) = above + 1 = 600*(Series_num) + 5*Shot_num - 100

High(Velmax) = address for Series_num + 501 = 600*(Series_num) + 401

■ FIGURE 1



Low(Velmax) = above + 1 = 600*(Series_num) + 402
High(Velmin) = above + 1 = 600*(Series_num) + 403
Low(Velmin) = above + 1 = 600*(Series_num) + 404
High(Velavg) = above + 1 = 600*(Series_num) + 405
Low(Velavg) = above + 1 = 600*(Series_num) + 406
High(SD) = above + 1 = 600*(Series_num) + 407
Low(SD) = above + 1 = 600*(Series_num) + 408

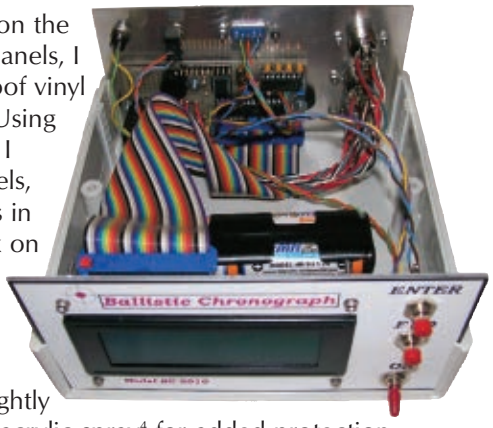
This allocation of EEPROM memory leaves addresses 0 through 499 and 6409 through 8191 free for future data.

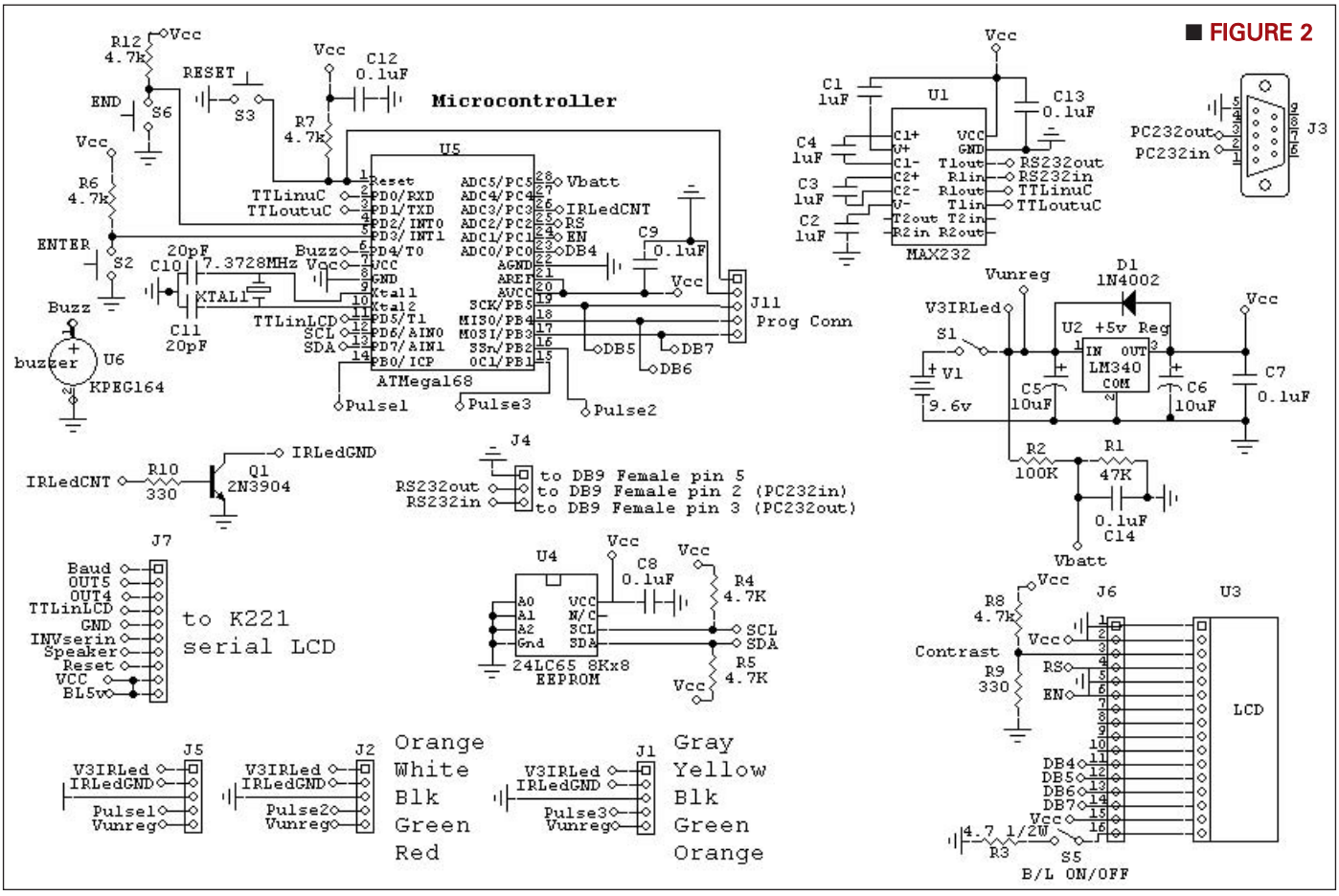
CONSTRUCTION

The design uses 13 small double-sided PCBs. The µC unit uses the Chronograph_uC PCB and each screen uses two of the Chronogrph_Sensor PCBs, along with two of the Chronograph_Photodiodes_IRleds PCBs.

µC unit

The Chronograph_uC PCB is fairly straightforward. After soldering the components and the wires to the connectors and switches, mount the board on the back panel. I used plain faucet washers as insulators between this board and the back panel. The same was also used for mounting the LCD. The LCD is connected to the PCB using ribbon cable and IDC connectors. If needed, there is a small area on the board for future prototyping.



For the printing on the front and back panels, I used weatherproof vinyl stick-on labels[3]. Using an inkjet printer, I printed both labels, cut the openings in the panels, stuck on the labels, and then cut the openings. As a final touch, each label was then lightly sprayed with an acrylic spray[4] for added protection.

■ FIGURE 2