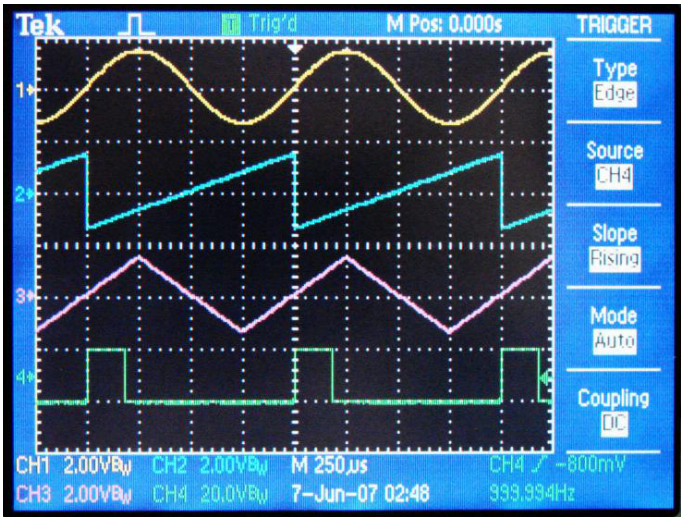
HIGHLAND TECHNOLOGY



T340

EMBEDDED WAVEFORM GENERATOR

Technical Manual

September 3, 2023

650 Potrero Avenue San Francisco, CA 94110 www.highlandtechnology.com tel: 415 551-1700 fax: 415 551-5129

650 Potrero Avenue, San Francisco, CA 94110
Phone 415-551-1700 • Fax 415-551-5129
www.highlandtechnology.com

NOTICE

HIGHLAND TECHNOLOGY, INC. PROVIDES THIS PUBLICATION “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

(Disclaimer of expressed or implied warranties in certain transactions is not allowed in some states. Therefore, the above statement may not apply to you.)

This manual may contain technical inaccuracies and/or typographical errors. Changes are periodically made to this manual which are incorporated in later editions. Highland Technology, Inc. may make changes and improvements to the product(s) and/or programs described in this publication at any time without notice.

The T340 has finite failure rates associated with its hardware, firmware, design, and documentation. Do not use the product in applications where a failure or defect in the instrument may result in injury, loss of life, or property damage.

IN NO EVENT WILL HIGHLAND TECHNOLOGY, INC. BE LIABLE FOR DAMAGES, INCLUDING LOST PROFITS, LOST SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF OR INABILITY TO USE SUCH PRODUCT, EVEN IF HIGHLAND TECHNOLOGY, INC. OR AN APPROVED RESELLER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, OR FOR ANY CLAIM BY ANY OTHER PARTY.

Contents

1. Introduction

This is the technical manual for the Highland Model T340 four-channel waveform generator module.

Features of the T340 include:

- Four independently programmable or synchronized waveform outputs: sine, triangle, sawtooth, square/pulse/PWM
- Channels may be synchronized to produce coordinated polyphase or time-aligned PWM signals at same or ratioed frequencies
- 0 to 2 MHz outputs with 0.004 Hz resolution
- Up to 20.48 volts peak to peak output, programmable 10:1 attenuation and DC offset
- Simple programming procedures for basic sinewave generation
- Programmable offset allows wave+offset or direct DC DAC functionality
- Programmable channel phase allows generation of quadrature or polyphase waveforms
- Programmable digital pulse/PWM outputs can simulate transducers or quadrature encoders
- Test output and built-in self-test (BIST) are included
- Includes channel test connector, allowing in-system check of channel performance without removing field wiring
- External universal power supply or 12-volt DC power
- RS-232 serial interface standard; Ethernet optional
- Other products in the T340 family of waveform generators include:
    - T344: 4-channel compact 32 MHz arbitrary waveform generator
    - T346: 4-channel compact 32 MHz arbitrary waveform generator w/ complex modulation
    - V340: 8-channel VME function generator with transformer coupling
    - V344: 8-channel VME 32 MHz arbitrary waveform generator
    - V346: 8-channel VME 32 MHz arbitrary waveform generator w/ complex modulation

This manual applies to the standard T340-1 version, and the T340-2 which includes the Ethernet option.

T340-1 Power Endplate

T340-2 Power Endplate

T340 Signal Endplate

2. Specifications: T340 waveform generator

FUNCTION	4-channel compact function generator
CHANNELS	4, DC coupled with 50 Ω output impedance
OUTPUTS	4 separate or synchronized sine, sawtooth, triangle, or square/pulse/PWM outputs, programmable frequency 0 to 2 MHz with 0.003725 Hz resolution 14 bit DAC output resolution Two programmable amplitude ranges, ± 10.24 V and ± 1.024 V Programmable DC offset anywhere within amplitude range Programmable phase and PWM duty cycle
OFFSET ERROR	10 mV max
GAIN ERROR	2% max, typically < 0.2% to 100 KHz
FREQUENCY ACCURACY	± 0.02%, typically < 20 PPM
OPERATING TEMPERATURE	0 to 60°C; extended MIL/COTS ranges available
CALIBRATION INTERVAL	One year
POWER	+12 V, 700 mA max J12 12 volt power supply adapter furnished
COMMUNICATIONS	RS-232 standard, 38.4 kbaud Optional 10/100 Ethernet
CONNECTORS	Outputs and test, SMB jack Power, 2.5 mm coaxial, center positive RS-232 and alternate power, D9 female
INDICATORS	LEDs for communications, error
PACKAGING	4.0″ (L) x 4.75″ (W) x 1.25″ (H) extruded aluminum
CONFORMANCE	OEM product has no UL/FCC/CE compliance requirements Designed to meet UL/FCC/CE requirements Power adapter when furnished is UL/CE certified

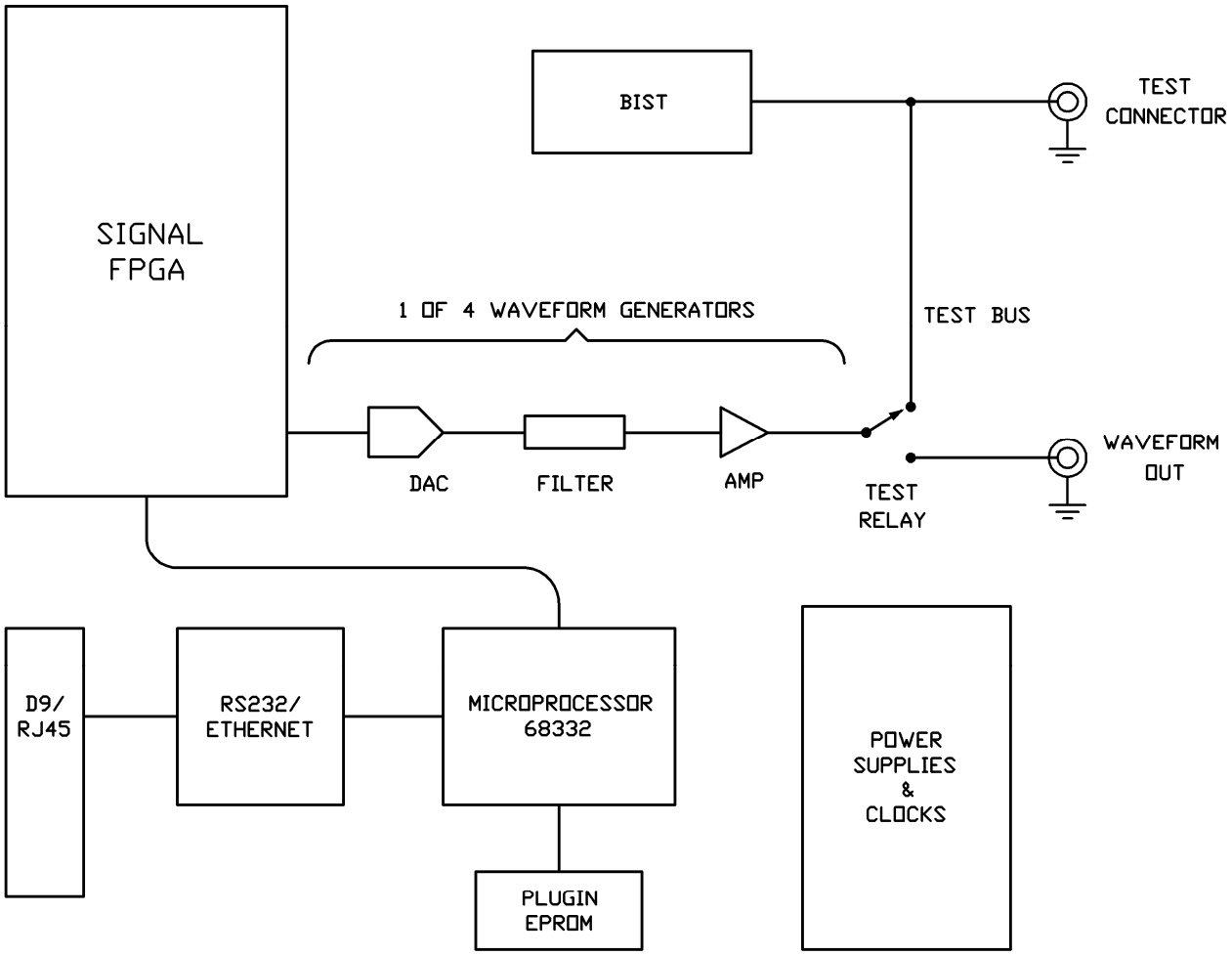
3. Overview

The T340 includes 4 independent DDS-based waveform generators, referred to as channels 0, 1, 2, and 3.

An internal microprocessor manages all data I/O and communicates via an RS-232 interface, with optional Ethernet.

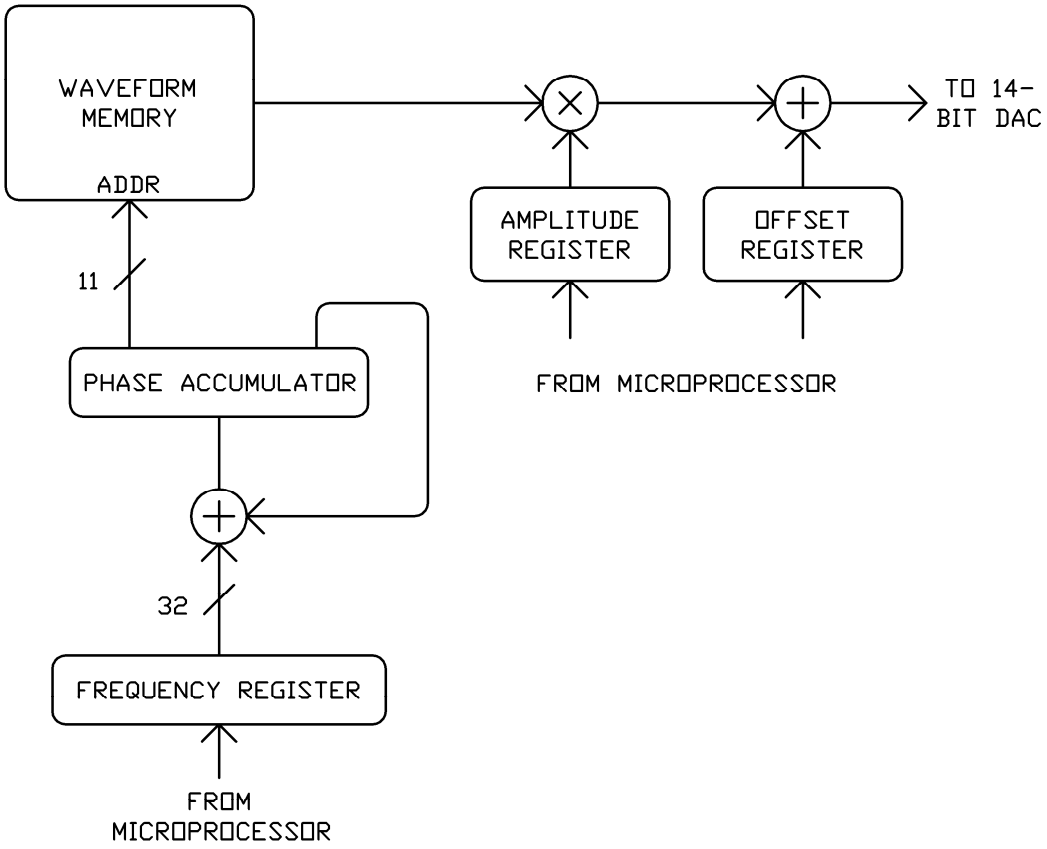
Relays are provided to reroute any waveform output channel to the internal test bus, thence to the BIST block for self-test, or to the dedicated SMB test connector for external calibration checks without disrupting field wiring.

The overall block diagram of the T340 is shown below:



Waveforms are generated by direct digital synthesis. A 32-bit phase accumulator is clocked at 64 MHz, advancing in phase by a programmable amount. The most significant 11 bits of the advancing phase word is passed through a 2K x 16 bit waveform lookup table, synthesizing a sine, triangle, or sawtooth wave. The output of the lookup table is amplitude scaled by digital multiplication, offset by an adder, and then drives a 14 bit D/A converter. The DAC output is then lowpass filtered and amplified to become the channel output.

The scale factor of each DAC is programmable X1 or X0.1, allowing low-level outputs to be generated at full 14-bit DAC resolution.



Each of the four channels also incorporates a pulse/PWM generator that may be substituted for the waveform lookup table. The PWM logic generates a waveform of variable duty cycle and full-scale bipolar swing, which can then be scaled by the amplitude, offset, and X0.1 signal path.

The output stage of each channel consists of a lowpass filter, 50-ohm power amplifier, and a test-bus relay.

4. Connectors and Installation

4.1 Mechanical Installation

The T340 mechanical dimensions are shown in section 11. It is preferred that the T340 be securely bolted to a grounded metal surface. If rear fastener access is not convenient, the T566 mounting flange is available.

The standard T340 is not suited to operation in wet or condensing environments.

4.2 Connectors

The T340 includes the following connectors:

J1	SMB jack	0 channel 0 waveform output
J2	SMB jack	1 channel 1 waveform output
J3	SMB jack	2 channel 2 waveform output
J4	SMB jack	3 channel 3 waveform output
J5	SMB jack	T test output
J8	2.1 x 5 mm	+12 power input
J9	D9 female	RS-232 and alternate +12 power
J10	RJ45 female	optional Ethernet

4.3 Signal Connectors J1-J4

Connectors J1 through J4 are channel 0 through 3 signal outputs respectively. They are SMB jacks, with active output impedance of 50 ohms and unloaded signal swing as high as +-10.24 volts.

4.4 Test Connector J5

J5 is an SMB jack used for verification of T340 outputs. Under software control, any of the four channel outputs may be diverted to J5, allowing verification of channel functions and calibration without disconnecting the normal output cables. See section 9.

4.5 Power Connector J8

The T340 requires +12 volts DC at 0.6 amps max, 0.7 amps for the Ethernet version. Actual power consumption will be well below these limits if the outputs are not required to furnish their full 100 mA per channel maximum output. A wall-plug universal power supply is furnished with the evaluation kit, or users may supply +11.8 to +12.75 VDC power. The evaluation power supply with US plug is Highland part number J12. The international AC plug adapter kit is part number J14.

The standard power connector is a 2.1 x 5 mm coaxial power type, center positive. The T340 grounds the low side of the power input. DC power can also be supplied to pins 6 (+12) and 9 (ground) of the D9 RS-232 connector.

The T340 power input is protected by a self-resetting polyfuse and a transzorb zener diode, and will withstand reasonable overvoltage or polarity reversal.

4.6 RS-232 Connector J9

The female D9 connector provides the RS-232 interface and an optional power supply input. The Pinout is as follows:

Pin	Function
2	Serial TXD (reply data from T340)
3	Serial RXD (commands to T340)
5	Ground
6	+12 volt power in
9	Ground

Note that, if the unit is powered through the J8 connector, +12 will appear on J9 pin 6, which a PC will see as a high DSR signal. The T340 may be connected to a standard 9-pin PC serial port with a straight-through male-female D9 cable.

4.7 Ethernet Connector J10

J10 is the optional RJ45 10/100 Ethernet connector. If the Ethernet option is present, both J9 and J10 are active, although only one communications path should be used at any one time. See section 7.

4.8 LEDs

Two COMM led's appear to the right of the J9 communications connector. The orange led will flash whenever the T340 receives incoming serial characters, and the blue led will flash when it sends reply data.

A green led is located on the outputs end-plate, labeled PWR. It will illuminate at powerup and then blink about once a second after startup initialization to indicate that the internal firmware is operating normally.

The red ERR led is located to the left of the PWR led. It will normally be off, and will flash if any error flags are set.

See section 8 for notes on led operation during BIST self-test.

4.9 Available Accessories

The following T340 accessories are available:

T566	Mounting Flange
J12	12-volt, 0.84 amp power supply 100-240v 50/60 Hz, USA plug
J14	International plug adapter set for J12
J53	3’ SMB-BNC cable

5. Programming

5.1 General Comments

The T340 accepts ASCII serial commands from the standard RS-232 interface or from the optional 10/100 Ethernet adapter. Refer to Section 7 for details about configuring the Ethernet interface.

For evaluation, serial commands may be typed using any common serial communications program, for example HyperTerminal or the standard "Telnet" utility. A **HElp** command is available, summarizing serial commands and operating modes. The **STatus** command will send back a summary of T340 settings.

The standard baud rate is 38,400. The receive buffer is limited to 1024 bytes, and the T340 ignores serial input while it is processing the current command line.

In the following section, text using this font...

0Phase 45 <cr>

represents a command string sent to the T340, terminated with a carriage return character <cr>. Italic text...

OK <cr> <lf>

represents a reply from the T340. All commands must be terminated with semicolon or <cr>, and all reply lines are terminated by <cr> <lf>.

5.2 Command Strings

Users send serial ASCII command strings to the T340, to which the T340 immediately replies. Incoming characters are not echoed. Because serial characters are buffered by both a PC OS and the T340, and because the T340 may spend milliseconds or more to process commands, user software must wait for a response to each command line before sending another command.

Each command consists of a command keyword, followed by an optional second alpha keyword or by a numeric argument. Multiple commands may be sent in a single line, separated by semicolons. When a full line is received, terminated by the final <cr> character, the buffered line is executed, in the order received.

Keywords may be fully spelled out, or may be sent as their first two characters; only the first two characters are significant. In this documentation, a word that has two possible forms is written with the short form capitalized, and the rest of the word in lower-case letters. The actual T340 protocol is case insensitive.

Examples

`2Phase 45` indicates that the short form is "**`2P 45`**", and the long form is

`2PHASE 45` both of which are recognized commands which set the phase shift of channel 0

All forms are case insensitive. One or more spaces are required to separate keywords from arguments.

Output signal amplitudes are sent in volts, as **`3Amplitude 1.50`**, shortform **`3A 1.5`**, which sets the amplitude of the channel 3 output.

Most value-setting commands may be sent without an argument, in which case they become queries of the associated value.

`2Phase` (no argument)

evokes the reply

`45.00`

which represents the phase advance of channel 2, in degrees.

A frequency may be sent as

`1Freq 455.22K` to set the frequency of channel 1

where acceptable suffixes are:

H - Hz
K - kiloHertz
M - megaHertz

and exponential notation is not supported. Default is Hertz.

When frequencies are sent in this form, some rounding will usually occur when the frequency is converted to the internal phase-accumulator scaling. In some cases, it is important that frequencies be exactly known, or that ratios of frequencies be exact integer multiples. For those cases, the **`nRaw`** command can be used; see section 5.7.4.

Since long strings of numbers can be difficult to read, a "verbose" mode is available, which will send frequencies and other long numbers in the form

01,999,999.999

Certain incoming ASCII characters are treated specially:

All lowercase letters are converted to uppercase

TAB is treated as a space.

ETX, ESC, and DEL are equivalent to BS, command line abort. When any of these characters is received, all command execution is aborted and the receive buffer is flushed.

Most control characters, $, and linefeed are ignored.

A "blank" input line, <cr> only, evokes the response ***T340 <cr> <lf>***

A single backslash \ character, as the first and only character on a line, will immediately re-execute the last-received full command line. A terminating <cr> is not required.

The T340 does not support hardware or software flow control. Other baud rates are available on special order.

5.3 Command Strings

A command begins with a command keyword (or its 2-letter abbreviation), followed by a secondary keyword or a numeric argument. Multiple commands on a line may be separated by semicolons.

One or more spaces are required between a keyword and its argument. Whitespace may not break up a command token or an argument, but is otherwise allowed. Commas are ignored.

Query commands are requests for specific data. A query is often a "set"- type command without an argument.

All commands must be terminated by either an end of line indicator (carriage return, ASCII 13, denoted <cr>) or the semicolon separator ; for multiple commands on a line. Linefeeds are ignored.

Since the T340 receive buffer is limited to 1024 bytes, users should not program multiple commands per line that might exceed this length. If at any time a backspace, esc, or del character (ASCII codes 8, 27, or 127) is received, the T340 will abort any command execution, flush its receive buffer, and prompt for a new command.

5.4 Reply Strings

Each received command will evoke a reply indicating the execution status of the command. For query commands, the reply is the requested data. For other commands, successful completion will yield a reply of ***OK***. If multiple commands are issued on one line, multiple responses will be sent back on a single line, separated by semicolons. For the command line...

```
1PHASE 90; 1PHASE; 1LOAD TRIANGLE
```

the reply will be of the form

```
OK;90.00;OK
```

All reply strings are terminated with carriage return/linefeed.

If an error occurs while processing a command, the reply ***??*** will be returned. If multiple commands are present on a command line, and any command produces an error, the erroneous command will respond with the ***??*** indicator and no remaining commands will be processed.

Numerical replies to queries will be in fixed-point decimal numeric form, with embedded commas included if Verbose mode is set.

5.5 Realtime Issues

User command lines are stored in a buffer until the <cr> character is received, at which time the entire command line is parsed and executed in the order received. Each command sends its reply characters, typically a requested value or the ***OK*** response, as the command is executed. Any additional incoming characters following the command-line <cr> are ignored until the entire command line is processed and the final response-line <cr> <lf> is returned.

Most simple commands execute in hundreds of microseconds, and their realtime execution rate is dominated by the 38.4 kbaud (3840 characters/second) serial communications rate. Shortform commands reduce communications overhead. Long reports are of course baud rate limited, with the **STatus** report or the **HElp** pages taking as long as several hundred milliseconds.

When channel settings are changed via the **INstall** command (or an end-of-line autoinstall), the firmware will immediately strobe all four channels, coherently updating the frequency, phase, and amplitude of all channels; see sections 6 and 5.7.9.

5.6 T340 Command Summary

The following is a summary of serial ASCII commands which may be sent to the T340.

5.6.1 Channel Control Commands

LONG FORM		SHORT FORM	FUNCTION
0SET	**1**	**0S 1**	set channel 0 controls
0AMP	**2.5**	**0A 2.5**	set channel 0 amplitude
0FREQ	**1.72K**	**0F 1.72K**	set channel 0 frequency
0RAW	**126500**	**0R 126500**	set channel 0 raw frequency
0PHASE	**45**	**0P 45**	set channel 0 phase
0DC	**-2**	**0D -2**	set channel 0 DC offset
0WIDTH	**4096**	**0W 4096**	set channel 0 PWM width
0LOAD	**SINE**	**0L SI**	load channel 0 sinewave
0LOAD	**SAWTOOTH**	**0L SA**	load channel 0 sawtooth
0LOAD	**TRIANGLE**	**0L TR**	load channel 0 triangle
1SET	**1**	**1S 1**	set channel 1 controls
1AMP	**2.5**	**1A 2.5**	set channel 1 amplitude
1FREQ	**1.72K**	**1F 1.72**	set channel 1 frequency
1RAW	**126500**	**1R 126500**	set channel 1 raw frequency
1PHASE	**45**	**1P 45**	set channel 1 phase
1DC	**-2**	**1D -2**	set channel 1 DC offset
1WIDTH	**4096**	**1W 4096**	set channel 1 PWM width
1LOAD	**SINE**	**1L SI**	load channel 1 sinewave
1LOAD	**SAWTOOTH**	**1L SA**	load channel 1 sawtooth
1LOAD	**TRIANGLE**	**1L TR**	load channel 1 triangle
2SET	**1**	**2S 1**	set channel 2 controls
2AMP	**2.5**	**2A 2.5**	set channel 2 amplitude
2FREQ	**1.72K**	**2F 1.72**	set channel 2 frequency
2RAW	**126500**	**2R 126500**	set channel 2 raw frequency
2PHASE	**45**	**2P 45**	set channel 2 phase
2DC	**-2**	**2D -2**	set channel 2 DC offset
2WIDTH	**4096**	**2W 4096**	set channel 2 PWM width
2LOAD	**SINE**	**2L SI**	load channel 2 sinewave
2LOAD	**SAWTOOTH**	**2L SA**	load channel 2 sawtooth
2LOAD	**TRIANGLE**	**2L TR**	load channel 2 triangle
3SET	**1**	**3S 1**	set channel 3 controls
3AMP	**2.5**	**3A 2.5**	set channel 3 amplitude
3FREQ	**1.72K**	**3F 1.72**	set channel 3 frequency

3RAW	**126500**	**3R 126500**	set channel 3 raw frequency
3PHASE	**45**	**3P 45**	set channel 3 phase
3DC	**-2**	**3D -2**	set channel 3 DC offset
3WIDTH	**4096**	**3W 4096**	set channel 3 PWM width
3LOAD	**SINE**	**3L SI**	load channel 3 sinewave
3LOAD	**SAWTOOTH**	**3L SA**	load channel 3 sawtooth
3LOAD	**TRIANGLE**	**3L TR**	load channel 3 triangle

5.6.2 "Quad" All-channel Control Commands

LONG FORM		SHORT FORM	FUNCTION
QSET	**1**	**QS 1**	set all channel controls
QAMP	**2.5**	**QA 2.5**	set all channel amplitudes
QFREQ	**1.72K**	**QF 1.72K**	set all channel frequencies
QRAW	**126500**	**QR 126500**	set all channel raw frequencies
QPHASE	**45**	**QP 45**	set all channel phases
QDC	**-2**	**QO -2**	set all channel DC offsets
QWIDTH	**4096**	**QW 4096**	set all channel PWM widths
QLOAD	**SINE**	**QL SI**	load all channels, sinewave
QLOAD	**SAWTOOTH**	**QL SA**	load all channels, sawtooth
QLOAD	**TRIANGLE**	**QL TR**	load all channel, triangle

5.6.3 Output Control Commands

LONG FORM		SHORT FORM	FUNCTION
AUTOINSTALL	**1**	**AU 1**	automatically apply pending settings
AUTOINSTALL	**0**	**AU 0**	cancel automatic mode
INSTALL		**IN**	apply all buffered channel settings
SYNC		**SY**	synchronize channels
WAIT	**340**	**WA 340**	wait specified number of milliseconds

5.6.4 Save/Recall/Reboot Commands

LONG FORM		SHORT FORM	FUNCTION
NAME	**text**	**NA text**	declare the name of the current setup
SAVE		**SA**	save settings to EEPROM
RECALL		**RE**	recall settings from EEPROM

LOAD DEFAULT	**LO DE**	load default setup
DEMO 2	**DE 2**	run a demonstration setup
BOOT	**BO**	restart the T340 firmware

5.6.5 Reporting Commands

LONG FORM	SHORT FORM	FUNCTION
STATUS	**ST**	show T340 status report
POWER	**PO**	return +12 volt supply voltage
UPTIME	**UP**	return uptime, seconds
ERRORS	**ER**	return error flags
IRQ	**IR**	query 1 KHz interrupt counter
SNAPSHOT	**SN**	snapshot realtime channel phases
IDENTIFY	**ID**	return ID string
***IDENTIFY**	***ID**	LXI-compatible version of Identify
VERBOSE 1	**VE 1**	show long numbers with commas
VERBOSE 0	**VE 0**	show long numbers without commas
COMMENT text	**CO text**	command is ignored

5.6.6 Test Commands

LONG FORM	SHORT FORM	FUNCTION
MODE 3	**MO 3**	control test relays
BIST 1	**BI 1**	run built-in self-test

5.6.7 Help Commands

LONG FORM	SHORT FORM	FUNCTION
HELP	**HE**	return general HELP message
HELP CHANNELS	**HE CH**	return help on channel operations
HELP CONTROLS	**HE CO**	return help on general controls
HELP BIST	**HE BI**	return help on self-test
HELP DEMO	**HE DE**	return help on demos

5.7 Command Details

In the text below, **nVerb** represents a generic channel command, where "n" may be the characters 0, 1, 2, or 3, and **nV** is the short form.

Most commands accept a second keyword or a numeric argument, and most commands become queries if an argument field is not present.

5.7.1 Channel Control Settings : nSet

Four commands are provided to assert basic channel settings: **0Set, 1Set, 2Set,** and **3Set**. Each may be followed by a numerical value, setting the channel control word of the respective channel. If the numerical argument is omitted, the command becomes a query of current settings

The T340 powers up with all channel control words zeroed, which results in normal operation. The channel control word may be treated as a 16-bit integer, arranged as…

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							PWM								DIV

If users leave the DIV bit low, the channel output range is +-10.24 volts peak (7.24 volts RMS), as scaled by the channel amplitude register. If the DIV bit is set high, amplitude is reduced by a factor of 10:1, to +-1.024 volts peak.

If the PWM bit is set, the channel works in pulse-width-modulation (PWM) mode.

So…

0Set	**0**	places channel 0 in default mode
1Set	**1**	turns on the channel 1 10:1 attenuator
2S	**256**	places channel 2 into PWM mode
3S	**257**	puts channel 3 into PWM, attenuated mode
0S		queries the current channel 0 setup

Other setup bits are reserved for future versions.

The **QSet** command sets up all four channels simultaneously.

5.7.2 Set Channel Amplitude : nAmplitude

Four commands are provided to set channel amplitudes: **0Amplitude, 1Amplitude, 2Amplitude,** and **3Amplitude**. Each may be followed by a numerical value, setting the peak output voltage of the respective channel. If the numerical argument is omitted, the command becomes a query.

0Amplitude 5.00 or **0Amp 5** or **0A 5**

sets the maximum channel 0 output to 5.00 volts. A sine, square, or sawtooth waveform would then swing from -5.00 to +5.00 volts peak. A PWM output would have a baseline of -5 volts and an active high level of +5.

The maximum allowed value is 10.24 volts. Negative numbers are allowed,

2Amp -10.24

where a negative amplitude corresponds to an inverted version of a positive signal.

Note that the specified levels are into a high-impedance load, and are reduced by 2:1 into a 50 ohm load.

The **QAmp** ("quad amplitude") command sets all four levels simultaneously. As a query, **QAmp** will return a string of the form…

05.000, 05.000, 05.000, 02.500

5.7.3 Set Channel Frequency : nFrequency

Four commands are provided to set channel amplitudes: **0Freq, 1Freq, 2Freq,** and **3Freq**. Each may be followed by a numerical value, setting the waveform frequency of the respective channel.

Frequency defaults to Hertz, where

3Freq 15750H or **3F 15750** sets channel 3 frequency to 15,750 Hz

Users may also specify K (KHz) or M (MHz), as

2F 3.579545M

The **QFreq** ("quad frequency") command sets all four frequencies simultaneously.

The maximum legal frequency is 2.125 MHz. Negative frequencies are allowed, to a limit of -2.125 MHz. Negative frequencies essentially walk the waveform memories backwards. If, say, three channels were set up to simulate a "clockwise" 3-phase AC voltage set, programming them to a negative frequency would change their rotational sense to counter-clockwise.

If the numerical argument is omitted, the ***nFreq*** command becomes a query. The value is returned in Hertz, in the form…

+03579545.031 in non-verbose mode, or

+03,579,545.031 in non-verbose mode, or

The value represents the current channel phase accumulator summation value, converted back to Hz, so may be slightly rounded from a value previously sent using the **nFreq** command.

As a query, **QFreq** returns a verbose string of the form…

0,001,000.000, 0,002,000.004, 0,003,000.006, 0,004,000.010

or, in non-verbose mode,

0001000.000, 0002000.004, 0003000.006, 0004000.010

5.7.4 Raw Channel Frequency : nRaw

Frequencies entered in engineering units, via the **nFreq** command, are converted into the internal frequency-control register scaling, whose LSB weight is about 3.7253 milliHertz, which often results in a small rounding error. In some cases, this rounding error is not acceptable. One case might be where the T340 is used to simulate speed sensors from a geared rotating machine, where one channel may need to run at precisely 5 times that of another, and phase coherence must be maintained. Any rounding errors in setting frequencies will cause phase creep between channels.

To avoid rounding errors, channel frequencies may be set using the **nRaw** commands.

0Raw 268,436 sets channel 0 close to 1 KHz, and

1Raw 1,342,180 sets channel 1 to precisely 5x that frequency

Given the numerical argument N of the command, the resulting frequency is

F = 16e6 * N / 2^32

= N * 0.003725290 Hz

or

N = F * 268.435456

The maximum allowed value of N is 570,425,344, corresponding to a 2.125 MHz output. Negative values are allowed.

An **nRaw** command, as a query, will return the current "raw" frequency setting as an integer. So one could "translate" frequencies to raw form by executing the two command lines…

```
0Frequency 60

0Raw
```

and get back the reply

```
16106
```

QRaw sets all four channels. As a query, it returns…

```
0,000,268,436,  0,000,536,872,  0,000,805,308,  0,001,073,744
```

5.7.5 Set Channel Phase : nPhase

The **0Phase, 1Phase, 2Phase,** and **3Phase** commands set channel phases. They are followed by a numeric argument, the phase in degrees, in the range -359.99 to +359.99.

```
2Phase 102.55     or     2P 102.55
```

causes the phase of channel 2 to lag (shift later in time) by 102.55 degrees. Negative phases introduce lead and move the waveform ahead in time. Phases are modulo 360, so that +90 degrees is equivalent to -270.

These commands without an argument become queries.

The **QPhase** command sets the phase of all channels. It returns a string…

```
090.00, 240.00, 120.00, 270.00
```

See section 6 for discussion of channel-channel phase synchronization.

5.7.6 Channel DC Offset : nDc

Four commands are provided to set channel DC offsets: **0Dc, 1Dc, 2Dc,** and **3Dc**. Each may be followed by a numerical value, setting the offset of the respective channel. If the numerical argument is omitted, the command becomes a query.

2Dc 5.00 or **2D 5** sets the channel 2 DC offset to +5 volts

The specified value, in the range of -10.24 to 10.24, becomes the DC baseline for the channel output. If the programmed waveform amplitude plus offset ever sum to more than about plus or minus 11 volts, the output will clip.

If channel 3 were in PWM mode, a TTL level (0 volts low, +5 volts high) would result from the commands

```
3Amp 2.5; 3Dc 2.5
```

The **QDc** command sets all four offsets simultaneously. Any of these commands without an argument becomes a query of the current offset value.

5.7.7 Set Channel PWM Width : nWidth

If a channel has been set up to operate in pulse-width (PWM) mode, the **0Width, 1Width, 2Width,** and **3Width** commands set pulse widths. They are followed by a numeric argument in the range 0 to 65535, where 0 corresponds to zero duty cycle (always low) and 65535 corresponds to 99.9985% high.

```
3Width 32768
```

would then request a square wave on channel 3. The square wave, or other requested duty cycle, remains at the requested duty cycle ratio as the channel frequency is varied.

QWidth sets the width of all channels simultaneously.

These commands without an argument become queries.

5.7.8 Load Channel Waveforms: nLoad

T340 units are shipped to load sine waves into all channel waveform memories at powerup. Other waveforms may be loaded into any channel.

The **0Load 1Load 2Load** and **3Load** commands are provided to load waveforms.

0Load Sawtooth or **0L SA**

loads a sawtooth into the channel 0 wave memory. It ramps from minus full scale (-10.24 volts max) to plus full scale (+10.24 max) and then rapidly returns low, at the selected channel frequency. Amplitude is of course adjustable using the channel **nAmplitude** command.

0Load TRiangle or **0L TR** loads a triangle into channel 0

2Load SIne or **2L SI** loads a sine wave into channel 2

The **QLoad** command loads the named waveform into all channels.

The query **0Load** will return the string

TRI or ***SAW*** or ***SIN*** or ***PWM***

Query **QLoad** will return a string of the form

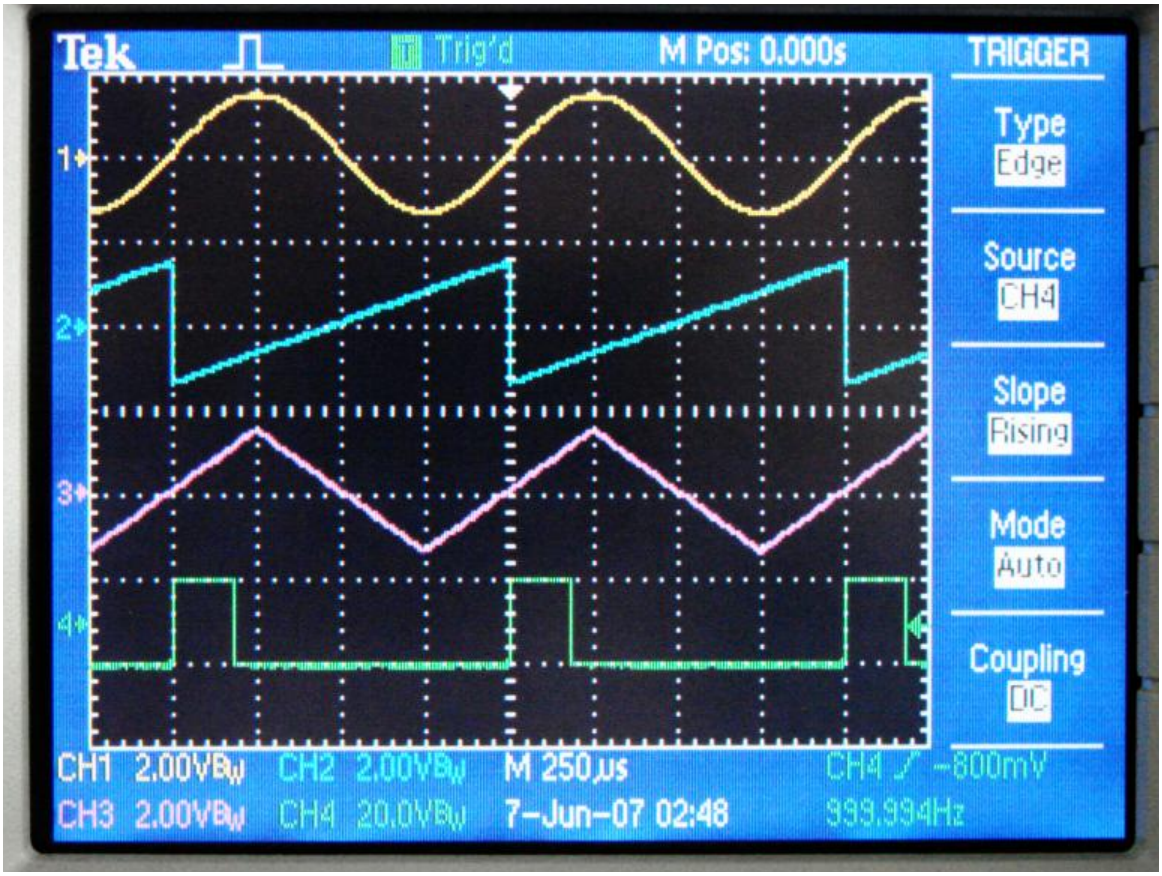
SIN, SAW, TRI, PWM

showing the waveforms currently loaded into channels 0, 1, 2, and 3 respectively.

Note that if a channel is programmed to operate in PWM mode, a query will return ***PWM*** as the channel setting, and will revert to the last-loaded memory content if PWM mode is later disabled.

If non-sine waveforms are loaded and then the **SAve** command is issued, the current waveform set will become the powerup default.

The figure below depicts sine, sawtooth, triangle, and PWM signals programmed on the four output channels.



5.7.9 Install Commands

Channel hardware settings (amplitude, frequency, phase, etc) are hardware double-buffered and are applied to the waveform generator hardware by the "install" action.

Normally, an Install is done at the end of every incoming serial command line, so channel settings are effectively applied immediately. This is "autoinstall mode."

`AUTOINSTALL 1`	or	**`AU 1`**	automatically apply settings, default factory-ship mode
`AUTOINSTALL 0`	or	**`AU 0`**	disable automatic mode

If autoinstall is disabled, new channel settings will be held pending until an **`INstall`** command is executed, at which time all channel settings are loaded in to the hardware coherently. This facility allows a large number of commands to be accumulated and then implemented in a single system clock, assuring that all channel settings change simultaneously and that phase coherence is maintained across channels.

`INSTALL`	or	**`IN`**	apply all pending channel settings

The INstall command may also be interspersed with channel settings within a long command line. For example, one could change the amplitude of the channel 1 waveform, wait 120 milliseconds, then change the amplitude of channel 3.

```
1Amp 5.25; INstall; WAit 120; 3Amp 7.5
```

See section 6 for discussion of channel synchronization.

5.7.10 Channels Synchronize Command: SYnchronize

If it is desired to maintain phase coherence across channels, channels must be programmed and then reset, which synchronizes their phase accumulators and restarts all channels at their programmed phases.

The single **SYnc** command, with no argument, will install any pending channel settings and synchronize all four phase accumulators. All four waveforms will jump to their zero-phase position, or to their programmed phase if a phase offset is programmed.

The **SYnc** command optionally accepts a numeric argument which is a bitmap which selects the channels to be updated and synchronized.

SYnc 1	sync channel 0
SYnc 2	sync channel 1
SYnc 4	sync channel 2
SYnc 8	sync channel 3

For example, channels 2 and 3 may be operating as a phase-synchronized pair, so the command **SY 12** would reset and synchronize their phase accumulators without affecting channels 0 or 1.

See section 6 for further comments on channel synchronization.

5.7.11 WAit Command

The WAit command delays command execution for the specified number of milliseconds. The maximum allowed delay is 10 seconds. For example, one could change the amplitude of channel 1, wait 250 milliseconds, and then change the amplitude of channel 2.

```
1Amp 2.5; INstall; WAit 250; 2Amp 4.4
```

Note that an explicit **INstall** command was needed to change the level of channel 1 before the normal end-of-line install.

5.7.12 Saved Setups: NAme, SAve and REcall

The T340 stores a "current setup" string, which is displayed in the **STatus** report and may be queried with the **NAme SEtup** command. The name can be changed with a command of the form

```
NAme SEtup POLYPHASE 50 HZ AT 2.5 VOLTS
```

The **NAme SEtup** command is terminated by <cr>, so should be the only command on a line.

The **SAve** command saves all current setups to nonvolatile EEPROM memory, including the current name. This saved setup will be restored at the next powerup, or whenever the **REcall** command is executed. So one could, say, program a T340 to make a 3-phase, 400 Hz sinewave set plus one additional PWM-mode trigger, name and save the setup, and have it continue to create those waveforms, even after a powerfail/powerup cycle.

New T340 units are shipped with the default setup saved, so have zero outputs when first powered up. To restore a T340 to this state, one could execute the command string…

```
LOad DEfault; SAve
```

5.7.13 Default Setup: LOad DEfault

The **LOad DEfault** command restores the T340 to its factory-default settings. These are not saved to EEPROM unless the command is followed by an explicit **SAve** command. The default setup is:

Autoinstall 1 = On

Verbose 1 = On

Channel 0 1 KHz sine wave, zero offset, zero amplitude
Channel 1 2 KHz sine wave, zero offset, zero amplitude
Channel 2 3 KHz sine wave, zero offset, zero amplitude
Channel 3 4 KHz sine wave, zero offset, zero amplitude

To see the sinewave outputs, send the command **QAMP 1 ,**
which will set all channel amplitudes to 1 volt peak.

5.7.14 Demo Command: DEmo n

The **DEmo n** command causes the T340 to load one of a number of demonstration setups.

DEmo 0 four sine waves, 1/2/3/4 KHz, 1 volt RMS

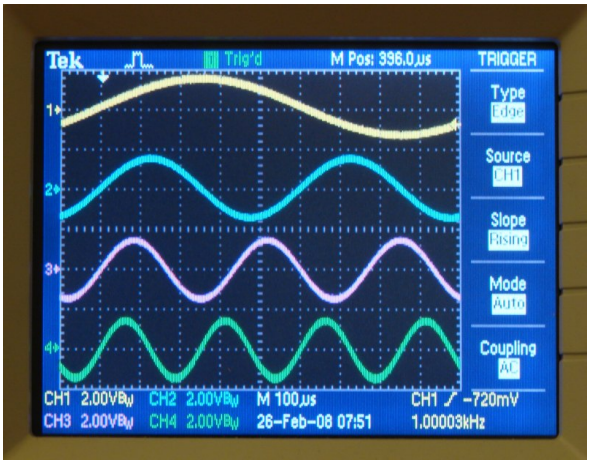
DEmo 1 3-phase 5V pk 60 Hz sines on 0/1/2, TTL sync on chan 3

DEmo 2 3-phase 5V pk 400 Hz sines on 0/1/2, TTL sync on chan 3

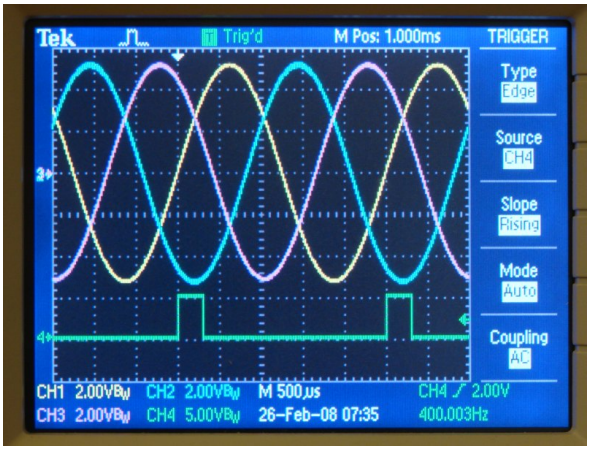
DEmo 3 sine/triangle/sawtooth/TTL pulse, 5V pk, 1 KHz

DEmo 4 four TTL PWM outputs, 10/25/50/90% duty, 100 KHz

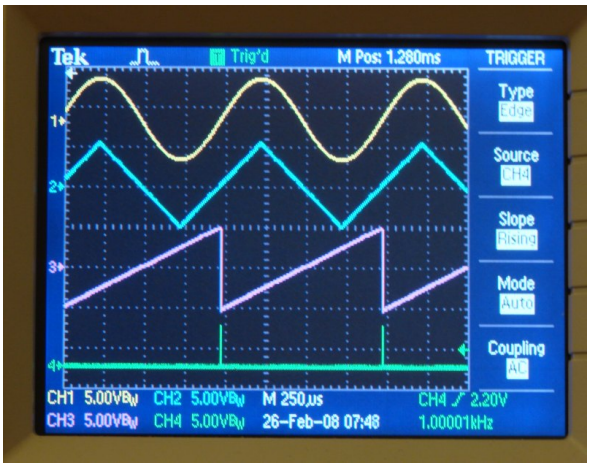
DEmo 5 XY plot, 5V pk, 1 Hz: cw circle, ccw circle, Lissajous



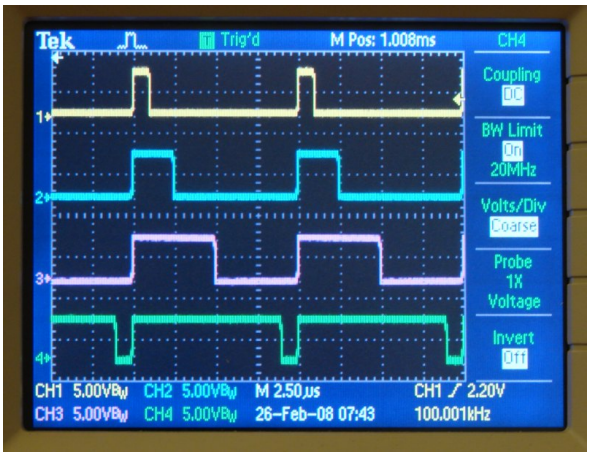
Demo 0



Demo 2



Demo 3



Demo 4

5.7.15 Restart Firmware: BOot Command

The **BOot** command restarts the T340 firmware. The saved setup is installed.

5.7.16 T340 Status Report: STatus

The **STatus** query returns a report of T340 settings. A typical report is shown below. Verbose mode was enabled.

Highland Technology Model T340 Waveform Generator

Firmware 28E340-A SN 0041 Dash 1 Cal 01-31-2007 13:29:59

Verbos ON Autoinst ON Mode 000 Up 0,000,081,106

Errors : 00000

Setup: * T340 Demo 0 1/2/3/4 kHz sinewaves 1 volt RMS *******

Ch	Div	Wave	Frequency	Amplitude	Offset	Phase	PWM
0	X1	SIN	0,001,000.000	01.415	00.000	000.00	32768
1	X1	SIN	0,002,000.004	01.415	00.000	000.00	32768
2	X1	SIN	0,003,000.006	01.415	00.000	000.00	32768
3	X1	SIN	0,004,000.010	01.415	00.000	000.00	32768

5.7.17 Report DC power: POwer

The **POwer** command returns the realtime value of the externally applied +12 volt power source.

The command **POwer** returns a string of the form ***12.084.***

5.7.18 Report Uptime: UPtime

The **UPtime** command returns the time since powerup, in seconds.

5.7.19 Report Errors: ERrors

The **ERrors** command returns an integer which identifies any errors. The returned form is...

00000 for no errors

00512 or a numeric value if errors are present

where the integer value represents the error flags word. Bits are...

bit 0 channel 0 setup error
bit 1 channel 1 setup error
bit 2 channel 2 setup error
bit 3 channel 3 setup error

bit 8 internal logic error
bit 9 calibration table lost; default cals are used
bit 10 saved setup recall failed; default setup used
bit 11 BIST a/d converter error

bit 12 +12 volt power supply error
bit 15 BIST execution error

5.7.20 REPORT IRQ COUNTER: IRq

The **IRq** command returns the value of the 32-bit system interrupt counter. It is incremented 1000 times a second, once each millisecond. The **IRq 0** command will clear the counter.

5.7.21 SNAPSHOT CHANNEL PHASES: SNapshot

The SNapshot command will coherently read the 16 most significant bits of all four channel phase accumulators and return the values as instantaneous phase angles of 0 to 359.99 degrees.

The serial command

SNapshot or SN

might return a string of the form…

321.31, 321.31, 321.31, 166.45

which would indicate that the phase accumulators of channels 0, 1, and 2 are synchronized, but 3 is not.

Note that the absolute values returned, 321.31 in this case, is usually meaningless, as it represents the phase accumulator of channel 0 when sampled at essentially an arbitrary time. The difference between returned values is meaningful to verify phase alignment. The snapshot values that are returned are independent of any channel phase settings.

If channels have different frequency histories since last synchronized, their relative phases will be unaligned. If it is desired to pull them back into phase alignment, one can restore them to operate at exactly the same frequency, snapshot their phases, and adjust one or more in phase to achieve alignment as desired. One can also carefully "walk" relative channel frequencies to creep channels into phase. Of course, the **SYnc** command can be used if instantaneous phase jumps are acceptable.

5.7.22 IDENTIFY COMMAND

The **IDentify** command returns a string which identifies the T340 hardware and firmware version. The returned string is of the form...

T340 Wavegen Firmware 28E340-A

Note that the T340 responds identically to the SCPI/LXI command ***IDN.**

5.7.23 VERBOSE COMMAND

The **VErbose 1** command places the T340 in verbose mode, where commas are included in all long numeric strings that are returned. This mode makes time settings and 32-bit integers easier to read, but may not be compatible with external software.

The **VErbose 0** command will cancel verbose mode.

VErbose alone will query this setting.

5.7.24 COMMENT COMMAND

The **COmment** command, and any following text up to a semicolon or end of line, is ignored.

5.7.25 TEST COMMANDS: BIst and MOde

The **BIst** command will execute the T340 self-test sequence.

The **MOde** command controls test relays when BIST is not running.

See section 8.

5.7.26 HELP COMMANDS

The **HElp** command will display a short command summary.

HElp CHannels	presents help about channel setup commands
HElp COntrols	lists general T340 control commands
HElp BIst	describes self-test and relay modes
HElp DEmo	describes available demo setups

6. Channel Synchronization

The T340 can maintain channels in exactly controlled frequency and phase relationships. In order to lock channels, their frequencies must be set equal or in **exact** integer ratios, then a **SYnchronize** command must be issued to restart them in phase.

Once channels are synchronized, individual channel phases, amplitudes, and offsets may be changed at any time without loss of channel-channel sync. Uncoordinated changes of frequency, however, will cause channel phase relationships to drift apart, and thereafter only another **SYnchronize** command can restore them to a known phase relationship.

Channel commands on a single line are, by default, buffered and applied to the waveform generator hardware at the end of the command line, when the final <cr> character is processed. So frequency changes that can all be programmed in a single command line preserve channel-channel phases.

Autoinstall mode (command **AUtoinstall 1**) enables end-of-line automatic hardware update. Autoinstall may be disabled (command **AUtoinstall 0**) should circumstances make it preferable that hardware update be explicitly controlled.

The general way to operate multiple channels with controlled phase relationships is…

Issue the **AUTOINSTALL 0** command to allow explicit control of channel updates.

Load channel frequencies using the **nFreq** or **nRaw** commands. The "raw" command form is required if channels are to be run at non-unity frequency ratios.

Load channel phases using **nPhase** commands

Load any other channel parameters: amplitudes, channel control, etc

Issue the **SYnc nn** command to install settings and synchronize the channels involved, or

SYnc with no argument to sync all channels.

Now all channels will be synchronized and will run at the specified phases.

In order to maintain phase control, all future frequency and phase changes should be made simultaneously on all channels, by issuing new frequency or phase setting commands to all related channels and then doing another **INstall** operation.

If all frequency change commands can be made by using the **QFreq** command, or by putting all frequency change commands in a single line separated by semicolons, the default autoinstall mode is safe to use, and specific **INstall** commands are not needed.

Two or more channels can be synchronized, with coherent phase control, even while operating at different frequencies, and with different waveforms. For example, channel 0 could be set up run at 60 Hz and channel 1 at 120 Hz, then the channels could be **SYnchroniz**'d to initialize them in-phase. In order that the phases not drift over time, the frequency setting of channel 1 must be precisely twice that of channel 0. Because of possible rounding errors in converting frequencies in Hertz to the internal phase accumulator scaling, the **nRaw** command should be used to set the channel frequencies in a precise 2:1 ratio.

7. Xport Ethernet Module Setup

The T340-2 uses a Lantronix Xport module as its Ethernet/TCP-IP interface.

Lantronix provides a PC utility "XportInstaller" to locate an Xport module and assign it an IP address. The Lantronix software utilities may be downloaded from

http://www.lantronix.com

Units are normally shipped set to IP address 192.168.254.183, port 2000. Most users will need to reassign the IP address to be compatible with their networks. If multiple T340s are used, assign a unique IP address to each. The Xport also supports dynamic IP address assignment.

The default Xport configuration may be verified and altered according to the following instructions:

Once the Xport module has been assigned an IP address, a web browser can be used to access the Xport module as a web page (type the IP address into the browser's address bar). The module can be configured with the Xport "Port Properties" tab selected.

The standard port properties, as set by Highland, are listed below. These should not need to be changed, but are listed here in case users might need to alter the Xport configuration.

Serial Protocol	RS232
Speed	38,400
Character size	8
Parity	none
Stopbit	1
Flow Control	none
UDP Datagram Mode	disable
UDP Datagram Type	-
Incoming Connection	Accept Unconditional
Response	nothing (quiet)
Startup	no active connection startup
Remote IP address	-
Remote Port	-
Local Port	2000
Flush On Active Connection	disable
Flush On Passive Connection	disable
At Time To Disconnect	disable

Packing Algorithm	enable
Idle Time	Force Transmit 12 ms
Trailing Characters	none
Send Immediate	disable
Sendchar 2-byte	disable
Sendchar 01	00
Sendchar 02	00
Disconnect Mode	ignore DTR
Check for Ctrl/D	disable
Port Password	disable
Telnet Mode	disable
Inactivity Timeout	disable
Inactivity Timer	5:0

If the configuration is edited, click the "update" tab to save.

8. BIST

The T340 features an automatic self-test sequence to allow the user to test the functionality of the unit without external equipment and without the need to disconnect field wiring.

Note: BIST is primarily a functional test and checks only approximate quantitative performance limits. It cannot allow absolute verification of module accuracy, as external NIST-traceable standards are required for formal calibration.

Although the BIST operations can detect most module failures, certain errors can be missed. They include:

- Failure of a connector pin or associated printed-circuit traces.
- Failure of a channel test relay.
- Low-order DAC bit errors.

Items tested include...

BIST a/d converter operation

Synthesizer (32 MHz) clock frequency accuracy

Channel full-scale output voltages

Channel divided-by-10 output voltages

Channel output frequency accuracy

Filter response

To invoke BIST, send the serial command

`BIst 0` or **`BIst`** to run tests and report error summary only

`BIst 1` to run tests and report numeric results of any errors

`BIst 2` to run tests and report all numeric results

During the test, the green LED will blink rapidly, and the red LED will come on solid for at least one second if any error is detected. Test time is about 7 seconds. After the self-test, all previous module settings will be restored. If any error was detected, an error flag bit will be left up, so the red LED will continue to flash. **`ERrors 0`** will clear the BIST flag.

9. Calibration Verification

The calibration of one or more T340 modules may be verified in their operating environment.

To verify channel performance accuracy, the TEST connector of one or more T340 modules may be connected to a precision voltmeter/frequency counter, such as the Keithley model 2100.

Route a selected channel output to the test connector with a command…

MOde 1 route channel 0 to the test connector

MOde 2 route channel 1 to the test connector

MOde 3 route channel 2 to the test connector

MOde 4 route channel 3 to the test connector

MOde 0 to resume normal operation

Now program the selected channel to some known frequency and amplitude, and check the values with the external instrument.

10. Operating Examples

10.1 Powerup

Connect the J12 power supply to the T340 DC power connector. At powerup, all four LEDs should light and, about three seconds later, all should go out except that the green POWER led will blink about once a second.

10.2 Serial Communications

Connect the T340 to the serial port of a PC, using a straight-through RS-232 cable. Only the transmit, receive, and ground lines are used.

Run a serial communications program such as HyperTerminal. Set it up for local port connection, 38,400 baud, 8 bits, no parity, 1 stop, no handshaking. A simple ASCII TTY33 or VT100 mode is acceptable.

When you type <enter>, the T340 should respond with its

T340 <cr> <lf>

response. Any time a key is hit on the PC, the orange LED on the T340 should flash. Any time the T340 replies, its blue LED will flash.

Type

ST to display T340 setup and status

HE to show the main Help message

10.3 Demo Modes

Connect one or more outputs of the T340 to an oscilloscope and type

DEmo 0

to invoke the first demo setup, basic sine wave outputs.

Now any of the channel control commands can be used to change the outputs. For example, typing **0Freq 20K** will change the channel 0 output to 20 KHz.

Type **HElp CHannels** for a summary of channel commands.

Type **HElp DEmo** for a list of other available demos.

10.4 Synchronizing Channels and Phase Control

The default mode of the T340 is for the four channels operate as independent waveform generators. When any channel parameter is changed, such as amplitude or frequency, the internal microprocessor detects the change and loads the appropriate hardware as soon as possible but with no guaranteed timing. In this mode, channel synchronization is not possible and the values in the channel phase-control registers are essentially meaningless.

In order to coordinate channels, it is necessary to synchronize channels and make future frequency changes synchronously.

For example, suppose we want to generate a 3-phase sine wave set using channels 0, 1, and 2. The command sequence could be…

LOad DEfault	load default setup as starting point
QFreq 50	set all 4 channels to 50 Hz
QAmpl 2.5	set all 4 channels to 2.5 volts peak
1Phase 120	set channel 1 to 120 degrees lag
2Phase 240	set channel 2 to 240 degrees lag
SYnc	install settings and synchronize channels

Now the 3-phase waveform set will be present.

The frequency of the set may be changed at any time using another **QFreq** command. Channel phases, amplitudes, and offsets may be changed at any time without affecting phase coherence. Since **QFreq** changes frequencies of all channels atomically, the default Autoinstall mode is acceptable. These command could be issued on separate lines, or on a single line separated by semicolons.

A basic frequency sweep can now be programmed using the **WAIT** command. To sweep the above setup from 50 to 70 Hz, send a command sequence like…

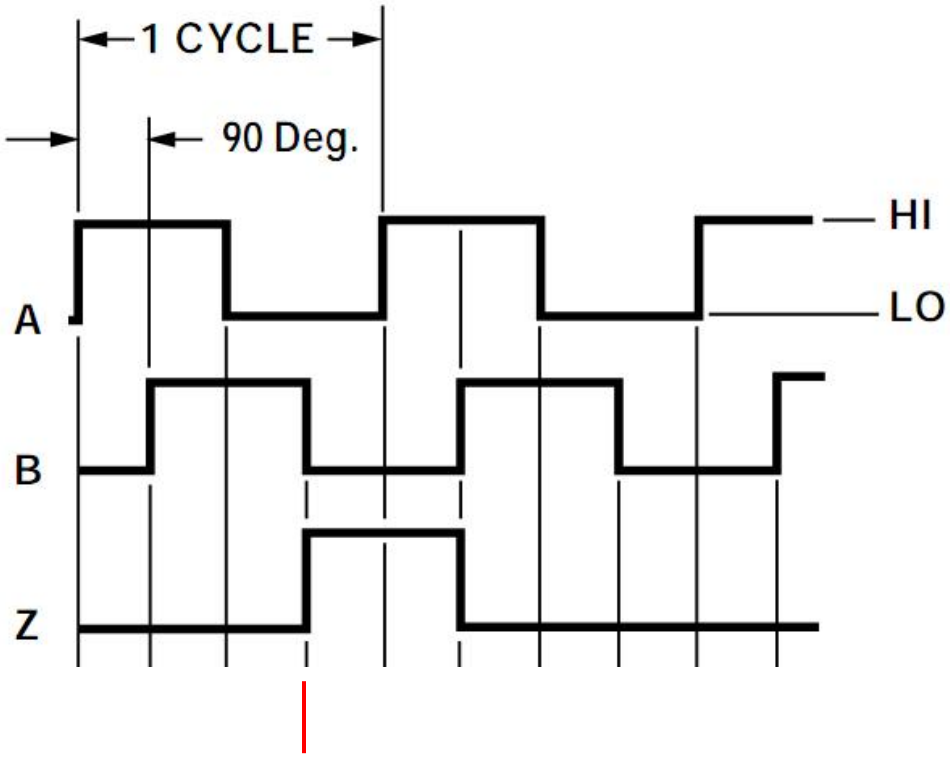
```
QF 51; IN; WA 250; QF 52; IN; WA 250; QF 53; IN, WA 250;
```

etc to 70 Hz. The command line, including the optional spaces, will be 360 characters long and will take about 5 seconds to execute.

This will step the frequency of all channels by 1 Hz every 250 milliseconds. Note that **`INstall`** commands are necessary after every frequency change to force updates within a command line.

10.5 Bidirectional Encoder Simulation

The PWM mode can be used to simulate a quadrature encoder. As an example, we could simulate a typical quadrature encoder having 2000 counts per revolution. It would output a pair of quadrature square waves, each making 500 cycles per revolution, and would have a third index output that goes high once a rotation. A typical waveform set is shown below. We could use T340 channels 0 and 1 to make the A and B quadrature signals, and channel 2 to make the Z index pulse. We assume a "half cycle index" as shown below.



0 degrees

We could program the T340 as follows:

`LOad DEfault`	load default setup as starting point
`QFreq 0`	set all 4 channels to zero frequency
`QSet 256`	set all channels to PWM mode
`0Wid 32768`	set channels 0 and 1 (A and B) to 50% duty cycle
`1Wid 32768`	
`2Wid 65`	set channel 2 (index Z) 1/1000 duty cycle

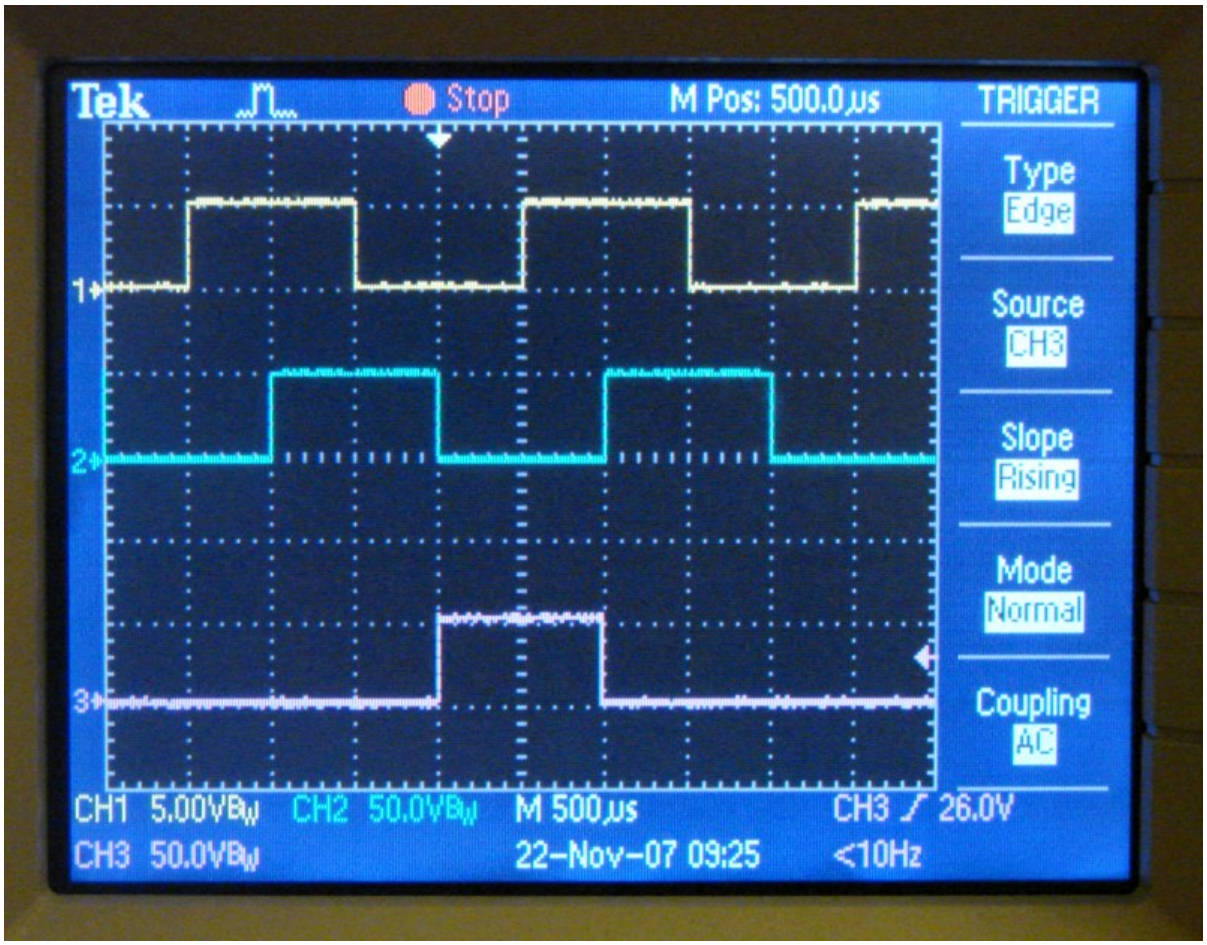
`0Phase 270`	A leads index by 270 degrees
`1Phase 180`	B leads index by 180 degrees
`QA 2.5; QD 2.5`	set all 4 channels for TTL outputs

`SYnc` install settings and synchronize channels

Now the encoder is "stopped" at the zero angle point indicated in red above. To begin rotation, program the frequency of the index channel, channel 2, to be the rotational speed in Hertz, and program 0 and 1 to be exactly 500 times higher. Use the "raw" frequency commands to keep this ratio exact.

To start running at 1 rev/second, 60 RPM, issue the command

```
0Raw 134500; 1Raw 134500; 2Raw 269
```



The resulting waveform set is shown above. Levels are TTL as programmed. Rise and fall times are about 40 ns.

The T340 has no direct mechanism for slewing channel phases to absolute angular positions. Users can implement algorithms which read channel phases, using the

phase snapshot macro, and dynamically adjust channel frequencies to converge on and stop at a desired absolute angular position.

The A and B channels could be used in sinewave mode by not setting their PWM control bits. This would simulate an encoder that has quadrature sine outputs.

10.6 DC DAC Outputs

Any T340 channel can be used as a simple DC output DAC. Program the channel waveform amplitude to zero, then use the **`nDC`** offset command set the output level.

11. Dimensions and Mounting

T340 mechanical dimensions are shown below. The evaluation T340 is furnished with the T566 mounting flange bolted to the bottom of the extruded enclosure to make it easier to install on mounting surfaces which do not have rear access.

The T340 may be mounted using the flange supplied, or the flange may be removed and the unit mounted with four 4-40 machine screws from below.

⚠ **CAUTION: Mounting screws may not penetrate more than 0.160 inches (4 mm) into the T340 enclosure.**

The T340-1 does not include the Ethernet connector

The T340-2 includes the Ethernet connector

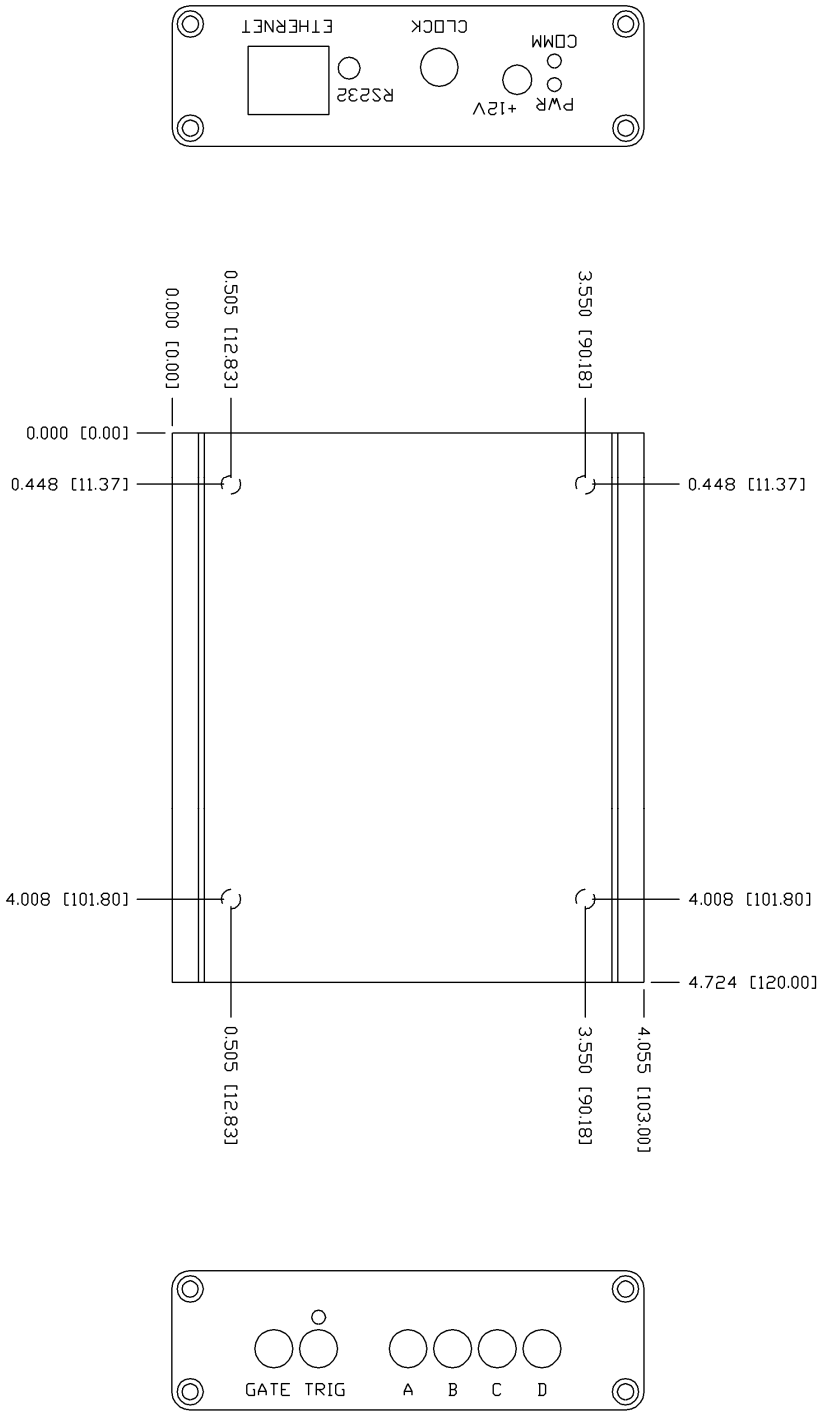


Fig 8.1 T340 Outline and Mounting

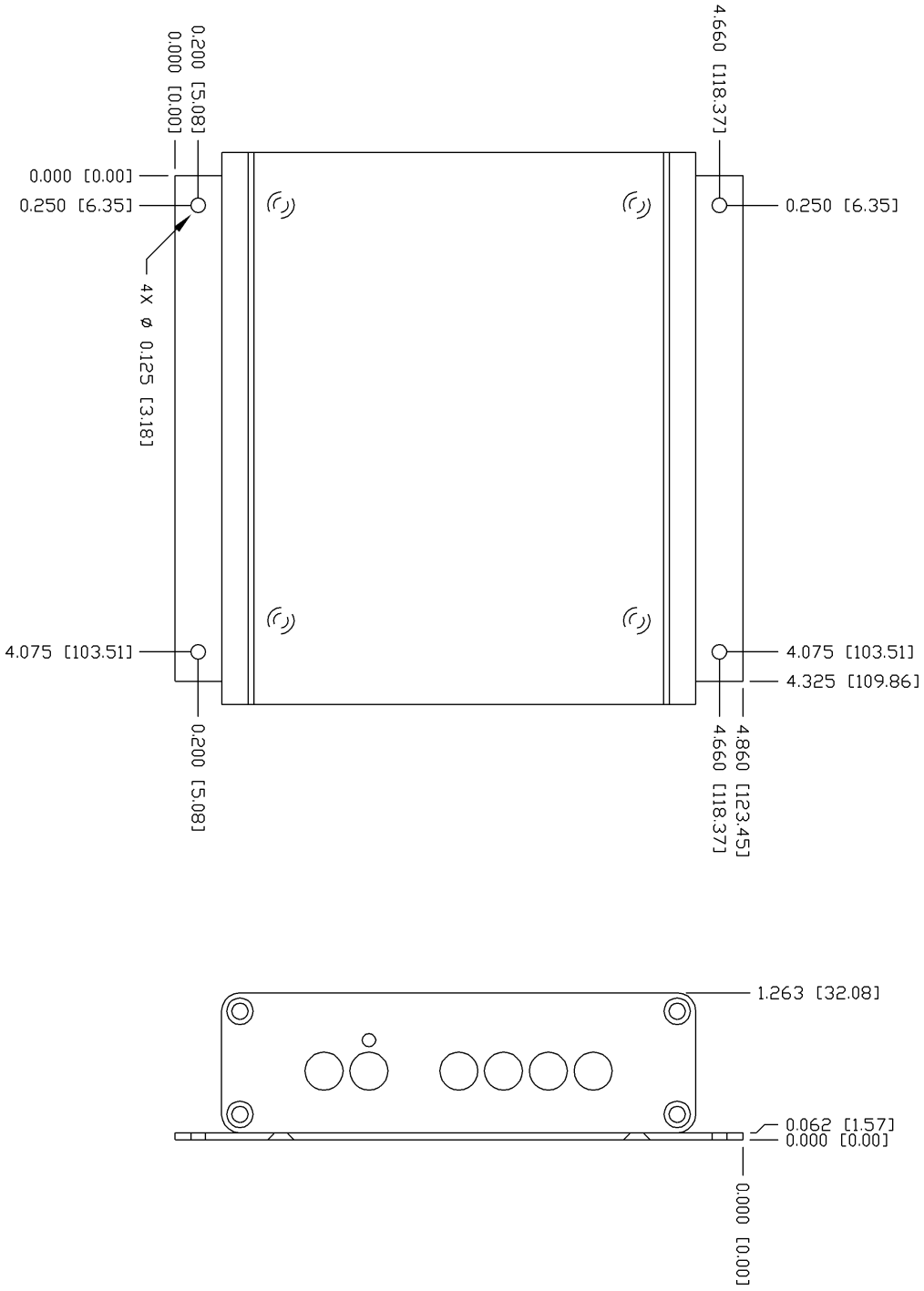


Fig 8.2 Flange Mounting Dimensions

12. Versions

T340-1 4-channel compact function generator

T340-2 4-channel compact function generator with Ethernet

13. Customization

Consult factory for information about additional custom versions.

14. Hardware and Firmware Revision History

14.1 Hardware Revision History

28D341 Revision C	Sep 2023 Improves manufacturability and addresses obsolescence Runs firmware 28E340C Functionally equivalent to Revision B
28D341 Revision B	Mar 2009 Improves manufacturability Runs firmware 28E340C
28D340 Revision A	Mar 2008 Initial PCB release

14.2 Firmware Revision History

The standard firmware is 28E340.

28E340 Revision C	Aug 2013 Adjusted BIST test limits to prevent false failures Increased the amount of high-frequency attenuation allowable in the filter test
28E340 Revision B	Nov 2011 Increased the limits for the ADC ZERO BIST test to allow for resistor inaccuracies

28E340 Revision A	Feb 2008 Initial firmware release
22C345 Revision C	Feb 2008 FPGA file associated with firmware

15. Accessories

J12-1	12 volt power supply (furnished with purchase)
J53-1	3' SMB to BNC cable
J53-2	6" SMB to BNC cable
J57-1	6′ D9 male to D9 female RS-232 cable
J57-2	10′ D9 male to D9 female RS-232 cable
P10-1	19" rack mount shelf (four t-boxes per rack)
T566-1	Mounting flange