LCD HMI
User Manual

for

RS232 VT100,

RS232 Modbus,

RS232 Dual-Channel ADC Monitor/Controller

&

Isolated RS485 Modbus

140415

Revision: 1.14

Contents

Revision History

1.01 - Draft
1.02 - Added photographs
1.03 - Added Mechanical drawing
1.04 - Modified TTL voltage levels & added connector/pin-out details. Using LK1 to reset to default values. Added extra Backlight intensity methods.
1.05 – Added Bootlace Ferrule info to “Connections”
1.06 – Added ADC Dual-Channel Monitor/Controller version details
1.07 – Added isolated RS485 version information
1.08 – Added LCD Modbus Registers and Bit-field Definition
1.09 – Revamped Controller implementation
1.10 – Added Modbus Auto Table feature and Signal Converters
1.11 – Added limitations to Modbus implementation
1.12 – Adjusted Modbus poll periods
1.13 – LCD130810 - Widened supply-voltage range to allow use from 12V solar panel; Changed analogue reference; Removed DC Jack and unused supply LED; Added field firmware re-programming capability; New pix.
1.14 – Using the increased MCU storage, all three RS232 operational variants, (VT100/Modbus & Controller), are available in the same package, with Firmware Version 3 and above. Added Product Feature Matrix.

Overview

This document describes the features of a 21 character by 8 line LCD module for a compact Human-Machine Interface, (HMI). This Specification applies to hardware revision LCD130810 and onward.

Four model variants are available:

1. VT100 protocol for text and graphics display.
2. RS232 RTU Modbus, 8-register display and relay / speed conversion.
3. Dual-Channel Monitor/Controller w/RS232 Modbus relay/slave
4. Isolated RS485 RTU Modbus, 8-register display and relay / speed conversion.

Version-3 firmware allows the VT100/ RS232 RTU Modbus & the Dual-Channel Monitor/Controller, to reside in the code-space of the enhanced storage MCU. The operational variant may be selected via the VT100 Configuration screen. Please note, the selecting the third variant, the Dual-Channel Monitor/Controller, will allow inspection of the associated VT100 screens and familiarisation of the product. However, without the factory-built extra components, this variant will not physically operate.

Start-up Screen

This initial screen gives the settings of the two RS232/RS485 ports. Note the CPU temperature, which can be tens of degrees Celsius higher than the local ambient.

Figure 1 – VT100 Start-up Screen

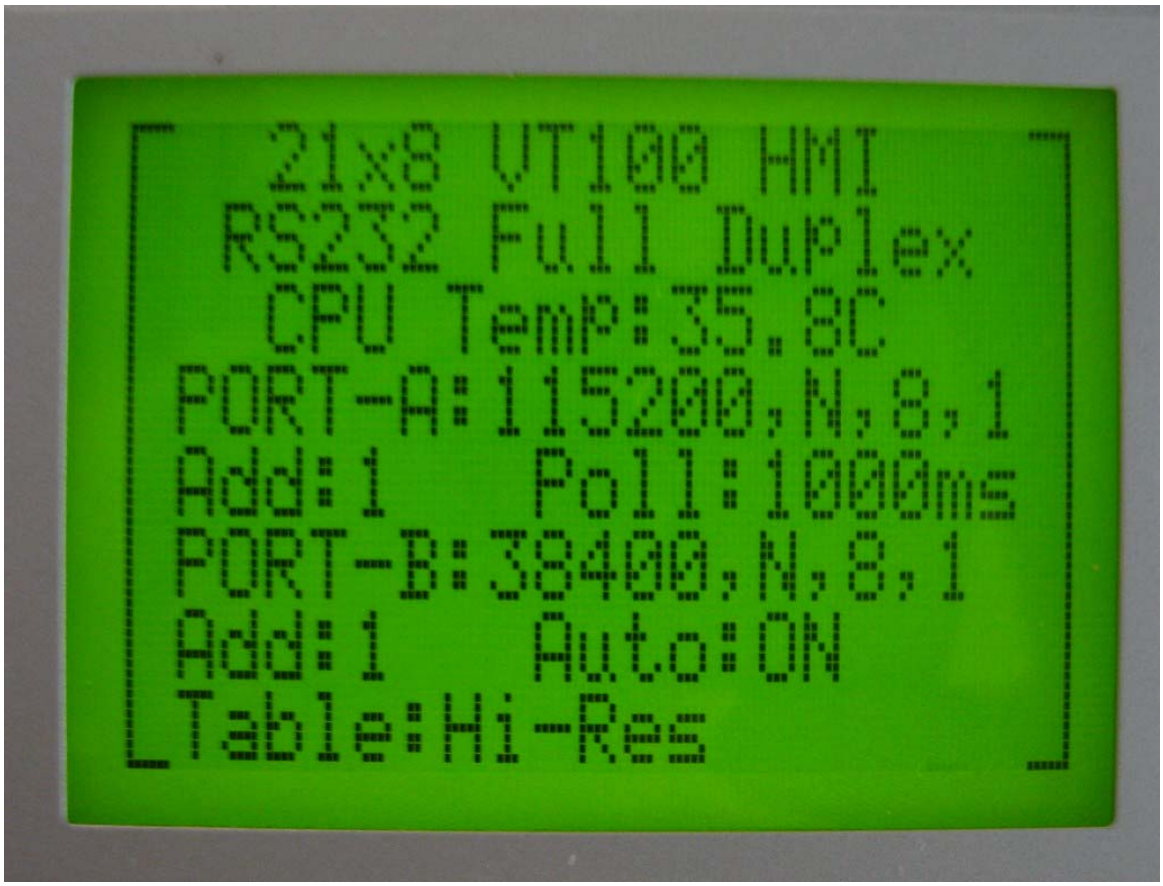


Figure 2 - Oblique View showing Jumpered LK1

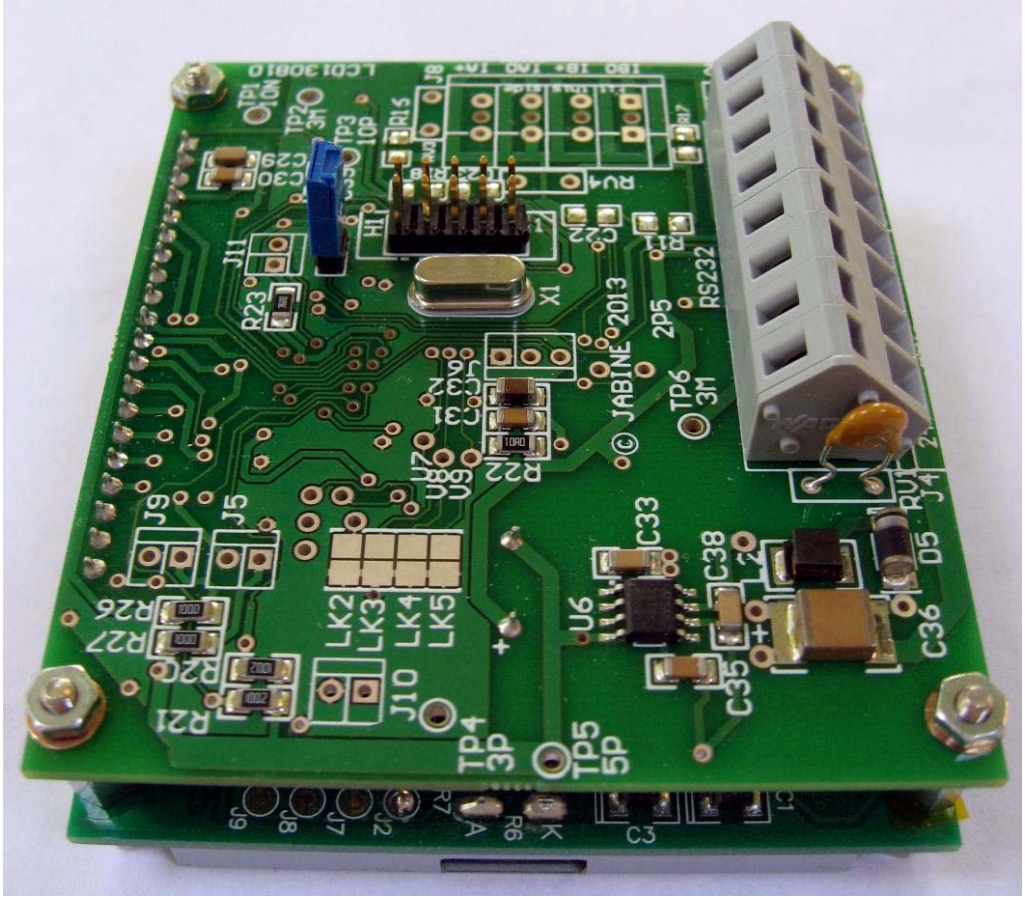


Figure 3 - VT100 Text Display

Common Specification

Environmental

Temperature Rating:

Operational:	-20 to 70°C (70°C for Display)
Storage:	-20 to 80°C (75°C for Display)
Relative Humidity:	0 to 90%, non-condensing

Mechanical

Dimensions:	78 x 70 x 35mm, (L x W x D)
Weight:	0.13kg
Fixing:	4 x M2.5 threaded Hex Pillars – screws required

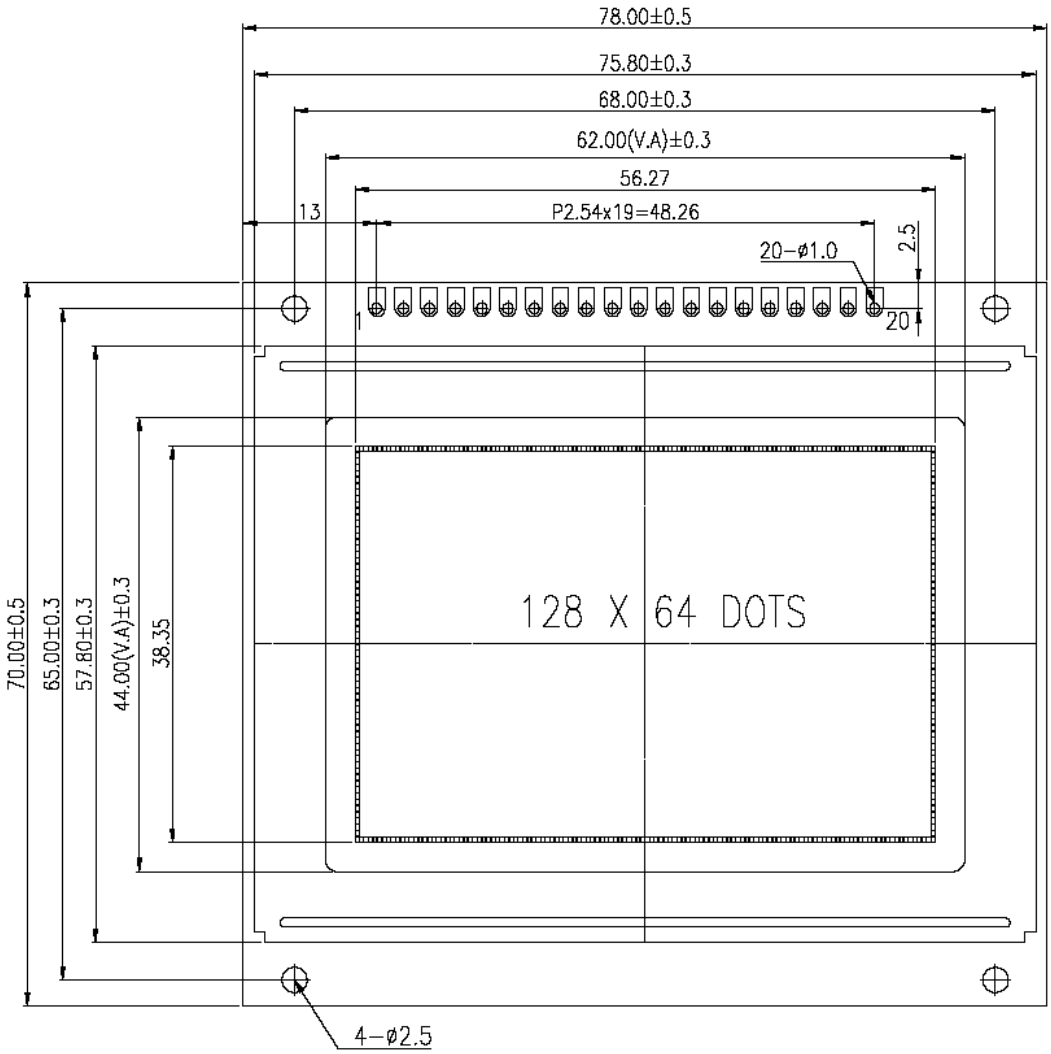


Figure 4 - Mechanical Fixing

Electrical

Supply Voltage:	9V to 32V dc; Reverse-voltage protection, with re-settable fuse
Supply Power:	~1.5 Watts
Connectors:	2-Pin connector w/cage-clamp connections

Display:

Type:	LCD Transflective/Positive (Black on Green/Yellow)
Mode:	FSTN
Duty:	1/64
Viewing Direction:	6 o'clock
Dot Size:	0.39 x 0.55mm
Display Area:	62.06 x 44.0mm (H x W)
Graphics Resolution:	128 x 64 dots
Text Resolution:	21 characters x 8 lines
Back-light:	Yellow LED, three settable levels: OFF-LOW/MEDIUM-HIGH
Contrast:	Preset, adjustable via configuration screen

Module Temperature

Accuracy:	+/-5% of full-scale accuracy of range: 10-50°C
Resolution:	+/-0.5°C

Communications Ports

Two three-wire RS232/RS485 Ports

RS232-A

Connectors:	3-Pin connector w/cage-clamp connections

CONFIGURATION

Protocol:	RS232 – VT100 Text – use TeraTerm VT100 Emulator
Baud Rate:	Fixed 115200,8,1,N
Activation:	Press '+++' within 10s of energisation

VT100

Protocol:	RS232 – VT100 Text & Graphics Commands
Baud Rate:	Programmable 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600 and 115200; default 115200,8,1,N
Flow Control:	Selectable XON/XOFF software control: default on.

MODBUS

Protocol:	RS232 Modbus RTU Master Interface
Address:	Programmable via configuration screen
Baud Rate:	Programmable: 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600 and 115200; default 9600,8,1,N
Polling Period:	Programmable: 1 to 30s

RS232-B

MODBUS

Connector:	3-Pin connector w/cage-clamp connections
Protocol:	RS232 Modbus RTU Slave Interface
Address:	Programmable via configuration screen
Baud Rate:	Programmable: 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600 and 115200; default 9600,8,1,N
Polling Period:	Minimum: 1s

RS485-A

Connectors:	3-Pin connector w/cage-clamp connections

CONFIGURATION

Protocol:	VT100 Text – use PC TeraTerm VT100 Emulator via RS232/USB to RS485 converter
Baud Rate:	Fixed 115200,8,1,N
Activation:	Press '+++' within 10s of energisation

MODBUS

Protocol:	RS485 Modbus RTU Master Interface
Address:	Programmable via configuration screen
Baud Rate:	Programmable: 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600 and 115200; default 9600,8,1,N
Polling Period:	Programmable: 1 to 30s

RS485-B

MODBUS

Connector:	3-Pin connector w/cage-clamp connections
Isolation:	1500Vdc
Protocol:	RS485 Modbus RTU Slave Interface
Address:	Programmable via configuration screen
Baud Rate:	Programmable: 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600 and 115200; default 9600,8,1,N
Polling Period:	Minimum: 1s

Field Reprogramming

This model supports firmware updates via the RS232 Service Port. Link, LK1 is provided with a handbag jumper. This must be removed and the unit power-cycled in order to effect the reprogramming process. Please note that firmware will be provided only if a generic problem exists in the field. Please consult the relevant Firmware Updating Procedure.

Optional Interfaces on VT100 & Modbus Units

These devices are NOT fitted as standard and must be specified on the order.

Relay/Buzzer/LED Drivers

Two drivers can be provided for interfacing to customer's equipment.
Two pin Molex headers J5 & J9, allow removable connection.
A 5V current-limited source is provided; A 100Ohm resistor limits current draw to 50mA.
The low-side driver switch is suitable for loads connected to the 24V supply.
The output may be set/reset under VT100 control

1.	5V Relay:	Direct connection, with external catch diode. (1N4004)
2.	24V Relay:	Use 24V supply and an external catch diode. (1N4004)
3.	Buzzer:	5V continuous tone type
4.	External LED:	Requires additional current-limiting resistor. (100R inclusive)

Push Button

A two-pin Molex connector, J10, for use with a momentary contact type switch, e.g. push-button 3V pull-up and ~1mA wetting current.

Function

<1s	Cycle Menu
>2s within first 10s	Load Default settings
>2s after first 10s	Reset Relays & LEDs(MONITOR mode)
>10s after first 10s	Re-boot

Indications

For the VT100 and RS485 Modbus variants, externally fitted Light Emitting Diodes, (LEDs), may be set/reset via the VT100 protocol.
With the RS232 Dual-Channel ADC Monitor/Controller variant, they are used to convey the following.

#	Connection	Name	Colour	State	Description
1	External via J12	Alarm	Yellow	ON	Parameter signal in Hi/Lo Alarm zone
2	External via J11	Trip	Red	ON	Parameter signal in Hi/Lo Trip zone

The LCD backlight serves to indicate energisation.

Diagnostics

On-board supply monitoring is employed and in the absence of the LCD drive voltage, the LCD is disabled and the LED back-light is flashed to draw attention to the problem.
Strategic system parameters are provided at the bottom-right of the configuration screen, along with an event log, which displays the last six entries.
VT100 commands may be typed in directly, using the TeraTerm terminal emulation software.

Dual-Channel Monitor/Controller Specification

This variant offers full Modbus capabilities, plus the ability to accept two ADC inputs for monitoring or control. The two parameters are scaled and added to the Hi-Res Modbus map, for remote access. A third register is employed to convey the Relay/LED status as a bit-field.

Analogue Inputs (Optional)

Analogue Inputs:	2 Multiplexed channels available +/-0.1% resolution +/-1% of full scale accuracy Range: 0-25mA (External devices must be self-powered)
Sample Period: sub-second	
Connector:	J8, 2-pole WAGO Cage-clamp per input
Protection:	Each input is zener-clamped at ~5V, with a series-connected re-settable fuse. (Allow 5mins to recover after activation)

Furniture

Push-Button

The two-pin Molex connector on J10, has several functions, dependant on mode and closure duration:

Alarm & Trip Reset

This is only relevant in Monitor mode, whereby both relays and LEDs are pre-defined to Alarm and Trip functions. Contact closure, (>2s), after at least 10s of energisation, will effect a reset of relays and LEDs.

Factory Defaults

Longer than 2s in the first 10s of energisation will reload the factory default settings.

External LEDs

Two drivers for externally connected LEDs are available on Molex connectors, J11 & 12, for Red and Yellow LEDs respectively.

External Relays

Two drivers for externally connected Relays are available on Molex connectors, J5 & 9.
A diode clamp MUST be employed for all reactive loads. A suitable device is a 1N4004 diode, with its cathode connected to the positive terminal of the external source.

Connections

All connections are made using a Cage Clamp™ block.

Use Bootlace Ferrules to provide strain-relief: Farnell #841-183; Weidmuller #H0,5/14; Insulated, 0.5mm, orange.
http://uk.farnell.com/weidmuller/h0-5-14/ferrule-insulated-0-5mm-orange/dp/841183

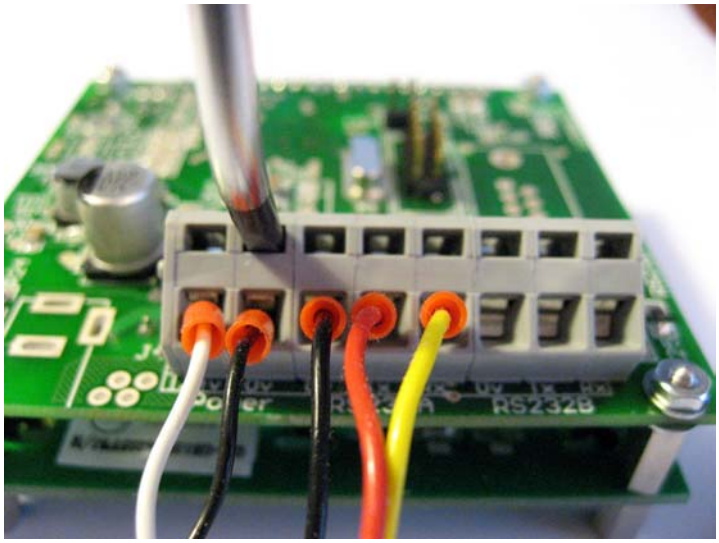
A suitable hand-crimping tool is: Farnell #299-870; Davico DCE 025
http://uk.farnell.com/davico/dce-025/crimp-tool-for-ferrules/dp/299870

Figure 5 – Hand Crimping Tool

Blade Tool

A screwdriver blade is inserted in the upper sloping rectangular slot and pushed down until the wire clamp opens. The bared wire is inserted and the blade withdrawn.

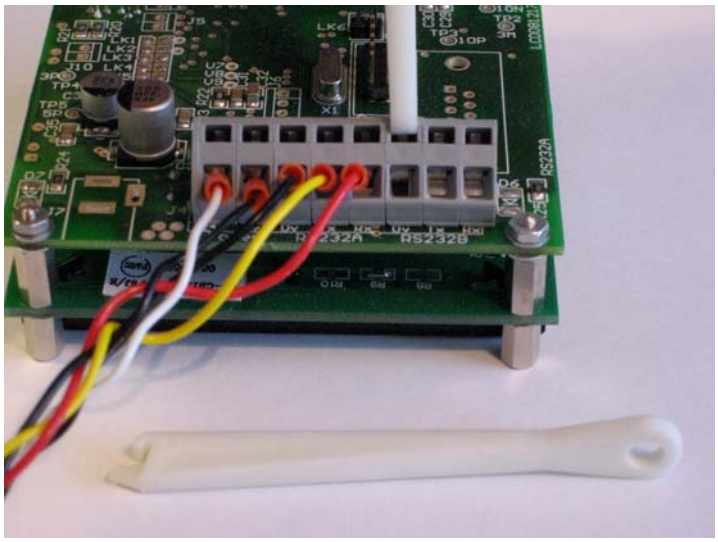
Figure 6 - Cable Insertion with Blade Tool



Lever Tool

An alternative and more effective tool is the WAGO tool, which acts as a lever, requiring minimal effort from the user.

Figure 7 - Cable Insertion with Lever Tool



Operating Tool: WAGO #258120 - Farnell #236-332
http://uk.farnell.com/wago/236-332/operating-tool-cage-clamp/dp/258120?_requestid=856303

Configuration

A set of PDA-sized screens utilising the VT100 protocol to offer display and editing of the otherwise inaccessible functions, may be evoked within 10s of energisation.. Many PDAs are available that are supported by third party VT100 Terminal Emulation. The screen size is 40 characters by 24 lines. PC emulators can be used and the standard 80x24 screen can be set to 40x24, for compactness.

A VT100 compatible terminal programme is required and configured for 115200bps,8,1,N.
An eminently suitable programme is the open-source freeware TeraTerm, (version 2.3):
http://www.vector.co.jp/authors/VA002416/teraterm.html
TeraTerm supports the first 16 COM Ports, but the installed configuration sets a maximum of only four. Edit the text file, "TERATERM.INI" and adjust the following entry accordingly:

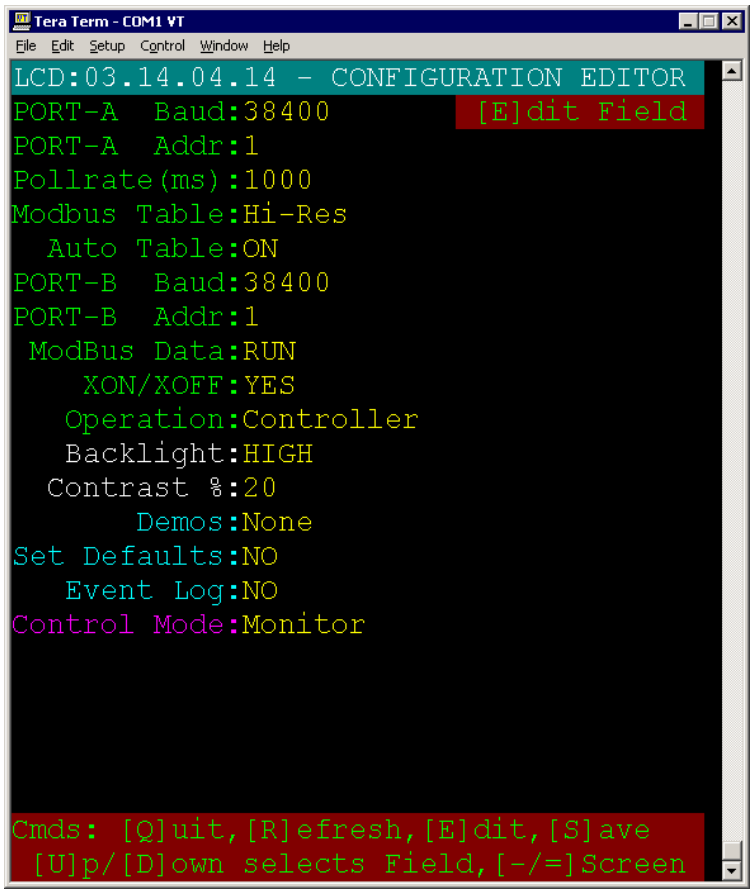
; Max serial port number
MaxComPort=16

See this URL for the latest user manual:
http://ttssh2.sourceforge.jp/manual/en/
INI settings:
http://ttssh2.sourceforge.jp/manual/en/setup/teraterm.html

Configuration Editor

This is the entry screen and provides setting of the communications protocols, LCD adjustments and Control Mode.
To enter the configuration screens, press three, or more '+' characters, within the first 10s of power-up.

Figure 8 - Configuration Editor



Commands

Edit

Allows the selected parameter to be changed.

Saving

When useful changes have been made to the configuration, they may be saved to non-volatile memory, for permanent usage.

Restart

A software restart is effected by ^R, (Ctrl+'R' keys).

Navigation

The [U]p/[D]own keys allow selection of a desired parameter. The pointer wraps from first to last and vice-versa.

Demonstration

Two demo screens may be evoked.

Text

This merely fills the LCD screen with the full character set.

Graphics

This is an animated display of a sinusoid, which draws ten overlaid staggered cycles, each with randomised amplitude. The display is then erased and the process repeated.

Modbus Table

When a pre-defined Modbus table is stored as the default, the name is retained. However, if the table is subsequently edited and saved, it will be named “CUSTOM”.

Modbus Data

[Run/Test] “Test” replaces the normal register data with fixed values based on the register number.

Set Defaults

This option will restore the default settings upon saving.
The factory defaults may be recovered using the following sequence:

- Remove power
- Close LK1
- Re-power
- Remove power
- Remove LK1
- Re-power

Note: LK1 is a solder-link; the pad to the right-hand side of LK1 may be held to GND whilst the supply is re-instated, thus effecting the reset.

Operation

This allows the selection of the operational mode of the unit. Editing this setting provides three options, VT100, Modbus and Controller. The latter allows a hands-on experience, but without additional components, it will *not* perform. Please consult the factory if this variant is required.
By default, the VT100 variant is set.

XON/XOFF

The setting for software flow-control is only relevant for VT100 usage. For a Modbus operation, this value is disabled, regardless of the configured choice.

Auto Table

To facilitate set-up of Modbus relay comms, an Auto-Table function is provided, but only works across our product range. The master port determines the Modbus table that its slave is utilising and automatically switches its internal table to match. The Marble PC application also has this feature, which seamlessly adjusts to the slave. This feature can be disabled, for use with third-party products.

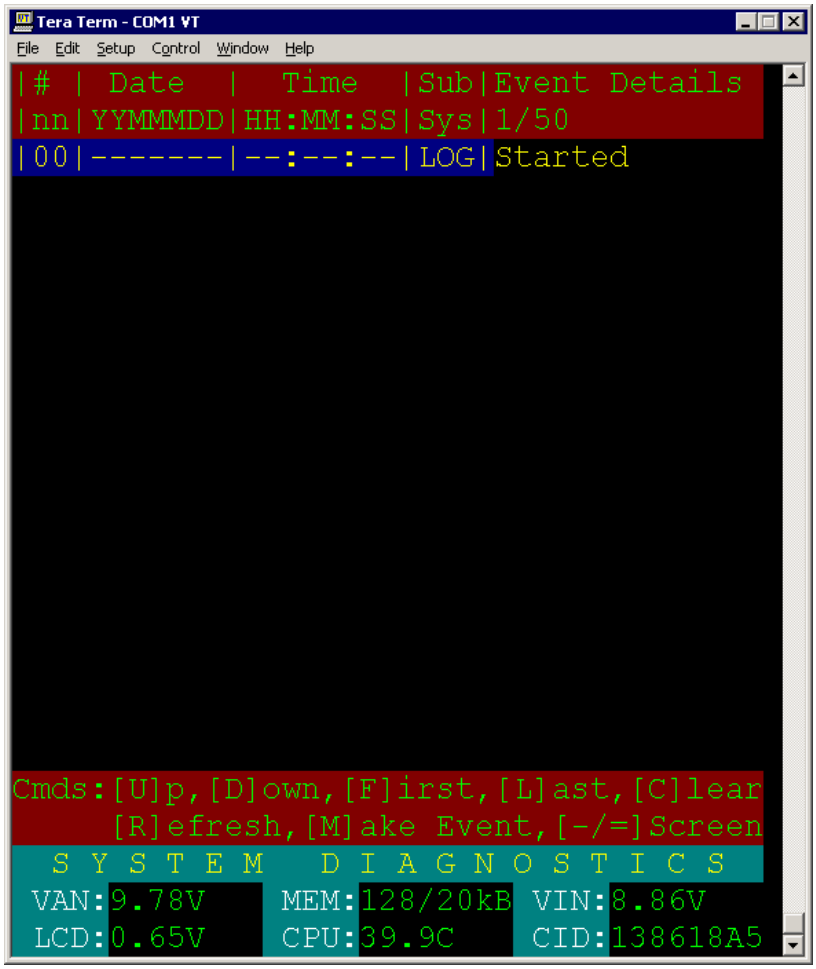
Event Log

[Off/On]
The “On” selection allows an alternate display between the normal Modbus Registers and the internal Event Log. This mode will provide insight to any configuration or running problems.

Event Log & Diagnostic Screen

The LCD Module has an integral event/error log, which records all major operations and fault conditions. A six entry display is incorporated on the configuration screen, but it is also useful to access this resource whilst in normal operation.
It is helpful to view the logged error messages, when debugging a Modbus connection. With this option asserted, the latest eight event entries are displayed, interlaced with the incoming Modbus data. There is no Real-time clock, hence the date/time fields are blank.

Figure 9 - Event Log & Diagnostic Screen



Event Log

Up to 50 entries may be recorded, any more will displace those at the bottom of the log.
Navigation keys allow the log to be inspected, with quick means for traversing to the [F]irst, or [L]ast entry of the log.
For test purposes, the user can [M]ake dummy entries, to see the log filling. They are marked with a TST subsystem label to differentiate them from real events.

Log Clearing

Pressing the [C] key effects this. A new log entry records the action.

Diagnostics

Useful voltages and other values are depicted to enable a quick appraisal of the system's integrity.

VIN

This field shows the supply voltage level.

LCD

This is the drive level for the LCD's negative voltage bias.

VAN

The field depicts the internal analogue supply voltage.

CPU

This is the CPU temperature, **NOT** the ambient.

MEM

These are the FLASH/SRAM resources on the CPU.

CID

This is the (almost) unique hexadecimal Card ID.

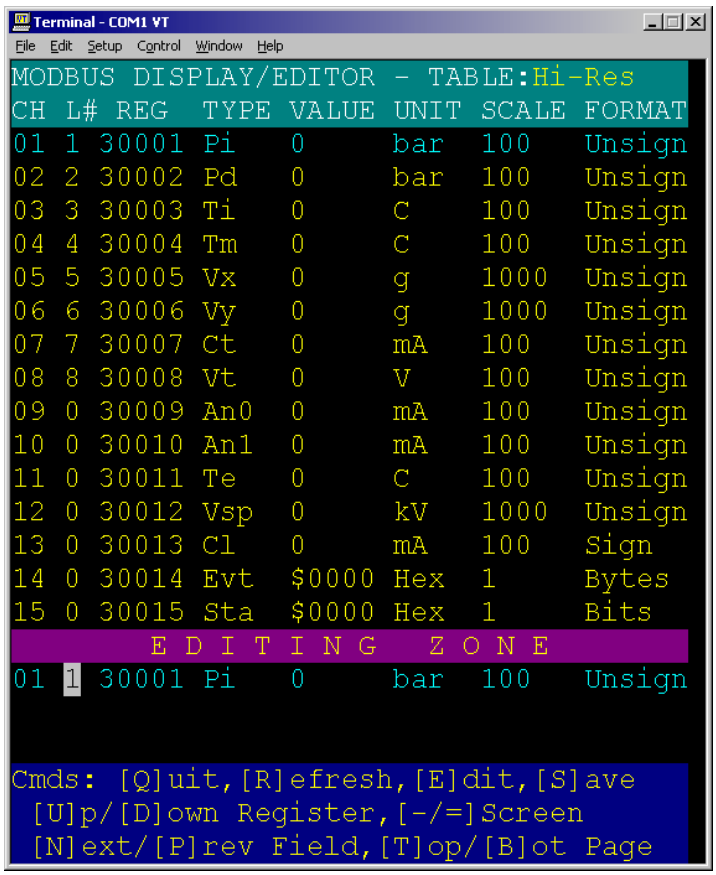
ANA & ANB

The current values of two analogue channels on the Monitor/Controller variant only.

Modbus Display/Editor Screen

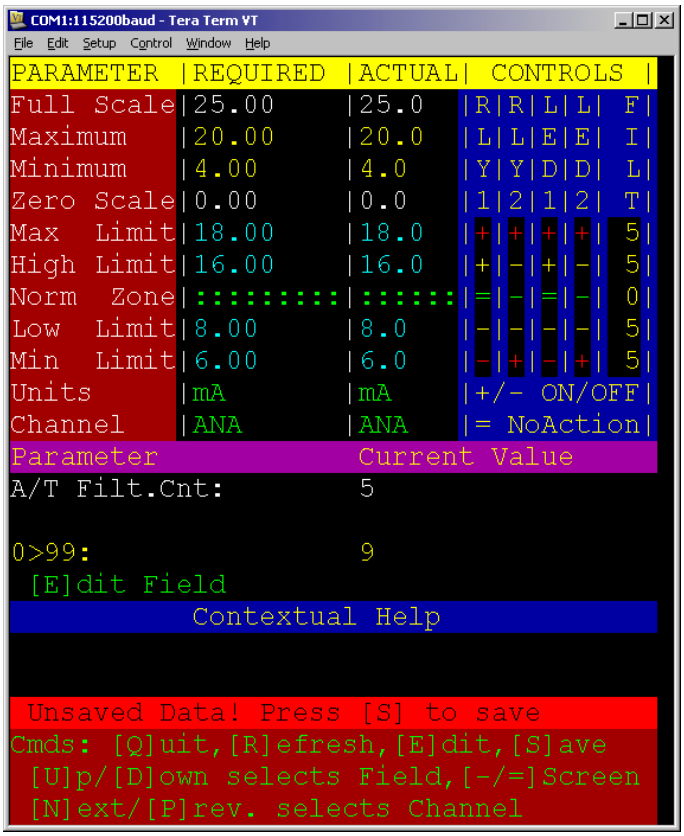
By selecting the desired table on the “Configuration Editor”, from the in-built list, the desired table may be modified and saved to the default table, when it will be labelled as “CUSTOM”. Since each table contains 30 entries, the table is displayed in two halves, the appropriate section is automatically displayed when entries are selected in that page.
The current values are displayed for each live channel, providing a useful debugging feature.
This screen allows a selection of the displayed Registers, Scale and Type.

Figure 10 - Modbus Display/Editor Screen



Analogue Channel Scaling & Editing

Figure 11 – Analogue Channel Editing Screen



Channels Selection

This is achieved by pressing the [P] or [N] keys, which will switch between the two available channels denoted as ANA and ANB.

Parameter Selection

The [U]p and [D]own keys select the parameters for editing; for convenience, the last entry wraps around to the first.

Scaling

Each channel has an actual range of 0 to 25mA, however, since most applications will use the standard 4-20mA range, to denote their user range, scaling must be performed to derive full-scale and zero-scale extents. Conceptually, this is complex, however, the diagram in Figure 12 shows the correspondence between actual values and the user's engineering units.

The procedure has been simplified to the point whereby only four values need entry. These are denoted in yellow text as "Maximum" and "Minimum" values for the "Required" and "Actual" scales. Entering the appropriate values will allow the full and zero scale values to be generated. When the entries are finalised, the may be committed to non-volatile memory for permanent usage.

Figure 12 - Scaling Diagram

Averaging

Each input channel's value may be selectively filtered with an averaging algorithm. The strength may be set from 0, (No filtering), to a maximum of 4. This feature can be employed to smooth noisy data, or to implement a measure of hysteresis.

Control Decision Matrix

There are two analogue inputs, two Relay/LED outputs and five zones defined by the four limits, (two each, high and low). Each relay may be assigned to either or both of the inputs and in each zone, its state may be either ON, OFF, or NO ACTION.
Three symbols are defined to denote the type of action:

1. + Relay/LED -ON
2. - Relay/LED-OFF
3. = Relay/LED-NO ACTION

Figure 13 - Output Action

```
COM1:115200baud - Tera Term VT
File Edit Setup Control Window Help
PARAMETER |REQUIRED |ACTUAL| CONTROLS |
Full Scale|25.00    |25.0  |R|R|L|L| F|
Maximum   |20.00    |20.0  |L|L|E|E| I|
Minimum   |4.00     |4.0   |Y|Y|D|D| L|
Zero Scale|0.00     |0.0   |1|2|1|2| T|
Max  Limit|18.00    |18.0  |+|+|+|+| 9|
High Limit|16.00    |16.0  |+|-|+|-| 9|
Norm  Zone|:::::::::|::::::|=|-|=|-| 0|
Low  Limit|8.00     |8.0   |-|-|-|-| 9|
Min  Limit|6.00     |6.0   |-|+|-|+| 9|
Units     |mA       |mA    |+/- ON/OFF|
Channel   |ANA      |ANA   |= NoAction|
Parameter              Current Value
Relay/LED1:            %00001111
   Zone   |Act|  [M]ove,[C]ycle,[F]ix
 Max Limit| + + < ON  in Zone
High Limit| +
 Norm Zone| =
 Low Limit| -
 Min Limit| -
 Unsaved Data! Press [S] to save
Cmds: [Q]uit,[R]efresh,[E]dit,[S]ave
 [U]p/[D]own selects Field,[-/=]Screen
 [N]ext/[P]rev. selects Channel
```

All decisions must be defined; a rapidly changing input can traverse a zone without registering, so it is imperative that zones above, or below, reflect the behaviour required in the intervening zones.

Filter Counts

All limit zones obey the filter timeouts set by the global filter count for each channel. However, action within the normal zone is immediate. Filter count values can be programmed from 0 to 99. Using a suitable count value forces a minimum switching time in an ON-OFF control strategy. When the signal value crosses a zone, the filter count for previous zone is reset to the default value.

Setting Actions

Choosing one parameter of either Relay/LED1 or Relay/LED2, for each analogue input channel accesses the actions. The screen will change to that shown in Figure 13. The following keys allow selection and editing:

[M]ove

This key allows selection of the five zones and wraps from the last back to the first.

[C]ycle

This presents one of the three decision choices.

[F]ix

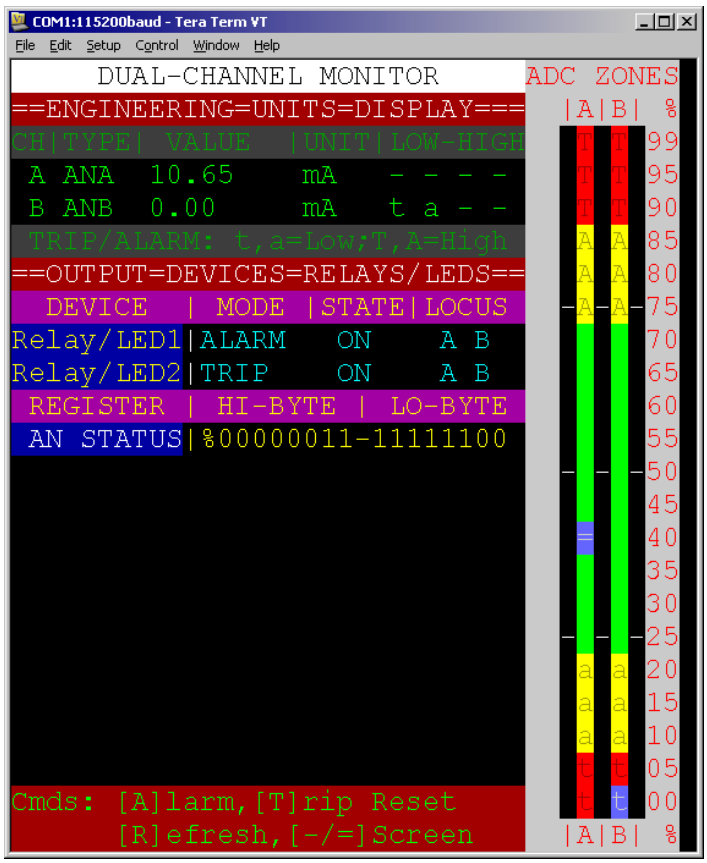
When the correct decision has been selected, press this key to hold the choice. A reminder is posted that data is unsaved; press [S] to commit changes to non-volatile memory.

Control Strategies

Any conceivable strategy may be implemented; the control shown here uses only input ‘A’. Relay/LED1 closes on a value above the high limit and opens with a value below the low limit. Relay/LED2 is used as a non-latching trip function on the Minimum and Maximum limits.

Dual Channel Controller

Figure 14 - Controller/Monitor



Engineering Units Display

Each channel is displayed with current values, with respective units.

Output Device Status

There are two relay drivers and two LEDs. These are shown with their functional names, according to the current Control Mode. In Monitor mode, both ADC channels use Relay/LED1 for Alarm output/indication and Relay/LED2 for Trip. Individual assignation is settable under Control Mode. The "Locus" indicates that both relays are controlled by both analogue inputs.

Channel Bargraph

This compact, yet informative display offers an overview of the limit/run zones, the current data value's relative position and the status of the filter count.

Relay Reset

Both relays may be reset individually, restoring the countdown filter values and marking the procedure in the Event Log. In the MONITOR mode, these are denoted as [A]larm and [T]rip, additionally, the action is marked in the Event Log. In the CONTROLLER mode, they are labelled as Relay[1] & Relay[2].

Status

The final line on the display shows a bit-field representation of the ANS Modbus Register. The definition of each bit is portrayed in Table 2.

Figure 15 - LCD Status Display

Modbus RTU

This product was originally developed for a niche market in the Oil & Gas exploration industry, specifically for equipment to obtain downhole pressure and temperature data on Electrically Submersible Pumps, ESP. However, this unit is eminently suited for other usage in the Process Control marketplace.

Modbus Variants

Several build options are available, including an isolated RS485 variant. Both RS232 and RS485 versions will perform a transparent Modbus "Relay" function, allowing a display on a dedicated line, whilst still performing the original communication task.

Modbus Relay

The term "Relay" is not to be confused with "Repeater", whereby the signal is merely amplified to extend a cable run. The relay function has one port configured as a Master, with the other, a Slave. The LCD Master repeatedly polls the attached slave device, retaining the latest values, such that the remote Master may request register values with minimal delay.

Speed Conversion

Since the two ports are independent, they may run at differing speeds, allowing a slow Slave device to be attached to a much faster Master, or vice versa. This consideration applies to both the RS232 and the RS485 protocol builds. A display-less version can be offered.

Modbus Maps

The module has pre-defined, public domain maps for various ESP manufacturer's product; these are selected via the configuration screen. Alternatively, a custom map can be defined and stored in non-volatile memory.
Embedded maps for other applications will be considered, should quantities justify their inclusion.
Each Map has a 30-entry capacity; registers do not need to be contiguous, although this facilitates block reads and therefore minimises traffic.
Since only eight registers may be displayed at any one time, the required register entries may be tagged with the desired display line. The resultant map may be saved to non-volatile memory, for automatic loading on power-up.
Only the HI-RES Map has support for the three LCD-derived registers.

Table 1 – HI-RES Modbus Table Entries for LCD Registers

Description	Modbus Register	Data Type	Units and Scaling
Analogue Channel A	30027	Unsigned Integer	User Defined (Default mA; x100)
Analogue Channel B	30028	Unsigned Integer	User Defined (Default mA; x100)
Relay/LED Status	30029	Bit Fields	x1 - See Table 2 Below

Table 2 - Modbus Status Register Bitfields

ANA LIMITS (TRIPS/ALARMS)				ANB LIMITS (TRIPS/ALARMS)				ANA ASSIGNMENT		ANB ASSIGNMENT		STATUS		MODE		Section
MAX	HIGH	LOW	MIN	MAX	HIGH	LOW	MIN	RLY/LED1	RLY/LED2	RLY/LED1	RLY/LED2	RLY/LED1	RLY/LED2	MONITOR/CONTROL		Function
b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	Bit number
1	1	0	0	0	0	0	0	1	0	0	1	1	0	x	0	Monitor
1:>=MAX	1:>=HIGH	1:<=LOW	1:<=MIN	1:>=MAX	1:>=HIGH	1:<=LOW	1:<=MIN	0:=UNUSED;1:=USED				0:=OFF;1:=ON		x	1	Control

Modbus Implementation

According to the publication, "MODBUS over serial line specification and implementation guide V1.02", page 13 of 44, (www.modbus.org), for new Modbus implementations, timeouts for high baud rates should adopt the following strategy:

> *For baud rates greater than 19200bps, fixed values for the 2 timers should be used: it is recommended to use a value of 750us for the inter-character time-out (t1.5) and a value of 1.750ms for inter-frame delay (t3.5).*

The LCD Modbus port is compliant with this directive.

Whilst several higher baud rates are provided, it is prudent to poll at the slowest rate commensurate with matching the throughput of the transmission. A five-second-poll period is sufficient for most operational requirements.

For lower baud rates, allow sufficient time for receipt of the complete response packet, before re-polling.

The Modbus implementation is currently limited to read commands 03 and 04 for registers 40001-40700 and 30001-30700. Please contact us if you requirement is outside of this scope.

Typical Modbus Display

The following figure displays the Modbus Register and dummy test data using the register value, but scaled as specified by the table.

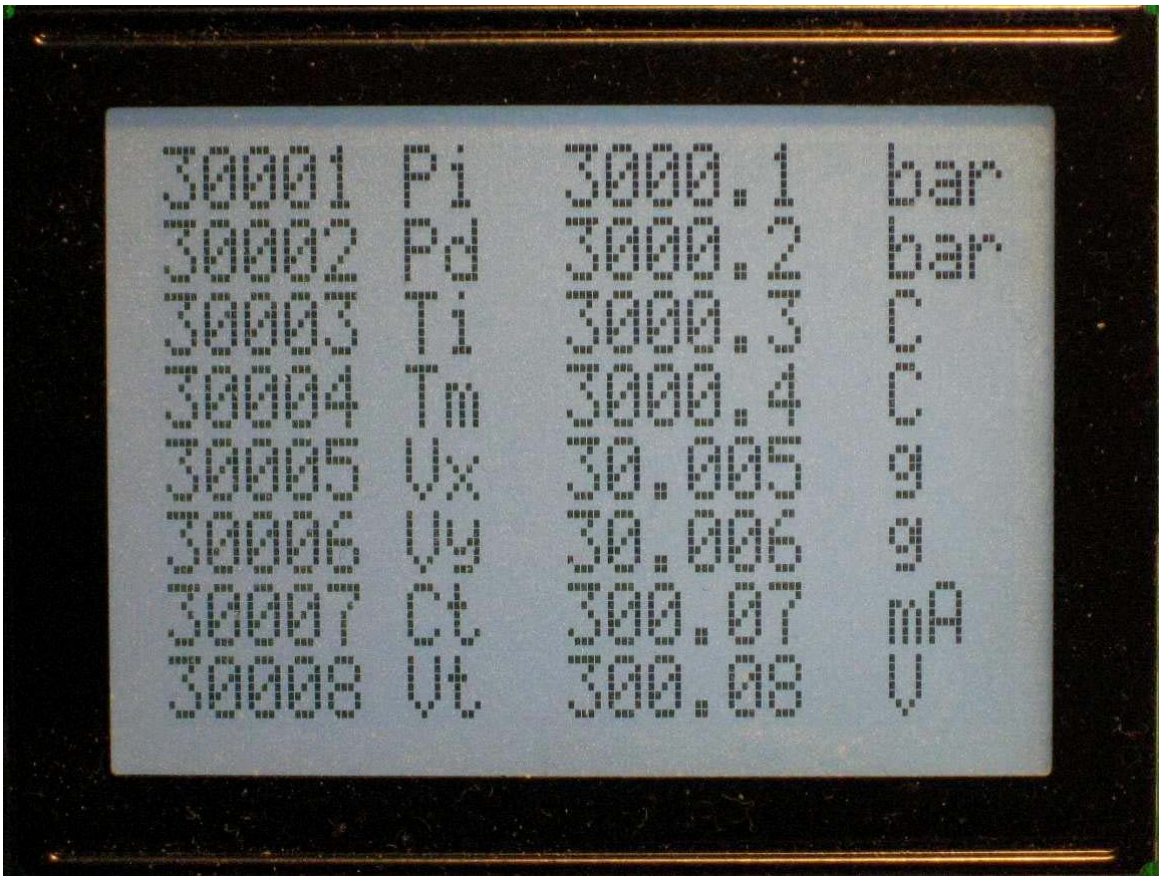


Figure 16 - Typical Modbus Display

Diagnostics

The display of Figure 16 is augmented by an error display, which will report the following four errors against the respective register entry. The error message uses the right-hand side of the display, since the value field is empty in such an event.

Modbus Errors

#	Error Display	Possible Cause
1	No Response	Wrong Baud-rate/No connection
2	Bad Address	Non-existent register
3	Bad Function	Wrong/Unrecognised Function Code
4	Bad CRC	Corrupted Packet

Appendix

Signal Converters

The following list of third party, validated signal converters is presented to help integrate our products. These are used in-house on a daily basis. Most USB items are based on either the Prolific PL-2303, or FTDI FT232R devices.

TTL<>RS232

B&B Electronics
TTL Converter – non-isolated
Port powered; TTL Male DB9; RS232 Female DB9
5V Version - Model: 232LPTTL
1-off $49
http://www.bb-elec.com/bb-elec/literature/232LPTTL-3406ds.pdf

3V3 Version - Model: 232LPTTL33
1-off $49
http://www.bb-elec.com/bb-elec/literature/232LPTTL-3406ds.pdf

RS232<>USB

Prolific Technology Inc

Prolific PL-2303
USB powered; Male DB9
Caveat: No driver for Vista-64
http://www.prolific.com.tw

1-off £13.99 ex VAT
http://www.startech.com/item/ICUSB232-USB-to-RS232-DB9-Serial-Adapter-Cable-Male-to-Male-Serial-Adapter-USB-to-Serial.aspx
1-off £12.82 ex VAT
http://www.saverstore.com/product/20003270/Startech-ICUSB232-USB-to-RS-232-DB9-Serial-Adapter

RS485<>USB

Soarland & Hexin
http://www.hexin-technology.com/USB_2.0_To_RS-485_Converter-Product-255.html
Model: HXSP-2108F
Prolific PL-2303
USB powered; Male DB9
Useful Female DB9 to screw terminal adapter
Caveat: No driver for Vista-64; Remove 120R termination
NB: Echo is OFF

1-off £15.16
http://www.sourcingmap.com/usb-rs485-rs485-serial-adapter-converter-p-43362.html

RS485<>USB

Future Technology Devices International
Model: USB-RS485-WE-1800-BT
FTDI FT232R
USB powered; cable, wire-ends
NB: Echo is OFF

1-off £21.50

http://apple.clickandbuild.com/cnb/shop/ftdichip?op=catalogue-products-null&prodCategoryID=91&title=USB-RS485+Cable

VT100 Implementation

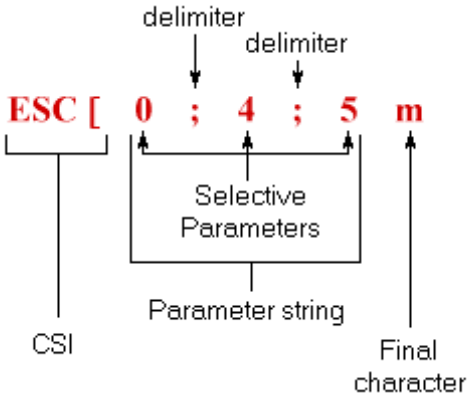
The industry standard, VT100 ANSI-mode escape sequences form a useful basis for control and placement of text on the LCD screen. These start with <ESC>[, <ESC>#, <ESC>(, or <ESC>), with the majority of the first type.
Most of the published sequences are implemented and others, even when inappropriate to this module, are decoded and ignored.
The protocol is extended by new, yet consistent commands. These are required for setting the LED backlight intensity and the optional output devices.

Standard VT100 Terminal Control Escape Sequences

Many computer terminals and terminal emulators support colour and cursor control through a system of escape sequences. One such standard is commonly referred to as ANSI Colour. Several terminal specifications are based on the ANSI colour standard, including VT100.

Standards: ANSI X3.641977 and ANSI X3.41-1974, which are replaced by the international standard ISO DP6429.

This URL will give a useful grounding:
http://ascii-table.com/documents/vt100/chapter3.php



The following is a partial listing of the VT100 control set, showing implemented, discarded and unimplemented sequences.

<ESC> represents the ASCII "escape" character, 0x1B. Bracketed tags represent modifiable decimal parameters; e.g. {row} would be replaced by a row number. Semicolons are used to delimit the numeric parameters.

A '#' prefix indicates a sequence that will NOT be implemented, or ignored.
A '$' prefix indicates a sequence that will be ignored and maybe implemented at a latter date.

Device Status

The following codes are used for reporting terminal/display settings, and vary depending on the implementation:

Query Device Code <ESC> [c

Requests a Report Device Code response from the device.

Report Device Code <ESC> [{code} 0 c

Generated by the device in response to Query Device Code request.

Query Device Status <ESC> [5 n

Requests a Report Device Status response from the device.

Report Device OK <ESC> [0 n

Generated by the device in response to a Query Device Status request; indicates that device is functioning correctly.

Report Device Failure <ESC> [3 n

Generated by the device in response to a Query Device Status request; indicates that device is functioning improperly.

Query Cursor Position <ESC> [6 n

Requests a Report Cursor Position response from the device.

Report Cursor Position - CPR <ESC> [{row} ; {column} R

Generated by the device in response to a Query Cursor Position request; reports current cursor position.

Terminal Set-up

The h and l codes are used for setting terminal/display mode, and vary depending on the implementation. Line Wrap is one of the few set-up codes that tend to be used consistently:

Reset Device <ESC> c

Reset all terminal settings to default.

 # Enable Line Wrap <ESC> [7 h

Text wraps to next line if longer than the length of the display area.

 # Disable Line Wrap <ESC> [7 l

Disables line wrapping.

Fonts

Some terminals support multiple fonts: normal/bold, Swiss/Italic, etc. There are a variety of special codes for certain terminals; the following are fairly standard:

$ Font Set G0 <ESC> (A

Set default 8x8 font.

$ Font Set G1 <ESC>) A

Set alternate 6x8 font.

Cursor Control

Cursor Home – CUP, HVP <ESC> [{row} ; {column} H

Sets the cursor position where subsequent text will begin. If no row/column parameters are provided (ie. <ESC>[H), the cursor will move to the home position, at the upper left of the screen.

Cursor Up – CUU <ESC> [{COUNT} A

Moves the cursor up by COUNT rows; the default count is 1.

Cursor Down - CUD <ESC> [{COUNT }B

Moves the cursor down by COUNT rows; the default count is 1.

Cursor Forward – CUF <ESC> [{COUNT} C

Moves the cursor forward by COUNT columns; the default count is 1.

Cursor Backward – CUB <ESC> [{COUNT} D

Moves the cursor backward by COUNT columns; the default count is 1.

Force Cursor Position <ESC> [{row} ; {column} f

Identical to Cursor Home.

Save Cursor <ESC> [s

Save current cursor position.

Unsave Cursor <ESC> [u

Restores cursor position after a Save Cursor.

 # Save Cursor & Attributes <ESC> 7

Save current cursor position.

 # Restore Cursor & Attributes <ESC> 8

Restores cursor position after a Save Cursor.

Display

Display Inverted <ESC> [5 h

Display Inverted

Display Normal <ESC> [5 l

Where ‘l’ is the lower -case letter L.
Display Normal

Display Off <ESC> [75 h

Display Inverted

Display On <ESC> [75 l

Where ‘l’ is the lower -case letter L.
Display On

Cursor On <ESC> [10 h or <ESC> [25 h

Cursor display in ON

Cursor Off <ESC> [10 l or <ESC> [25 l

Where ‘l’ is the lower-case letter L.
Cursor display in OFF

Scrolling – Not Implemented

This activity isn’t deemed useful for the small format display and is unlikely to be implemented

 # Scroll Screen <ESC> [r

Enable scrolling for entire display.

 # Scroll Screen <ESC> [{start} ; {end} r

Enable scrolling from row {start} to row {end}.

 # Scroll Down <ESC> D

Scroll display down one line.

 # Scroll Up <ESC> M

Scroll display up one line.

Tab Control – Not Implemented

Tabbing is only really relevant in an editing environment, not in a purely display mode.

 # Set Tab <ESC> H

Sets a tab at the current position.

 # Clear Tab <ESC> [g

Clears tab at the current position.

 # Clear All Tabs <ESC> [3 g

Clears all tabs.

Erase In Line

Erase End of Line <ESC> [K

Erases from the current cursor position to the end of the current line.

Erase Start of Line <ESC> [1 K

Erases from the current cursor position to the start of the current line.

Erase Line <ESC> [2 K

Erases the entire current line.

Erase ‘n’ Characters <ESC> [2 X - VT200 Command !!!

Erase 'n' characters, including the character under the cursor. This non-standard command is included since it was obviously lacking.

Erase In Display

Erase Down <ESC> [J

Erases the screen from the current line down to the bottom of the screen.

Erase Up <ESC> [1 J

Erases the screen from the current line up to the top of the screen.

Erase Screen <ESC> [2 J

Erases the screen with the background colour and moves the cursor to home.

Printing – Not Implemented

Some terminals support local printing, but we don't.

 # Print Screen <ESC> [i

Print the current screen.

 # Print Line <ESC> [1 i

Print the current line.

 # Stop Print Log <ESC> [4 i

Disable log.

 # Start Print Log <ESC> [5 i

Start log; all received text is echoed to a printer.

Define Key – Not Implemented

 # Set Key Definition <ESC> [{key} ; "{string}" p

Associates a string of text to a keyboard key. {key} indicates the key by its ASCII value in decimal.

Set Display Attributes

Set Attribute Mode <ESC> [{attr1} ; .. .; {attrn} m

Sets multiple display attribute settings. The following lists standard attributes:
Since the LCD is a monochrome display, colours will be mapped to either Black, or White.

Attributes	*Action*	*Comment*
0	Reset all attributes	
1	Bright	Not supported by LCD
2	Dim	Not supported by LCD
3	Not Used	
4	Underscore	Not supported by LCD
5	Blink	
6	Blink Reverse	Non standard usage
7	Reverse	
8	Hidden	
9	Blink Inhibit	Non standard usage

Foreground Colours		*Mapped*
30	Black	Black
31	Red	Black
32	Green	White
33	Yellow	White
34	Blue	Black
35	Magenta	Black
36	Cyan	White
37	White	White

Background Colours		*Mapped*
40	Black	Black
41	Red	Black
42	Green	White
43	Yellow	White
44	Blue	Black
45	Magenta	Black
46	Cyan	White
47	White	White

Control Characters

The control characters recognised by the LCD are listed below. All other control characters cause no action to be taken.

Control characters (codes 0x00-0x1F inclusive) are specifically excluded from the control sequence syntax, but may be embedded within a control sequence. Embedded control characters are executed as soon as they are encountered by the VT100. The processing of the control sequence then continues with the next character received.

Exceptions

If the <ESC> character occurs, the current control sequence is aborted, and a new one commences beginning with the <ESC> just received. If the character <CAN> (030) or the character <SUB> (032) occurs, the current control sequence is aborted. The ability to embed control characters allows the synchronisation characters XON and XOFF to be interpreted properly without affecting the control sequence.

Char	Hex	Action
<NUL>	0x00	Ignored on input; not stored in buffer
<ENQ>	0x05	Transmit “Answerback” message
<BEL>	0x07	Sound bell
<BS>	0x08	Move cursor to the left one position, unless it is at the left margin, in which case no action is taken.
<HT>	0x09	Move cursor to the next tab stop, or to the right margin if no further tabs are set.
<LF>	0x0A	Causes either a line feed or new line operation (See new line mode.)
<VT>	0x0B	Same as <LF>.
<FF>	0x0C	Same as <LF>.
<CR>	0x0D	Move the cursor to the left margin of the current line.
<SO>	0x0E	Invoke the G1 character set, as designated by the <ESC>) control sequence.
<SI>	0x0F	Invoke the G0 character set, as selected by the <ESC> (control sequence.
<DC1>	0x11	Causes terminal to resume transmission (XON).
<DC3>	0x13	Causes terminal to stop transmitting all codes except XOFF and XON (XOFF).
<CAN>	0x18	If sent during a control sequence, the sequence is immediately terminated and **not** executed.
<SUB>	0x1A	Same as <CAN>.
<ESC>	0x1B	Introduces a control sequence.
<DEL>	0x7F	Ignored on input; not stored in buffer.

Extended VT100 Terminal Control Escape Sequences

Two sets are incorporated, one for control functions and the other for drawing graphic entities

Control Sequences

Control Relay/Buzzer/External LED

Set Relay-1	SR1 <ESC> [80 h
Reset Relay-1	RR1 <ESC> [80 l
Set Relay-2	SR2 <ESC> [81 h
Reset Relay-2	RR1 <ESC> [81 l

Control On-board LEDs

Set LED-1	SL1 <ESC> [82 h
Reset LED-1	RL1 <ESC> [82 l
Set LED-2	SL2 <ESC> [83 h
Reset LED-2	RL1 <ESC> [83 l

LED Back-light Intensity <ESC> [{Pn} i

Where ‘i’ is either the lower or upper case letter i.
Pn, Levels 0..3:

‘0’ OFF	
‘1’ LOW	
‘2’ MEDIUM	
‘3’ HIGH	
‘4’ FLASH	Repeatedly flashes Backlight ON<>OFF, 300ms period
‘5’ PULSE	Repeatedly pulses Backlight from ‘1’>’2’>’3’>’2’>’1’ intensity levels
‘9’ RESET	Resets ‘4’ & ‘5’ – Need to set intensity to prior value

LCD Contrast <ESC> [{Pn} W

Contrast control is effected by a circuit that sweeps the LCD’s voltage over a range of 0 to –10V. The wide range allows the use of LCD displays from different manufacturers. To cater for this range the value of Pn is a percentage and can take any value between 0 & 99.

Graphics Sequences

A set of vector graphic drawing primitives is defined and is consistent with the standard text format. An attribute sequence is first sent to set the required operation, then one or more subsequent sequences provide the positioning information for the drawing act.
To enhance plotting operations, a set of graph layouts is pre-defined and may be evoked by a macrograph command. This avoids sending the individual drawing primitives and saves bandwidth.

Graphics Attributes

Graphics Attribute GA < ESC> [{Pn…} a

These are complementary draw/erase operations, where Pn:
Point
'0' Draw Point {x1;y1}
'1' Erase Point {x1;y1}
Line
'2' Draw Line {x1;y1;x2;y2} or continue Line from previous end point {x2;y2}
'3' Erase Line {x1;y1;x2;y2} or continue Line from previous end point {x2;y2}
Box
'4' Draw Rectangle {x1;y1;x2;y2}
'5' Erase Rectangle {x1;y1;x2;y2}
Fill Box
'6' Fill Rectangle {x1;y1;x2;y2}
'7' Erase Rectangle {x1;y1;x2;y2}
Circle, (Ellipse)
'8' Draw Circle (ellipse) centre & radius {x1;y1;r}
'9' Erase Circle (ellipse) centre & radius {x1;y1;r}
Due to the LCD's non-square pixels, commands '8'&'9' are of limited use.
NB: '{' & '}' are **NOT** transmitted. The semicolon **is** sent, to delimit the numeric parameters.

Graphics Drawing Functions GD

Draw Point <ESC> [x1 ; y1 G

Draw Line <ESC> [x1 ; y1 ; x2 ; y2 G

Draw Continued Line <ESC> [x2 ; y2 G

Draw Box <ESC> [x1 ; y1 ; x2 ; y2 G

Draw Filled Box <ESC> [x1 ; y1 ; x2 ; y2 G

Draw Circle <ESC> [x1 ; y1 ; r G

Erasing Graphics

Erase Graphics Screen to White <ESC> [3 J

Erases the graphics screen to White.

Erase Graphics Screen to Black <ESC> [4 J

Erases the graphics screen to Black.

Erase Graphics Screen to TA <ESC> [5 J

Erase the graphics screen to the current Text Attribute

MacroGraphs

These are pre-defined graphic frames, containing axes, lines and ticks. Since these are held locally to the LCD Module, their speed of execution is significantly faster than a discrete suite of commands sent via the serial link.

Draw MacroGraph Screen <ESC> [{Pn} Y

Where Pn:

- ‘0’ - Single axes, with ticks (Left & Bottom)
- ‘1’ - Double axes, with ticks
- ‘2’ - Central dotted line
- ‘3’ – Full border with anti-ticks – This gives best screen usage and readability
- ‘4’ - Just ticks – However, the single ticks can be confused with data-points

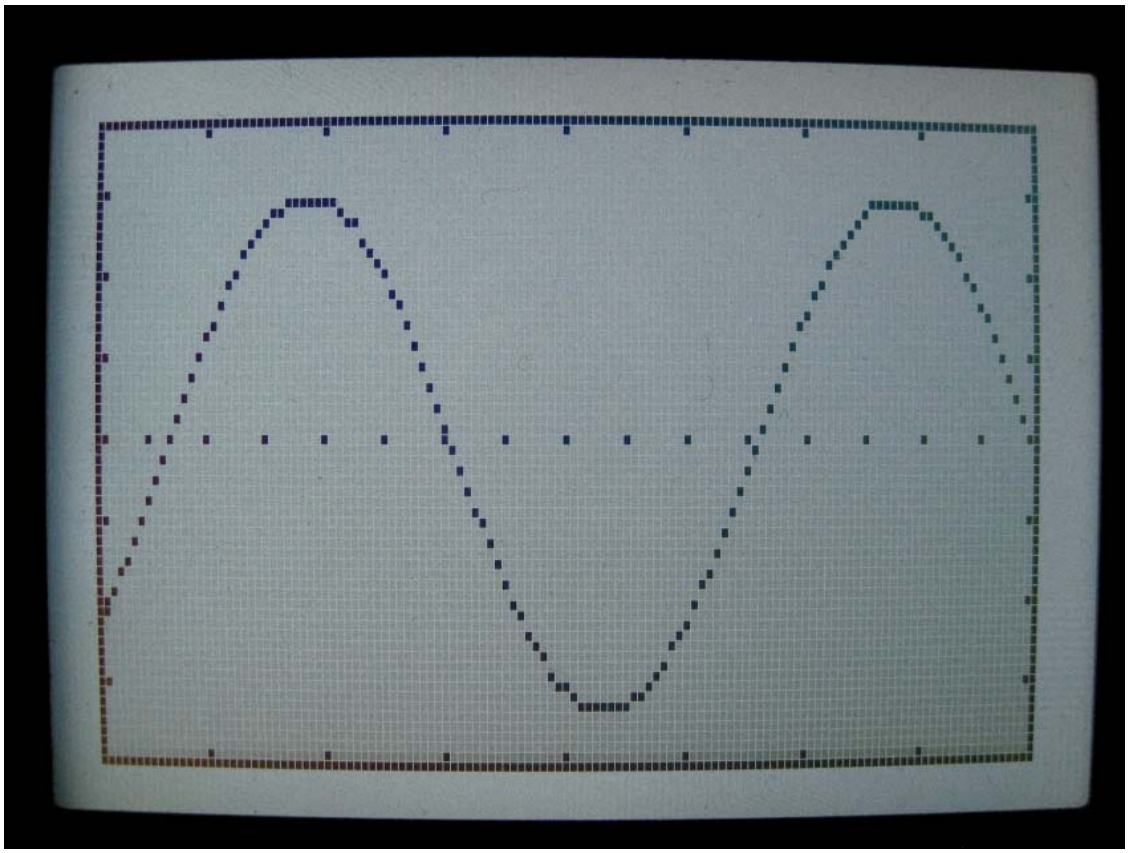
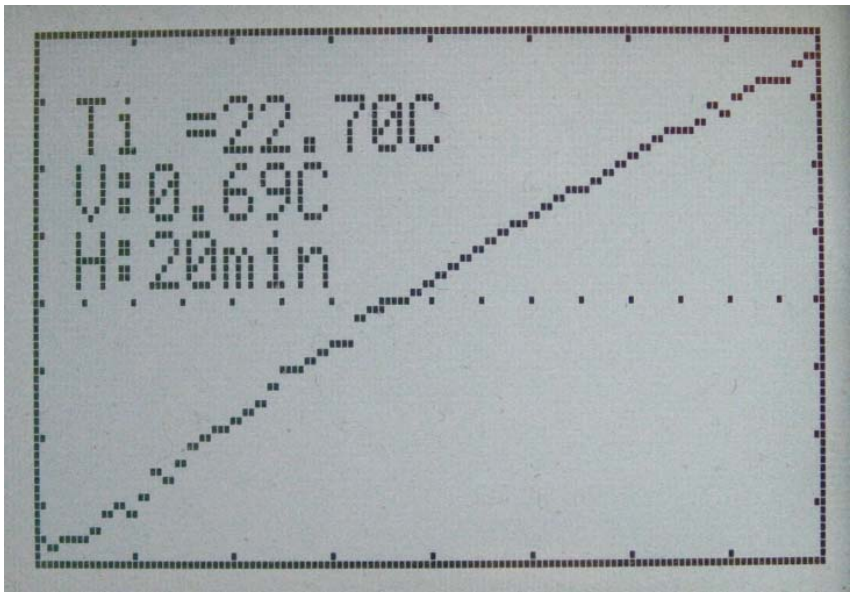


Figure 17 – MacroGraphs 1&2 with plotted sinusoid

An Example Application

Figure 18 shows a display from a real application, where both text and graphics content are combined. Two algorithms scan the plot data buffer, relocating the text block to avoid masking the plotted data. Trending finds the least populated corners and Averaging determines if the upper or lower half of the screen is the least populated. An auto-scaling algorithm ensures that the plot uses the full available vertical resolution.

Figure 18 - Graphics Plot with Text Annotation



An alternative means of displaying textual data is to flash the text box on and off at a slow rate. This allows otherwise obscured data to be observed, whilst still conveying the scaling etc..

Figure 19 - MacroGraph #3 with data in the noise level

Figure 19 shows a particularly stable signal, with +/-1 least significant bit change. (v) denotes the vertical span, so an LSB is equivalent to ~5mbar; “<21mins>” is the horizontal span, with a sample every 10s.

Product Feature Matrix

Legend:

FEATURES
x = Not Applicable
Y = Supported
y = Optional
N = None
n = Partial

CONNECTORS
C = Cage Clamp
T = Two Part
S = Screw Terminal

PROTOCOL
A = ESP Modulation - Standard
B = ESP Modulation – Enhanced
FSK = Frequency Shift Keying
MB = Modbus
VT = VT100

	Card Name	Transmission Protocol	Min Supply Voltage (Volts)	Max Supply Voltage (Volts)	Supply Power (Watts)	Output Tool Voltage (Volts)	Output Tool Current (mA)	Min Gauge Voltage (Volts)	Max Gauge Voltage (Volts)	Gauge Current (mA)	Max Operational Temperature (Celsius)	RS485 RTU Modbus - Isolated	RS232 RTU Modbus	USB Service Port	VT100 Configuration Screens	Analogue Inputs	Analogue Outputs	Real-Time Clock	On-board Logging	USB Memory Key Logging	Alarm & Trip Relays	Alarm & Trip Outputs	Push Button Reset	Integral LCD	LED Power ON	LED Tool ON	LED Data	Spectrum Compatible (n=VT100 only)	Connector Type
ESP Surface Card c/w Logging	BEM	A/B	20	30	5	120	30	x	x	x	70	Y	N	Y	Y	2	0	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	T
(legacy) ESP Surface Card c/w Logging	STU	A	20	30	5	120	30	x	x	x	70	Y	N	Y	Y	2	0	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	T
ESP Downhole Dual	BED	B	80	120	x	x	x	80	100	15	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ESP Downhole Dual	DDA	A	80	120	x	x	x	80	100	15	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ESP Downhole Single	BES	B	80	120	x	x	x	80	100	15	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ESP Downhole Single	DDS	A	80	120	x	x	x	80	100	15	150	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
TEC Surface Card c/w LCD	BTI	FSK	9	32	4	50	50	x	x	x	70	N	Y	N	Y	0	0	N	N	N	N	Y	Y	Y	Y	N	Y	Y	C
TEC Surface Card c/w Logging	BTM	FSK	9	32	3	50	50	x	x	x	70	Y	N	Y	Y	2	0	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	C
TEC Downhole Dual	BTD	FSK	20	100	x	x	x	20	100	25	150	x	x	x	x	x	x	x	N	N	x	x	x	x	x	x	x	x	x
TEC Downhole Single	BTS	FSK	20	100	x	x	x	20	100	25	150	x	x	x	x	x	x	x	N	N	x	x	x	x	x	x	x	x	x
XBD Analogue Output	XBD	MB	22	27	1	x	x	x	x	x	70	Y	Y	N	Y	0	1	x	N	N	x	x	x	x	Y	Y	Y	n	C
VT100/Master-Slave Modbus LCD RS232	LCD	VT/MB	9	32	1.5	x	x	x	x	x	70	N	Y	N	Y	0	0	N	N	N	x	y	y	Y	y	y	N	n	C
4-20mA Monitor/Controller Modbus LCD RS232	LCD	MB	9	32	1.5	x	x	x	x	x	70	N	Y	N	Y	2	0	N	N	N	x	Y	Y	Y	y	y	N	n	C
Master-Slave Modbus LCD RS485	LMD	MB	9	32	1.7	x	x	x	x	x	70	Y	N	N	Y	0	0	N	N	N	x	y	y	Y	y	y	Y	n	C

Table 3 - Product Feature Matrix