Elizabeth Nicholson, Matthew Bechberger and Patrick Yaremko, Cathodic Technology Ltd, Canada, review the process of developing a new cathodic protection survey instrument from concept to market.

Notes from a Napkin in Shanghai

As any equipment manufacturer will recognise, a demand or need for something is the first essential ingredient of any new product. After a successful NACE conference in 2011, staff from Cathodic Technology Ltd (Cath-Tech) were talking with its distributor from Beijing, SANO Technologies (Sano). Conversing in a hotel lobby, Sano highlighted the need for an easy to use cathodic protection (CP) data logger for performing routine test station surveys that could eliminate the need for handwritten field notes, provide the pipeline operator with more accurate and detailed data, as well as document when and where the readings were taken for regulatory compliance concerns.

During the discussion, notes were hastily made on napkins and other papers as the concept of what would be the CorrReader was thought out. A clear understanding of the customers' data requirements, cost considerations and existing technologies available was given initial consideration. Being in the oil and gas pipeline integrity instrumentation business for over 40 years, developing a specialised automated handheld CP instrument was fitting for Cath-Tech.

Requirements

Across the world, oil and gas pipelines must log critical CP data on a regular basis as part of their pipeline integrity management programme. Logging includes complex surveys such as close interval potential surveys (CIPS), direct current voltage gradient surveys (DCVG) and inline inspection, as well as regular monitoring of rectifiers, bonds and test stations. Test station surveys are still being performed globally with a regular digital voltmeter (DVM), such as a Fluke and a handwritten notebook.

To improve this, the new instrument needed to be a purpose built, handheld, outdoor device for performing regular test station surveys. It would be easy to use so that personnel with little to no training (for example, local landowners, students or interns) can acquire high quality data. Concurrently, the instrument needed to protect previously inputted data to prevent an untrained user from disrupting the records. Low cost is also required to get the equipment into the hands of many surveyors simultaneously. By allowing many technicians to have an instrument of their own, travel costs for dedicated survey workers and shipping costs for equipment are reduced.

Handwritten readings and notes can easily introduce human errors when recording data and later transcribing to a computer file. Integrated electronic logging satisfies regulatory compliance requirements and ensures that precise location and time data are captured. Electronic files are much easier to transmit, copy to multiple recipients, store and backup securely. Using commercially available MicroSD cards, the technician can simply swap the cards if a local computer for downloading the information is not available. The new instrument is programmed, charged and downloaded through a standard USB interface.

The CorrReader CP instrument has been designed to perform interrupted or polarised surveys. Interrupting the source of CP on a structure allows the surveyor to measure the polarised potential. Without interruption, the surveyor reads both the pipeline potential and errors from any other potentials in the ground. If the survey is performed with a normal DVM, readings are often

inaccurate due to imprecise timing. During an interrupted survey, there can be leftover capacitance or inductance due to the length of pipe and the nature of the coating on it. This causes spikes in the pipe-to-soil potential that are included in the reading on a DVM. Modern CIPS instruments improve accuracy by using the GPS system to delay the reading to a moment when the potential has stabilised, thus, recording an accurate pipe-to-soil potential.

Another emerging factor in the management of oil and gas pipeline integrity is monitoring of alternating current (AC) interference. It has been proven that induced AC on structures can cause corrosion and failures. Cath-Tech's instrument was designed to measure AC and direct current (DC) for each reading. Since the instrument is synchronised with the interruption cycle, it records separate 'off' and 'on' readings. Survey systems, such as CIPS, are unable to measure AC accurately as the long trailing wire will pick up AC current through induction and distort any readings. By developing a purpose built and easy to use instrument, these issues were addressed.

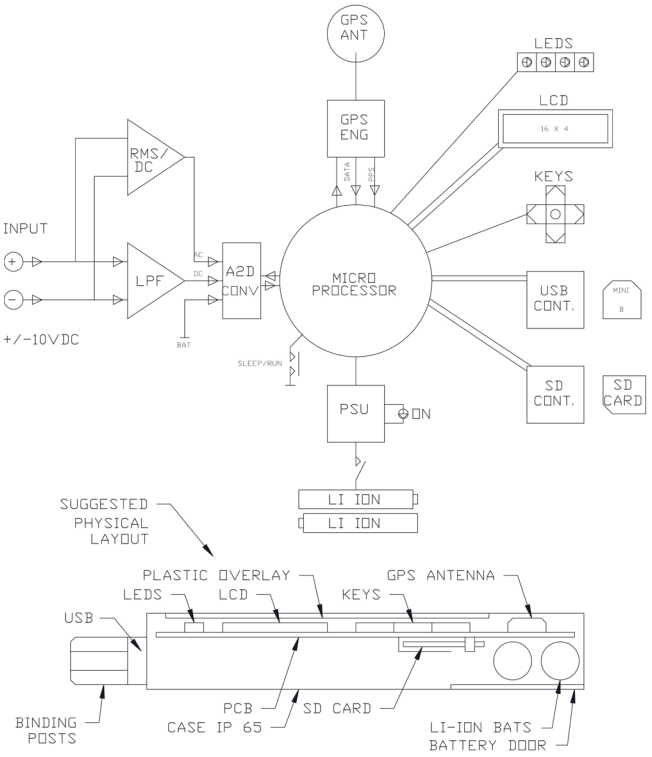

Figure 1. CorrReader block diagram schematic.

Figure 2. A field trial in Canada.

Development

The development team reviewed the requirements of NACE SP0207, section four and researched other CP survey instruments to investigate what features are necessary to obtain accurate readings. The circuitry was designed with a 10 mΩ input impedance and a -80 dB AC filter to ensure that DC readings are accurate with no imposed AC. It also uses an internal GPS module to synchronise with current interrupters and obtain the true off and on potentials. User configured measurement delays also ensure that accurate readings are obtained by waiting for any inductive or capacitive spikes to clear prior to measurement. Finally, the ability to enter comments at the time of measurement makes it easy to identify and organise data during an analysis.

The CorrReader is configured using a parameter file when it is connected to a computer via USB. The settings available are:

- Cycle time: 1 sec. minimum and 6 min. maximum.
- Off time: adjustable in 10 msec. increments.
- Starting level: can be configured for the cycle to have the on or the off first.
- On/off measurement delays: separate configurable delays for the on and off reading times.
- Local time offset: the UTC time offset can be entered to correct the GPS time to match local time.
- Number of readings: can be configured to record a 'batch' of 1 - 20 readings across multiple cycles to capture useful data.

The CorrReader has integrated error-checking to ensure that the user has configured the cycle on/off times and delay times correctly. When the user presses the 'Power' button, the unit starts up, checks the settings, obtains the GPS signal and begins to display voltage values without needing any additional action from the user. The user can then view the values in real time on the screen and press 'Enter' if and when they want to record the reading. After the reading is recorded to memory, the user has the option of entering any comments (location ID) using the arrow keys and on-screen keyboard.

When in the field, the instrument records the following data:

- DC off and on (±10 V, 0.1 mV precision).
- AC off and on (100 V, 0.1 V precision).
- Local time and date.
- GPS co-ordinates, number of satellites, position dilution of precision and altitude.
- User-entered comments, such as test point name or location ID.

The data is stored in a plain text .csv file, making it easy to import into any oil and gas pipeline information management database and is Pipeline Open Data Standard compatible. No special software is required to compare the data from the CorrReader with previous surveys. The file header also contains information on the settings that were used to obtain the readings, such as cycle time and measurement delay. Therfore, the operator can ensure consistent data collection over time. The instrument was also designed to accept firmware updates, permitting upgrades to units that are already in the field.

Testing

The CorrReader went through numerous tests both in a laboratory and in the field prior to its commercial launch. Throughout its development, the team worked closely with its production and field teams to confirm that the instrument was reading and recording accurately and to design for ease of production. The laboratory testing included AC rejection, filter settling time, battery consumption and GPS lock time.

There were two main opportunities for field testing. One was local with Cath-Tech staff, the other in China with Sano Technologies.

Cath-Tech staff went to a local ski resort during the off season and used CP to protect underground water and air pipes. This was an isolated system that was free of external influences, with easy access to rectifiers and no hazardous product involved. Staff interrupted four rectifiers with a cycle of 200 msec. off, 800 msec. on for a total cycle time of 1 sec. They then walked along the pipelines and took readings at snow machine hydrants. The instrument obtained an effective GPS lock and recorded valid on and off readings.

Figure 3. A field trial in China.

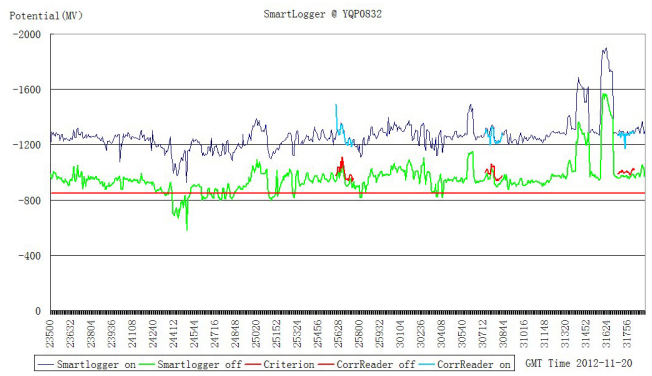

Figure 4. A graph comparing the CorrReader with a stationary data logger during a field trial in China.

Once Cath-Tech's development staff were satisfied with the operation and accuracy of the instrument, units were sent to Sano in China for evaluation and testing. The testing yielded some successful data and highlighted further work to be done. Issues with certain cycle times were exposed and these required software modification. The source of the problem turned out to be a software bug that would synchronise with the pulse per second from the GPS properly, but would not correctly locate the 'top of the minute' to match the cycle patterns with the interrupters. This was easily resolved in the software once the correct diagnosis has been made.

A watertight external USB port was added as a response to feedback and an option was added in the software to allow the technician configuring the instrument to override the measurement delay with their preferred value. If there is no delay value input, then the instrument calculates a value based on the off and on cycle times.

A sample of the data taken from the tests in China, which compared the CorrReader with a GPS-synchronised stationary data logger, is shown in Figure 4.

In order to keep the cost low, the development team also considered production challenges. Wherever possible, standardised off-the-shelf components were used, as this saves both time and cost. The electronics were designed to fit on one side of a printed circuit board and plug directly into the LCD screen. Minimising the separate subassemblies, as well as reducing custom components and wiring have made the assembly production more streamlined and efficient. Attention was also paid to the lifespan of the components chosen with a planned production life of seven years.

The CorrReader was submitted to an independent laboratory and tested for dust and water ingress. It successfully passed IP6X and IPX5 testing giving it a rating of IP65. It was also subjected to a 1 m drop test, which was also passed.

Conclusions

Since its release on the market, many companies have successfully utilised the CorrReader in their daily pipeline monitoring activities. The combination of accurately timed readings, electronic data recording and GPS location are ideal features for this. The integration of GPS and configurable delay times ensure that the reading is taken in synchronisation with the interrupters and without any distortion from induction spikes. It is important to obtain accurate instant off potentials, which can then be directly compared to data taken in a similar manner during a close interval survey.

If an oil and gas pipeline operator or government oversight auditor questions the validity of the data, the surveyor can use it to prove that they were present at that site, and validate that company protocols were followed. With no need to handwrite or transcribe data into a database, a major source of human error is eliminated. WP