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GETTING STARTED WITH THE PROPELLER EXPERIMENT CONTROLLER

This chapter describes how to get started with the Propeller Experiment Controller (PEC). It provides information on acquiring the necessary hardware and installing software. There are many hardware options when setting up a system that uses the PEC, much of this will vary based on individual needs. The Propeller Datasheet (Parallax Semiconductor, 2012), Propeller Manual (Martin, 2011), and other information on Parallax's website (Parallax.com) can be useful for determining the best setup for your application. As the specific needs vary per application, we cannot provide a tutorial on every option. Instead, we provide an overview of the commonly used hardware suitable for someone new to microcontrollers.

Hardware

Hardware for the PEC can be found at a variety of online electronics vendors (see Appendix B for links to online electronics vendors). The primarily vendor for Propeller products is the manufacturer, Parallax. Parallax's website provides most of the basic hardware for the PEC as well as sensors, actuators, and other devices that can be used in an experimental apparatus. Adafruit Industries (New York, New York; Adafruit.com), Pololu Robotics and Electronics (Las Vegas, Nevada; Pololu.com), Servocity (Winfield, Kansas; Servocity.com), and

Sparkfun Electronics (Niwot, Colorado; Sparkfun.com) are all popular hobby electronics websites. Although they may not always carry Propeller microcontrollers, these websites have many useful parts and tutorial information. They also offer a variety of **breakout boards**, small printed circuit boards that make it easy to install circuits, sensors or other devices in an embedded system. Several industrial electronics vendors, such as Allied Electronics (Fort Worth, Texas; Alliedelec.com), Digi-Key Electronics (Thief River Falls, Minnesota; Digikey.com), and Mouser Electronics (Mansfield, Texas; Mouser.com), provide an enormous selection of inexpensive parts, but offer little instructional information aside from technical datasheets. The industrial electronics vendors are best used when a known specific component is needed.

The PEC requires a few specific components in addition to the Propeller microcontroller chip: an EEPROM, a 5 MHz crystal oscillator, and an SD card socket. The EEPROM is used to save programs on the Propeller. When a Propeller powers on, it runs the program saved on the EEPROM, allowing the Propeller to be used without a connection to a computer. The 5 MHz crystal oscillator is used to enhance the Propeller's ability to operate at high speeds and precisely measure time. The SD card socket permits the PEC to create detailed data spreadsheets on a removable SD card that can be transferred to a personal computer. SD cards can also be used as external memory. To transfer data to the computer, an SD card reader for the computer is also needed. If you want to use the PEC to control an automated apparatus, but do not require data output, a 5 MHz crystal oscillator and an SD card socket may not be required.

A number of other hardware components are not strictly required by the PEC, but instead make the Propeller easy to use for beginners and experts alike. Loading programs to Propeller is facilitated by a USB mini-B programming port. The USB port also permits information to be sent from a Propeller to the Parallax Serial Terminal application. Standard USB A to mini-B cables can be used to connect the Propeller to a computer during programing. **Pin headers** allow temporary or permanent connections between the Propeller's I/O pins and an experimental apparatus. A barrel jack power supply connector, along with 5 VDC and 3.3 VDC **voltage regulators**, allow a variety of power supplies to be easily connected. The voltage regulators can transform a larger power supply (i.e., 9 VDC) into 3.3 and 5 VDC used by many circuits and devices, including the 3.3 VDC needed to power the Propeller itself. The larger power supply may also be used for devices requiring more power, such as small motors.

Development Boards

Fortunately, most of the hardware needs can be found in Propeller development boards. Instead of purchasing and assembling all the commonly required individual components, development boards offer the standard requirements attached to a single circuit board. Below, we describe some development boards and other equipment to meet the basic hardware requirements of the PEC. A comparison of the development boards can be seen in Table 4.1.

Table 4.1
Propeller Development Boards

	SD Card Socket	Barrel Jack Connector	Voltage Regulators	Pin Headers	Price
DNA	Yes	Yes	3.3 and 5	All 32 pins	$45
ASC+	Yes	Yes	3.3 and 5	Only 24 pins	$50
QuickStart	No	No	3.3 only	All 32 pins	$35
Project Board USB	No	No	3.3 only	None	$30
Activity Board	Yes	Yes	3.3 and 5	Only 16 pins	$80
Board of Education	Yes	Yes	3.3 and 5	Only 16 pins	$130

Note: All boards have an EEPROM, crystal oscillator and USB programing port.

The Propeller Platform DNA (MGH Designs, Knoxville, Tennessee; Mgh designs.com) is our preferred development board (see Figure 4.1). This board is a general-purpose platform that includes a built-in µSD card socket, EEPROM, and crystal oscillator. It also has two pin headers that can be used to make temporary or permanent connections between the Propeller's I/O pins and an experimental apparatus. The pin headers need to be soldered in place. However, they can be installed in several positions to facilitate different types of connections to an apparatus. The Propeller Platform DNA contains both a barrel jack connector and a screw terminal for connecting power supplies. It can be powered from either connector, or by a connection to the VIN and VSS pin headers. The USB mini-B port used to program the Propeller can also provide power from a computer or USB DC adapter. Dual voltage regulators allow the Propeller Platform DNA to power both 3.3 and 5 VDC devices. Presently, the DNA board is primarily made to order, but small numbers are often in stock. The basic DNA board costs $45.00. A variant of the board is also available that includes a real-time clock (RTC) and extra flash memory, but this is a little more expensive ($60.00) and the additional components are not required for most purposes.

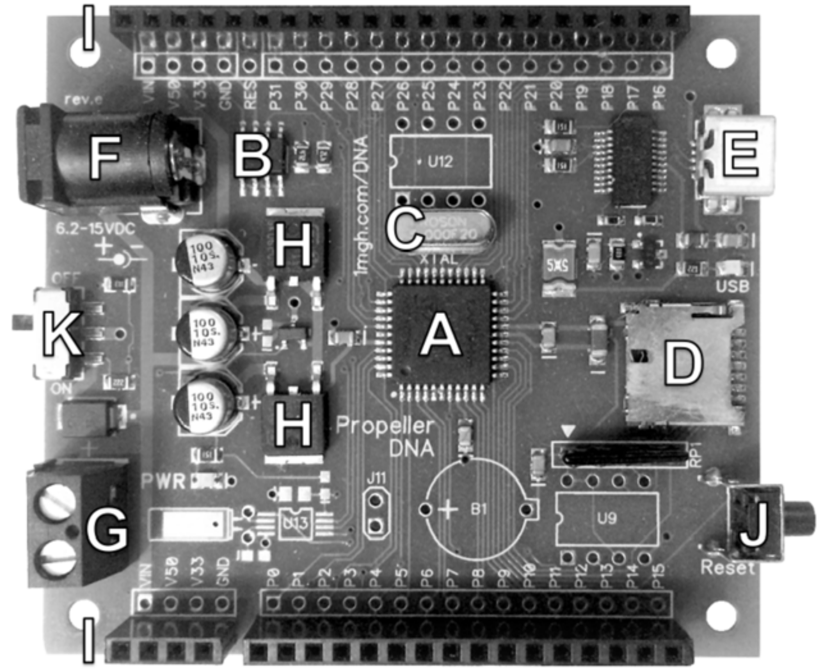

Figure 4.1: Propeller Platform DNA. This development board measures 7.1 by 6.4 cm and has all the features required by the Propeller Experiment Controller system. A — Propeller microcontroller. B — EEPROM. C — Crystal oscillator. D — µSD card socket. E — USB mini-B programing port. F — Barrel jack power supply connector. G — Screw terminal power connector. H — 3.3 and 5 VDC regulators. I — Pin headers for all I/O pins and power connections.

MGH Designs also produces the Propeller ASC+. Similar to the Propeller Platform DNA, the ASC+ contains a µSD card socket, EEPROM, crystal oscillator, barrel jack power connection, and USB mini-B programming port. It can be powered from the barrel jack, or from the USB programming port. The pin headers on the ASC+ are compatible with the popular Arduino Uno (Arduino; New York, New York) pin header layout. The ASC+ also includes a built in **MCP3208** ADC chip (Microchip; Chandler, Arizona) for analog input. This board is very useful for users that have experience with the Arduino, or equipment designed to interface with an Arduino. The ASC+ is a drop-in replacement for most Arduino applications. The built-in ADC is also very useful. Unfortunately, the pin headers are not as convenient to use as the DNA's pin header layout, but as the ASC+ matches the Arduino's layout, this is not a concern for many people. The ASC+ costs $50.00 and is available from MGH Designs and is also often sold on Parallax's website.

The P8X32A QuickStart is a development board created and distributed by Parallax. The QuickStart includes an EEPROM, crystal oscillator, USB mini-B programing port, and easy-to-use pin header. It also has eight LEDs and eight touch pads to make programming demonstrations very easy. Unfortunately, it does not have a built-in SD card socket; a separate SD card socket board can be used if detailed data output to a computer is required. The QuickStart also lacks a convenient barrel jack power connection. Instead, it can be powered by a connection to the VIN and VSS pin headers, or through a computer connection to the USB mini-B programming port. An additional connection between pin header #30 and VSS will allow the QuickStart to be powered from a USB DC adapter. The QuickStart has an onboard 3.3 VDC regulator but does not have a 5 VDC regulator. The QuickStart costs only $35.00, but the price reflects a lack of SD card socket and barrel jack power connection included with the DNA and ASC+ boards.

The Propeller Project Board USB is also created by Parallax. It includes an EEPROM, crystal oscillator, USB mini-B programing port, and 3.3 VDC regulator. Many other components can be easily installed directly on the board as the board includes soldering connections for through-hole and surface-mount components. These connections can be used to install pin headers, SD card sockets, voltage regulators, barrel jack power connections, and any other specialized devices needed for an experiment. The Propeller Project Board USB is designed to allow the user to build permanent circuits onto the board itself, and so it is better for advanced users and permanent installations. Unless pin headers are installed, it does not offer the modular connections of the DNA, ASC+, or the QuickStart. The Propeller Project Board USB costs $30.00.

Parallax also offers two development boards that feature a very wide range of hardware components, The Propeller Activity Board and the Propeller Board of Education. Both boards feature all the required hardware for an experiment controller in addition to other components such as audio connections, microphones, VGA connections, connections for XBee wireless devices and more. They also feature built-in **solderless breadboards** for convenient prototyping. Both boards are excellent for educational projects where the user needs to demonstrate the Propeller's ability to interface with a wide variety of devices. They also have good potential to be used as an experiment controller. Unfortunately, the pin headers only provide access to 16 I/O pins. These boards are also more expensive, at $80.00 for the Propeller Activity Board and $130.00 for the Propeller Board of Education.

SD Card

The PEC uses an SD card to create detailed data spreadsheets. SD cards come in many varieties. They can first be categorized by their physical size. Standard

SD cards measure 32 x 24 mm, mini SD cards measure 22 x 20 mm, and μSD cards measure 11 x 15 mm. Despite differences in physical dimensions, SD cards all function the same way. Most of the recommended development boards include μSD card sockets for the smallest type of SD card. SD cards also come in several storage size categories. The PEC has been tested with regular sized SD cards (up to 2 GB) as well as larger SDHC SD cards (up to 32 GB). The PEC has not been tested with the newest size format, SDXC, which supports sizes above 32 GB. Although it may be tempting to purchase the largest SD card, the PEC does not require much storage space on an SD card. When using a 1 GB SD card, the PEC could store around 64 million events.

Several classes (2, 4, 6, and 10) are used to represent the read/write speed of SD cards. The class number represents the minimum read/write speed of the SD card, in MB/s. Generally, the greater the class number, the faster the SD card. The PEC is very fast, however, and does not need to add much information to the card, so the class of the SD card should not be a concern. SD cards can also be formatted in several manners. In order to be used by the PEC, the SD card must be formatted to FAT16 or FAT32 using a master boot record (MBR) partitioning scheme. This formatting is default for most SD cards. However, SD cards may be reformatted if needed. On a Windows PC, SD cards may be reformatted by right-clicking the drive icon and selecting Format. On a Macintosh, SD cards may be reformatted in the Disk Utility application.

Power Supply

The Propeller requires a 3.3 VDC power supply. The current draw will vary per application but will generally be under 1 amp. An experimental apparatus also has specific power requirements, so the overall power requirements of a PEC system vary greatly. In many cases, the most convenient way to power a Propeller is to use a barrel jack power supply connector in conjunction with a voltage regulator. This is the technique used by most development boards. The boards described in Table 4.1 work well with the 7.5 VDC, 1.6 amp power supply available from Parallax's website.

Software

Installing Software to Program the Propeller

Free software to program the Propeller is available at Parallax's website (Parallax.com). A number of options are available depending on the user's computer operating system and preferences. As personal computers and their operating systems continue to rapidly evolve, we cannot provide one single solution that will work for every user. However, we will provide a few notes here, and make current information available at CAVarnon.com. It is important to note that while personal computers and the software to program the Propeller may change over time, the functions of the Propeller microcontroller, and the Propeller Experiment Controller software will always remain consistent.

At the time of this writing (Spring, 2018), several applications are available that can be used to load programs to the Propeller. To find this software, click on the "Support" tab at the top of the Parallax website, and then click on "Propeller Software". The first application, **Simple IDE**, can be used by Windows PC, Macintosh, Linux, and Raspberry Pi users to program the Propeller in Spin (with Propeller Assembly) or C/C++. **Propeller IDE** can also be used by Windows PC, Macintosh, Linux, and Raspberry Pi users, but can program the Propeller in Spin (with Propeller Assembly) or PropBASIC. **Propeller Tool** is a Windows PC exclusive application used to programing the Propeller in Spin (with Propeller Assembly). Finally, **Brad's Spin Tool (BST)** can be used by Macintosh and Linux users to program the Propeller in Spin (with Propeller Assembly). Generally, we find that Propeller Tool is one of the easiest options for Windows PC users. For Macintosh computers, we find BST to be the best option for older operating systems (prior to macOS Sierra), and Propeller IDE to be an adequate replacement for newer operating systems (macOS Sierra and later). Simple IDE provides more language-options for the Propeller, but new users may find it overwhelming. In addition to these applications, Parallax's website also provides links to USB drivers that may be needed to allow your computer to communicate with the Propeller.

Each of the applications to load programs to Propeller provides many similar functions. Code can be written inside the application, much like instructions can be written in a text editor. Figure 4.2 shows the general layout of Propeller Tool on a Windows PC. The other applications have a similar layout. Once a program is complete, it can be loaded to the Propeller in two ways. First, the program can be loaded to RAM. Programs loaded to RAM will load quickly, run once, and will not run again if the Propeller is reset. Loading programs to RAM is often useful when testing code. Each application uses a slightly different command to load programs to RAM: Propeller IDE — "Project… Run", Simple IDE — "Program… Load RAM & Run", Propeller Tool — "Run… Compile Current … Load RAM", BST — "Compile… Compile and Load to RAM". Programs can also be loaded to EEPROM. Programs loaded to EEPROM will take longer to load, but will be permanently placed into the Propeller's EEPROM, and will run each time the Propeller is turned on. Resetting the Propeller will not remove the program. Only overwriting a new program to EEPROM will remove the previous program. Loading programs to EEPROM is often useful when a finalized program has been created, or when the Propeller needs to operate independently from a personal computer. Each application uses a slightly different command to load programs to EEPROM: Propeller IDE — "Project… Write", Simple IDE — "Program… Load EEPROM & Run", Propeller Tool — "Run… Compile Current … Load to EEPROM", BST — "Compile… Compile and Load to EEPROM".

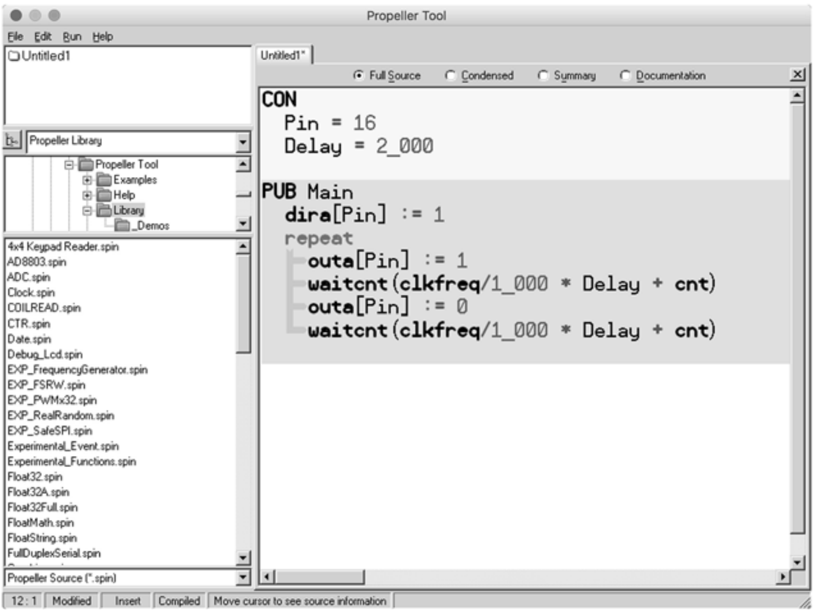

Figure 4.2: Propeller Tool.

All of these applications also make use of a **library folder** where object programs are stored. Users can create or download objects from the Propeller Object Exchange to add to the library folder. In most of these applications, the user can select their own library folder. In Simple IDE, the library folder can be selected in "Tools… Properties". Note that there are separate library folders for Spin and C/C++ programs. In Propeller IDE, the library folder can be selected in "Edit… Preferences" on Windows PC, or "Propeller IDE… Preferences" on Macintosh computer. In Propeller Tool, the library folder is created by the installer and cannot be changed but can be found in the Propeller Tool folder along with the application. By default, the installer program places Propeller Tool folder at C:\Program Files\Parallax Inc\Propeller Tool. In BST, the library folder can be selected in "BST… Preferences".

Installing the Propeller Experiment Controller Software

The PEC software can be downloaded from CAVarnon.com/software. The software is downloaded as a folder containing several Spin files. These files need to be placed in your Spin library folder. Programs written in Spin can incorporate the PEC software by importing the PEC files as objects. The user is then free to use the PEC software to build a variety of experiment programs. Some demonstration experiment programs are also available at CAVarnon.com/software. The following three chapters will describe the PEC software in greater detail.