



KONGSBERG

Kongsberg Mesotech Ltd.

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1. PURPOSE

This document briefly describes the digital telemetry standards, formats and protocols implemented in our MS1000-compatible line of digital telemetry single beam sonar system products.

2. ACRONYMS AND ABBREVIATIONS

The following abbreviations and acronyms are freely used in this document:

KML	Kongsberg Mesotech Ltd.
TIA	Telecommunications Industry Association
EIA	Electronics Industry Association
ADC	Analog to Digital Converter
bps	bits per second (baud rate)
lsb	least significant BIT
msb	most significant BIT
...H	suffix indicating a Hexadecimal value

3. SERIAL COMMUNICATION CONCEPTS

3.1 Downlink and Uplink

The terms downlink and uplink are used to indicate the direction of data flow on the communications link. The perspective is normally from the viewpoint of a processor or controller.

Downlink refers to the data flow away from the processor to a peripheral, and uplink refers to the data flow towards the processor from a peripheral.

3.2 Full-Duplex and Half-Duplex

A Full-Duplex serial communications link implements separate, unidirectional, signal paths for the uplink and downlink data flows. This allows for simultaneous uplink and downlink data flows without collision.

A Half-Duplex serial communications link implements a single, bi-directional, signal path that is shared between the uplink and downlink data flows. To prevent collisions, a communications protocol is required to determine the data flow direction and the active sender.

A communications protocol can also be used to operate a Full-Duplex link in Half-Duplex mode for reasons other than collision control.

4. ASYNCHRONOUS SERIAL COMMUNICATION STANDARDS

Synchronous communication schemes use a clock line between the sender and receiver to identify the individual data bits of the transmission.

Asynchronous communication omits this clock line and instead both sender and receiver operate at the same (known) clock rate, and the sender inserts start and stop bits in the transmission to help the receiver detect the individual data bits.

KML digital telemetry systems implement two common asynchronous serial data transmission standards: RS-232, RS-485. RS-422 is also available as an option (contact KML for further information).

All three of these standards were written by the EIA to allow asynchronous serial communications between peripherals and computers.

Note that none of these standards specify the message format of the data bits or the software protocols used between the sender and receiver, rather they specify the Transmit and Receive voltage levels representing the binary states “0” and “1” on the transmission medium.

4.1 RS-232 (TIA/EIA-232-F)

The RS-232 standard is a complete communications interface standard that specifies the mechanical, electrical and functional requirements for the interface.

Electrically it specifies an unbalanced (single-ended), uni-directional, point-to-point interface.

Maximum RS-232 data rate = 20kbps on a 50ft cable. Higher rates are possible over shorter cables.

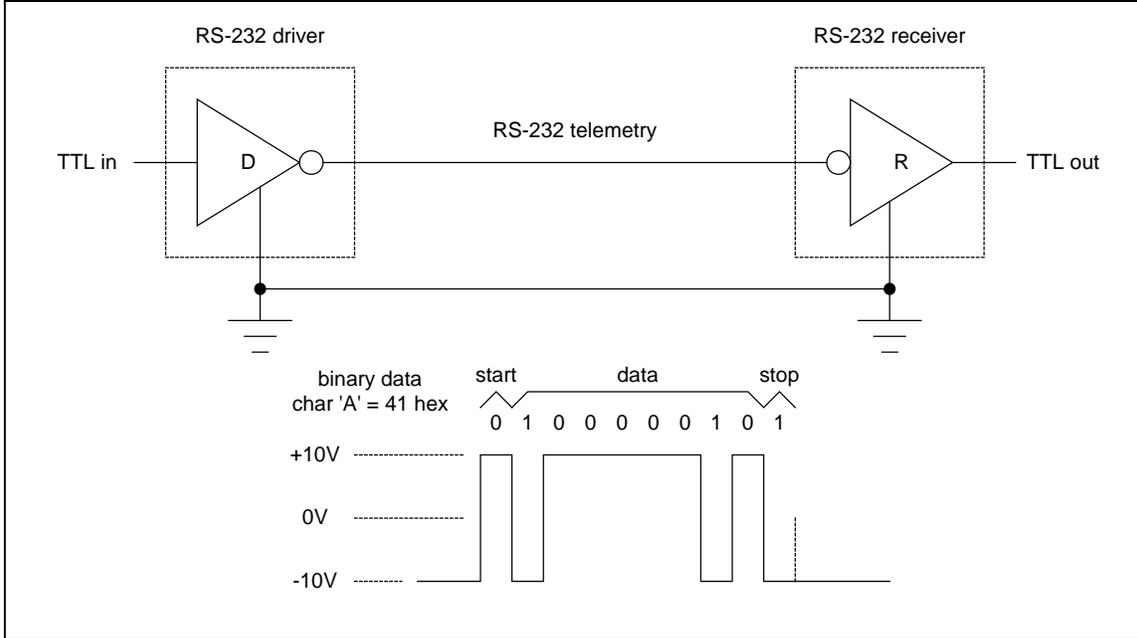


Figure 1: Typical RS-232 Application

TIA/EIA-232-F Major Electrical Specifications:

Driver loaded output voltage (3k Ω)	$\geq 5.0V $
Driver open circuit output voltage	$\leq 25V $
Driver short circuit current	$\leq 100mA $
Driver maximum slew rate	$\leq 30V/\mu s$
Driver output resistance (power off)	$\geq 300\Omega$
Maximum capacitive load seen by driver	2500pF
Receiver maximum input voltage	$\pm 25V$
Receiver thresholds	$\pm 3V$
Receiver input resistance	3k Ω to 7k Ω

4.2 RS-422 (TIA/EIA-422-B)

The RS-422 standard is an electrical standard that specifies a unidirectional single driver, multiple receivers, and a balanced, terminated interface.

Termination is located at the receiver end of the cable, and the stub length should be minimized to limit reflections.

Maximum data rate = 10Mbps for cable lengths up to 40ft.

Maximum cable length = 4000ft for data rates up to 100kbps.

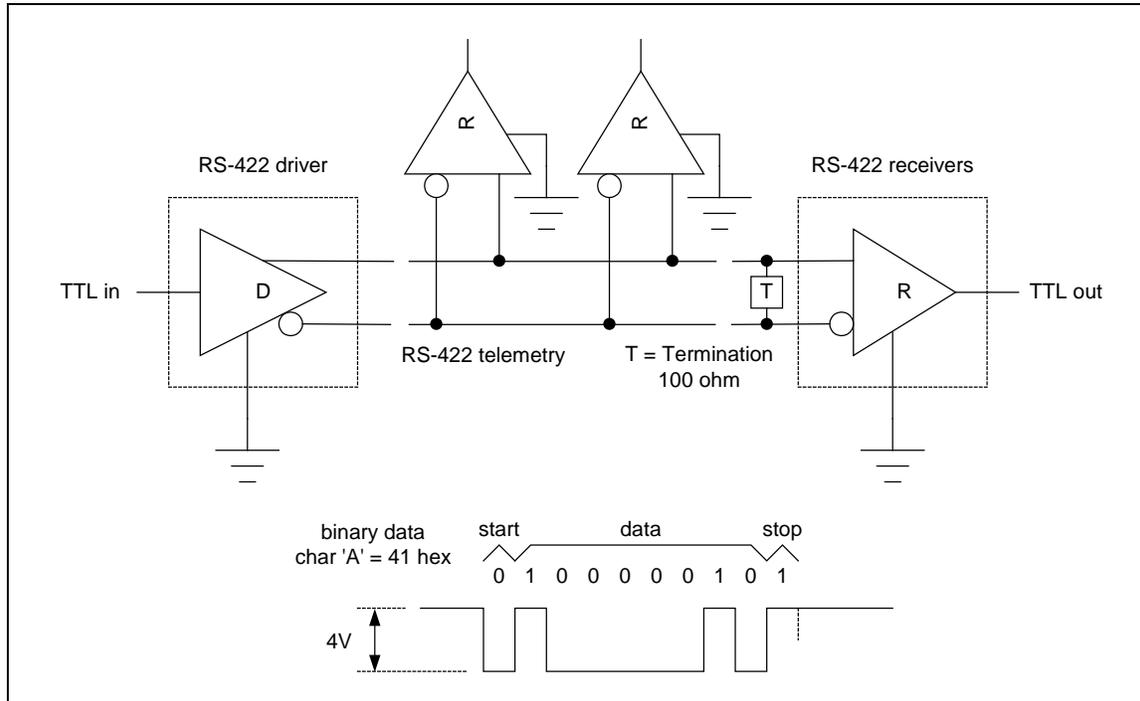


Figure 2: Typical RS-422 Application

Major RS-422 specifications:

Driver loaded output voltage	$\geq 2.0V $
Driver open circuit output voltage	$\leq 10V $
Driver short circuit current	$\leq 150mA $
Driver output impedance	$\leq 100\Omega$
Receiver common mode range	$\pm 7V (\pm 10V)$
Receiver maximum differential input voltage	$\pm 12V$
Receiver operating differential range	$\pm 200mV$ to $\pm 6V$
Receiver thresholds	$\pm 200mV$
Receiver input resistance	$\geq 4k\Omega$

4.3 RS-485 (TIA/EIA-485-A)

The RS-485 standard is an electrical standard that specifies multiple balanced drivers, multiple balanced receivers, and a balanced terminated interface. TIA/EIA-485 allows multiple driver/receiver operation in multipoint, party-line configurations and specifies a bidirectional, half-duplex, multipoint interface.

Maximum transceiver loads = 32.

Maximum data rate = 10Mbps for cable lengths up to 40ft.

Maximum cable length = 4000ft for data rates up to 100kbps.

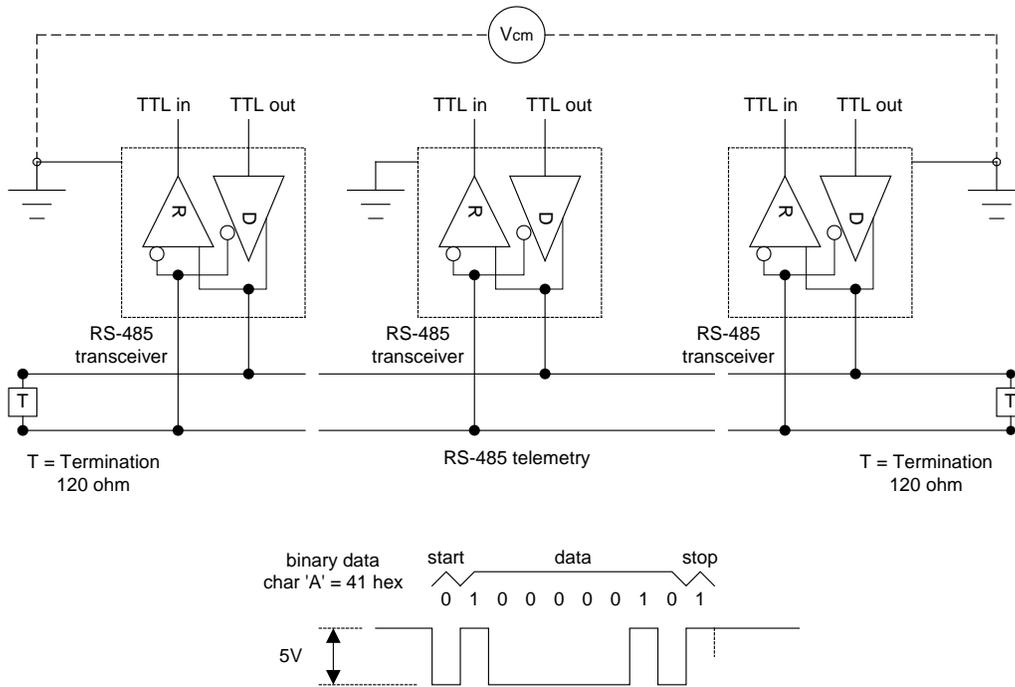


Figure 3: Typical RS-485 Application

Major RS-485 specifications:

Driver loaded output voltage	$\geq 1.5V $
Driver open circuit output voltage	$\leq 6.0V $
Driver short circuit current (-7V to +12V)	$\leq 250mA $
Common mode range (V_{cm})	-7V to +12V
Receiver thresholds	$\pm 200mV$

5. DIGITAL TELEMETRY

Digital telemetry, as used in this document, is a loose term used to describe the serial communications link between the KML Digital Surface Processors and the KML Digital Sonar Heads, as well as KML Digital Altimeters.

KML Digital Heads sample the analog sonar return signal to convert it to digital data samples, which are sent to the Surface Processor over the digital telemetry link.

The Surface Processor may either be:

- A sub-system consisting of a PC running host software (e.g. MS1000) that communicates to the Sonar Head either directly by RS-232C or RS-485 serial link. The KML MS1000 Head Interface Box is available to provide head power and RS-485 telemetry interface; the PC interfaces to this box via RS-232C or USB (depending on model) serial connection.
- A KML Surface Processor (e.g. MS900D, MS1000R) that integrates host PC and Head Interface Box functions into a single turnkey unit.

The telemetry link from the Surface to the Head(s) is referred to as the **downlink** data flow, and the link from the Head(s) to the Surface is referred to as the **uplink** data flow.

Digital telemetry data is generated as a serial bitstream in the format described in section 5.1.

This serial bitstream is sent to the telemetry driver which converts the data bits into RS-232/RS-422/RS-485 voltage levels and drives the telemetry link.

KML Digital Heads provide built-in power-up auto-detect selection between RS-232 and RS-485 serial interface. Consequently, the interface type selection is driven by that used at the surface. For KML turnkey Surface Processors, this is user-configurable. For KML Head Interface Boxes, RS-485 is normally implemented.

5.1 Telemetry Data Format

All telemetry information is sent in serial bitstreams, one bit at a time, in the following 10-bit packet format:

Start	=	1 bit
Data	=	8 bits
Stop	=	1 bit
Parity	=	None

The 8-bit data is sent with the **lsb** (least significant bit) first, and the **msb** (most significant bit) last.

Although the term actually only applies to the data portion, the whole telemetry packet is usually referred to as a telemetry “character”.

Figure 4 shows the data format and binary levels to send the ASCII character ‘A’ (binary value = 41H).

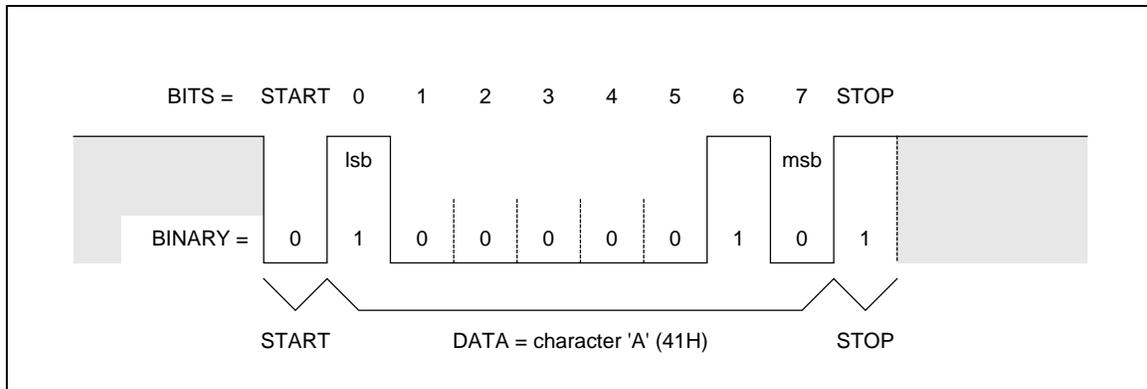


Figure 4: Telemetry Data Format

5.2 Telemetry Data Rates

The uplink baud rate is variable in increments of 300bps, but for compatibility reasons only de-facto standard rates of 9600, 19200, 38400, 57600, 76800, 115200, 230400, 460800, and 921600bps are implemented (maximum rate may be limited by head and surface processor capabilities). The uplink rate initially is set to the *default bit rate* ("**DBR**"), normally 9600bps.

The downlink baud rate may either be fixed to **DBR** or variable, depending on the capabilities available in the head and surface processor. If variable is supported, the downlink rate will be set to the uplink rate. Variable downlink capability is useful in systems and applications where different up and downlink rates cannot be tolerated.

The variable downlink baud rate mechanism, supported in more recent software revisions, is backward-compatible with older, fixed-downlink rate systems. This allows, for example, heads with variable downlink baud rate capability to operate at **DBR** when connected to a surface processor requiring fixed downlink rate operation.

On power-up, **DBR** is assumed for both downlink and uplink. Subsequently, after system self-test and initialization sequences are complete, the uplink rate is normally auto-optimized by a Surface-Head negotiation process to select the fastest supported baud rate that passes all telemetry tests. If variable downlink rate is supported in the surface processor and the head, the downlink rate is also adjusted accordingly (to equal the uplink rate) during the negotiation sequence.

DBR is normally 9600bps, but can be changed if such capability is available in the head and surface processor. This feature is useful to support applications requiring up & downlink be fixed to a specific bit rate on power-up. Changing **DBR** involves remote changing of a setting stored in the head's internal non-volatile configuration memory.

5.3 Telemetry Protocol

KML digital telemetry implements a Master-Slave relationship between the Surface Processor and Digital Heads, and uses a Half-Duplex telemetry protocol.

All communications take place in the form of predefined, formatted messages. These messages contain commands, responses, requests, parameters, data, etc. and are identified by unique message types.

Master-Slave relationship:

The Surface processor is always the Master, and the Heads are always Slaves. All communications are initiated by the Master. Slaves can never initiate any communications, but can only respond to messages from the Master, using matching response messages.

Telemetry message transactions:

All telemetry communications are conducted as individual transactions. A transaction starts when the Master sends a message to a Slave, and terminates when the Master receives a response from that Slave.

Half-Duplex operation:

Operating in Half-Duplex mode, there can not be more than one active telemetry driver on the telemetry link, and all other telemetry agents must be in receive mode. When there is no telemetry activity, the Master and all Slaves are in receive mode.

To maintain a "mark" signal level on the telemetry link when all agents are in receive mode, the Master side telemetry drivers and receivers implement failsafe termination resistors to force a differential voltage of more than 200mV on the telemetry link. Third party telemetry systems between a digital head and the surface processor are expected to also implement this failsafe resistor termination on the Master side.

A typical RS-485 failsafe termination resistor network is shown in Figure 5.

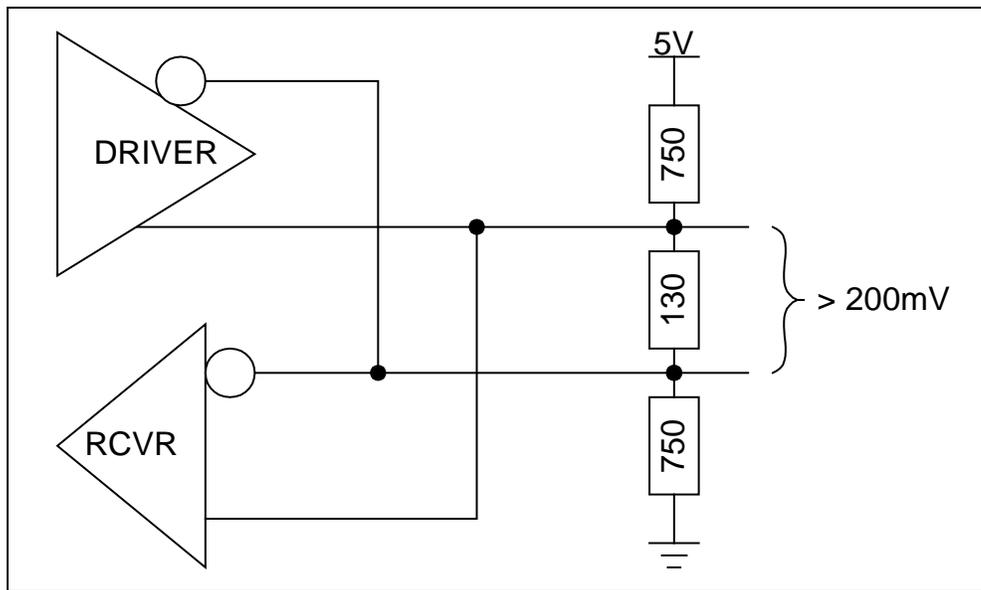


Figure 5 : RS485 Failsafe Termination

5.4 Telemetry Timing

The telemetry protocol mandates link turnaround times between send and receive, and between receive and send. This is required to eliminate data collisions in half-duplex operation and also allows telemetry subsystems to implement auto-sensing techniques to correctly switch between uplink and downlink telemetry in half-duplex operation.

The telemetry protocol also mandates certain inter-character timeouts to prevent the telemetry agents from waiting forever for a transaction to complete. This is required in the event of data loss due to very noisy telemetry lines.

Half-Duplex Turnaround Timing:

All telemetry turnaround times are fixed and not related to the actual baud rates in effect.

After the stop-bit of the last character of a message has been shifted out of the sender's output shift register, the telemetry driver shall be in high-impedance state within 3ms.

After receiving the last complete telemetry character of a transmission in its receive buffer, a telemetry agent shall wait at least 3ms before enabling its telemetry driver.

Note that this timing protocol produces a "receive only" period of at least 1ms between transmissions during which all telemetry agents are in receive mode. This 1ms roughly equals the transmission time of 1 character at 9600bps.

Inter-Character Timing:

The time delay between 2 successive valid telemetry characters on the telemetry link shall not exceed 500ms.

This allows the receiver to timeout if a transaction takes too long to complete, and prevents the telemetry system from lock-up.

6. ANALYSIS OF MEASURED RS-485 AND RS-232 SIGNALS

Figure 6 and Figure 7 show the RS-485 and RS-232 telemetry signals for sending the character 'A' (41H) at a baud rate of 9600bps.

Observe the following characteristics of the data bits of both RS-485 and RS-232 signals:

- Data bit 0 (lsb) is send first, and data bit 8 (msb) is sent last.
- The data bits are framed by 1 start bit and 1 stop bit.

Observe the following differences between the RS-485 and RS-232 telemetry signals:

- The RS-485 signal is differential, as a pair, with one signal of the pair the inverted replica of the other, while the RS-232 is a single signal with the data inverted from the binary values of the data bits.
- The RS-485 signal pair are both unipolar, with a switching range of about 4V, while the RS-232 signal is bipolar, switching from -10V to +10V.
- RS-485 drivers are enabled before sending data and disabled after sending data, while the RS-232 drivers are always enabled.

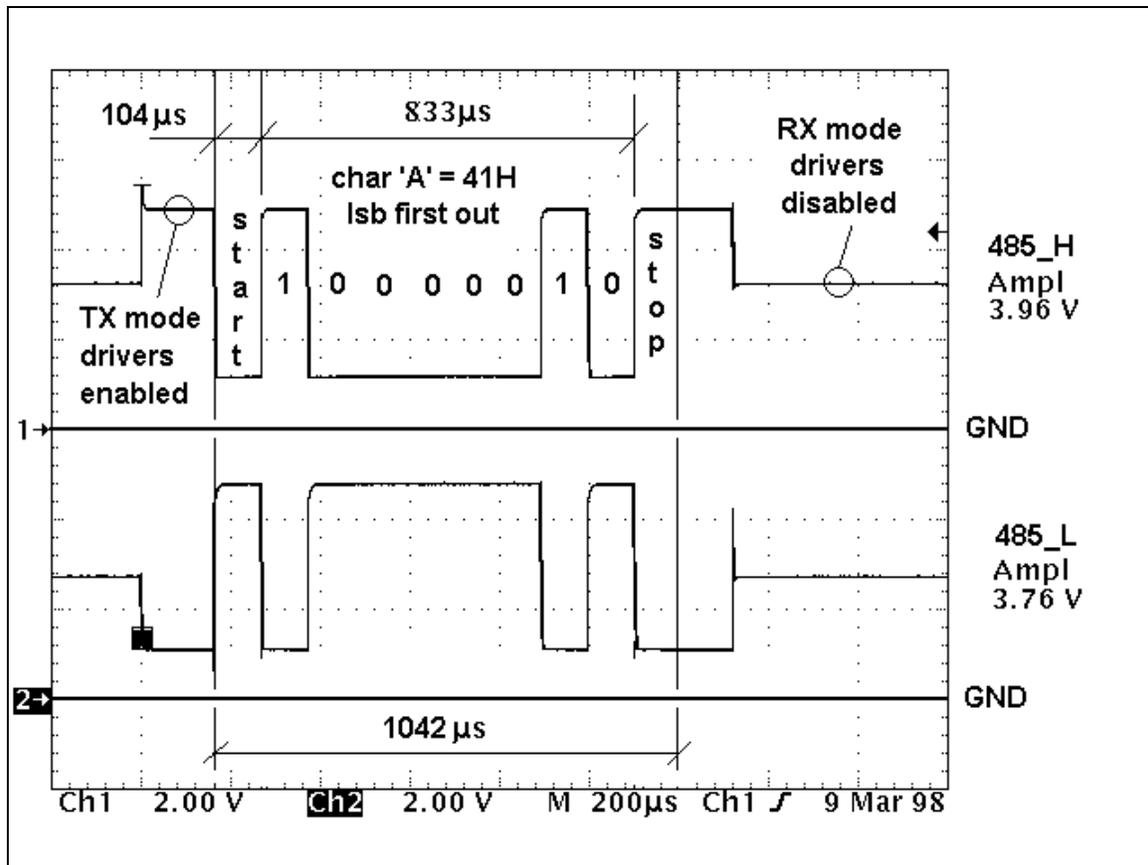


Figure 6 : RS-485 Telemetry format and timing at 9600bps

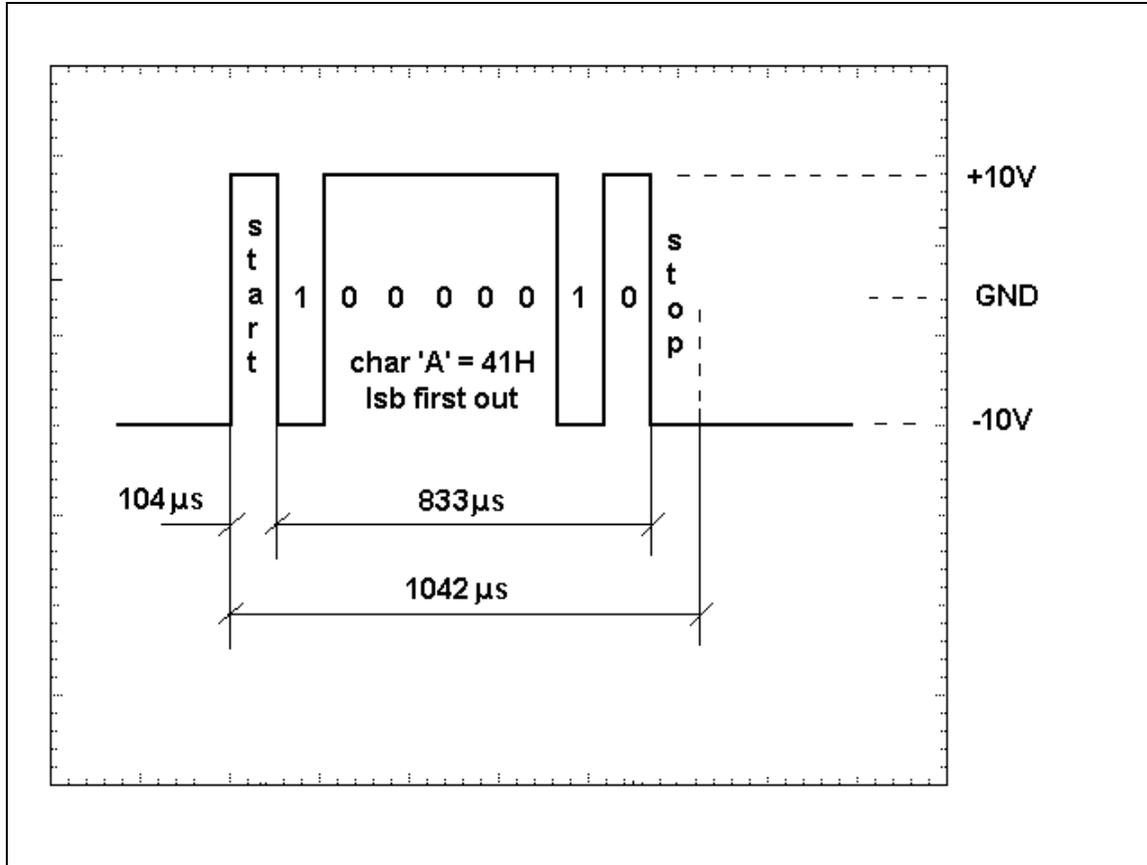


Figure 7: RS-232 Telemetry format and timing at 9600bps

Figure 8 shows a typical step-and-ping command/response transaction between a KML Surface Processor and a KML Digital Head in an example where the downlink rate is fixed at 9600bps. The figure includes time-zoomed views of portions of the telemetry sequence.

In response to the STEP-PING command, the Digital Head activates the acoustic transmit pulse and samples (digitizes) the analog sonar return.

These digitized sonar data samples are not uplinked to the surface in real-time, but are captured in a local buffer before the Head uplinks them. Surface controlled gain is applied to the digital sonar samples numerically in the Head software.

The Surface Processor receives the uplinked sonar data samples and converts them to colored pixels and sends them to a CRT display as a visual representation of the sonar return.

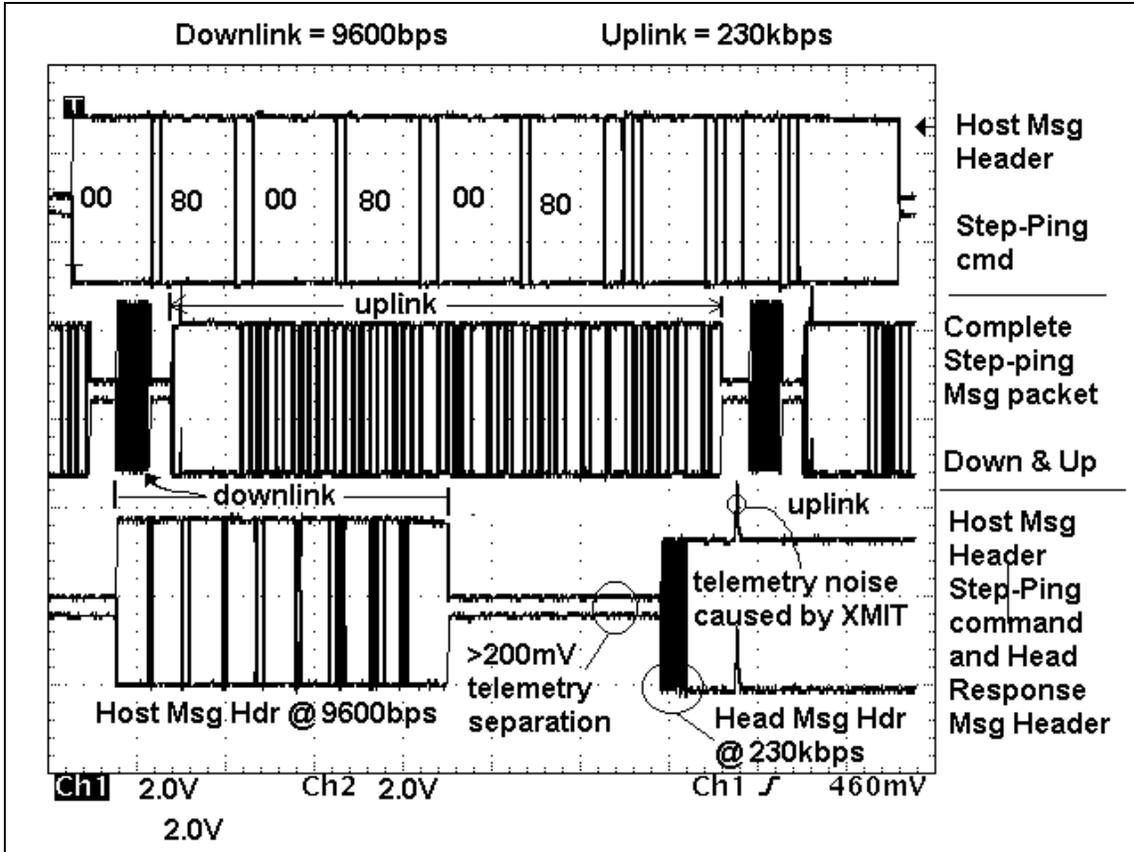


Figure 8: RS-485 STEP-PING command/response transaction