24-bit Digital Phase Shifter On-Chip
Model: A-20L-0-1113

1. General Specifications

Absolute maximum ratings

Supply Voltage Range: +/- 8 to +/- 15 V DC (Recommended Supply Voltage: +/- 9 V)

Warning: Operating outside the specified supply voltage range may damage the device. Trinity Research Labs shall have no responsibility for any consequences of using the phase shifter chip in a manner that is not specified in this document.

Maximum Input Voltage: +/- 5 V peak

Maximum Operating Temperature Range: -40˚C to 90˚C

Maximum Power Consumption: 1 W

Maximum Output Current: 50 mA peak at 50 Ω load

Maximum Output Voltage Noise: 14 nV/√Hz (typically 7 nV√Hz), 10 Hz – 100 KHz

Weight: 32 g

Dimensions (L x W x H): 53 mm x 32 mm x 12 mm

C-Tick compliant, RoHS compliant, Meets Requirements for CE marking

Lead Free Assembly

Phase shifter input characteristics

Input Impedance: 50 Ω

Recommended Frequency Range: 10 Hz to 10 kHz pure sine wave signal

Recommended Maximum Input Voltage Swing: +/- 1 V

Phase shifter output characteristics

Output Impedance: 50 Ω

Unity Gain at 50 Ω source impedance and 50 Ω load

Recommended Maximum Output Voltage Swing: +/- 1 V

Total Harmonic Distortion: < 0.01% (at +/- 1V output voltage swing and 50 Ω load)

Output Voltage Noise: ~7 nV/√Hz, 20 Hz

2. Design Specifications

Phase shifter central frequency setting

The current model A-20L-0-1113 is set to 20 Hz central frequency by connecting two external 25 μF 1% matched ceramic capacitors between Pin11 and Pin12 and between Pin15 and Pin16 (see the bottom view of the phase shifter chip depicted in Fig. 1).

$$f_{central} = \frac{500}{C(\mu F)}$$

By choosing another value of the capacitors, the type A phase shifter can be set to any other central frequency within its operational frequency range (see "Phase shifter input characteristics" section above).

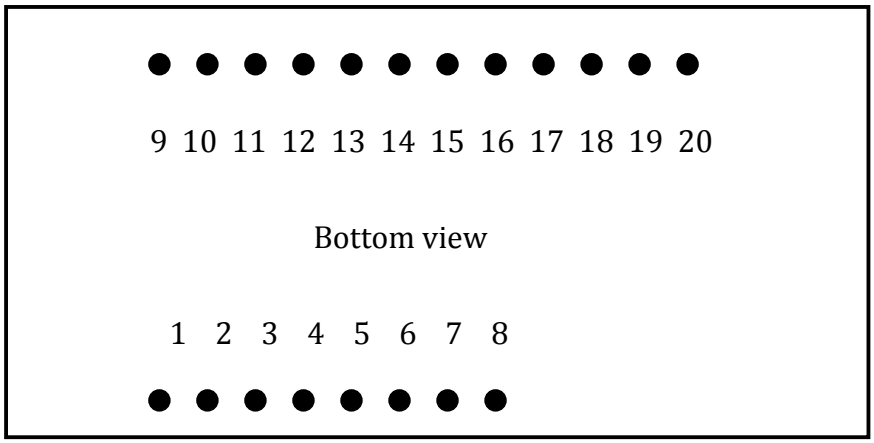
Warning: The current phase shifter model A-20L-0-1113 has been linearised at the default value of central frequency, which is 20 Hz. This provides a true linear phase shift as a function of digital control numbers varying from 0.00000001 to 0.99999999, which are being sent to the phase shifter via RS232 communication protocol. A typical phase shift versus digital control numbers plot is depicted in Fig. 2 below. By choosing another central frequency, the true linear phase shift may not hold at the design specifications provided.

The true linear phase shift holds within +/- 15% off the central frequency.

Phase Shift Capabilities

Total software controlled phase shift: ~45 deg
Guaranteed true linear phase shift margins: 40 deg
Bias Phase Shift set by external trim resistor: ~ 90 deg

Figure 1: Phase Shifter Basic Connection.



Pin1 : - Vs (negative supply voltage rail)
Pin2 : +Vs (positive supply voltage rail)
Pin3 : GND
Pin4 : not connected
Pin5 : GND
Pin6 : PC TX (RS232…)
Pin7 : PC RX (RS232…)
Pin8 : not connected

Pin9 : Signal In
Pin10 : GND

Pin11 - Pin12 : An external capacitor (25 µF 1% for the 20 Hz central frequency setting)

Pin13 – Pin14 : External 0 – 500 Ω trim resistor (or a fixed 255 Ω resistor)

Pin15 - Pin16 : An external capacitor (25 µF 1% for the 20 Hz central frequency setting)

Pin17 – Pin18 : No connection

Pin19 : GND
Pin10 : Signal Out

Optional: An external gain setting resistor Rg (trim or fixed) can be connected between Pin17 and Pin18. The gain of the phase shifter is as follows:

$$gain = \frac{Rg}{255\Omega + \frac{Rg}{2}}$$

Warning: The Rg value of less than 510 Ω is not recommended as this will increase output voltage noise and set the phase shifter below unity gain.

If there is no external resistor connected between Pin17 and Pin18 (Rg = ∞), the gain of the phase shifter is set to 2 (the default value).

Figure 2: Phase shift versus digital control numbers plot. The blue section is a precise line fit over 40 degree phase change.

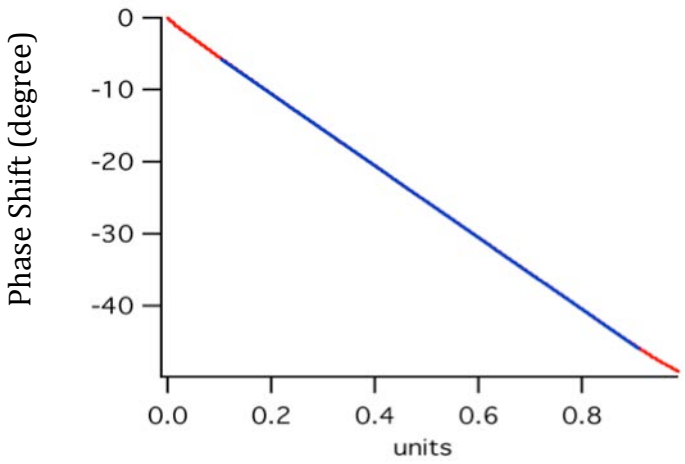


Figure 3: A typical deviation from true linear phase shift over 40 degree phase change (≤ 0.2 %).

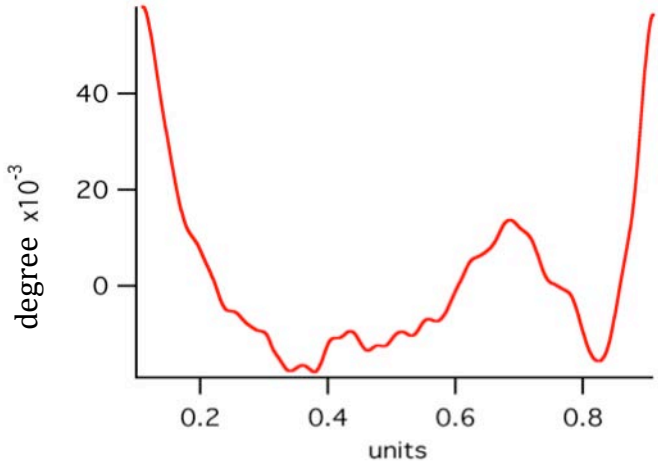
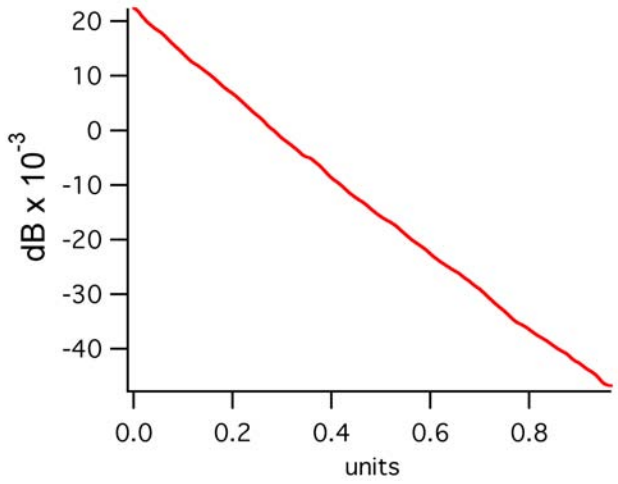


Figure 3: A typical Insertion Loss plot (~ 0.06 dB over 40 degree phase change).



3. Communicating to the Digital Phase Shifter

The Digital Phase Shifter is a microprocessor controlled Phase Shifter configured for a set constant frequency given in the product description above. This document describes technical details involved in communicating to the DPS unit from a computer or from Data Terminal Equipment (DTE), the serial port configuration required, and the input message protocol of the DPS unit, which an user written program can use to control the DPS unit.

DPS Unit's RS232 Port Setting

Each Digital Phase Shifter has a RS232 port in null modem 57600 baud 8/N/1 configuration:

Speed: 57600 Baud
Data bits: 8-bits
Parity: None
Stop bits: 1 bit
The DPS unit's RS232 configuration is fixed.

Computer's RS232 Settings

The computer or Data Terminal Equipment (DTE) that communicates and controls the phase shifter requires the same RS232 port settings as given above, i.e. 57600 Baud in 8/N/1 configuration. Refer to your computer's manuals on how to configure or serial port to these setting. A general description of the method, for the following operating system platforms is given here.

Unix workstations

Use system initialisation configuration file, "/etc/inittab" to set the computer's port parameters. Most Unix system will have a configuration program, such as "tip" for Sparc Solaris that aids serial port configuration. Refer to the system's manual for specific details.

GNU/Linux computers

Use the same as for Unix workstations. Or use the "setserial" program. Refer to the manual "man setserial" for details. Other hardware devices such as Serial-to-USB adapters and multi-port serial cards would also do as communications ports on GNU/Linux systems, once the Linux Kernel is configured for the specific device hardware.

Mac OS X computers

Macintosh computers usually do not have a physical built-in RS232 port on the machine, and a Serial-to-USB adapter with a software driver is required. Most adapters will work on a Mac with one of the following OS X drivers:

Prolific PL2303:	PL2303_MacOSX_v1_5_1.zip
FTDI USB Serial:	FTDI_MacOSX_v2.2.18.zip

If your adapter doesn't work with either of these, try the following sources:

- Silicon Labs - CP210x USB to UART Bridge Virtual COM Port (VCP) drivers.
- Belkin - USB Serial Adapters: F5U257, F5U103, F5U003 (poor OSX support).
- Keyspan OSX serial-USB adapter drivers can be found in their Support Section.

Note that the adapter would need to support the 57600 baud rate of the Digital Phase Shifter on your computer to communicate and control the Digital Phase Shifter.

Once the adapter and driver is installed, you can use the Mac's terminal program "screen" to set the port parameters to the required settings of 57600 baud, 8/N/1. For more information see the manual "man screen" on your computer.

Microsoft Windows computers

Microsoft Windows systems can use the computer's physical built-in RS232 port, multi-port serial card, or a Serial-to-USB adapter with a driver specific to your version of the Window's System. The actual device port used to connect to the Digital Phase Shifter would need to be configured to the same settings of 57600 baud, 8/N/1.

For Microsoft Windows 2000, XP, Vista, 7 and 8, the RS232 port can be configured by using the "device Manager" program, which is found in the "Control Panel" of the Windows system. Refer to the Windows manual for specific details. Once the correct port settings have been entered in the Device Manager application, apply it to save the configuration for the "Com" port in question.

Host to DPS Unit Shift Rate Communications Latency

The rate at which the Digital Phase Shifter can change phase from one setting to another is dependent on the choice of physical RS232 connection between the host machine and DPS unit. Computers that have the RS232 UART unit directly attached to the host machine's bus have low latency in the order of a few milliseconds or less. Hosts communicating with the DPS unit via a Serial-to-USB adapter have the highest latency, as high as 500 ms delay between sending one phase setting command and the next to the DPS unit.

For fastest phase change rates, if important, it is recommended to use a computer with a built-in RS232 port on the machine.

Programs to communicate with DPS

The Digital Phase Shifter employs serial terminal protocol to communicate between the controlling computer or DTE and the DPS unit. There are many terminal programs available, some common ones are:

- Hyperterminal (Windows XP and earlier)
- Kermit
- ExtraPutty
- Minicom
- ZTerm

Set the program's terminal port setting to 57600 baud, 8/N/1 configuration for the computer's RS232 port and connect.

Digital Phase Shifter Protocol

This section assumes the user is familiar with serial communications interface protocols, including their definitions and use.

Phase Shifter Command

The DPS unit accepts ASCII numeral only text input messages terminated by the carriage return character - "\r" of hexadecimal value of 0D.

Command **"Phase Setting"** is an input message to the DPS unit in hardware Phase Units (PU) transmitted as an ASCII text value, terminated by a carriage return character "\r". The accepted hardware PU range is between the values of 0 and 1, exclusive; with lowest message of "00000001" and highest message of "99999999". The lowest increment or decrement value is 0.00000001, between the stated limits.

Please note that the leading two text characters "0." should be stripped from the sending input message. The trailing "00" characters can also be stripped from the serial input message to the DPS unit.

The following input message sets the DPS unit to a Phase Shifter Unit value of 0.0002:

0002\r

Command	Example	DPS Response
Phase setting	“0002\r”	“> ” if command executed
	“0.0002\r”	“> ” value 0 and DPS unit value set to near zero.
	“Unknown command”	Error Message if not executed.

In order o obtain the phase value in units of radians one would need to find the conversion factor from Phase Unit to radian, which depends on a particular Phase Shifter model.

4. Digital Phase Shifter GUI Demonstrator Software

The Digital Phase Shifter GUI demonstrator software is a program that communicates with a Trinity Research Labs Digital Phase Shifter unit. This document describes the prerequisite requirements, installation and operation of the GUI for Microsoft Windows computers.

Software dependencies

The Digital Phase Shifter GUI is partly Java based, and depends on the Java Runtime Environment 7 (JRE7). If your computer has an older version, or no runtime environment, you can download JRE7 from Oracle's download site:

http://www.oracle.com/technetwork/java/javase/downloads/index.html

and follow the instructions therein to install the JRE on your computer.

CDROM Contents

The provided CD disc contains the Microsoft Windows installer program for the DPS GUI, phaseshifter-windows and additional MS Windows dynamic libraries in folder RXTX. For further information, please read the README files on the disc.

Digital Phase Shifter GUI demonstration Program

If you intent to use a Plug-and-Play Serial-to-USB adapter to interface between the Digital Phase shifter unit and a computer, please attach it first to your computer's USB port before executing the Digital Phase Shifter GUI application.

On starting the Digital Phase Shifter GUI, a Graphical User Interface opens with a DPS main window interface that has a control to connect to the RS232 Port of the Phase Shifter device, with other control panels that automatically send input messages to the DPS unit. The following figure illustrates GUI running under MS Windows 7, the appearance is same under the other operating system platforms with identical functionality.

In the “Select Serial Port” control panel there is a drop down list button and a push button.

The content of these can be as follows:

- **“No Ports Found”** and **“Refresh”**

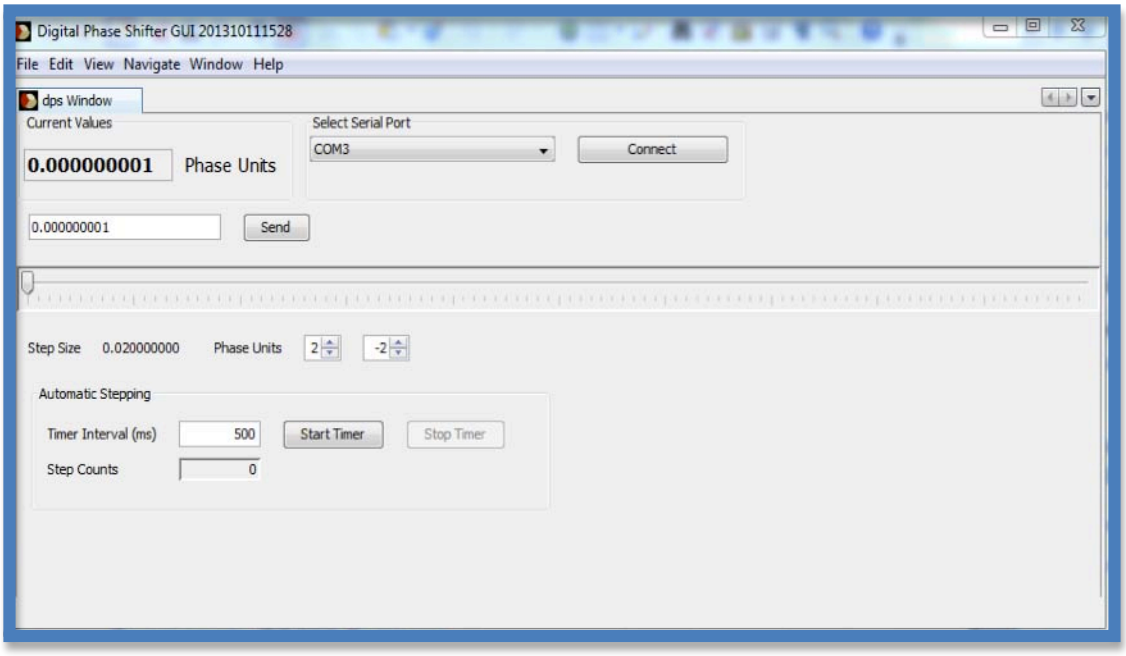
In this case when the DPS GUI started, a search found no available communications ports. If the host computer has software using any existing serial ports, disconnect one, and then press the “Refresh” button. Alternatively, insert a Serial-to-USB adapter that the OS already has a driver for, and then press “Refresh”

- **“COM3”** and **“Connect”**

In this case at least one serial port was found on start up. Select the COM port number, which is physically connected to the DPS unit, and then press the “Connect” button. In a few moments, if port configuration and connection is successful, the button will display “Connected”.

Note that some low numbered COM ports (COM3), may be an internal device in the host machine without a physical port on the body.

In some cases, particularly with newer versions of Windows, connection is not successful, mainly due to users not having sufficient privileges for the application to change the hardware settings. For example, in the case of a MS Windows 7 OS, close the DPS GUI down and change the COM port protocol settings using the Device manager and save the configuration. Then try again using the DPS GUI.



- **“COM4”** and **“Connected**

In this case successful connection has been to the selected COM port of the host. The control function on the DPS Window will now send messages to the port when operated.

DPS GUI functionality

The main DPS GUI window shows the application's current hardware Phase Unit (PU) value, reported as Phase Units. The GUI application makes no assumptions about the conversion factor between the DPS's hardware PU to radians. To find out what is the actual factor for a specific DPS unit, see that particular DPS unit's specification report provided.

To send a specific Phase Unit setting value message to the DPS unit, enter a value in the field provided and then press send.

Below that is a slider type control interface. When mouse pointer focus is on the slider interface (click on it to gain focus), the following mouse and keyboard functions are available:

- Clicking of either side of the slider's position marker, the PU value changes by one tenth

- Pressing either of the “Page Up” or “Page Down” on the computer's keyboard, changes the PU value by one tenth

- Very small PU changes are achieved by the arrow keys

- Manually move the slider. When Slider Marker is moving manually, note that PU values are transmitted to the DPS Unit in 200 ms intervals

These changes in slider position are automatically transmitted to the DPS unit.

Automatic phase changes in the step size selected are provided by the timer interface on the main GUI. To change the default delay period of 500 ms between phase steps, enter new period value into the box provided, and press “enter” on your keyboard. Note that if your serial communications link is via a Serial-to-USB adapter, there is significant latency between input messages rate. It is unlikely to achieve step rates below 500ms. Those host machines with a built-in RS232 port, input messages latency to the DPS unit from the host machine can be as low as a few milliseconds or less.