



SHOTTRACK VOD305

HIGH RESOLUTION TDR VOD MEASUREMENTS

ShotTrack® high speed TDR measurement systems
ShotTrack VoD305 patent pending.

SPECIFICATIONS:

Unit specifications:

- Instrument type: One channel - Time-domain reflectometer
- Consumable: Low cost standard co-axial cable
- Pulse type: Negative 6 volts (note2)
- Power supply: 7.6-volt LION battery (> 12 hours' operation from full charge) (note2)
- Size: 18 x 7 x 4 cm
- Weight: 0.75 Kg
- Display: 4 character 7 segment bright LED display
- Indicators: Multi LED status indicator in ON/OFF button
- Charging: Intelligent internal LION battery charger On and Charging indication
- Sample rate: 256 KHz
- Dead zone: First 40 meters of cable.
- Sample storage size: 1024000 samples @ 16 bit
- Timing: GPS synchronized timing. (note3)
- IP Rating: IP 67
- Use: VoD measurement at site above or under ground
- Communications: USB or Bluetooth long range wireless

GPS Specifications:

- 72-channel u-blox M8 engine,
- GPS L1C/A, SBAS L1C/A, QZSS L1C/A, GLONASS L1OF, BeiDou B1

Horizontal position accuracy:

- Autonomous 2.5 meters SBAS 2.0 meters

Accuracy of time pulse signal

- RMS 30 ns 99% 60 ns

Wireless Specifications:

- Bluetooth 2.1 + EDR
- Transmit power +20dBm Receive sensitivity -90dBm
- Range 1000 meters (with Long Range Bluetooth modules each end)

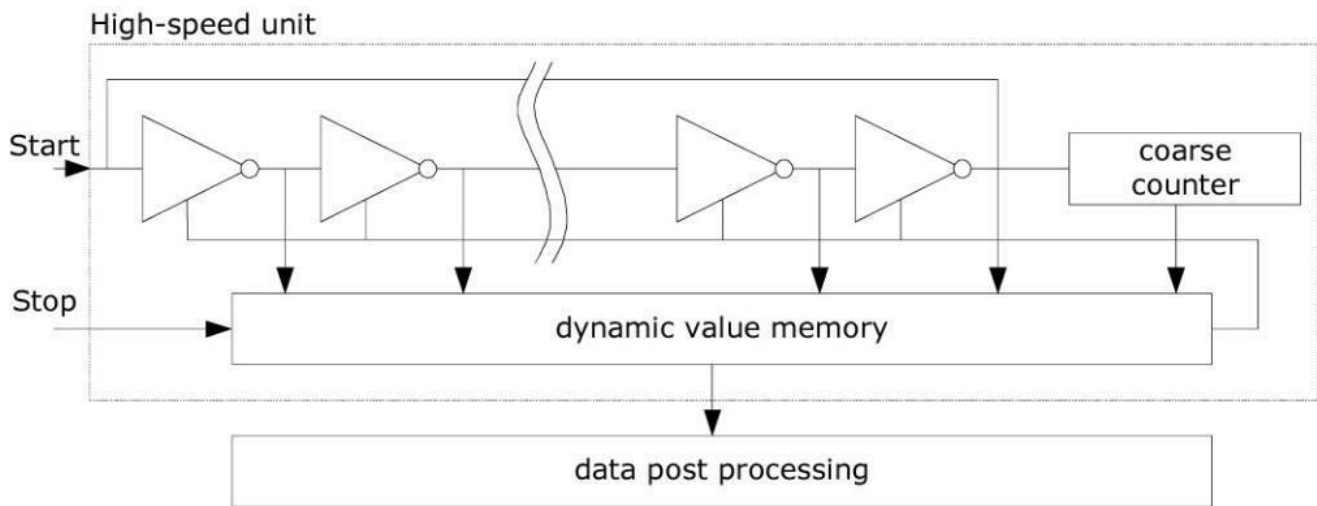
USB

- USB 2.0 High Speed

THEORY OF OPERATION

The ShotTrack Mini uses a dedicated TDC (Time to Digital Converter) chip for accurate timing measurements.

Digital TDCs use internal propagation delays of signals through gates to measure time intervals with very high precision. The diagram below clarifies the principal structure of such an absolute-time TDC. Intelligent circuit structures, redundant circuitry and special methods of layout on the chip make it possible to reconstruct the exact number of gates passed by the signal. The maximum possible resolution strongly depends on the maximum possible gate propagation delay on the chip. ^{Note4}



An output pulse is generated by the high speed field programmable gate array device which is injected into the cable. After a precise “guard time interval” the Time to Digital Converter is supplied with a start pulse. The detector circuit then produces a “stop” pulse when the original injected pulse is reflected from either an open or short circuit back to the unit. This “stop pulse” halts the Time to Digital Converter and the time elapsed is saved.

This sequence is repeated at 256 KHz until a reduction of cable length of 10 nanoseconds is received and a total of 507,000 samples have been recorded after the trigger. There is a pre-trigger of 5000 samples making a total of 512,000 samples which equates to a record time of 2 seconds.

The BIN size (LSB) is typically 90 picoseconds at 3.3 V and 25 °C ambient temperature. The RMS noise is about 60 picoseconds (0.7 LSB). The gate propagation delay times strongly depend on temperature and voltage. This is compensated for by an internal calibration.

As the temperature cannot be known for the trigger time (normally there is a substantial delay between the unit setting itself and the shot firing time) a further calibration is done after the unit has triggered and the data is compensated accordingly.

This time vs. temperature compensation is conducted for the “Time to Digital” converter along with the “propagation Delay” for the Pulse generation and detection circuitry.

SYNCHRONIZED TIMING

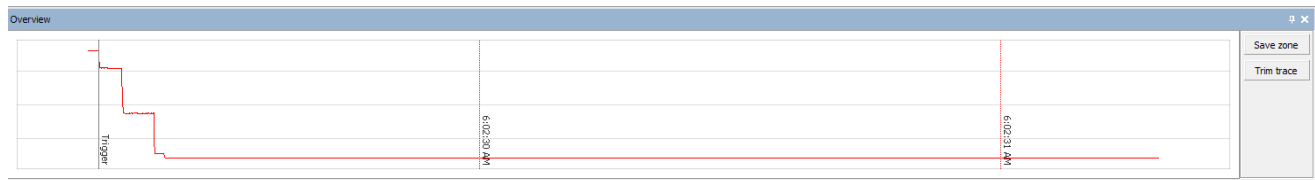
The ShotTrack Mini uses a dedicated GPS module to produce a Pulse per Second (PPS) signal that is embedded into the data. Every sample period at the sample rate of 256 KHz (3.90625 microseconds) the PPS is checked and the state embedded into the sample data. The leading edge of the PPS pulse represents the UTC second time stamp. This then “time stamps” the data to an accuracy of 3.90625 microseconds. The PPS timing is displayed on the Overview bar of the software suite.

This “time stamp” is compatible with the ShotTrack ViB monitor and allows synchronized timing between the data captured by the VoD and ViB units.

The relationship between the data saved for the Vibration Monitor and the VoD Monitor is scalable. At the Maximum sample rate of the vibration monitor of 64 KHz there will be exactly 4 VoD samples for each vibration monitor sample. For 32 KHz there will be 8 VoD samples etc. This allows for data to be time aligned and the PPS will aid in matching the data sets to give an accuracy of the slowest sample. This would be 15.625 us when using the highest vibration monitoring frequency.

If the VoD monitor cable is inserted into the first (initiating hole) of a blast, then propagation times can be measured from the blast initiation to the vibration monitor sites with an accuracy of 5.625 us.

DATE AND TIME



Date and time information comes from the GPS module. If the GPS has acquired enough satellites to get a fix, then this information comes directly from the latest GPS data otherwise it comes from the RTC on the GPS unit.

Providing there has been at least one GPS fix since the batteries are installed or recharged from completely flat then the Time and Date will be accurate to the internal RTC accuracy updated from the last GPS fix.

Start and Trigger times will therefore be accurate to 3.90625 microseconds when GPS data is available and to a degraded accuracy if there has been no GPS fix over an extended time.

If using underground, then switching the unit on for a few minutes above ground will synchronize the RTC and produce as accurate timing as possible.

COMMUNICATIONS

USB

Plug in cable to rear of unit.



BLUETOOTH

Switch unit on



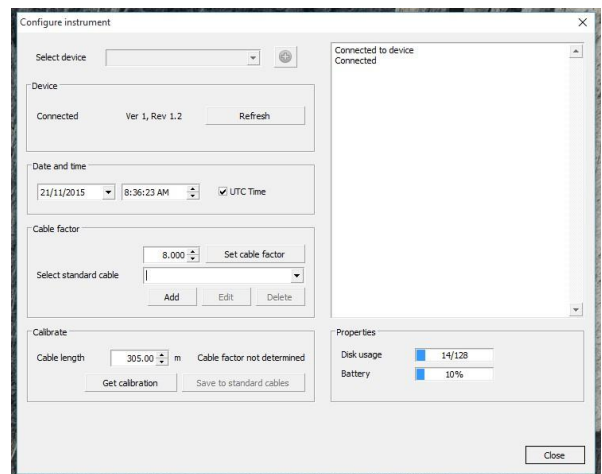
Whichever communications mode is used USB or Wireless the unit connects to ShotTrack VoD software suite.

These configuration commands are possible.

- **Calibrate unit to types of cable:** Interrogate unit for cable return time for calculation of cable factor.
- **Upload the configuration factor to unit:** Set unit to cable factor.

The unit sends various operation conditions to the software.

- **Time set in unit:** This can be viewed as UTC or Local time
- **Current Cable factor:** This is the cable factor set in the unit
- **Firmware version:** Current firmware version.
- **Disk usage:** This shows the number of files saved and the maximum possible
- **Battery:** Percentage of battery life remaining.



OPERATION

- The unit should be placed where it is intended to be left for the shot and the cable connected.
- The unit is then turned on with a 1 second or longer press of the ON/OFF button. The Button illuminates Blue and then should be released.
- The unit will display the battery condition “capacity left” 10 to 100% for 6 seconds.
- The unit starts measuring the cable length and shows this length on the display.
- After 1 minute if a valid cable length is detected the unit will SET itself.
- The SET date and time is retrieved from the GPS module when valid.
- The ON/OFF button will illuminate RED to indicate that the unit is SET.
- The display will be turned off.
- When the unit is triggered ON/OFF button illumination is extinguished to indicate a successful trigger and the unit will enter “wait after trigger mode”.



If after reading the triggered data, the unit detects that the cable has returned to its original length then the unit will RE-SET itself assuming a transient trigger condition has falsely triggered the unit (for example a truck running over the cable)

- The unit will then enter a ½ hour “wait after trigger mode” to allow for a Bluetooth connection to download the data if required. The button will flash slowly in this state.
- After this period has expired the unit switches itself off.

The Button illumination in DISPLAY and WAIT AFTER SHOT states flashes RED when not connected to Bluetooth or BLUE if connected. The unit will not enter the SET state from DISPLAY mode when connected to a Bluetooth device. If a Bluetooth connection is initiated while the unit is in SET mode awaiting a trigger, then the unit resets itself to DISPLAY mode. When the Bluetooth connection is disconnected the unit will SET itself after 1 minute.

SWITCHING UNIT OFF

- Press the ON/OFF button holding the button on for an extended time (3 seconds). When the button illuminates Blue release the button and the unit will switch itself off. The unit will switch off from DISPLAY, SET, WAIT AFTER SHOT or Calibrate cable states.

To retrieve the data, the unit can be plugged into a USB port while the unit is switched off or by initiating a Bluetooth connection when the unit is switched on.

Up to 64 events can be stored before the saved data has to be erased to make room for another 64 events.

CALIBRATING UNIT TO A FULL CABLE REEL

- Connect a full 305 meter (1000 foot) cable to unit
- Press ON/OFF Button for 7 seconds
- Unit display shows a flashing 8888 to indicate calibration start
- Release Button
- The current temperature will be displayed after 5 seconds and updated every two seconds until a stable temperature has been detected.
- The unit is then calibrated to the cable.
- The calibration factor to 3 decimal point is shown for 10 seconds.
- Unit switches off.
- At any point the operation can be cancelled by pressing the ON/OFF Button for three second

Note1: Based on a VoD of 5000 meters per second.

Note2: compliant for use with electronic and electric detonator systems

Note3: Enhanced accuracy when GPS "Fix" valid otherwise accurate to GPS internal RTC

CHARGING:

The ShotTrack VoD mini has an internal 7.4 volt 4 aH LION battery.



Charging is accomplished by plugging a standard 12-volt plug pack into the right hand rear socket.

When the plug pack is connected and switched on the right hand LED on the display panel is illuminated. The left hand LED is on while the battery is charging and is extinguished when the battery is fully charged.

TRADEMARKS

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PATENT PENDING

ShotTrack VoD 305

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