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A Guide to the Application of SHM Intelligent Data Loggers

This guide is intended to show the capabilities of SHM Communications data loggers and so help the user to build effective systems.

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Applications

1. Inputs

1.1 Pulse Counting

Pulse counting inputs are typically used for :-

- Electricity (kWh, kVAh, kVARh)
- Gas
- Oil
- Water

The input source should be a volt-free contact closure or electronic equivalent.

The maximum pulse rate is 20 pulses per second, but higher rates are possible if an external pulse pre-scaler is used. Contact SHM for details.

SHM can supply a full range of compatible electricity meters.

Gas meters often incorporate a light-duty relay pulse output contact for each of measure of gas consumed, which can be sensed directly by SHM loggers. However in the case of main supply loggers, regulations require the fitting of an isolating barrier relay.

It is usually possible to share a pulse signal with another piece of equipment (eg. a Building Management Controller). The method of connecting the two inputs together depends on the type of equipment involved. SHM will be pleased to advise on how to do this. In a few circumstances, an additional intermediate relay may be required.

1.2 Temperature

Logging a building's internal and external temperature is vital to measuring energy efficiency in a targeting and monitoring system.

The UL8 logger is specifically designed to interface to standard 10 kohm PTC thermistor sensors, and incorporates all the necessary linearization. SHM can supply fully compatible internal and external sensors.

Temperature is logged as degrees centigrade with a range -80.0 to +150.0, and a resolution of 0.1 degrees.

If thermistor sensors are not suitable, any other device that produces a voltage (0 to 10 volts) or current (4 to 20 mA) can be used, with the data logged as an analog quantity. In this case the conversion of the reading into temperature must be performed by the application software.

1.3 Analog

The UL8 logger can be configured using jumpers on the PCB to accept voltage or current inputs and log the 14-bit analog value, averaged over one minute.

The voltage input range is 0 to 10 volts, and the current input range from 0 to 20 mA.

Analog values are stored as integers, and any scaling must be performed by the application software.

Analog sensors normally need an external power supply (typically 24 volts DC). However the UL8 logger provides an unregulated DC supply that can sometimes be used to power a 4 to 20 mA current loop. Whether this supply is suitable depends on the voltage drop across the sensor, the number of sensors and the fitting of options (Modem, RS485 interface) inside the UL8. An application note for this is available from SHM, who will be pleased to advise on specific applications. The internal supply will not have sufficient voltage when the logger is running on its internal battery (mains interruption).

1.4 RF Link

The RL32 logger combines 8 universal inputs (like a UL8) with up to 24 channels that connect to sensors or meters via a Radio Frequency link, removing the need for direct wiring between meter and logger.

Several battery-powered transmitters can be located around the site, each transmitting either pulse counts or temperature (from either an internal sensor or an external one). These transmissions are picked up by a central receiver that relays them to the logger. Repeaters can be used to extend the range of the system.

1.5 Modbus

The ML32 logger combines 8 universal inputs (like a UL8) with up to 24 channels that are read from Modbus RTU slave devices. Normally these channels would read the energy registers of Modbus-enabled electricity meters (eg. Northern Design **Cube** range, or Carlo Gavazzi **EM** and **WM** ranges), but parameters can be read from any Modbus RTU slave.

Modbus channels can be configured as “Pulse Counting”, where the value always increases with time (eg. meter energy registers) or “Analog” where the value can take on any value within limits (eg. Current or kW).

2. Logging

2.1 Synchronized Logging

SHM loggers normally log data at regular time intervals based on the internal clock. For example when logging at 15 minute intervals, data will be stored at 00, 15, 30 and 45 minutes past the hour.

The main electricity meter on a site typically stores billing data based on 30 minute periods, but the timing reference may not be exactly at 00 and 30 minutes past the hour.

In order to log data in synchronism with the main meter, the 30-minute pulse output of the main meter can be connected to any unused logger input and act as a trigger. The data will be logged whenever the trigger contact closes. All Code 3 and Code 5 electricity meters are capable of providing a 30-minute pulse output.

The use of an external logging trigger can be configured on a per-channel basis. It is possible to mix internally and externally triggered channels within a logger.

SHM loggers also have an output relay which normally produces a 30-minute pulse 1 second wide at 00 and 30 minutes past the hour on the internal clock. This can be used to synchronize external equipment. The 30 minute pulse is not available if the relay is configured as an alarm.

The internal clock in SHM loggers is capable of switching its rate fast or slow in response to a time message sent from a PC. If all loggers are regularly interrogated and sent an accurate time by the PC software, their clocks should never differ by more than a few seconds. Thus for a network of loggers on a site, the logging of data will effectively be synchronous with the PC clock over the whole site.

2.2 High Resolution Logging

Normally, 30 minute logging is sufficient for most purposes. However sometimes it is desirable to analyze data during critical periods with greater resolution (every minute). With SHM loggers it is easy to do this. There are two methods.

Firstly, the logger channel can be re-configured at the start of the critical period to log every minute, and then be set back to the original interval at the end of the period. Changing the logging interval does not cause loss of data. The logger will store channel data at both the low and high resolution. Logging at high resolution does mean that the time span of data in the log will be less (each channel typically stores 3000 readings - 2 days worth at 1 minute, 63 days at 30 minute sampling).

The second method is to use a second channel to store the same data but at a higher resolution. A spare channel must be available to do this. The UL8 logger has 8 channels and 8 inputs, and normally Input 1 is assigned to Channel 1, Input 2 to Channel 2 and so on.

However any input can be assigned to any channel, and an input can be assigned to more than one channel. Thus the input to be measured is assigned to the spare channel, and that channel is configured to log every minute. Normally only the low-resolution channel's data is collected regularly. Whenever high-resolution data is wanted it can be collected from the spare channel. A channel logging every minute can store approximately 2 days worth of data.

In addition, it is possible to monitor the instantaneous values to get a second-by-second picture of what is happening on each channel.

2.3 Security and Integrity

For many users, all loggers are within a closed and controlled communication system, and no special security precautions are necessary. SHM loggers are normally delivered with null passwords, so the user has full unrestricted access and does not need to be concerned with passwords.

SHM loggers support four levels of security, each controlled by 32-bit passwords :-

- Read channel data (1 password per channel)
- Configure channel data (1 password per channel)
- Commission logger
- Control the clock/calendar

Because each channel has its own set of passwords, it is possible to configure different levels of security for each channel.

By programming null passwords for reading data, and valid passwords for all the others, the logger will permit public access to read data, but restrict any changes to users who know the passwords.

SHM loggers always provide high integrity data. Data is protected against power loss and will retain logged data and time for 60 days. The optional UPS battery provides full functionality for 5 days without mains power.

All messages to and from the logger have checksums. When reading logged data, each block of readings contains an additional 16-bit validator that is calculated using a 32-bit key. This ensures the data has not been tampered with.

The logged data provides a full audit trail of events that have occurred. Apart from the regular logged data, the following information is stored :-

- Logger Power-Down Events
- Logger Power-Up Events
- Time Changes
- Data Interrogation Times
- Configuration Changes
- Mains Failure

3. Communications

3.1 Networked Loggers

If there are several SHM loggers on a site, they can be interconnected using an RS485 network. The loggers are connected in a loop, with one unit being the common access point.

The connection between each logger consists of 2 wires (preferably twisted pair) plus ground. The maximum recommended distance between loggers is typically 1200m.

The main PC connects to the access point and can talk to any of the loggers on the network. Each logger also has a local access connector that allows it to be interrogated locally by a portable PC as well as via the network.

To take advantage of networking, the logger must be ordered with the necessary RS485 option fitted. Different options are required depending on whether the logger is an intermediate node or the access node at the end of the loop :-

- Normal Node
- RS232 Access Node (access direct from PC or via an external modem)
- Modem Access Node (access via integral logger modem)

A convenient alternative is to bring both ends of the loop back to the controlling PC, and drive the RS485 loop via an RS232 to RS485 converter connected directly at the PC serial port.

3.2 Telephone Modems

For communication via modems, the integral SHM modem is recommended. It is a 2400 baud device with MNP-5 data compression and MNP-4 error correction and achieves fast and reliable data transfer. It is fully operational even without mains power (provided the logger has the UPS battery fitted). This modem is only certified for use in the UK.

Alternatively, an external modem can be used. Most modems are suitable, provided they support the Hayes 'AT' command set. Modems that have data compression and error correction are preferred.

The modem must be set up by the user with a suitable profile. Modems supplied by SHM will be appropriately pre-programmed.

3.3 GSM Modems

Where provision of a telephone landline is inconvenient, SHM loggers can be fitted with a GSM modem (with external aerial) to allow data to be collected via the cellular mobile network.

The central can be fitted with either a landline or GSM modem to dial up the logger and collect the data.

3.4 Ethernet Gateway Unit (EGU)

This is a terminal server that provides an interface between a 10/100BaseT Ethernet network and a single logger or RS485 network of loggers. External and internal versions are available.

If the software running on the host PC supports it, direct communication with the loggers using TCP/IP protocol is possible. Stark Reality XLeMs, and UREAD, UCSV and UCOMM support direct connection via TCP/IP. If direct connection is not supported, another EGU can be configured in "Ethernet Modem Mode" and connected to the serial port of the host PC. This allows the PC to "dial up" one of the remote EGUs using standard modem "AT" commands. It may also be possible to install a "virtual serial port" driver on the PC that makes the remote EGU look like a standard serial port to the host software.

4. Communications Cost Saving

4.1 Line Sharing

Installation costs can be saved by sharing a telephone line with a FAX, modem or voice telephone, particularly if there is a period of the day when the other device is rarely used (typically at night).

The logger can either use the integral modem, or have its own external modem, and may additionally be the access point to a network of loggers connected via RS485 links.

There are two approaches to this, Answer Window and Dial In.

With Answer Window, the logger only answers calls during a pre-programmed time window. The logger's modem is programmed to answer after only one ring. If the line is shared with a FAX or other modem or answering machine, this must be programmed to answer after more than one ring to prevent conflict.

With Dial-In, the logger (or network of loggers connected via RS485 links) is programmed to dial the number of the controlling PC at a specific time every day. The actual time is randomized by 10 minutes, and the logger will keep trying for up to one hour if it cannot get through. A Dial-In logger can share the line with any device without restriction.

The following points should be taken into consideration when choosing which method to use :-

- With Answer Window, the call is charged to the central PC's number
- With Answer Window, the line must be unutilized for part of the day, and any other devices may need to be re-programmed to answer after more than one ring.
- With Dial In, the call is charged to the outstation's number.
- Dial In requires a line that can make outgoing calls. Settlements lines are invariably set up for incoming calls only.

For Answer Window, the software application at the central controlling PC must be capable of dialling out at stipulated times of day only.

For Dial-In, the software application at the central controlling PC must be capable of establishing which logging equipment is present at the other end of the line and then collecting all outstanding data.

5. Special Functions

5.1 Alarms

SHM loggers can be programmed to check their inputs for alarm conditions and notify the user if any parameter goes out of limits.

Each channel in the logger can be programmed with two alarm thresholds (High and Low). The channel can be programmed to generate an alarm if its reading is between the two threshold values or outside the two values. Each channel alarm can also be individually enabled or disabled.

When an alarm condition is detected, an Alarm Flag is logged alongside the historical data.

The logger can be programmed to use latching or non-latching alarms.

Non-latching alarms are simplest, in that when the channel reading changes to a non-alarm value, the channel alarm ceases.

Latched alarms are used if alarm notification is to persist until acknowledged by the user, even if the original alarm condition ceases. The alarm is acknowledged by sending a special message to the logger. Acknowledging the alarm will clear the alarm condition even if the channel reading is still at an alarm value. The channel alarm will only be re-activated if the reading subsequently changes from a non-alarm value to an alarm value.

The way the alarm condition is detected depends on the type of channel as follows :-

- Analog or Temperature channels are checked once per minute (at 00 seconds) using the value averaged over the previous minute.
- Digital channels are checked once per minute (at 00 seconds) using the increase in count since the start of the whole logging period. Note that if the alarm becomes active during one logging period, it will stay on at least until the end of the next logging period (as it is only at this time that it is clear that the channel is not going to generate an alarm again).
- Status channels are checked once per second.

When alarms occur, the logger can be programmed to notify the user using the on-board relay and/or by dialling in to a PC.

The relay is provided with contacts that are closed for the non-alarm condition and open for the alarm condition. This means that if the logger power fails or if the cable is cut, an alarm will be raised.

If latching alarms are programmed, and notification is via the on-board relay, it is possible to program one of the logger inputs to be used for a reset button or remote contact that will cancel the relay alarm. Once the alarm relay has been reset, it will only be re-activated if a new channel alarm occurs.

5.2 Simple Control

The alarm function together with the on-board relay can be used to implement a simple control function, such as a thermostatic control.

To do this, one channel is connected to a temperature sensor, and its Low alarm threshold set to -80.1 degrees (to disable the low threshold) and the High threshold set to the desired temperature (eg. 20 degrees). The channel is programmed to generate an alarm if the input falls outside these values, and the logger is programmed for non-latched alarms and to notify the user via the on-board relay.

If the temperature is below 20 degrees, the alarm will be off, and the relay contacts will be closed. Once the temperature exceeds 20 degrees, the alarm will come on, breaking the relay contacts.

The relay contacts can be used to switch power onto a heater or boiler control relay. Note that because the relay logic is 'fail-to-alarm', the alarm is active (with relay open) when heating is **not** required.

To produce a thermostatic control that works on several sensors (ie. generate heat if any sensor temperature is below the threshold), each temperature channel must be set to generate an alarm when the temperature is below its upper threshold. However in this case the relay contacts will be open when heating is required, so an intermediate changeover relay would be required to switch on the heater.

6. Software

6.1 Stark Reality

Stark Reality software is recommended for automatic data collection, analysis and the production of reports and charts.

SHM loggers have been optimized to work with this software package.

Reality supports time synchronization, connection via telephone modems, scheduled dial-out (for use with Answer Window), outstation Dial In and alarms.

6.2 XLeMs

XLeMs stands for Excel-based Energy Monitoring Software. It is an easy-to-use application that collects data automatically from SHM loggers and stores the readings in a relational database.

These readings can then be extracted from the database and written in the form of Microsoft Excel spreadsheets. By using familiar Excel skills, you can present the data in exactly the format you want it (charts, invoice etc).

Once you have produced a template (eg. for a monthly report), it only takes a few clicks to generate a report for the month you require. You can also schedule reports to be run automatically every day, week or month as appropriate and optionally send the report via Email.

6.3 UREAD

This application can be used in conjunction with Stark Reality.

UREAD is designed to run on a laptop PC that is taken round to each logger to collect its data via its local interrogation port. The data is written to the PC's disk in Stark DF2 format. These files can subsequently be imported into the Reality database.

UREAD would be used if the normal communications network (telephone lines, RS485 links) suffers any long-term disruption. When automatic data collection cannot take place, the data can still be collected manually using UREAD.

UREAD supports the Modem Serial Switch and can also operate remotely via Ethernet, RS485 network, telephone or radio modem.

6.4 UCSV

This application is used where the logger is used without Stark Reality or XLeMs.

UCSV reads the historic data from loggers and writes it as CSV (Comma Separated Variable) text files to the PC disk. These files can easily be imported into spreadsheets (such as Microsoft Excel) for subsequent analysis.

Sample Excel macros are provided with UCSV to assist in automatically drawing graphs of the data.

UCSV supports the Modem Serial Switch and can also operate remotely via Ethernet, RS485 network, telephone or radio modem.

6.5 UCOMM

UCOMM is a utility used to set up and configure every programmable parameter in SHM loggers.

UCOMM supports the Modem Serial Switch and can also operate remotely via Ethernet, RS485 network, telephone or radio modem.