VelDist

77GHz FMCW Radar Sensor

User Instruction Manual

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Fig.A. VelDist in Adalet housing, lens horn antena 3" aperture, 4^0 beam width.

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1. Product description.

VelDist is millimeter microwave FMCW radar sensor designed for distance (and simultaneous distance and velocity) measurement in various industrial applications requiring high robustness, narrow beam and high penetration power against environmental obstructions such as snow, rain, spray, mist, dust, smoke etc.

Fig. 1. Velocimeter with 3 inch lens-horn, 4.5" cylindrical housing.

2. Specifications (preliminary, subject to changes).

Distance range:	1-200m
Velocity range:	+/-50m/s (distance dependent)
Accuracy:	+/-2cm (distance) and +/-1cm/s (velocity)
Response time:	minimum 100ms (depends also on the filtering setup)
Housing:	cast aluminum cylindrical enclosure by Adalet, with a screwed-on lid with glass window; explosion-proof approval ratings. Weight: 3.5kg. External diameter 5 inch (12.5cm), height 6 inch (15cm). Two threaded conduit ports, ¾ inch NPT. One used for antena mount and one free, available for cable connection.
Antena:	Aluminum horn with polypropylene (low temperature applications) or teflon lens (high temperature applications). Length 5.75 inch (14.5 cm), external diameter 3 inch (7.5cm),

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Environmetal protection: similar to Nema-4. Operating temperature –10C to +45C.

Housing approvals: class I group B,C,D, class II group E,F,G, class III type 4X, class I zone 1 A Ex d IIC,
Exd IIC IEC 60529 IP66

Housing cable port: ¾" NPT (conduit entry)

Power Supply: 24V DC (19-29V) / 0.5A, fuse 2A

Transmitter Output: 10-50mW continous wave, frequency swept in 76-78GHz range (1GHz bandwidth)

Process Variable Output: Analog output in form of a 4-20mA source from common 24V supply line (default) or opto-isolated bipolar sink (jumper-configurable). Voltage burden = 8V. Max load resistance 640 ohm. Current span is 3.5-25mA. Second output option requires an optional (additional) quadrature differential pulse output board and provides ground-isolated externally supplied frequency-modulated pulses (either 5V or 24V depending on the power supply used, 0-100kHz), where frequency is proportional to velocity or equivalently, each pulse has a direct relation to an incremental distance movement of the strip. The third method consists of using the serial data link interface to read the output process variable (or other internal sensor variables) digitally to a PC controller or PLC.

Diagnostic/setup data port: serial RS232-TTL 9.2-115kbaud, no handshaking. It is recommended to attach a USB or a RS485 interface (not included), for interfacing to a PLC or a PC. This port can be used for sensor diagnostics, for transfering sensor output variables, for setup and for calibration.

Configuration: Manual – direct parameter entry using a 2 lines by 8 characters LCD and two push-buttons (requires opening the enclosure).
Remote – using serial data link and 'snnvvvvv' command (see chapter 5). Remote configuration does not require enclosure opening.

Distance calibration: calibration procedure consists of placing a calibration reference target at a known distance to the transmitter (placed inside the enclosure at the bottom narrow end of the horn antenna). Execute calibration procedure remotely through serial connection (command "c008"") or using pushbuttons and LCD (see "Calibrate" screen)

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Velocity calibration: calibration procedure consists of placing a calibration reference belt loop device of a known velocity across the radar beam, intersecting the beam at exactly 45 degree angle (parameter "Angle" must be equal 45 degrees). CalDopp parameter has to be adjusted to match the known velocity with the measured velocity.

Temperature range: -20C .. +45C (estimate, not fully tested)
(Note: temperature drift of sensor output +/-5% over the full range, in the current evaluation version, firmware 0.23)

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3. Installation.

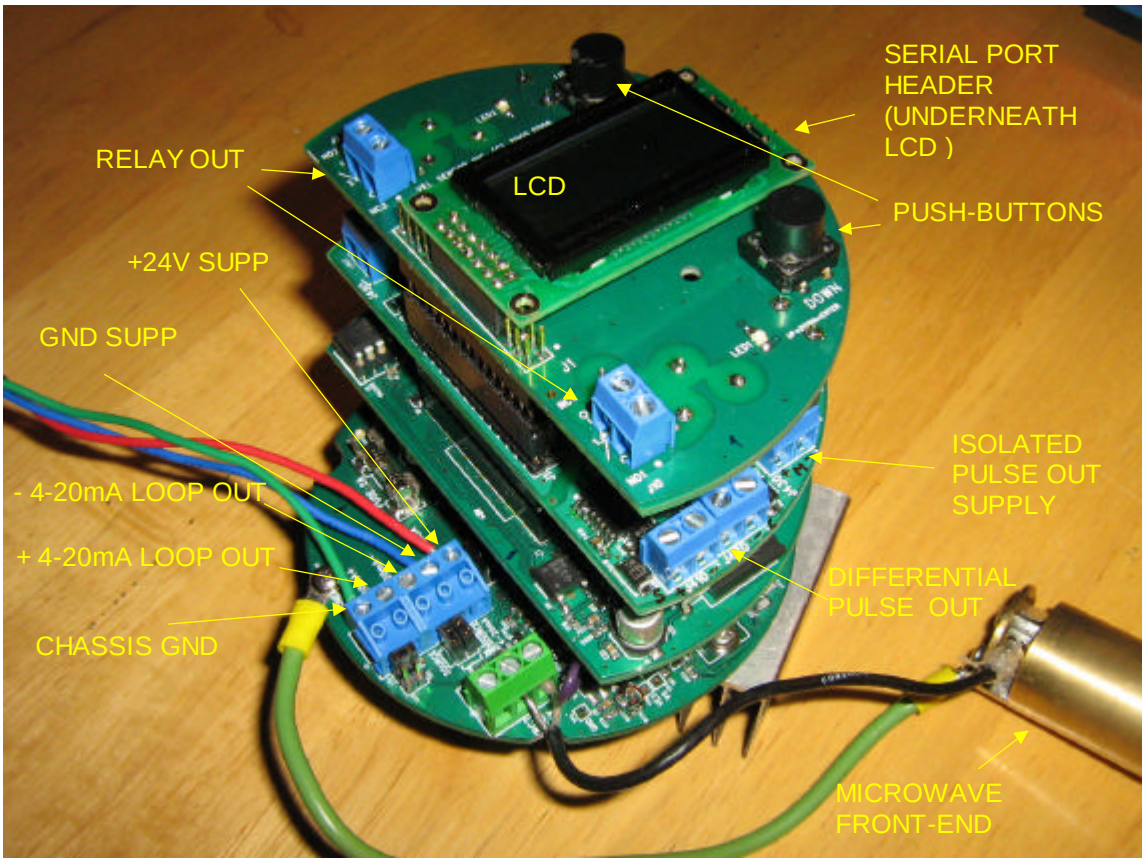

Fig.3. Inside the housing, board stack and connections. The boards are (bottom to top): Analog Driver and Power, CPU, Quadrature Pulse Output (optional) and LCD board.

Power and signal output cables (24V DC power and for example 4-20mA current loop or optional quadrature pulse output) are passed through the cable conduit port in the enclosure. +24Vdc power, ground and loop current connections are available on the 5 way detachable terminal block on the bottom board (see Fig.3). Pulse output terminals and relay terminals are mounted on different boards of the stack (refere to a separate manula for pulse output board and silnkscreen marking on the boards). Power the sensor up and set up the configuration parameters while the enclosure is open, using UP and DOWN push-buttons, and observe the LCD screen.

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4. Configuration screens and information screens.

The unit is equipped with a 2 lines by 8 characted LCD module. Two (UP and DOWN) push-buttons allow scrolling through a number of screens, and executing edit (ENTER) function by simultaneous pressing of UP and DOWN buttons. Some screens may require a 3-digit password number **(password number is hard-coded as 008)** to be entered before ENTER operation and parameter modification is executed. Any modified parameter is automatically saved in EEPROM within one measurement cycle (about 100ms).

The following list of screens is implemented as of the current version of the firmware

Dist Syy
x.xxx uu - Displays distance x.xxx in units indicated by characters uu = m , ft , in , cm or mm, and shows also the signal to noise ratio in yy field (00..99). This is the main and most important screen displaying the primary sensor output variable.

Vel mm/s
xxxxx - Displays target velocity xxxxx in mm/s units. This is the second most important screen displaying the secondary sensor output variable.

Loop
x.xxx mA - Displays the loop current in milliampers. Note: the loop current is a linear function of velocity (see above) determined by two set points by screens "Set 4mA" and "Set 20mA" and can be fine-tuned and calibrated to a high accuracy by two other screens "Trim 4" and "Trim 20". Note: this screen shows the current value that is internally set, not the actual current in the output loop circuit.

Status
…….. - Displays system status messages. The messages are scrolling automatically once every 2 seconds, and are automatically cleared (unless underlying condition reoccurs) every 10 seconds. The following conditions may be shown:

Hi Noise	- high noise level
Hi Sig	- radar echo is too strong
Low Sig	- radar echo is too weak
No Echo	- loss of radar echo
[blank]	- no messages, operating normally

Note: the above four screens will normally be displayed automatically after power up and would rotate every 2 seconds, for example "Dist Qyy" followed by "Vel mm/s" followed by "Loop" followed by "Status" (if there are messages to be displayed, otherwise skipped) and then again "Dist Qyy" and so on.

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Diagnost
…….. - Displays diagnostic messages. The messages are scrolling automatically once every 2 seconds, and are accumulating ("sticky"). The messages persist and are not cleared automatically even if the underlying condition that caused them ceases to occur. The message list is the same as for "Status" screen above. Messages can be cleared manually by executing ENTER [1] twice.

Totalizr
xxxxxxxx - Displays time integral of velocity, in mm units. This quantity represent the total integrated strip length. Execution of ENTER (twice) resets this value back to zero.

Freq Hz
xxxx.xx - Displays the frequency in Hz of the highest spectral peak of the signal spectrum. The frequncy is proportional to target distance.

FDopp Hz
xxxx.xx - Displays the Doppler frequency in Hz (related to velocity) of the moving target, based on the difference between the FFT spectrum obtained on the rising and the falling FMCW ramp.

TotAmpPP
x.xxx V - Displays total peak-to-peak voltage over the entire spectrum integrated over all frequencies excuding DC. Equivalent to RMS voltage times 2.83 .

SigAmp
x.xxx V - Displays peak-to-peak amplitude of the single largest peak signal.

Noise
x.xxx V - Displays peak-to-peak baseline noise amplitude in the spectrum, calculated around the base of the largest peak.

RawFreq
xxx.xx - Displays the raw unscaled target peak frequency (related to distance not to velocity) in units of FFT bins (0..512)

TX volt
x.xxx V - Displays a voltage applied to the microwave transceiver circuit. The voltage is set by a potentiometer on the bottom board (beside the

[1] ENTER function is triggered by pressing UP and DOWN buttons simultaneously. The top right character on the screen changes to "!" to indicate a pending ENTER condition. During a pending ENTER, a parameter value may be incremented or decremented or a list of selections may be scrolled (on some screens) using UP or DOWN keys. Subsequent execution of ENTER completes the sequence, and the exclamation character is cleared.

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fuse) for the maximum signal strength and clean uniform signal waveform. Typically it should be within tha range of 2.6-3.9V (for E2V components) or 5.8-6.3V (for MDT components). Note: it should not be adjusted by the user!

TX curr
xxx.x mA - Displays the microwave transceiver current (for diagnostics).

Temperat
xx C - Displays temperature inside the unit (Celsius)

SuppVolt
xx.xx V - Displays the supply voltage value. Should be 12-29V DC (for diagnostics).

Units
uu - Selects distance display units, from the list of: uu = mm , cm , in , ft/s and meters (m).

Damping
xxx - Selects the strength of the damping filter for the output velocity variable. The selection is: 1,2,4,8,16,32,…4096. Setting of a very high value makes the sensor response very slow but less noisy. Setting it to a low value makes the response fast but may make the distance reading and loop current output more noisy (if the target distance fluctuates or if the signal is unstable due to obstructions, process variability, tank filling etc). It does not affect velocity reading. Default value is 1.

Median
xx - Selects the length of the median filter acting upon the distance output variable (prior to the "Damping" filter). It filters out the "way-out" way-out readings caused by intermittent noise or signal fading. The selection is: 1,3,6,12 and 24. Setting a high value makes the distance output signal more stable but slows down the sensor response time. It does not affect velocity readings. Default value is 3.

SpectAvr
xx - Selects the length of power spectrum accumulation (Spectral Averaging): 1,2,4,8,16,32 and 64. Spectral Averaging acts as time filter upon every spectral frequency bin, prior to peak detection and prior to Median filtering stage. High value makes power spectrum more stable but acts as a low pass filter for the output variables distance and velocity. High spectral averaging value slows down the response time against quick changes in the distance and quick changes in velocity. It affects both distance and velocity readings. Default value is 4.

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FreqRng

xxxxxxxx - Selects internal A/D sampling range (F Nyquist) from the list of:

1) "Lo 3kHz"
2) " 6kHz"
3) " 12kHz"
4) " 29kHz"
5) "Hi 53kHz" - MUST USE THIS DEFAULT SETTING!
6) "by SetAD" - special manual adj using "Set A/D" screen

Changing FreqRng is equivalent to changing the A/D sampling rate. Note: current version of VelDist must have option number 5 selected! the other options exist for test purpose and should never be used.

Set 4mA

x.xxx uu - Set distance point for 4.00mA loop current. Since the (optional) pulse output board is set to output zero frequency at 4.000mA current, setting it to 0 will ensure that the zero pulse frequency always corresponds to zero velocity.

Set 20mA

x.xxx uu - Set distance point corresponding to 20.00mA loop current.

Raw Fmin

xxx - Set lower window boundary for spectral frequencies in 0..512 units (spectral frequency bin). The purpose of this variable is to limit the low frequency range (= low distance) to prevent detecting low frequency artifacts as valid target peaks. Note: permitted range is 1-510 (0=DC)

Raw Fmax

xxx - Set upper window boundary for spectral frequencies in 0..512 units (spectral frequency bin). Note: permitted range is 1-510 (512=Nyquist freq). The main purpose of Raw Fmin and Fmax setting is to prevent detecting spurious peaks. In particular, Fmax can be set to eliminate the target peaks beyond the maximal expected target range.

F Hz kHz

xxxx yyy - Display minimum frequency xxx (Hz) and maximum frequency range yyyy (kHz) corresponding to Raw Fmin and Raw Fmax settings, respectively (see the previous two screens above).

SysFault

xxx - Select exception-handling method in case of system faults or errors. The choice is:
"22mA" – set current loop output on 22.00mA
"3.6mA" – set current loop output on 3.6mA
"Hold" – hold a last good value on the current loop output

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LOEFault

xxx - Select exception-handling method in case of the Loss-Of-Echo situation. The choice is:
"22mA" – set current loop output to 22.00mA
"3.6mA" – set current loop output to 3.6mA
"Hold" – hold a last good value on the current loop output

LoopTst

xx.x - Current loop test. Press ENTER (UP&DOWN) and set a current value. Press ENTER again to exit. This is diagnostic feature to help calibrating the current loop receiver, chart-recorder, testing wiring connections etc.

Data Log

xxx - Select data logging frequency. The choices are: 2s, 10s, 1m, 10m, 1h, 3h and "Never". Each data record contains velocity, time stamp and some internal variables and flags. History log can be downloaded through RS232 diagnostic port and displayed with VelTerm.exe (utility program provided by www.velsensor.com), Windows' Hyperterm or similar. Maximum number of data records is 1008, beyond which the history file will scroll out the oldest data.

BaudRate

xxxxxx - Select the baud rate for diagnostic RS232 port. The choices are:
"9.6k NoH" – 9600 bit/s, no handshaking
"19.2k NoH" – 19200 bit/s, no handshaking (default, recommended for slow PCs)
…
"115k NoH" – 115000 bit/s, no handshaking (recommended for fast PC and when using RS232/USB interfaces)

Cal Dist

xxxx mm - Calibration reference distance in mm. Value of this parameter has to be equal to the actual distance to the calibration target used during calibration (see "Calibrate" screen). The distance should be measured by a tape or other calibrated device. This parameter is used only during calibration in order to calculate the "CalFac" parameter. It is not relevant outside of the calibration procedure.

Calibrate

Escape/Proceed - Start calibration procedure (when Proceed is selected). “Cal Dist” parameter is used as the actual known distance to calibration target. A calibration target could be for example a tank bottom if the tank is empty. The result of the calibration are calculated automatically and recorded as new value of "CalFac" parameter.

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CalOffs

xx.x mm - Calibration offset in mm units. Used in the linear formula that converts the signal frequency obtained from the FFT power spectrum to the target distance. This should almost always be set to zero except when a fine-adjustment of the zero point is necessary. This parameter should not be used for trimming the current loop or pulse board offsets. For current loop trimming use "Trim 4" and "Trim 20" screens. For the optional pulse output board trim use "I offs" screen.

CalFac

xxxx um - Calibration factor in um/Hz units. This is a multiplicative factor used in the linear formula that converts the signal frequency obtained from the FFT power spectrum to the target distance. Note: running of the calibration procedure (see "Calibrate" screen above) modifies and re-assigns this value!

CalDopp

xxxx mm - Calibration constant for velocity scale in (um/(s*Hz)). Since there is no velocity calibration procedure implemented in the current firmware, this value has to be set manually to match an observed known speed.

Angle

xxx.x dg - Beam incidence angle in degrees, between the antena direction and the strip edge. Allowed range is 0-89.9 degrees. This angle is used in the conversion of Doppler frequency f into velocity v by a formula:

v = (CalDopp*f)/cos(Angle)

Note: executing the distance calibration procedure ("Calibrate" screen) does not modify "Angle" nor "CalDopp" parameter.

FFT wind

xxxxxxx - Selection of FFT spectrum windowing method:

Rectangl - rectangular
Kais30dB - Kaiser window, suppressed side lobes by 30dB
Kais60dB - Kaiser window, suppresses side lobes by 60dB
K30dB80% - like Kais30dB but with 13.33% of data deleted from the top of the ramp, and 6.67% from the bottom of the ramp
Rect 80% - rectangular window but with 13.33% of data deleted from the top of the ramp, and 6.67% from the bottom of the ramp

TestFlgs

0 - Binary flags alowing activation of self-test options (factory use only). Do change from the default value: under normal operation must be =0.

Tsmp us

xxx.xx - Displays the actual A/D sampling time in microseconds.

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LoopTime

xxx.x ms - Displays the actual sensor update time (main loop time) in ms.

Set A/D

xxx - Alternative setup screen for setting the sampling rate clock divisor. Note: use this screen only for setting up a non-standard sampling rate, under normal circumstances use "FreqRange" screen for setting the velocity range and the A/D sampling time.

Trim 4

xxxxx - Setup of the current loop trimming parameter to calibrate the 4.00 mA point. Typical value is about 3300 (range 0-65534). While this screen is in the entry mode, the current loop is forced to output 4mA. The actual current should be measured with an ammeter and the paramater value has to be adjusted so that the current is exactly 4.000mA.

Trim 20

xxxxx - Setup of the current loop trimming parameter to calibrate the 20.00 mA point. Typical value is 59000 (range 0-65534). While this screen is in the entry mode, the current loop is forced to output 20mA. The actual current should be measured with an ammeter and the paramater value has to be adjusted so that the current is exactly 20.00mA.

Note: "Trim 4" and "Trim 20" screens are meant for fine-tunning of the accuracy of the current loop output circuit using an ammeter connected through the loop, such that when the LCD screen shows a certain current value, the actual loop current is exactly equal to that. This is not meant for setting the 4 and 20mA set points versus distance or for trimming the zero pulse frequency on the optional pulse output board. For that purpose screens "Set 4mA" and "Set 20mA", or "I Offs" should be used.

Min Amp

x.xxx V - Set the minimum Doppler signal amplitude (peak-to-peak volts). Signals that are smaller are ignored.

Gain

x - Set receiver gain 0-10, such that the signal amplitude is typically 0.15 to 1.5V. Default gain = 5

Set T

xxx.x C - Set temperature (factory calibration of temperature sensor offset). Must enter the actual (independently measured) temperature inside the enclosure.

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Set Vref

xxxx mV - Set internal voltage reference value (factory calibration only). Should be measured by a voltmeter on pin 1 of the 30-way header. Typically it should be about 3600mV .

SetR6/R3"

xx.xxx - set resistor ratio R6 /R3 for calibrating the ramp voltage scale. Resistor R6 is on VEL-DRV-3 board, R3 is on VEL-CPU-3 board. Typical ratio is 33k/5.6k = 5.9. This factor affects the operation of the Ramp Min, Max, Ramp1/8, 1/4 etc screens.

Set Rly1

x.xxx uu - Set the switching point for relay 1, in distance units, for "Dist Swi" selection (below). Setting a positive value causes relay 1 to switch ON when distance goes above the set value. If the set value is negative, relay stays on when the distance is lower, and switches OFF when the distance is higher than the absolute value set. When the value set is exactly zero then the relay is disabled (always OFF). This parameter is ignored when Rly1Mode is not "DistSwi".

Rly1Mode

xxxxxxxx - Select relay 1 mode of operation from the list of:

1) "DistSwi" - switching on distance threshold as set by **SetRly1** screen
2) " LOE " – switch ON on Loss Of Echo condition
3) "No LOE" – switch OFF on Loss Of Echo condition
4) " Fault " – switch ON when a fault occurs that invalidates the measurements (including LOE).
5) "No Fault" – switch OFF on fault (including LOE)

Set Rly2

x.xxx uu - Set the switching point for relay 2, in distance units, for "DistSwi" selection (below). Setting a positive value causes relay 2 to switch ON when distance goes above the set value. If the set value is negative, relay stays on when the distance is lower, and switches OFF when the distance is higher than the absolute value set. When the value set is exactly zero then the relay is disabled (always OFF). This parameter is ignored when Rly2Mode is not "DistSwi".

Rly2Mode

xxxxxxxx - Select relay 2 mode of operation from the list of:

1) "DistSwi" -switching on distance threshold as set by **SetRly2** screen
2) " LOE " – switch ON on Loss Of Echo condition
3) "No LOE" – switch OFF on Loss Of Echo condition
4) " Fault " – switch ON when a fault occurs that invalidates

the measurements (including LOE).
5) “No Fault” – switch OFF on fault (including LOE)

T(days)
xxxx - Displays the total working time in days, from the first factory power up.

Dist Rng
xxx.xx m - Displays the actual calculated maximal distance range in m (the max range depends on the calibration coefficient).

Ramp Max
xx.xxx v - Set the maximum voltage level for FMCW ramp (frequency sweep ramp). Must be less than the TX voltage. Typical value is -1V to +2V.

Ramp 1/8
xx.xxx v - Set the ramp voltage offset (from the linear) at 1/8 distance from the ramp start.

Ramp 1/4
xx.xxx v - Set the ramp voltage offset (from the linear) at 1/4 distance from the ramp start.

Ramp 2/4
xx.xxx v - Set the ramp voltage offset (from the linear) at 1/2 distance from the ramp start.

Ramp 3/4
xx.xxx v - Set the ramp voltage offset (from the linear) at 3/4 distance from the ramp start.

Notes: the distances expressed as 1/8,1/4 etc are fractions of the total ramp length (typ 9.2ms). The purpose of the above offset values is to define a non-linear ramp profile. The ramp is defined in terms of piecewise linear subsections but the actual ramp profile is additionaly smoothed out using a runing average filter of 1/4 length. Whenever trasmitter voltage is adjusted by a potentiometer "Vtx P5" on the VEL-DRV-3 board, ramp profile must be regenerated by re-booting the sensor, re-powering or re-entering one of the offsets (or Ramp Min, Max).

Ramp Min
xx.xxx v - Set the minimum voltage level for FMCW ramp (frequency sweep ramp). Typical value is -11 to -5V.

0.001%/K
xxxxx - Overall Temperature Correction factor in 0.001%/K units, the range is -32768 to +32767. This permits correcting the temperature drift and

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affects the display variable "Distance", the primary sensor variable returned by the serial port (V command) as well as the 4-20mA output scaling. It would affect also the associated quadrature pulse frequency output (if VEL-PULSE-3 board is plugged in).

Itempc/K
xxx.xx uA - Temperature Correction factor for current loop output in uA/K. This parameter is meant for correcting the thermal drift of the loop current output circuit . Note: for correcting the overall thermal drift of the sensor use the previous screen parameter. ("0.001%/K").

I offs
xxx.xx uA - Constant offset correction for the loop current output in uA. Main purpose of this screen is to correct the pulse output board offset if necessary (pulse board converts loop current to frequency and ought to output zero frequency for the 4.000mA loop current)

VelDist
Rel. x.xx - Displays the product name and the firmware revision number x.xx. Displays additional product information in the bottom screen line (scrollable) when ENTER is pressed. Current firmware revision is 0.23.

5. PC Host Application 'VelTerm.Exe'

VelTerm is a PC host based application which interfaces to the velocimeter via a serial RS232 connection available through the 10-way 2.54mm DIL header (see also connection diagram at the end of this chapter).

The operation in principle is quite similar to commercially available terminal emulators such as Hyperterm however; VelTerm has some built in functionality for visualization and exporting of the velocimeter data. The main screen presented to the user is as follows.

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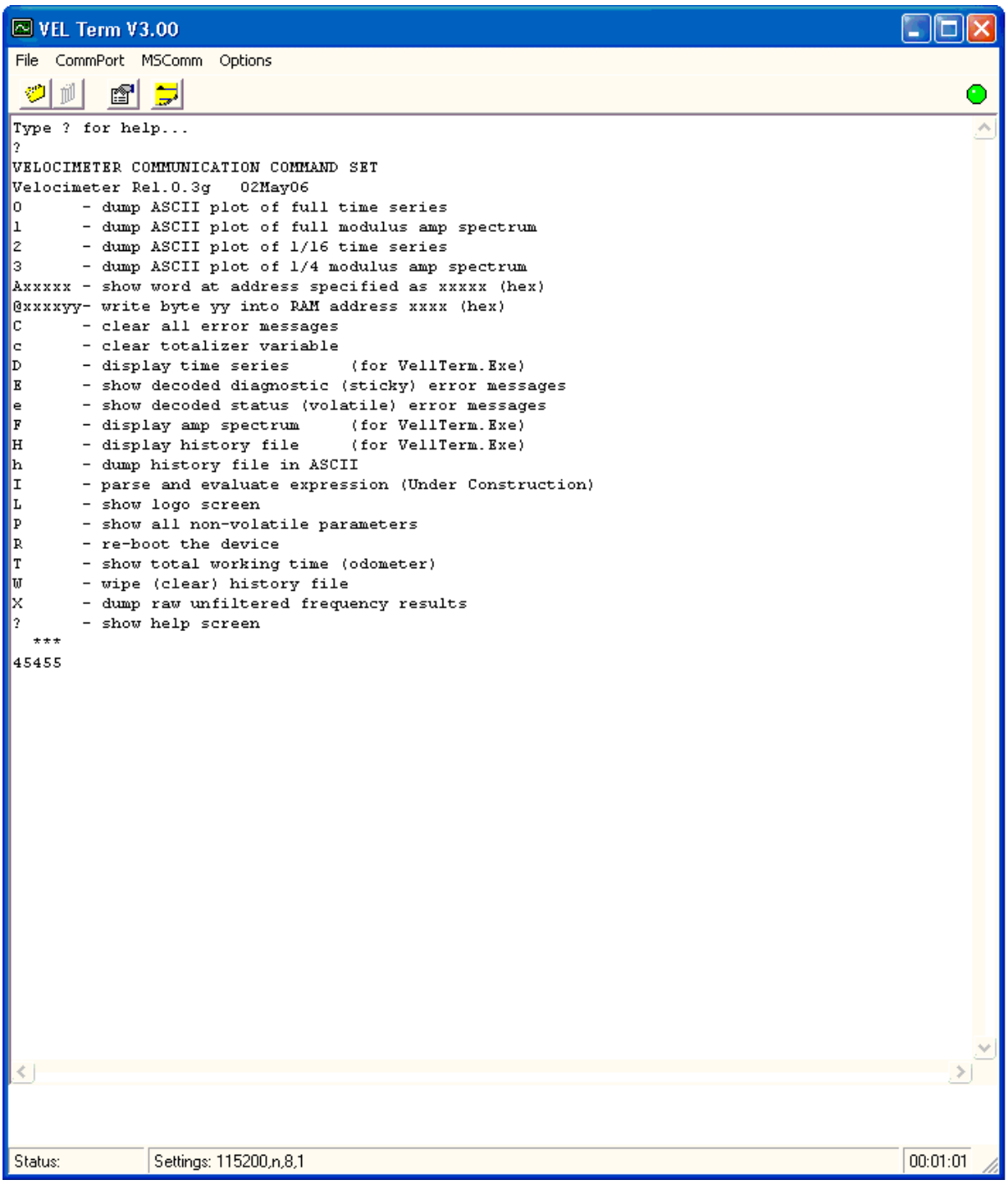
The easiest way to get an overview of VelTerm operation is by pressing the question mark **'?'** key. This will update the screen with a list of VelTerm commands as listed below.



The main data visualization features which are useful for diagnostic and data analysis are 'D', 'F' and 'H'.

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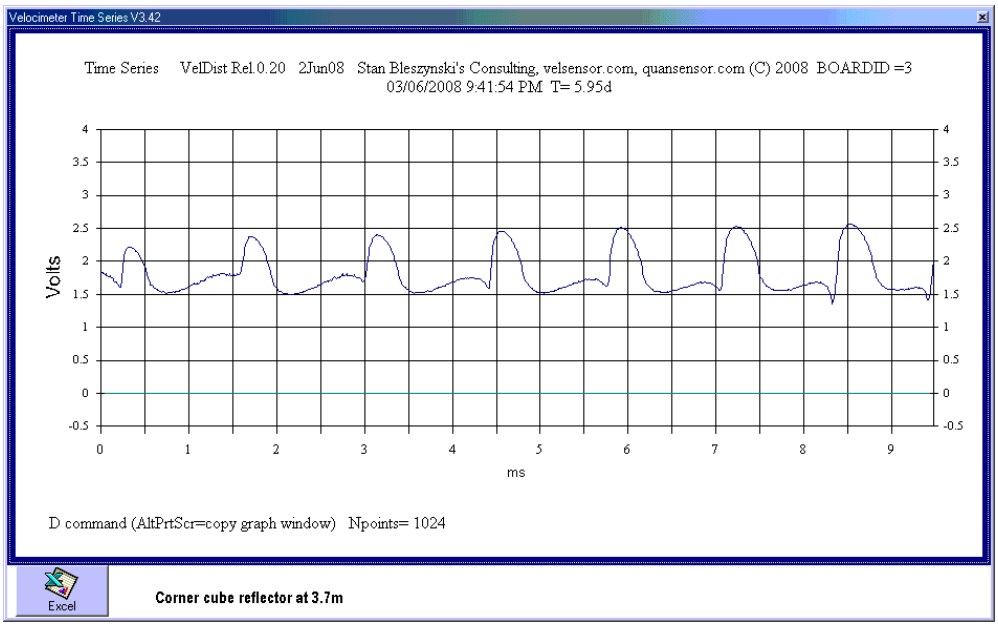
'D' Command

The 'D' command downloads a raw time series data from the sensor and displays a chart of voltage vs. time. This feature is particularly useful for installation and adjustment of the unit and essentially emulates an oscilloscope. This can facilitate adjustment of the unit such as to maximize signal strength (voltage amplitude).



The 'Excel' button in the lower left hand corner of the screen launches Microsoft Excel, creates a new workbook and automatically populates two columns of data with time in ms as the independent variable and voltage as a function of time as the dependent variable. This feature allows the customer to use the features of Excel for further data analysis or visualization as per their own unique requirements.

Each time D command is executed, a buffer of 1024 data points collected during FMCW sweep ramp is displayed. Data gathered during the rising and the falling ramps are displayed alternatively, that is if first D displays the rising ramp data, a subsequent D will display falling ramp etc.

Note: down ramp data can be distinguished from the up ramp data by having the longer flat margin at the left (only when "FFT win" = "K30dB80%" or "Rect 80%")

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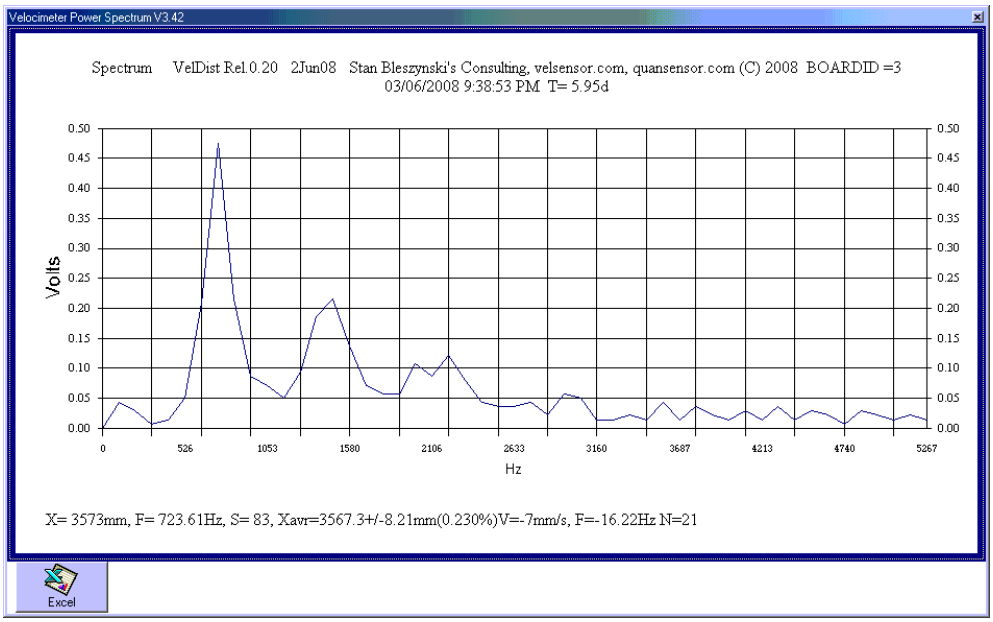
'F' Command.

The 'F' command provides the frequency domain equivalent of the 'D' command in that it is also a visualization tool to assist installation and troubleshooting but in this instance it displays a Fourier spectrum of the data and displays signal power as a function of frequency. In this regard it is basically like an on board Spectrum Analyzer.



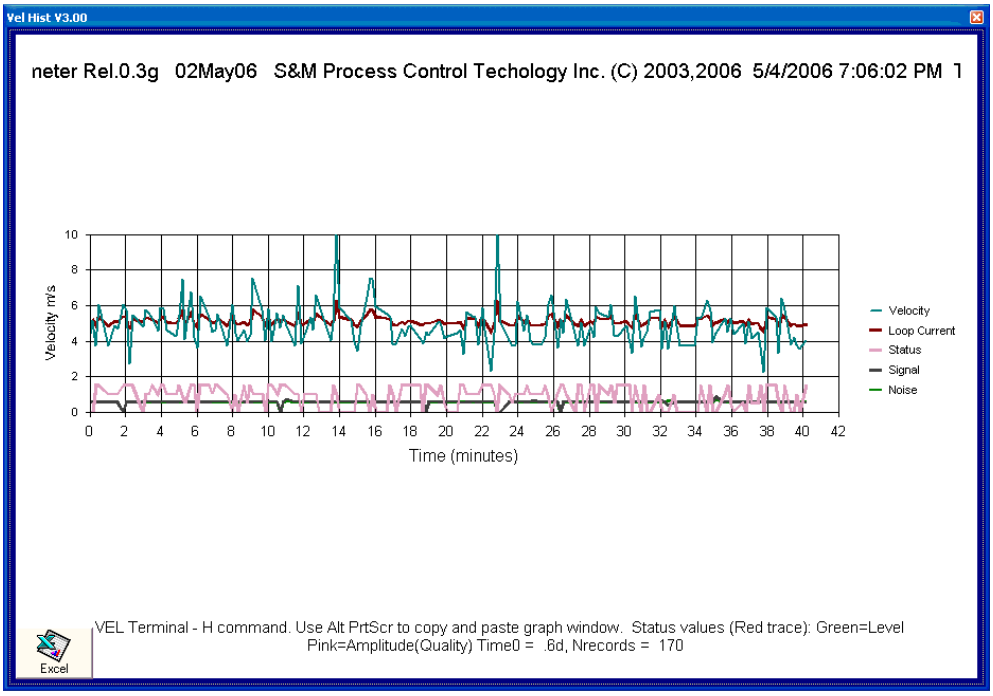
Again, the Spectral display screen contains a button to facilitate exporting the data to Excel. In this instance, two columns of data are populated on the spreadsheet, the independent variable is frequency in Hz and the dependant variable is in volts squared as a function of frequency i.e. V^2(Hz) which represents units of energy spectral density. The spectral peak in the plot above represents the Doppler frequency of a real moving target. These frequency peaks are subsequently calibrated internally in the Velocimeter unit and converted to report results in units of target velocity (m/s, ft/s etc.)

Each time F command is executed, a buffer of 1024 data points collected during FMCW sweep ramp is FFT'ed and displayed. The rising (up) and falling (down) ramp spectra are displayed alternatively, that is if first F displays the rising ramp spectrum, a next F will display the falling ramp spectrum etc. Note: the down ramp spectrum can be distinguished (from the up-ramp) by having its zero frequency component always zeroed.

'H' Command.

The Velocimeter unit contains an internal EEPROM which facilitates data logging. At user defined intervals, the unit will take a snapshot of

primary process variables. These, together with some system and environmental variables and error messages are time-stamped and logged in EEPROM. The ‘H’ command provides a means for the end user to read the contents of the EEPROM, display them in tabular and graphical format and also to export them to Microsoft Excel. After the data is read in from the system, VelTerm will launch the following graph. The graph contains various information relating to the primary process variables together with diagnostic information.



Again the graph has a button which exports the logging history to Excel. This appears as follows:

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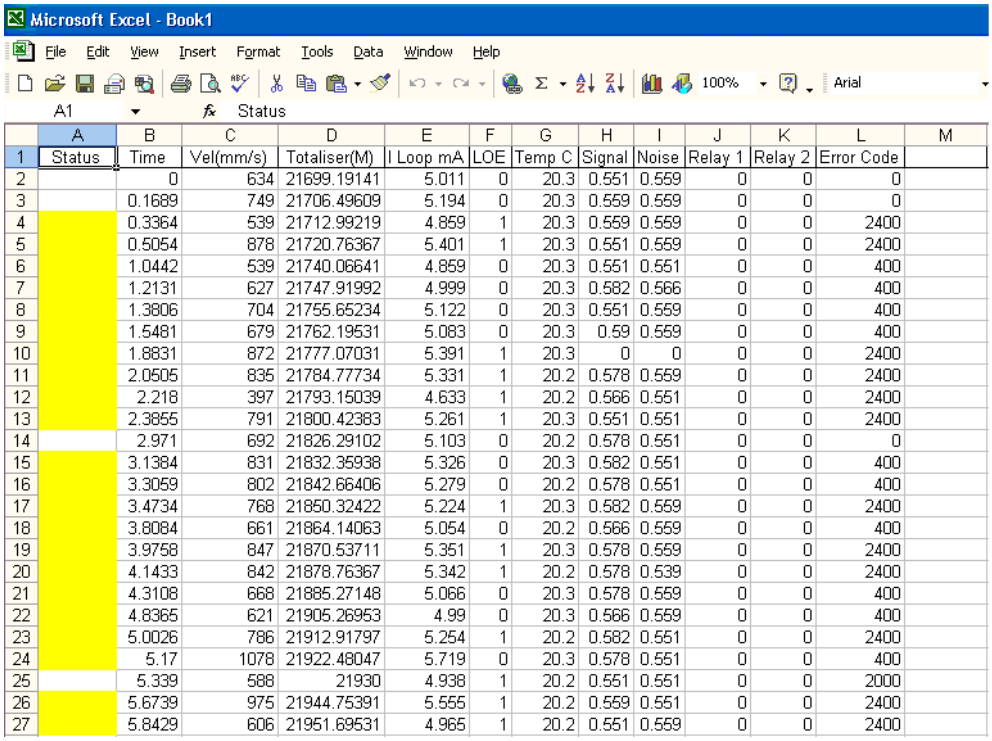

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Window Help

A1 Status

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Status	Time	Vel(mm/s)	Totaliser(M)	I Loop mA	LOE	Temp C	Signal	Noise	Relay 1	Relay 2	Error Code	
2		0	634	21699.19141	5.011	0	20.3	0.551	0.559	0	0	0	
3		0.1689	749	21706.49609	5.194	0	20.3	0.559	0.559	0	0	0	
4		0.3364	539	21712.99219	4.859	1	20.3	0.559	0.559	0	0	2400	
5		0.5054	878	21720.76367	5.401	1	20.3	0.551	0.559	0	0	2400	
6		1.0442	539	21740.06641	4.859	0	20.3	0.551	0.551	0	0	400	
7		1.2131	627	21747.91992	4.999	0	20.3	0.582	0.566	0	0	400	
8		1.3806	704	21755.65234	5.122	0	20.3	0.551	0.559	0	0	400	
9		1.5481	679	21762.19531	5.083	0	20.3	0.59	0.559	0	0	400	
10		1.8831	872	21777.07031	5.391	1	20.3	0	0	0	0	2400	
11		2.0505	835	21784.77734	5.331	1	20.2	0.578	0.559	0	0	2400	
12		2.218	397	21793.15039	4.633	1	20.2	0.566	0.551	0	0	2400	
13		2.3855	791	21800.42383	5.261	1	20.3	0.551	0.551	0	0	2400	
14		2.971	692	21826.29102	5.103	0	20.2	0.578	0.551	0	0	0	
15		3.1384	831	21832.35938	5.326	0	20.3	0.582	0.551	0	0	400	
16		3.3059	802	21842.66406	5.279	0	20.2	0.578	0.551	0	0	400	
17		3.4734	768	21850.32422	5.224	1	20.3	0.582	0.559	0	0	2400	
18		3.8084	661	21864.14063	5.054	0	20.2	0.566	0.559	0	0	400	
19		3.9758	847	21870.53711	5.351	1	20.3	0.578	0.559	0	0	2400	
20		4.1433	842	21878.76367	5.342	1	20.2	0.578	0.539	0	0	2400	
21		4.3108	668	21885.27148	5.066	0	20.3	0.578	0.559	0	0	400	
22		4.8365	621	21905.26953	4.99	0	20.3	0.566	0.559	0	0	400	
23		5.0026	786	21912.91797	5.254	1	20.2	0.582	0.551	0	0	2400	
24		5.17	1078	21922.48047	5.719	0	20.3	0.578	0.551	0	0	400	
25		5.339	588	21930	4.938	1	20.2	0.551	0.551	0	0	2000	
26		5.6739	975	21944.75391	5.555	1	20.2	0.559	0.551	0	0	2400	
27		5.8429	606	21951.69531	4.965	1	20.2	0.551	0.559	0	0	2400	

The leftmost column ‘Status’ is color coded and represents a status flag for the current data sample, the legend is Red = Fatal Error, Orange = Warning, Yellow = System Information. The next column is the timestamp which is in units of the Velocimeter system timer which is currently approximately equal to 87 mS. The next column is velocity reported in mm/s followed by the totalizer value which represents integrated strip length in metres. The I Loop mA column contains the output current on the 4-20mA current loop. The LOE column contains a flag variable which indicates ‘Loss of Echo’ condition associated with the current data sample. Temp C is the Velocimeter internal temperature as measured by the on board temperature sensor. Signal and noise represent the instantaneous Doppler signal amplitude and spectral background noise and are expressed as dimensionless values between 0 and 1. Relay1 and Relay2 are flags representing the status of the on board relays which are user programmable to trip under predefined conditions. Finally the Error code column is a hexadecimal value where each bit is mapped to a specific error, warning or information condition.

Other useful commands:

E - display decoded system status and duagnostic messages in plain English (sticky, non-volatile). Use 'C' command to clear.

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C - clear diagnostic and status codes (affects 'E' command)

e - display decoded system status and diagnostics in plain English. This is instantanous status updated/refreshed or cleared automatically every 10 seconds.

V – displays results in ASCII format in 2 lines of text. First line containing distance in mm, velocity in mm/s, signal quality S (arbitrary units 00..99), 8 digit status code (hex), average spectral peak frequency in Hz and differential (Doppler) frequency. The format is position-fixed usinf printf C language syntax of:

```
"Dist=%6ldmm Vel=%6dmm/s S=%02u stat=%08lX
Favr=%5lu.%02uHz Fdif=%6ld.%02uHz"
```

The second line contains

```
"  ***  \r\n xxxxx\r\n"
```

where xxxxx is the inverted 16-bit checksum of the entire block of data sent (using 8-bit ASCII codes), preceeding the checksum (but excluding the checksum string of numbers itself).

This command can be used by a host controller or a network master server to asynchronously poll the sensor output variables and the sensor status. The output is sent within the next measurment cycle time from the time of sending the command, that should be about 100ms.

{ - begins continous (auto-repeat) display of “V” command output every 2.0 seconds. The format of the data is the same as the first line of the "V" command output, but without the second line (no checksum).

} - ends the above command (‘R’ command or power reset also terminate it)

[- begins continous (auto-refresh) graphic display of power spectrum, similar to “F” command, refreshing automatically every 2.0s. Note: the power spectrum alternates between falling and rising slopes of FMCW sweep ramp. Normally both slopes produce similiar data and similar spectra but a small differences may be observed, especially if the target moves. The down ramp spectrum can be distinguished (from the up-ramp) by having its zero frequency component always zeroed.

] - ends the above comand (‘R’ command or power reset would also terminate it)

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P - shows the list of all internal configuration parameters and values. This is important command that should be executed every time the sensor is reconfigured and the configuration data should be captured and saved (use File-->Open Log/Close Log menu in VelTerm.exe).

S - list all configurable parameter numbers that can be accessed through “s” (lowercase s) command. Displays the command formats and parameter ranges.

s - assign a new value vvvvvv to a parameter number nn. The command format is: snnvvvvvv where nn is the parameter number nn=14..50 (use “S” command to disply the list), vvvvvv is 6 digit decimal parameter value to be assigned. All 6 digits must be passed, the leading zeros must be inserted explicitly. If the value is negative the first v may be minus sign for example -6 value is entered as 'snn-00006'. A modified parameter is automatically saved in EEPROM within one measurement cycle (100ms).

The ‘snnvvvvvv’ command allows configuring the sensor through the digital remote serial link rather than using push-buttons and LCD interface. For example s19000004 command causes the Damping filter to be assigned a value of 4 (which produces a 16 cycle long averaging16=2^4). Another example useful for installation testing is the loop test command such as: s29000201. It forces the loop output to 20.1mA current (and also forces the optional quadrature pulse output) until sending s29000000 restores the normal operation (it would time out after 5 minutes, also ‘R’ command or power reset would cancel s29). Note: the allowed range for loop current is 3.6..25.0mA (with accuracy degraded beyond 21mA).

h - similar to H command but dumps history data in ASCII text format that can be captured by a terminal program in text mode (without using VelTerm.exe graphics.

W - wipe (erase) all history file.

c008 - start distance calibration procedure (008 = password). The sensor must be pointed to a strong reference target at a known distance. The target distance has to be entered as s36xxxxxx parameter value, prior to the execution.

X - dump the buffer contents of consecutively measured (every 100ms) unfiltered distance values in internal units (0..51200).

x - dump the buffer contents of consecutively measured (every 100ms) unfiltered velocity values in internal units (0..51200).

R - reboot the sensor CPU and reload firmware. Clears any pending command. The same effect as power reset.

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6. RS232 Data Link Port

UART port for diagnostics, data transfer and configuration is available through the 10-way 2.54mm DIL header going through the entire board stack. It can be accessed from the top board. A photo below shows the 10 way header on the top above the LCD panel.

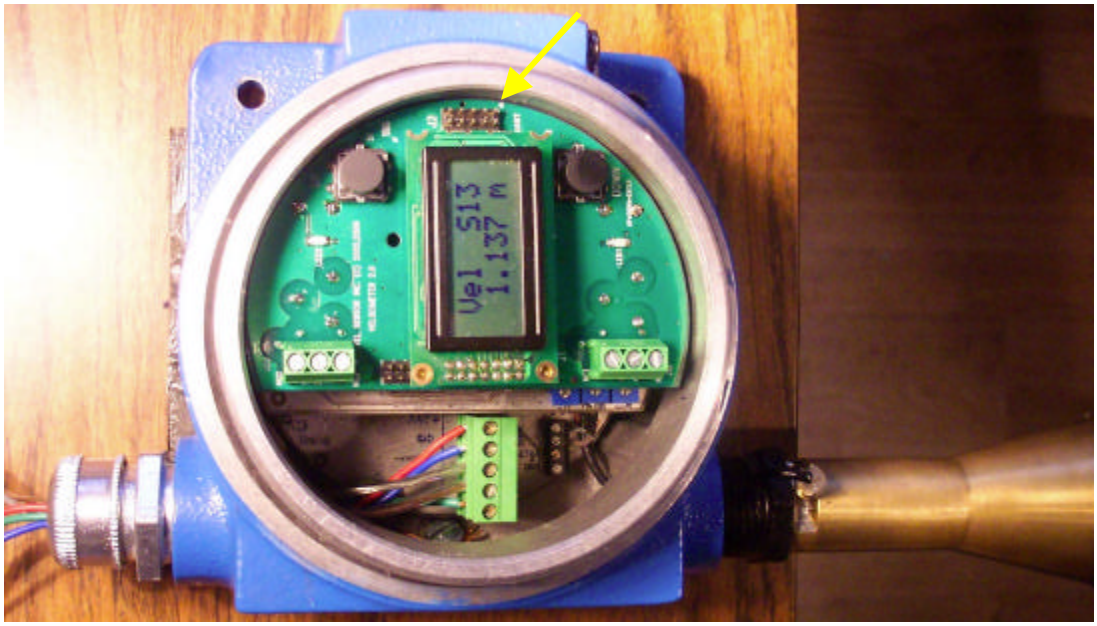

Fig. Sensor top board view (serial port shown by a yellow arrow)

+3.7V	1	2	CTS1/RTS1
CLK1	3	4	**RXD1**
CE	5	6	EPM
GND	7	8	-RST
CNVss	9	10	**TXD1**

Table 1. Pin-out of 10-way serial port header. The serial port conforms to 0-3.7V signal levels (3V TTL UART).

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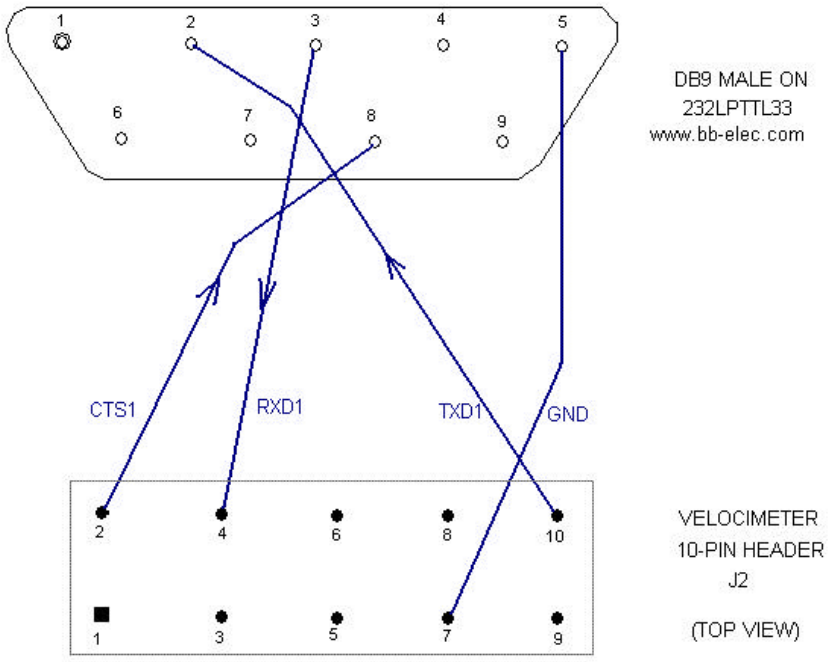
Wiring diagram for the serial port connection.

Serial port as is provided by the sensor has 0 to 3V digital signal levels. Use TTL-to-RS232 converter to translate the digital levels to RS-232 standard, for example "232LPTTL33" product from http://www.bb-elec.com .



Note: only RXD1, TXD1 and GND are required for RS232 data link, other pins are used for in-circuit programming. RS232 data format is 1 start bit, 8-bits, no parity, 1 stop bit and no handshaking, allways ASCII (32-127), byte values >127 are not used. Baud rate is software selectable from 9600, 19200 (default, for slow ports), 57kbaud (recommended) to 230kbaud (works only on fast PC's when using USB/RS232 interfaces).

Note 2: when data link cable has to be substantially longer than 10m, it is recommended to connect the 232LPT33 (TTL-to-RS232) interface on the cable within a few meters from the sensor and then connect another cable-inteface RS232-to-USB within a few meters from it. RS-485 interface may also be used.

7. Mounting, Installation and Application Notes. (to be finished)

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