RS-485 interface for external use of the GPS receiver of the Kinemetrics® dataloggers

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Summary

In this technical report, we present an electronic interface that we designed and produced as part of a new system that allows the remote acquisition of data provided by the GPS receiver for the *Quanterra* Q330 and Q330HR dataloggers, and for the whole range of the *Altus* series of systems produced by Kinemetrics, using an RS-485 bus via a serial cable that can be of kilometres in length. This function is not normally available for any of the equipment reported and it is needed when the installation of the GPS receiver antenna needs to be more than some tens of metres from the datalogger. This can be necessary, for example, for installations in tunnels, in large buildings, or for seafloor systems with a cable connection to the surface.
This document describes the functioning and the hardware of the interface boards, particularly considering the *Quanterra* Q330 datalogger. The system designed in this way is introduced as an element that maintains all of the functions of the apparatus in a fully transparent mode without the need to modify the communication-software procedures for the exchange of data between the datalogger and the integrated GPS receiver, therefore leaving untouched the various functional modalities normally associated with the GPS receiver.

Functioning principles

The Quanterra Q330 is equipped with a GPS receiver module (M12 Motorola®) for the correct time marking of the data acquired. The operating manuals specify that the GPS receiver inside the Q330 can be used in various modes: continuous functioning, or for a predefined time, or only when the tracking of the phases is lost. In this last case, the quality of the GPS signal drops to 60% (still a good level of GPS signal) and decreases by a further 1% about every 10 minutes. This means that under these conditions after a time of about 8 hours the level drops to 10% (equivalent to an absence of GPS signal).
In such cases, a new time base is used, provided by a TCXO (high-stability quartz with temperature compensation) usually coupled via the use of a phase-locked loop (PLL) circuit, with the timing signal from the GPS receiver.

The quartz oscillates with a clock at 15,360 MHz and has a thermal stability of 10 ppm/°C. This results in a time drift of the datalogger clock of a few seconds about every 30 days of use in the absence of a GPS signal, with the datalogger continuously functioning.
The technical specifications supplied by Kinemetrics describe the possibility of using an external GPS receiver through the use of some lines of the connector labelled as "Ext. GPS" on the front panel of the Q330. In this case, it is possible to export the data in NMEA format directly from the GPS receiver through a serial interface made available physically via this connector (supported by two serial standards: RS-232 and RS-422).
For our needs for the running of a data acquisition experiment from the seafloor, there was the need to use an external GPS receiver to be connected to the Q330 datalogger via a serial cable of a length of about 400 m . Initially, we thought to use the active GPS antenna, provided with the equipment for the Q330 datalogger with an appropriate RF cable of the required length. This, however, meant that there was the need for a line-amplifier for the GPS signal due to the high loss along the cable (about 0.3 dB $\cdot m^{-1}$ for a very good quality cable), without knowing if it would be possible to continue to use the GPS receiver inside the Q330 on the seafloor, at about 100 m feet in depth.
Therefore, it was preferable to modify the Q330 datalogger by taking out the integrated GPS receiver and designing two electronic modules that would at the same time provide for further functions. Importantly, these would act as RS-485 interfaces between the GPS receiver (once removed from the Q330) and the datalogger, allowing the digital GPS signals to be passed over long distances (up to 3,000 metres of cable with a baud-rate of 9,600 bps, or over with appropriate digital line amplifiers that are commercially available at low-cost).
The bidirectional interface conversion system from the serial RS-232 standard (TTL with active low voltage levels of +3 V) to the RS-485 bus standard, here referred to as GPS-485, comprises two electronic modules that need to be installed as described below.
Specifically, the system allows the reception of the data by the Q330 from the above-mentioned GPS receiver connected to the antenna, through a serial cable provided of four differential twisted pairs. This allows the exchange of control data and the receiving of information from the GPS, with the receiving of the 1PPS signal and the turning on (and turning off) of part of the electronics of the two interfaces, and consequently, of the GPS receiver.
The system comprises:

- Antenna for receiving the GPS signal;
- Interface board (referred to as the GPS-485 receiver side) with which, as indicated below, the GPS receiver module from the Q330 will be connected. It also contains the RS-232/RS-485 interface with the line-driver/receiver circuits, the power supply circuits, and all the electronics necessary for the monitoring of the charge condition of a specific back-up battery for the GPS module;

– Serial connection cable (1:1) for the two boards;
– Interface board (referred to as the GPS-485 datalogger side) containing, as will be shown later, the RS-485/RS-232 interface with the line-driver/receiver circuits, and the power supply circuits.

Figure 1 illustrates the complete connection scheme of the two interface boards with the GPS antenna and the Q330 datalogger.

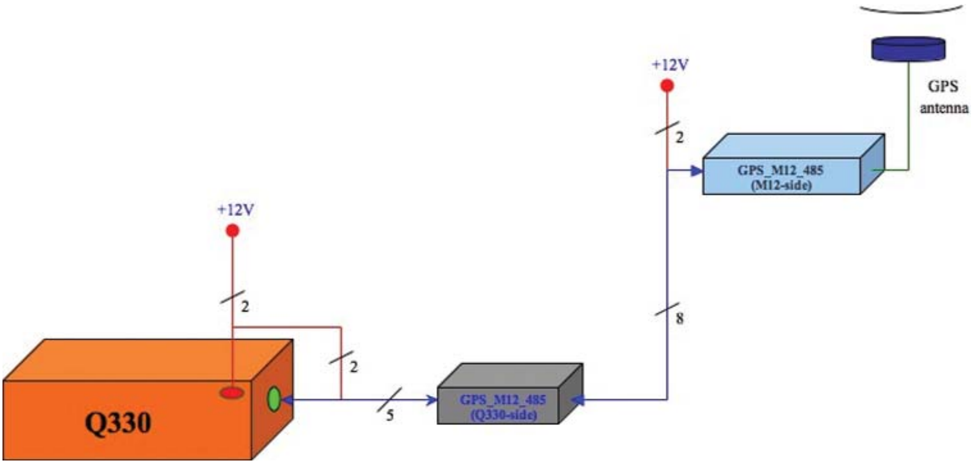

Fig. 1. The final connection scheme.

Interface description

The system includes two interface boards. One of these (on the GPS receiver side) contains all of the electronics necessary for the power supply to the GPS receiver, the active antenna, and the interface circuits necessary for the control of the GPS data to be transmitted through the RS-485 bus with a serial cable over long distances. This board can also receive configuration commands from the GPS receiver that are sent from the datalogger; in particular, this board is used to interface this information from electrical levels that conform to the RS-485 standard, to TLL at +3 V logic levels.
The other board (on the datalogger side) will carry out the same functions as the board above but in an opposite sense, except regarding the GPS receiver and the antenna, which, obviously, are not a part of this side.
The exchange of information between these two interface boards is through the above-mentioned cable containing four twisted pairs (with a characteristic impedence of 120 Ω). The cable can be up to 3 km in length.

The interface boards are completely active only when the GPS is turned on via the Willard© management software of the datalogger. Once this is done, the controlling digital differential line reaches the high-logic state and activates all the rest of the electronics that had remained in standby mode. The introduction of the two interface boards allows the use of the GPS receiver for the datalogger in an fully transparent mode.
No software modifications are needed for the system, which will therefore continue to function as before. The two boards can be installed inside their own containers to protect them from external atmospheric agents, or they can be mounted in the same box that normally contains the instrumentation.

The datalogger-side board

The Figure 2 shows the interface circuit that manages the data acquired by the GPS receiver and that is directly connected to the datalogger (modified). Table 1 provides a summary of the technical specifications of this circuit board.

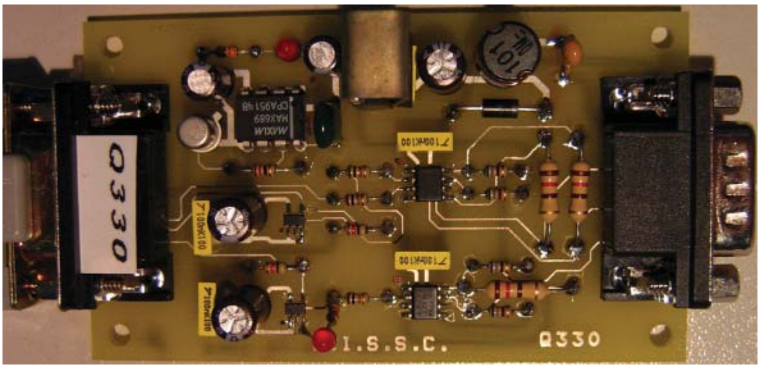

Fig. 2. GPS-485 (datalogger side).

The power supply to the board is external and can be provided by a normal 12 V battery. The power supply input circuit is protected by a self-resetting fuse to protect against possible short circuits or other anomalies; moreover, there is also diode protection against possible accidental inversions of the polarity of the power supply.
There are also two switching-type voltage regulators. One of these provides the power supply at +5 V for the line-driver/receiver circuits for the RS-485 bus. The other voltage regulator, at +3 V output, provides the power supply

Tab. 1. Technical specifications of the board on the datalogger side.

Power supply	8 ÷ 14 V DC
Current	30 mA @ 12 V DC
Data Rate	Up to 100 kbps for a cable length less than 1200 m
Connectors	DB9 male (RS-485 cable side) DB9 female (datalogger side)
Monitor LEDs	GPS power, 1PPS
Container	Plastic box
Weight	40 g
Dimensions	100 x 50 x 20 mm

for the step-down DC/DC converter from +5 V to +3 V for the signals received from the GPS receiver module[1].
The line driver/receiver interface circuits on the RS-485 bus in this board are used to be able to correctly carry out dialogue with the remote GPS receiver. In particular, this involves adapting the differential signals received (RX+, RX-, 1PPS+ and 1PPS-) to a TLL logic level standard and then to adapt them to a TLL logic level at +3 V, as described below. As a similar concept, but in the opposite sense, this is done to adapt the differential signals to be transmitted to the GPS receiver (TX+, TX-, ON+ and ON-) and to the activation circuit of the power supply, from a TLL logic level at +3 V to differential levels compatible with the characteristics of the RS-485 bus.
An equivalent circuit was planned for the differential input signal pair (1PPS+ and 1PPS-) coming from the GPS receiver, and for the differential output signal pair (ON+ and ON-) needed for the remote turning on of the GPS receiver (which under normal running conditions the current absorption is about 100 mA).
Downstream of the 1PPS signal received, there is a LED that flashes at a frequency of 1 Hz to indicate the correct functioning of the external GPS receiver. As indicated above, the interface line-receiver circuits on the RS-485 bus installed on this board have output signals at the TLL logic level standard.

[1] In this case, for the power supply to the interface board on the side of the K2 datalogger, no power supply circuits are needed at present. Indeed, here the need is only for a voltage of +5 V for the power supply to the line driver/receiver circuits on the RS-485 bus that is taken from the connector of the datalogger itself that is normally used as the power supply of the internal GPS receiver. Moreover, the +3 V voltage is not needed because the GPS receiver (ACEIII, Trimble®) has a serial communication interface with the TTL standard of +5 V.

Since it is planned that the interface to the GPS receiver of the Q330 will carry out dialogue with the Q330 via a serial port with a TLL of +3 V, instead of the standard, the signals received (RX and 1PPS) need to be adapted to this voltage logic level.
An equivalent circuit was planned for the RX input signal coming from the GPS receiver[2].

The GPS receiver-side board

The Figure 3 shows the interface circuit that manages the data acquired by the GPS receiver removed from the Q330 (and the commands directed to it) to be transmitted to (received by) the Q330 datalogger (modified) via the serial connection cable on the RS-485 bus, and Table 2 provides a summary of the technical specifications of this board.

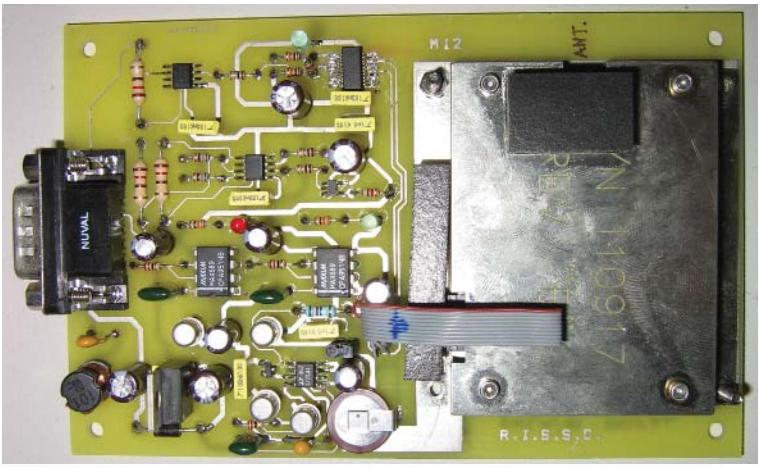

Fig. 3. GPS-485 (GPS receiver side).

The power supply is also external for this board and can be provided by a normal 12 V battery. The power supply input circuit is protected by a self-resetting fuse to protect against possible short circuits or other anomalies; moreover, it is also protected by a diode against possible accidental inversions of the

[2] In this case, there are no DC/DC step-down converter circuits. Indeed, here the need is only for a single pair of line-driver/receiver circuits on the RS-485 bus, because the GPS receiver (ACEIII) has a serial communication interface with the TTL standard of +5 V.

Tab. 2. Technical specifications of the board on the GPS receiver side.

Power supply	8 ÷ 14 V DC
Current	40 mA @12 V DC (GPS receiver off)
Data Rate	Up to 100 kbps for a cable length less than 1200 m
Connectors	DB9 male (cable side) MMCX plug (GPS antenna)
Monitor LEDs	GPS Power, 1PPS
Container	Plasic box
Weight	80 g (GPS receiver not included)
Dimensions	150 x 80 x 20 mm

polarity of the power supply. There are also three switching-type voltage regulators that are the same as those for the interface board on the datalogger side. One of these provides the power supply at +5 V for the line-driver/receiver circuits for the RS-485 bus. The other two voltage regulators at +3 V provide the power supplies for the step-down DC/DC converter from +5 V to +3 V for the signals transmitted by the GPS module towards the datalogger, and for the power supply to the GPS antenna.
The electronics scheme adopted for the power supply section is the same as that for the interface board on the datalogger side, with the particular considerations already discussed.
In addition, there is a monitoring circuit for the recharging of the 3 V lithium back-up battery for the retain of the data received by the GPS module in the case of loss of external power.
In the same way, the line-driver/receiver interface circuits on the RS-485 bus on this board are also used to allow dialogue between the GPS receiver and the remote datalogger. In particular, this involves the adapting of the differential signals transmitted to the datalogger (TX+, TX-, 1PPS+ and 1PPS-) to a TTL logic level standard and then their adapting to a TLL logic level of +3 V. The same procedure, but from the opposite side, is followed to adapt the differential command signals transmitted from the datalogger to the GPS receiver (RX+, RX-, ON+ and ON-) and to the power supply activation circuit, from TLL logic levels at +3 V to differential levels on the RS-485 bus.
The pair of integrated devices used is the same as that for the interface board on the RS-485 bus for the datalogger side with the relevant changes in the input/output signals.
Also in this case, the signals needed for the dialogue with the GPS receiver must be converted to +3 V. Therefore, a pair of voltage step-down DC/DC converters are used, identical to those designed for the interface board on the

datalogger side, with the exception that the signals to be treated are RX and POWER_ENABLE (ON)[3].

Electrical interconnections

The interface board for the RS-485 bus on the GPS receiver side has a DB9 male connector mounted on the printed circuit, which makes available the differential signals for the transmission of the GPS data (TX+ and TX-), the transmission of the 1PPS logic signal (1PPS+ and 1PPS-) and the reception of commands directed to the GPS receiver module (RX+ and RX-) coming from the datalogger, as well as a pair of activation signals (ON+ and ON-) that allow the remote turning on and partial turning off of the boards through the Willard software.
The GPS receiver side board also has a connector (*SamTech*®, FTSH-105-D2-L-DH header) mounted on the printed circuit on which the logic signals (TTL +3 V, negative logic) are available for transmission of the GPS data (TX) and of the 1PPS logic signal from the GPS receiver module, and for the reception of commands directed for the GPS receiver module (RX) coming from the Q330 datalogger after the voltage conversion from the RS-485 level. This connector also has an activation line that provides remote control for the turning on and the partial turning off of the board.
The interface board for the RS-485 bus on the datalogger side has two DB9 connectors (male and female) mounted on the printed circuit. These make available the differential signals for the transmission of commands destined for the GPS receiver (TX+ and TX-), the reception of the 1PPS timing signals (1PPS+ and 1PPS-), and the reception of the GPS data for the datalogger (RX+ and RX-) coming from the GPS receiver, as well as a pair of transmission signals (ON+ and ON-) that provide remote control for the turning on and the partial turning off of the board.

[3] In this case, there is the need for a single switching voltage regulator at +5 V and there are no step-down DC/DC converter circuits, in agreement with the considerations indicated above.

Automatic analysis of seismic data by using Neural Networks: applications to Italian volcanoes

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Abstract: The availability of the new computing techniques allows to perform advanced analysis in near real time, improving the seismological monitoring systems, which can extract more significant information from the raw data in a really short time. However, the correct identification of the events remains a critical aspect for the reliability of near real time automatic analysis. We approach this problem by using Neural Networks (NN) for discriminating among the seismic signals recorded in the Neapolitan volcanic area (Vesuvius, Phlegraean Fields). The proposed neural techniques have been also applied to other sets of seismic data recorded in Stromboli volcano. The obtained results are very encouraging, giving 100% of correct classification for some transient signals recorded at Vesuvius and allowing the clustering of the large dataset of VLP events recorded at Stromboli volcano.

Introduction

Active volcanoes produce a wide variety of seismic events related to different physical processes. A systematic and efficient monitoring of the volcanic activity helps in eruption forecasting and provides the scientific data to understand the structure and dynamics of the volcanoes.

A key contribute to the monitoring improvement is the automation of many functions, which can enhance the capability to analyze several types of data in short time and to determine the significant parameters for volcano status description. Thus, an effective automatic strategy for the detection and discrimination of seismic signals integrated into an analysis system in real time could considerably reduce the heavy and time-consuming work of the experts without affect the monitoring system reliability.

Several methods exist in literature for the detection and discrimination of different typologies of seismic signals (Hartse et al., 1995; Gitterman et al., 1999; Joswig 1990; Rowe et al., 2004). However, encouraging results have been rea-