

# Understanding Signals with the PropScope

---

## Student Guide

VERSION 1.0 DRAFT 402

PARALLAX 

## WARRANTY

Parallax warrants its products against defects in materials and workmanship for a period of 90 days from receipt of product. If you discover a defect, Parallax will, at its option, repair or replace the merchandise, or refund the purchase price. Before returning the product to Parallax, call for a Return Merchandise Authorization (RMA) number. Write the RMA number on the outside of the box used to return the merchandise to Parallax. Please enclose the following along with the returned merchandise: your name, telephone number, shipping address, and a description of the problem. Parallax will return your product or its replacement using the same shipping method used to ship the product to Parallax.

## 14-DAY MONEY BACK GUARANTEE

If, within 14 days of having received your product, you find that it does not suit your needs, you may return it for a full refund. Parallax will refund the purchase price of the product, excluding shipping/handling costs. This guarantee is void if the product has been altered or damaged. See the Warranty section above for instructions on returning a product to Parallax.

## COPYRIGHTS AND TRADEMARKS

This documentation is Copyright 2010 by Parallax Inc. By downloading or obtaining a printed copy of this documentation or software you agree that it is to be used exclusively with Parallax products. Any other uses are not permitted and may represent a violation of Parallax copyrights, legally punishable according to Federal copyright or intellectual property laws. Any duplication of this documentation for commercial uses is expressly prohibited by Parallax Inc. Duplication for educational use, in whole or in part, is permitted subject to the following conditions: the material is to be used solely in conjunction with Parallax products, and the user may recover from the student only the cost of duplication. Check with Parallax for approval prior to duplicating any of our documentation in part or whole for any other use.

BASIC Stamp, Board of Education, Boe-Bot, Stamps in Class, and SumoBot are registered trademarks of Parallax Inc. HomeWork Board, PING)), Parallax, the Parallax logo, Propeller, and Spin are trademarks of Parallax Inc. If you decide to use any of these words on your electronic or printed material, you must state that "(trademark) is a (registered) trademark of Parallax Inc." upon the first use of the trademark name. Other brand and product names herein are trademarks or registered trademarks of their respective holders.

ISBN #####

##-##-##-##-##-HKTP

Comment [AL1]: Editor to-do

## DISCLAIMER OF LIABILITY

Parallax Inc. is not responsible for special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, goodwill, damage to or replacement of equipment or property, or any costs of recovering, reprogramming, or reproducing any data stored in or used with Parallax products. Parallax is also not responsible for any personal damage, including that to life and health, resulting from use of any of our products. You take full responsibility for your BASIC Stamp application, no matter how life-threatening it may be.

## ERRATA

While great effort is made to assure the accuracy of our texts, errors may still exist. Occasionally an errata sheet with a list of known errors and corrections for a given text will be posted on the related product page at [www.parallax.com](http://www.parallax.com). If you find an error, please send an email to [editor@parallax.com](mailto:editor@parallax.com).

## Table of Contents

<b>Preface</b> .....	<b>7</b>
Audience.....	7
Support Forums.....	8
Resources for Educators.....	9
Foreign Translations.....	10
About the Author.....	10
Special Contributors.....	10
<b>Chapter 1 : PropScope Introduction and Setup</b> .....	<b>11</b>
Test Measurements in Electronics.....	<b>Error! Bookmark not defined.</b>
PropScope Measurement Tools in a Nutshell.....	12
Activity #1 : Hardware & Software Setup.....	18
Activity #2 : Configure and Adjust PropScope Probes.....	19
Summary.....	23
<b>Chapter 2 : DC Measurements</b> .....	<b>25</b>
About Supply and Other DC Voltages.....	25
Activity #1 : Ground Test.....	27
Activity #2 : Vdd and Vin DC Supply Voltages.....	34
Activity #3 : Digital to Analog (D/A) DC Voltage.....	37
Activity #4 : Voltage Dividers.....	46
Activity #5 : Advanced Topic – I/O Pin Voltage Vs. Current.....	55
Summary.....	63
<b>Chapter 3 : Human Speed Measurements</b> .....	<b>79</b>
Human Speed Vs. Electronic Speed.....	79
Activity #1 : Potentiometer Variable Voltage Output.....	79
Activity #2 : High/Low Signal Voltages and Frequencies.....	83
Activity #3 : Multiple High/Low Signals.....	93
Activity #4 : DAC and Function Generator Waveforms.....	97
Activity #5 : Simulated Heartbeat.....	105
Summary.....	111
<b>Chapter 4 : Pulse Width Modulation</b> .....	<b>121</b>
Pulses for Communication and Control.....	121
Activity #1 : Pulses for Servo Control.....	121
Activity #2 : Duty Cycle in PWM DAC.....	134
Activity #3 : Infrared Object Detection.....	139
Activity #4 : Pulses for TV Remote Communication.....	148
Summary.....	161
<b>Chapter 5 : Synchronous Serial Communication</b> .....	<b>171</b>
Synchronous Serial Devices.....	171

Activity #1 : ADC0831 Analog to Digital Converter.....	172
Activity #2 : Write Code From a Timing Diagram.....	174
Activity #3 : Verify Microcontroller Signalling.....	177
Activity #4 : Trouble-Shooting Examples.....	182
Activity #5 : Refine and Test the Code.....	188
Summary.....	193
<b>Chapter 6 : Asynchronous Serial Communication.....</b>	<b>205</b>
Asynchronous Serial Devices.....	205
Activity #1 : ASCII Codes.....	206
Activity #2 : First Look at Serial Bytes.....	209
Activity #3 : A Closer Look at a Serial Byte.....	215
Activity #4 : True Vs. Inverted.....	219
Activity #5 : Hardware Flow Control.....	223
Activity #6 : Probe the Serial Port.....	228
Summary.....	237
<b>Chapter 7 Basic Sine Wave Measurements.....</b>	<b>253</b>
Sine Wave Examples.....	253
Activity #1 : Generate and Measure Sine Waves with the PropScope.....	253
Activity #2 : Measure BASIC Stamp Musical Notes.....	260
Activity #3 : Summed Sine Waves.....	269
Activity #4 : Finding Sine Wave Components in Signals.....	275
Activity #5 : Advanced Topic: Compare Two Sine Waves.....	280
Summary.....	291
<b>Chapter 8 : RC Circuit Measurements.....</b>	<b>311</b>
Resistors, Capacitors, and RC Circuits.....	311
Activity #1 : RC Growth and Decay.....	311
Activity #2 : RC Sensor Measurements.....	322
Activity #3 : RC Circuit's Role in D/A Conversion.....	337
Activity #4 : RC D/A Converter Decay from Load.....	345
Activity #5 : Advanced Topic: Low Pass Filter.....	348
Summary.....	354
<b>Chapter 9 : Op Amp Building Blocks.....</b>	<b>365</b>
Operational Amplifiers.....	365
Activity #1 : Comparator.....	366
Activity #2 : Voltage Follower as an Output Buffer.....	370
Activity #3 : Noninverting Amplifier.....	374
Activity #4 : Inverting Amplifier.....	383
Summary.....	388
<b>Index.....</b>	<b>408</b>





## Preface

---

This text introduces basic circuit measurement techniques with these PropScope features:

- Voltmeter
- Oscilloscope
- Function Generator
- Logic Analyzer
- Spectrum Analyzer

The types of electrical signals these devices measure are also introduced along with the terms and concepts commonly used to quantify them. This text also provides an introduction to DC, AC, and binary signals found in common supply sources, communication systems and control systems.

The measurement techniques in this book are introduced in a variety of courses and grade levels. So this text leans toward qualitative introductions, and when math is required, it uses the simplest expression available. This helps keep it compatible with various levels of theory provided by the various disciplines, grade levels and their theory textbooks. For introductory and survey courses, at home students, and hobbyists, this book can be studied in step-by-step detail. More advanced courses can use this book as a primer, or sections of this book can be studied before lab work that requires a particular measurement techniques.

### AUDIENCE

This text is designed to be an entry point to technology literacy and as an easy learning curve for embedded programming and device design. The text is organized so that it can be used by the widest possible variety of students as well as by independent learners. Electronics and pre-engineering students' comprehension and problem-solving skills can be tested with the questions, exercises and projects (with solutions) in each chapter summary. The independent learner can work at his or her own pace, and obtain assistance through the Stamps in Class forum cited below.

## SUPPORT FORUMS

Parallax maintains free, moderated forums for our customers, covering a variety of subjects:

- Propeller Chip: for all discussions related to the multicore Propeller microcontroller and development tools product line.
- BASIC Stamp: Project ideas, support, and related topics for all of the Parallax BASIC Stamp models.
- SX Microcontrollers: Technical assistance for all SX chip products, including the SX/B Compiler, and SX-Key Tool.
- Sensors: Discussion relating to Parallax's wide array of sensors, and interfacing sensors with Parallax microcontrollers.
- Stamps in Class: Students, teachers, and customers discuss Parallax's education materials and school projects here.
- Robotics: For all Parallax robots and custom robots built with Parallax processors and sensors.
- The Sandbox: Topics related to the use of Parallax products but not specific to the other forums.
- Completed Projects: Post your completed projects here, made from Parallax products.
- HYDRA System and Propeller Game Development: Discussion and technical assistance for the HYDRA Game Development Kit and related Propeller microcontroller programming.





## **RESOURCES FOR EDUCATORS**

We have a variety of resources for this text designed to support educators.

### **Stamps in Class “Mini Projects”**

To supplement our texts, we provide a bank of projects for the classroom. Designed to engage students, each “Mini Project” contains full source code, “How it Works” explanations, schematics, and wiring diagrams or photos for a device a student might like to use. Many projects feature an introductory video, to promote self-study in those students most interested in electronics and programming. Just follow the Stamps in Class “Mini Projects” link at [www.parallax.com/Education](http://www.parallax.com/Education).

### **Educators Courses**

These hands-on, intensive 1 or 2 day courses for instructors are taught by Parallax engineers or experienced teachers who are using Parallax educational materials in their classrooms. Visit [www.parallax.com/Education](http://www.parallax.com/Education) → Educators Courses for details.

### **Parallax Educator’s Forum**

In this free, private forum, educators can ask questions and share their experiences with using Parallax products in their classrooms. Supplemental Education Materials are also posted here. To enroll, email [education@parallax.com](mailto:education@parallax.com) for instructions; proof of status as an educator will be required.

### **Supplemental Educational Materials**

Select Parallax educational texts have an unpublished set of questions and solutions posted in our Parallax Educators Forum; we invite educators to copy and modify this material at will for the quick preparation of homework, quizzes, and tests. PowerPoint presentations and test materials prepared by other educators may be posted here as well.

### **Copyright Permissions for Educational Use**

No site license is required for the download, duplication and installation of Parallax software for educational use with Parallax products on as many school or home computers as needed. Our Stamps in Class texts and BASIC Stamp Manual are all available as free PDF downloads, and may be duplicated as long as it is for educational use exclusively with Parallax products and the student is charged no more than the cost of duplication. The PDF files are not locked, enabling selection of texts and images to prepare handouts, transparencies, or PowerPoint presentations.

## FOREIGN TRANSLATIONS

Many of our Stamps in Class texts have been translated into other languages; these texts are free downloads and subject to the same Copyright Permissions for Educational Use as our original versions. To see the full list, click on the Tutorials & Translations link at [www.parallax.com/Education](http://www.parallax.com/Education). These were prepared in coordination with the Parallax Volunteer Translator program. If you are interested in participating in our Volunteer Translator program, email [translations@parallax.com](mailto:translations@parallax.com).

## ABOUT THE AUTHOR

Andy Lindsay joined Parallax Inc. in 1999, and has since authored eight books and numerous articles and product documents for the company. Much of the material Andy develops is based on observations and educator feedback that he collected while traveling the nation and abroad teaching Parallax Educator Courses and events. Andy studied Electrical and Electronic Engineering at California State University, Sacramento, and is a contributing author to several papers that address the topic of microcontrollers in pre-engineering curricula. When he's not writing educational material, Andy does product and application engineering for Parallax.

## SPECIAL CONTRIBUTORS

The Parallax team assembled to prepare this textbook includes: Lesson design and technical writing by Andy Lindsay; cover art by Jen Jacobs; graphic illustrations by Rich Allred and Andy Lindsay; technical review by Joshua Donelson, technical nitpicking, editing, and layout by Stephanie Lindsay. Thank you to: Stamps in Class program founder: Ken Gracey, Education Manager: Aristides Alvarez, PropScope Software Developer: Hanno Sander of Hannoware.com, BASIC Stamp Editor Software Developer: Jeff Martin, and PropScope hardware developer: David Carrier. Thank you also to our customer reviewers for their questions, recommendations, corrections: Lisa Quackenbush, pending...

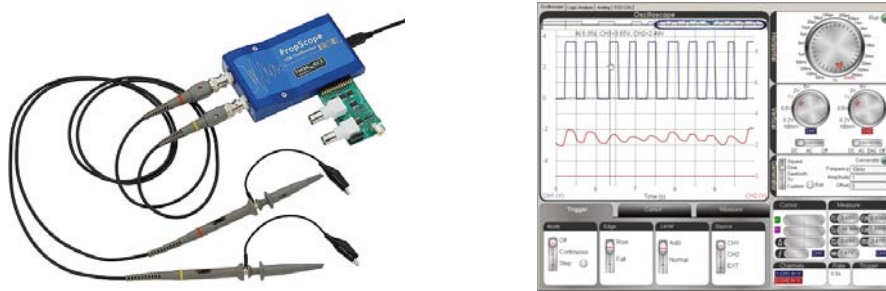
**Comment [AL2]:** ...but she hasn't seen it yet, so be nice in your correction emails. In fact, send them to me at [alindsay@parallax.com](mailto:alindsay@parallax.com) instead of to Stephanie at [editor@parallax.com](mailto:editor@parallax.com).

**Comment [AL3]:** Insert names of other contributing reviewers here.

## Chapter 1: PropScope Introduction and Setup

The PropScope USB hardware and software shown in Figure 1-1 make it possible to take a variety of electrical and electronic test and diagnostic measurements with your computer.

**Figure 1-1:** PropScope USB Hardware and Software



Many of the PropScope's capabilities used to require a test bench full of measurement equipment. Figure 1-2 shows examples (left to right) including the voltmeter, function generator, mixed signal oscilloscope (a combination oscilloscope and logic analyzer) and a spectrum analyzer.

**Figure 1-2:** Test Equipment Examples



While it's true that each of these individual pieces of equipment can outperform the PropScope in the jobs they were designed to do, they could also add up to more than 20 times the cost if purchased new. So, the PropScope provides their basic functionalities along with an affordable starting point for learning to take test measurements. Armed with the PropScope and the techniques this book introduces, you'll be able to test and trouble-shoot many of the circuits and signals in your next electronic or robotic project.

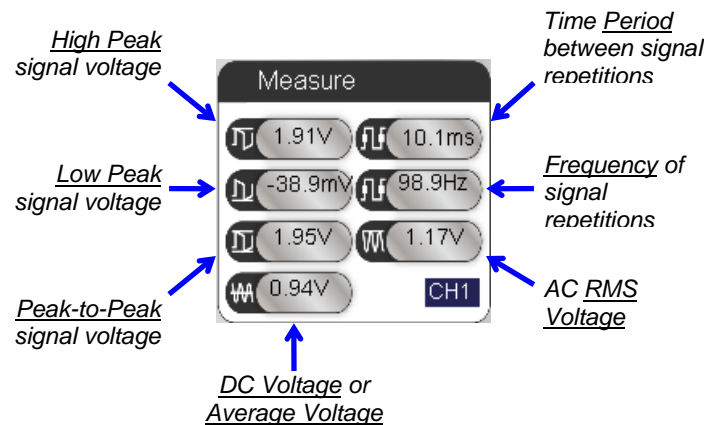
## PROPSCOPE MEASUREMENT TOOLS IN A NUTSHELL

This section briefly explains each of the PropScope's measurement tools along with some of their most common uses. The PropScope is equipped to perform the functions of all these pieces of test equipment:

- Voltmeter
- Oscilloscope
- Function Generator
- Logic Analyzer
- Spectrum Analyzer
- XY Plotter

### Voltmeter

The PropScope's voltmeter features are shown on the lower-left and right of the Measure display in Figure 1-3. The lower-left value can be used to measure DC voltage, like across a battery's terminals or the regulated supply voltage for a microcontroller. You will take a variety of DC voltage measurements, starting in Chapter 2: DC Measurements.



**Figure 1-3**  
PropScope  
Measure Display

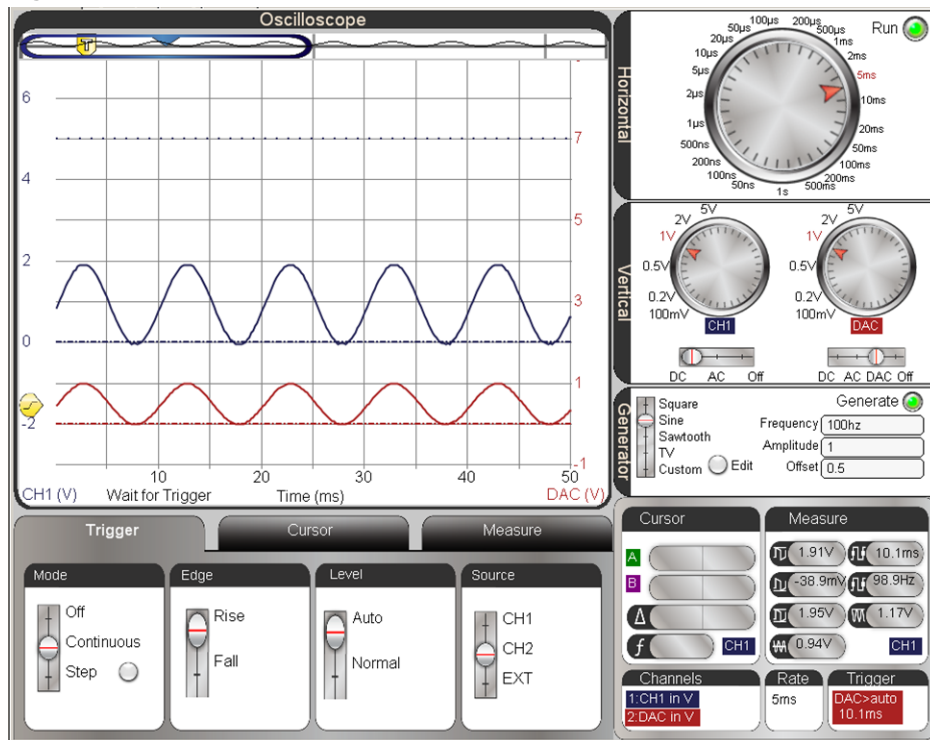
Certain voltages that vary with time in a pattern that repeats periodically are called periodic signals. Periodic signals have an average voltage that the field that displays DC voltage can also display. A signal's average voltage is also called a DC offset, and is introduced in Chapter 3: Human Speed Measurements. The RMS voltage on the lower-

right side of Figure 1-3 is a convenient way of quantifying voltages like those measured at AC wall outlets, and is explained in more detail in Chapter 7: Basic Sine Wave Measurements. The other fields shown in the figure summarize other attributes of periodic signals, and are components of oscilloscope measurements you will take, starting in Chapter 3: Human Speed Measurements.

**Oscilloscope**

Many voltages that vary over time need to be monitored, and the oscilloscope is the perfect tool for it because it measures and plots voltage vs. time. The Oscilloscope screen in Figure 1-4 is plotting two sine wave voltage signals. One sine wave (the shorter one on the bottom) is a signal going into an amplifier circuit that will be introduced in Chapter 9: Op Amp Building Blocks. The taller sine wave above it is the amplified version measured at the amplifier’s output.

**Figure 1-4: PropScope Oscilloscope View**

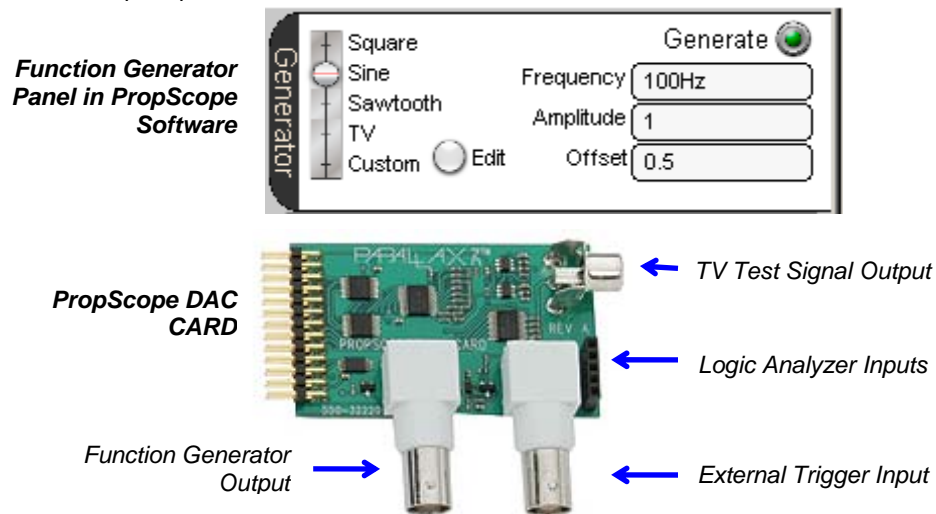


The Oscilloscope in Figure 1-4 has a Horizontal dial for adjusting the amount of time displayed in the x-axis and Vertical dials for adjusting the amount of voltage displayed by two independent voltage y-axes. One of the voltage scales is on the left side of the plot, and the other is on the right. The voltage scales can be configured to convenient increments for displaying the signals measured by the PropScope hardware. The Oscilloscope also has a Trigger settings tab for positioning the signal on the screen and a Cursor tab with tools for manually measuring voltage and time differences in the signal(s). The Measure tab displays measurements for both signals that resemble Figure 1-3.

### Function Generator

A function generator can synthesize a variety of voltage signals. These signals can be applied to a circuit input, and then the oscilloscope can measure results at a circuit output. In some cases, this helps verify that the circuit is functioning properly. In other cases, it is useful for measuring the circuit's properties and the affect it has on signals.

Figure 1-5: PropScope Function Generator



Common function generator signals include square waves (a series of high/low signals), sine waves, and a triangular pattern called "sawtooth." The PropScope function Generator panel in Figure 1-5 also has an Edit feature that allows you to draw an arbitrary

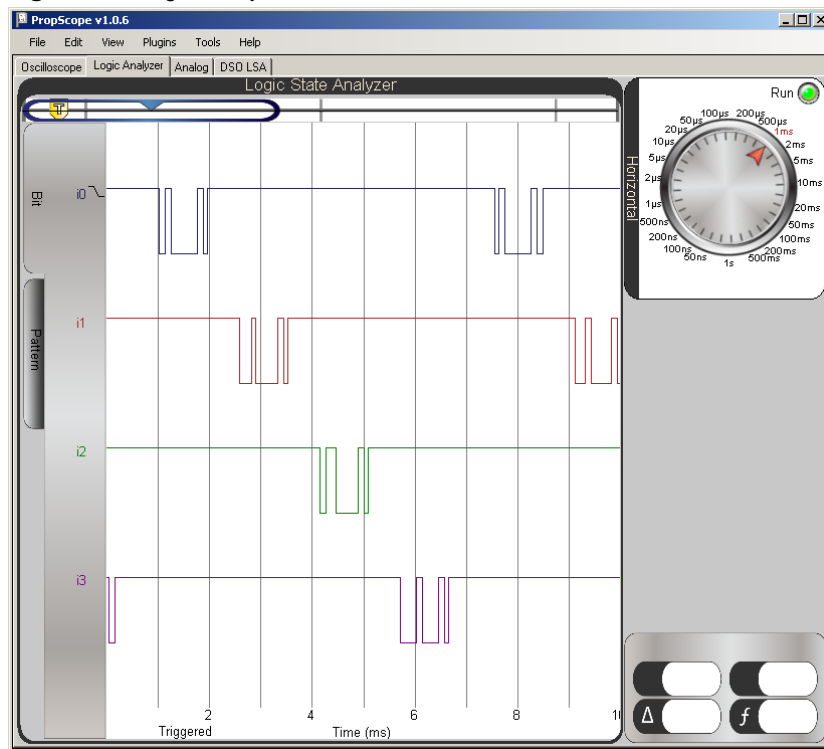
waveform that can be transmitted by sliding the waveform selector switch to the Custom setting. In addition to the signals listed, you can set DC voltages by setting the value in the Amplitude field to 0, and then adjusting the Value in the Offset field for the desired DC voltage (from 0 to 4.7 V). PropScope function generator voltages are set and measured, starting in Chapter 2: DC Measurements.

### Logic Analyzer

When digital devices communicate, there may be several signal lines exchanging binary high/low voltage signals. A logic analyzer plots the binary activity of multiple signal lines over time. Figure 1-6 shows an example from one of the projects at the end of Chapter 6: Asynchronous Serial Communication. The PropScope is monitoring four BASIC Stamp I/O pins, which are sending a sequence of four slightly different messages using a form of binary signaling called asynchronous serial communication.

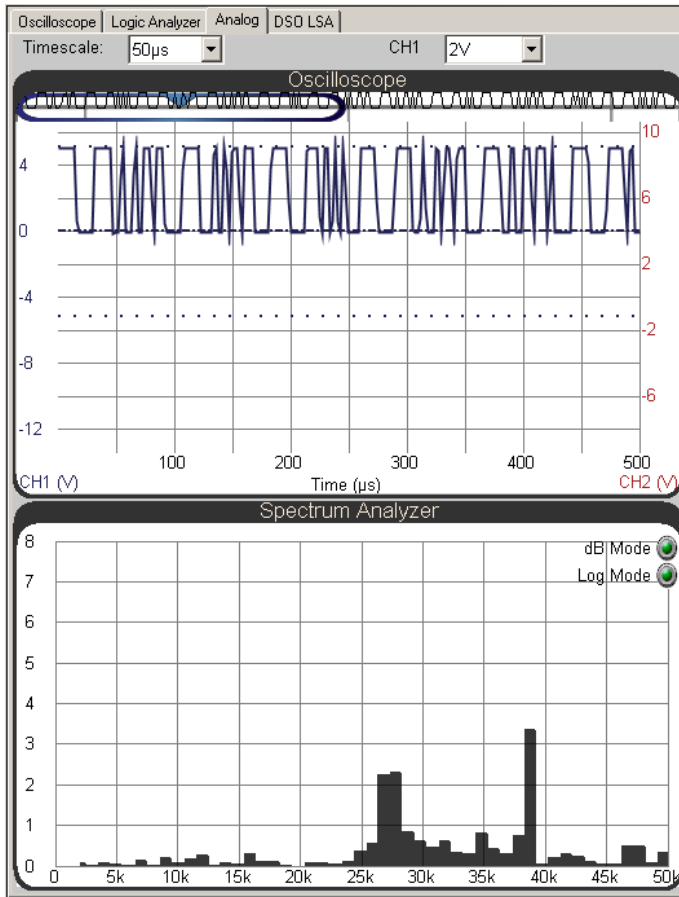
**Comment [AL4]:** PropScope Software v1.0.6 allows you to enter values up to 5 V. At 4.8 V on my scope, a 50 mV binary signal rides on the DC voltage and its frequency and duty cycle can be adjusted by the Horizontal dial. This symptom can be viewed with a bench top scope set to 50 mv/div, 20 ms/div.

Figure 1-6: Logic Analyzer



### Spectrum Analyzer

A spectrum analyzer plots the amplitudes of sine wave components in a signal vs. their frequencies. Many signals have one or more sine wave components. A few examples of when a signal's sine wave components need to be tested are: (1) engine monitoring for unhealthy vibration patterns, (2) finding radio signal interference, and (3) testing telephone dial tones.



**Figure 1-7**  
Oscilloscope above  
Spectrum Analyzer in the  
PropScope's Analog  
View

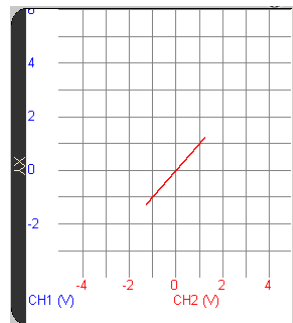
A fourth example in Figure 1-7 shows the PropScope's Analog view, which is monitoring a rapidly switching binary signal that synthesizes two sine waves. It would be very difficult to tell what sine wave signals the binary switching synthesizes by looking at it in



the upper Oscilloscope screen. The lower Spectrum Analyzer screen shows two prominent vertical bars in a graph, one in the 27 kHz sine wave frequency neighborhood, and the other at about 38.5 kHz. The 38.5 kHz signal is useful for emulating TV remote signals and infrared object detection as you will see in Chapter 4: Pulse Width Modulation. Examining the sine wave components of the binary signal will also be covered in Chapter 7: Basic Sine Wave Measurements.

### **XY Plot**

This tool plots two signals voltages against each other. One signal's voltages is treated as x-values and the other as y-values. It is useful for determining certain relationships between two different signals. The line tipping at  $45^\circ$  in Figure 1-8 indicates that the two signals are “in phase,” like the two sine waves in Figure 1-4. Their shape is the same, and the lower and upper sine wave's features are vertically aligned with no shift to the right or left. Certain circuits will introduce delays between the signal at the input and the one at the output, which would result in an apparent left or right shift of one of the sine waves. This would produce an elliptical or even circular shape, or a line with a different angle, instead of the  $45^\circ$  slope shown in Figure 1-8.



**Figure 1-8**  
XY Signal Plot

## **TEST EQUIPMENT USES AND PROPSCOPE EXAMPLES**

The voltmeter, oscilloscope, function generator, logic analyzer, spectrum analyzer and xy plotter are arguably six of the most widely used pieces of test equipment in the electronics industry. Many engineers, technicians, repair specialists, students, and hobbyists use them to measure signals at various test points in circuits and systems. Specialized versions of many of these tools can also be found in the automotive and biomedical industries as well as in many science labs.

Most of the electronic devices we use on a daily basis were designed by groups of engineers, and tested by engineers and/or technicians. Each subsystem underwent multiple circuit and signal test measurements interleaved with trouble-shooting to get to the finished product. Student and hobby projects often employ similar step-by-step approaches. Many devices also need to be repaired if they malfunction, which also involves test measurements.

There are many different types of signals and measurement techniques employed in the various fields of electronics and design. By following the activities in this book, you will get some initial, hands-on experience with many of the more common signals and measurement techniques as you use the PropScope to measure:

- DC supply and AC voltage
- Binary signal levels and timing for control and communication
- Digital signals that describe analog voltage measurements
- Sine waves for audio and analysis of filters and other circuits
- Sine wave components of audio, digital, and infrared signals
- Exponential decay for sensor measurements
- Amplifier signal conditioning

Along the way, you will also see a variety of circuit design and microcontroller programming techniques that can be found in common electronic products. If you completed *What's a Microcontroller*, *Robotics with the Boe-Bot*, or other Stamps in Class texts before starting here, you will also have the opportunity to use the PropScope's measurement tools to more closely examine the signaling involved in indicator and motor control, sensor monitoring, and communication with peripheral integrated circuits and other computers.

### ACTIVITY #1: HARDWARE & SOFTWARE SETUP


The PropScope Quick Start guide is packaged with the PropScope and is also available from the PropScope product page. It lists computer system requirements and guides you through installing the PropScope software and connecting the hardware.

- ✓ Go to [www.parallax.com/go/PropScope](http://www.parallax.com/go/PropScope) and click the Go to Product Page button.
- ✓ Complete the steps in the PropScope Quick Start Guide.
- ✓ When you get to the step titled “Measure” continue from here.

**Comment [AL5]:** Help file needs adjustment. Stated OS Support (W95 and W98) are not compatible with signed USB drivers.

Many of the activities in this book involve measurements of BASIC Stamp 2 microcontroller signaling as it interacts with circuits. These circuits are built from parts and components included in the Understanding Signals Parts Kit. In these activities, you will use the BASIC Stamp Editor to load example programs into the microcontroller. The BASIC Stamp Editor software is available for free download from the Parallax web site. For best results, get the latest version before continuing.

- ✓ Go to <http://www.parallax.com/basicstampsoftware> and download and install the latest BASIC Stamp Editor
- ✓ Connect your board (Board of Education with a BASIC Stamp 2 or BASIC Stamp HomeWork Board) to your PC and run a simple test program to make sure it is up and running. If you have never done this before, click the BASIC Stamp Editor's Help menu, and select Getting Started.



**If you do not already have a BASIC Stamp Microcontroller:** Consult the Kit Choices section at [www.parallax.com/go/WAM](http://www.parallax.com/go/WAM).

**If you are new to Microcontrollers:** The Understanding Signals Parts Kit has all the parts you'll need to complete chapters 1-5, 7, and 8 in the *What's a Microcontroller?* tutorial. If you have not already completed this text and are new to microcontrollers, it's highly recommended before continuing here.

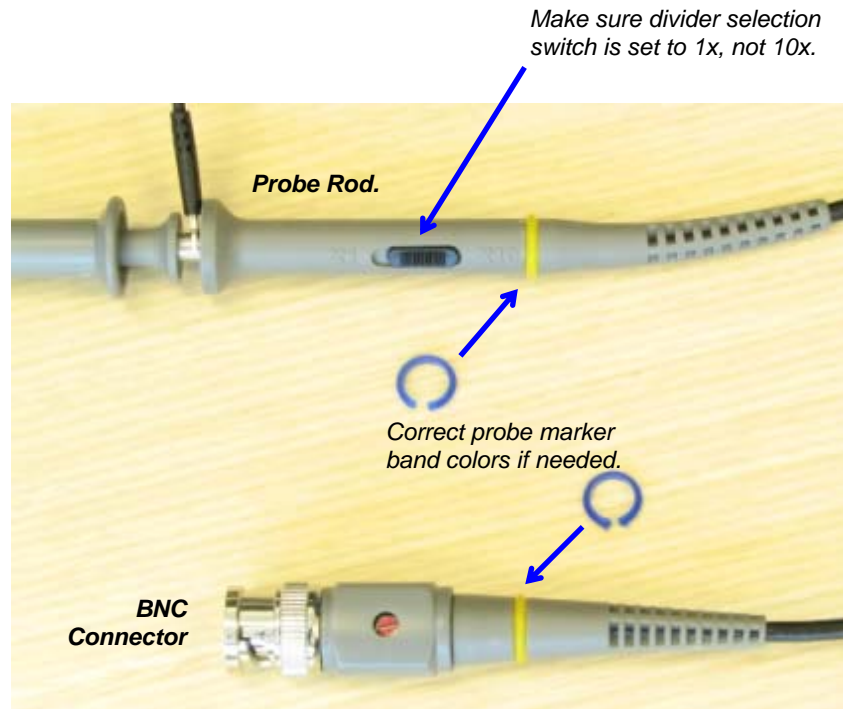
- ✓ Locate the free PDF version of the *What's a Microcontroller?* text in the BASIC Stamp Editor software's Help menu (version 2.5 or higher).
- ✓ Complete Chapters 1-5, 8 and 9.
- ✓ Skip Chapter 2, Activity #5 and Chapter 3, Activity #5.

## ACTIVITY #2: CONFIGURE AND ADJUST PROPSCOPE PROBES

The PropScope hardware and software may need some small configurations and adjustments to make them compatible with the measurements and instructions in this book. First, one probe should be marked with blue marker bands, and the other with red. Marker bands make it easy to tell which probe is connected to a given PropScope channel at a glance. The probe kit comes with several different colors of bands, including red and blue. Each probe should have two marker bands of the same color, one on the probe rod and the other on the BNC connector as shown in Figure 1-9.

- ✓ Make sure one probe has matching red color bands on its probe rod and BNC connector.
- ✓ Make sure the other probe has matching blue color bands on its probe rod and BNC connector.

Figure 1-9: Probe Rod and BNC Connector Adjustments



**BNC stands for** Bayonet Neill-Concelman. Bayonet is name of the latching mechanism and Neill and Concelman are the names of the connector's inventors.

The probe rod in Figure 1-9 also has a switch labeled X1 X10. These settings are typically pronounced “ten X” and “one X” or “times ten” and “times one”, and notations of 10x and 1x are common. These settings will be explained in more detail later in the book. For now, it’s important to make sure that both probe rod switches are set to X1.

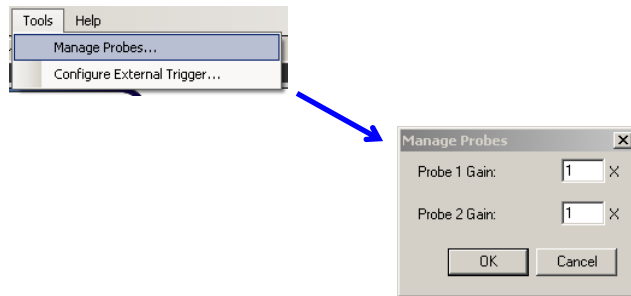
- ✓ Check each probe rod and make sure it is set to X1.

A 10x probe reduces the signal voltage the measuring device receives to 1/10 of the voltage applied to the probe. This voltage scaling is part of a circuit inside the probe that reduces the interactions with test circuits, and it also makes larger voltage measurements


possible. In contrast, a 1x probe does not reduce the signal voltage and improves resolution of measurements in the ranges we will study on the Board of Education.

The PropScope software needs to know whether the probe is set to 1x or 10x since that setting would make it necessary to either multiply by 1 or 10 before reporting the measurement. Since our probes are set to 1x, the software has to be configured accordingly.

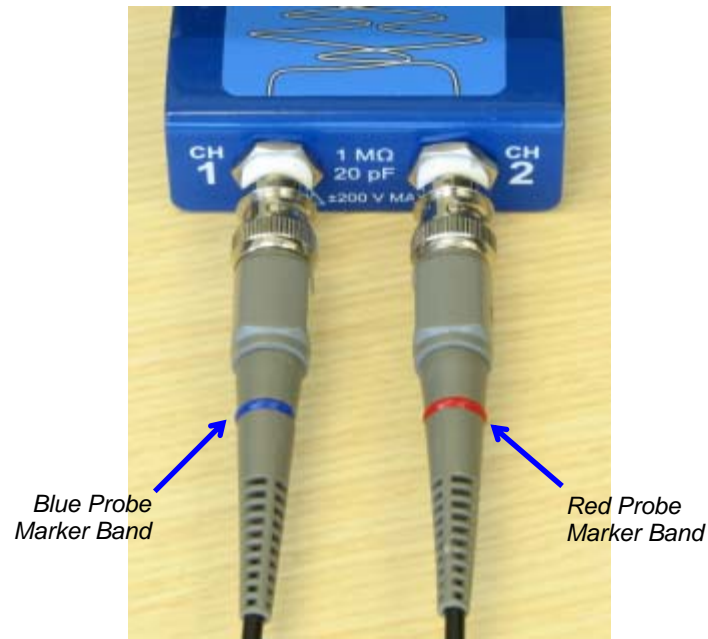
- ✓ In the PropScope software, click Tools and select Manage probes. Set the probe gain to 1 for both probes.



**Figure 1-10**  
Configure Probe Gains to 1x

By default, the software color codes voltage measurements from CH1 as blue, and those from CH2 as red. So the probe with the blue marker band should be connected to the PropScope's CH1 BNC connector and the probe with the red band should be connected to the PropScope's CH2 BNC connector, like in Figure 1-11. 

- ✓ Make sure the probe with the blue marker bands is connected to the PropScope's CH1 BNC connector and the probe with the red bands is connected to CH2.



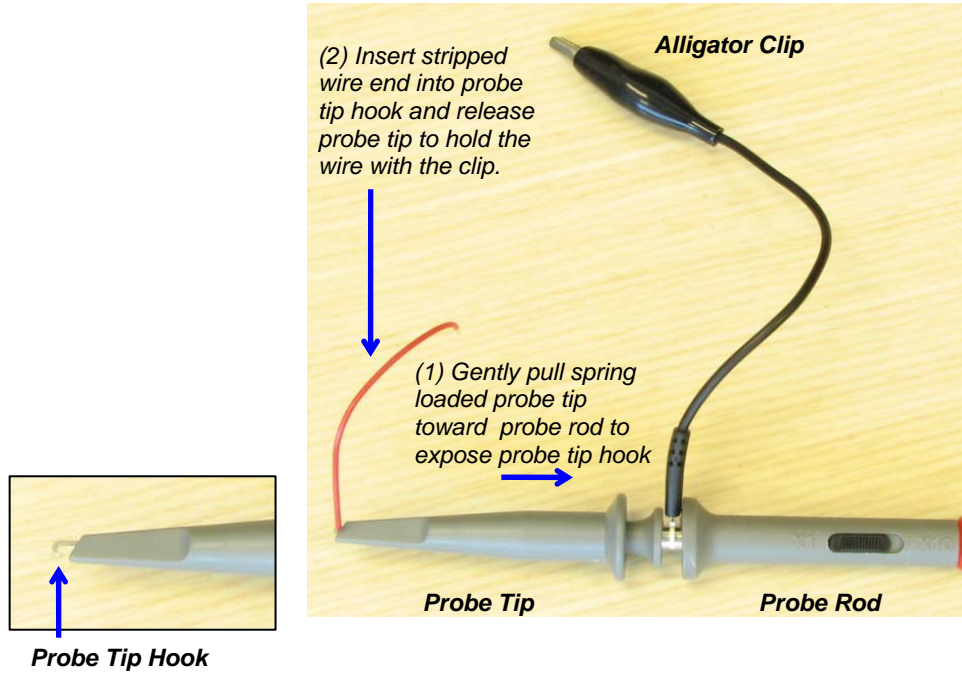
**Figure 1-11**  
Channels and  
Marker Bands

*Connect the probe with the blue marker bands to CH1 and the probe with the red marker bands to CH2.*

Each PropScope probe has two clips shown in Figure 1-12: a black alligator clip and a hook in the probe tip. Both are spring loaded so that they can grip and hold wires and leads. A convenient setup for testing the voltages at breadboard sockets is to grab the stripped end of a jumper wire with a probe tip. The other end of the jumper wire can then be inserted into breadboard sockets to test voltages at various points.

- ✓ Grab a jumper wire that matches the color of each probe's marker bands. (1 blue and 1 red jumper wire)
- ✓ Extend the probe tip hook shown in Figure 1-12 by gently pulling the spring loaded probe tip toward the probe rod.
- ✓ Insert one of the jumper wire's stripped ends into the probe tip hook.
- ✓ Release the probe tip. The spring loaded tip should retract and grip the jumper wire.

**Figure 1-12:** Grab a Stripped Wire end with the Probe Tip Hook



### SUMMARY

The PropScope is a USB hardware peripheral and software that allows your computer to perform the functions several different electronic test equipment components. Examples of test equipment the PropScope can stand in for include the voltmeter, oscilloscope, function generator, logic analyzer, spectrum analyzer and XY plotter. These devices are used by engineers, technicians, students, hobbyists and repair technicians for product development, projects, diagnostics, and repairs.

PropScope setup involves following the software installation and hardware connection instructions in the PropScope Quick Start Guide. Marker bands help make it clear which probe is connected to a given PropScope channel at a glance, and they should be adjusted to match the colors of the channel information displayed by the PropScope: blue for CH1 and red for CH2.

Each probe tip has a spring loaded alligator clip that gets connected to the ground connection of the device under test, and a probe tip that can grab wires and leads with a spring loaded, retractable hook. Grabbing a jumper wire with the retractable hook will simplify probing breadboard sockets on your breadboard. As with the color bands, use a blue wire with the CH1 probe and a red one with the CH2 probe.

### **Questions**

1. What does a voltmeter measure?
2. What does an oscilloscope plot?
3. What does a logic analyzer plot?
4. What does a spectrum analyzer plot?
5. What does an XY plotter plot?

### **Solutions**

- Q1. Voltage, either DC or AC.
- Q2. Voltage vs. time.
- Q3. High/low signals vs. time.
- Q4. The amplitude of sine wave components vs. their frequencies.
- Q5. The voltage of one signal on the y-axis vs. the voltage of another on the x-axis.