Troubleshooting Profibus PA

A practical example

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On a recent field assignment to troubleshoot a network, we were reminded of how robust Profibus is and how, even though troubleshooting is a science, it is not black and white. One of the reasons that we found this site visit so interesting was that things were not as they first appeared. In this article we will go over the process we followed and the things we learnt.

The Site

The site was a specialty chemical company producing chemicals used in the petro-chemical industries. All the instruments were located in hazardous environments and the intrinsically safe aspect of Profibus PA was used. The site consisted of a Siemens APACS DCS with two Profibus DP networks that uses Satelline-3Asd wireless modems to connect to a total of 15 Profibus DP/PA Link modules, located in cabinets all around the plant.

The wireless modems used a licensed frequency for transmission, and were capable of transmitting long distances. However, the environment that they were being used in was not very friendly to wireless technology. There were a lot of obstacles and electromagnetic noise to overcome.

Each link module is configured for 20 to 25 instruments with about six to eight instruments per Profibus PA segment using Profibus DP/PA Ex couplers.

The two Profibus DP networks are both set up to run at 9600 baud, and with special Profibus DP bus parameters due to the radio modems.

The retry limit was set to 5, a value the customer had received from the wireless modem manufacturer. This is high, especially for 9600 baud.

The layout of the two networks is shown in the Figure 1.

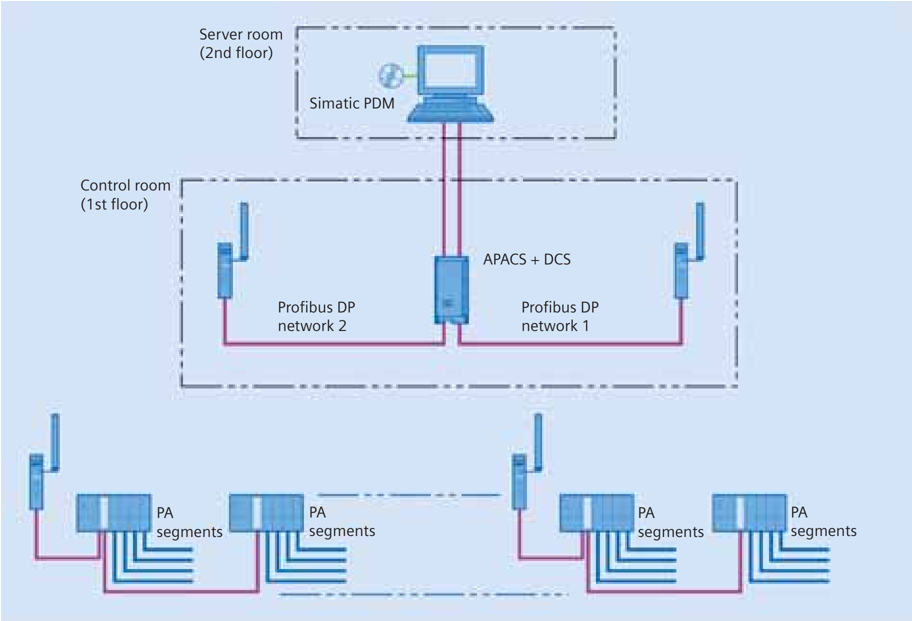

Figure 1: The control system includes two Profibus DP networks with a Siemens APACS DCS

Reported problems

Our customer reported a number of issues:
- communicating to some nodes gave problems
- Profibus errors on the DCS
- PDM sometimes looses connections

However, the site was functional and was getting all the data in within a couple of seconds, which met the site requirements.

Troubleshooting Tool

Before you can troubleshoot a network, you need the correct tools (Figure2). The two key tools for Profibus are a bus analyzer and an oscilloscope. We used a Profibus bus monitor called ProfiTrace which has a special PA probe so that you can view the messages right on the Profibus PA side of the network. For troubleshooting, we used a low cost USB oscilloscope which worked well for this purpose. The oscilloscope is useful because you can get a lot of information from looking at the Profibus PA waveform.

Since there was great number of field devices, Simatic PDM was a key troubleshooting tool. As it turned out the key problems at this site were not instrument based, so we ended up just using Simatic PDM to confirm that all the instruments were configured properly and had no errors. This is important because a badly set-up instrument will generate diagnostic requests on the bus which might look like a bus problem at first sight.

Troubleshooting Profibus DP

When troubleshooting a large Profibus PA system, you should always start with looking at the Profibus DP side. One of the advantages of Profibus is that in general you use the same troubleshooting equipment for both Profibus DP and Profibus PA – the only real difference is the physical layer. The physical layer refers to how you transmit the ones and zeros. Profibus DP uses a modified RS-485 physical layer which uses a differential signal to transmit the information. Profibus PA uses a far more complex method called Manchester Encoded bus powered which is defined in IEC 61158-2 standard. This is a method where power and communications can be done on the same two wires.

The fist step in troubleshooting Profibus DP was to do a visual inspection of both Profibus DP networks. Then we connected the Profibus bus monitor to both DP networks multiple times and took traces and monitored performance.

The visual inspection proved to provide the most information. Technically, at installation several Profibus DP wiring guidelines were violated by mixing cable types, and not using powered terminators (see Figure 3). However, the network was running at 9600 baud and the copper wires were going less than 100 meters, which meant that these violations would have had no impact on the error rate. Also during the visual inspection, we noticed that a couple of the


Figure 2: Trouble shooting tools

Figure 3: One of the panels shows violation of Profibus DP wiring guidelines

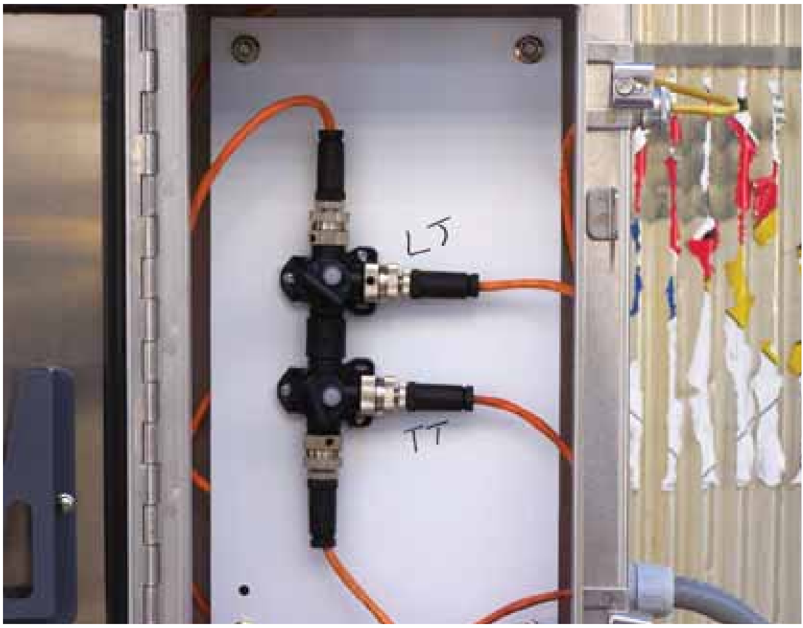

Figure 7: "T" connector junction box with M12 connectors

antennas were not mounted correctly. It looked like they had not been tightened enough and had slipped. Once we looked at the Profibus bus monitor and looked at the retry rates to the different stations, we saw that the ones with the largest retry rates were also the ones with the mounting issues.

Fixing the antennas improved things to a point where the DCS was no longer getting Profibus error messages. We were still getting retries, but given the high electrical noise and the number of obstacles in the Chemical Plant, there were limits to how much we could improve the performance of the network.

Troubleshooting Profibus PA

The Profibus PA segments proved to be far more interesting and far more challenging. The first phase of the investigation was to attach the Profibus bus monitor and the oscilloscope to each Profibus PA segment to get an overview of what was going on.

Since these segments were located in intrinsically safe areas, we needed a hot work order before we opened each cabinet. Each area was checked for chemical vapor and all necessary people were notified, which took about an hour for each cabinet. Checking out a large network in an intrinsically safe area requires a considerable amount of time.

Below is a summary of the four major problems that we found, and how they were determined.

Problem 1

Figure 4 shows the waveforms from segment 2, which with its angled peaks and valleys shows there is a problem. Figure 5 shows an ideal wave form in Profibus PA. Figure 6 shows the waveform of a short run with no terminator.

We call this a problem in the sense that the waveform is not consistent with the ideal waveform; the peak to peak voltage is too high and the peaks and valleys are distorted. When we attached the bus monitor to the segment, we saw zero retries and zero errors on this segment. All the instruments were properly functioning, but we were not content with the overall result. We were also getting a similar waveform from most of the other segments, many of which were having communication problems. Something was not right.

An ideal waveform has a peak to peak voltage of around 800mV (Figure 5). If you are missing a terminator, then you get a peek to peak voltage of around 1.5 V and distortions at the top and bottom (Figure 6). Also, as you increase the size of the network, the peak to peak voltage is lowered.

In the case of segment 2, the waveform peak to peak is over 800mV. The distortion at the top and bottom is similar to a segment that is missing a terminator. Just looking at the waveform, we thought that we were examining a long run with a missing terminator. However, the run was under 500 meters, which is not that long; so what else could be causing that level of distortion?

After verifying that there were indeed two terminators on this network, we started looking at how it was wired in detail. This required reading some specifications and doing a few lab bench tests.

We found the answer at the T-connectors and cable types that had been mixed (Figure 7). The site was using Siemens T-connectors and Belden Profibus PA cable. The Siemens T-connectors are vampire type connectors and are designed to match the impedance of the Siemens Profibus PA cable. The IEC 61158-2 standard does not state an exact specification for class A cable. It states a range. Therefore one manufacturer will pick one set of values and another vendor will pick another. When you mix cable types, you get reflections similar to what you get when you are missing a terminator; only to a lesser degree. In this case, the site was unknowingly mixing cable types.
We concluded that given the size of their wire runs, this was not a problem for communications; the bus monitor sup-

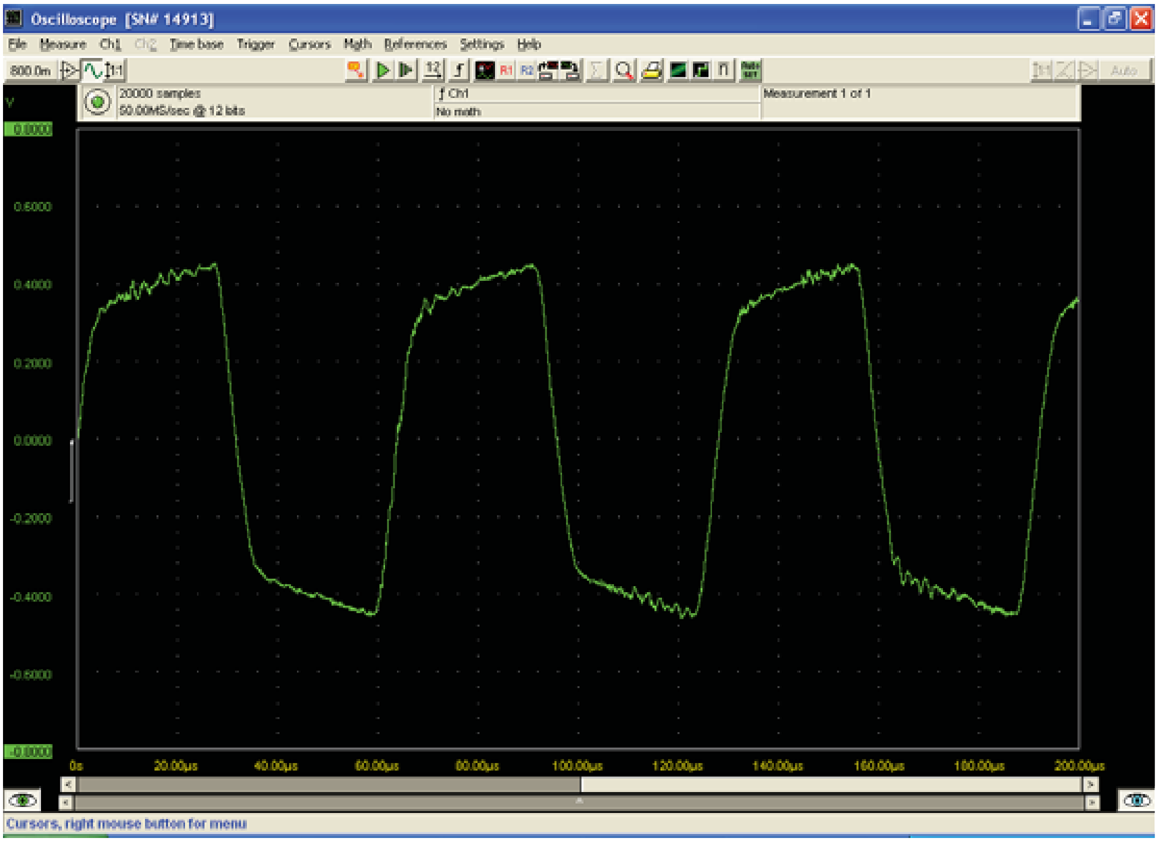

Figure 4: Segment 2 waveform; the angled peaks and valleys indicate problems.

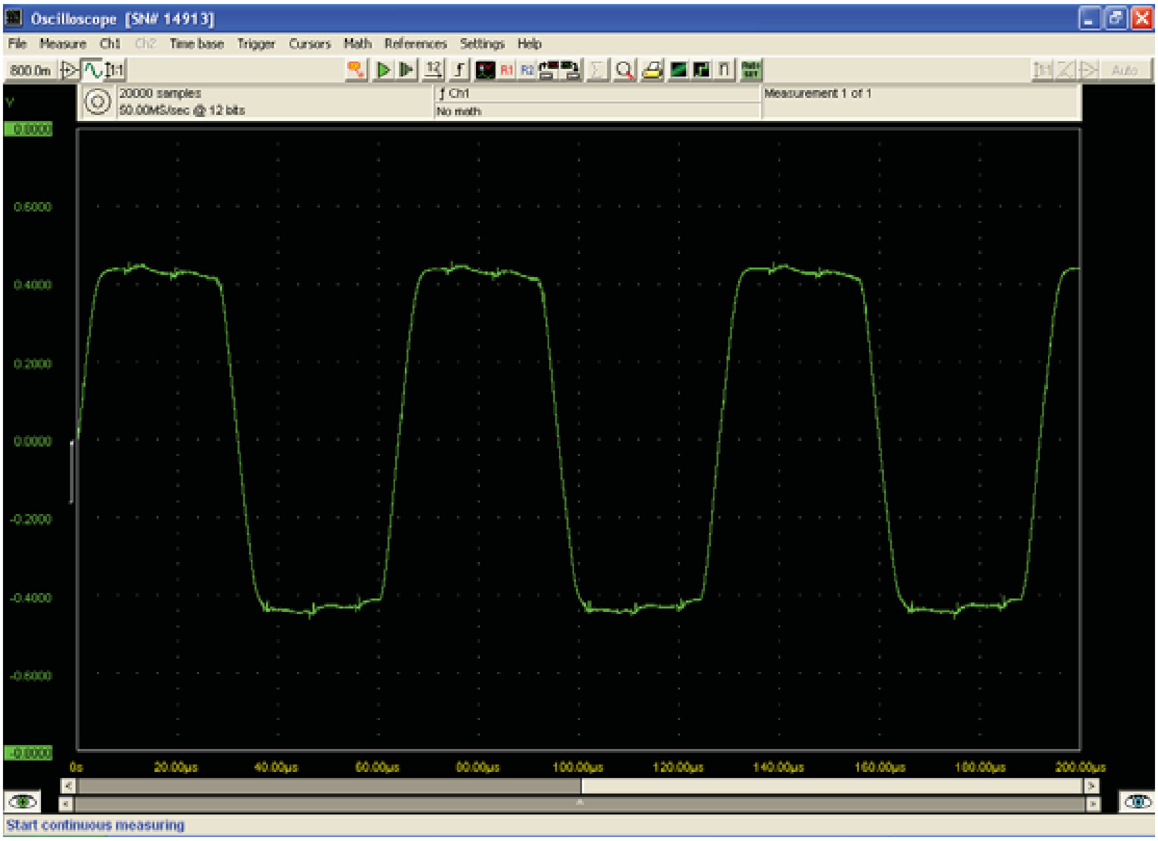

Figure 5: Ideal wave form; a symmetrical form shows perfect communication of signals.

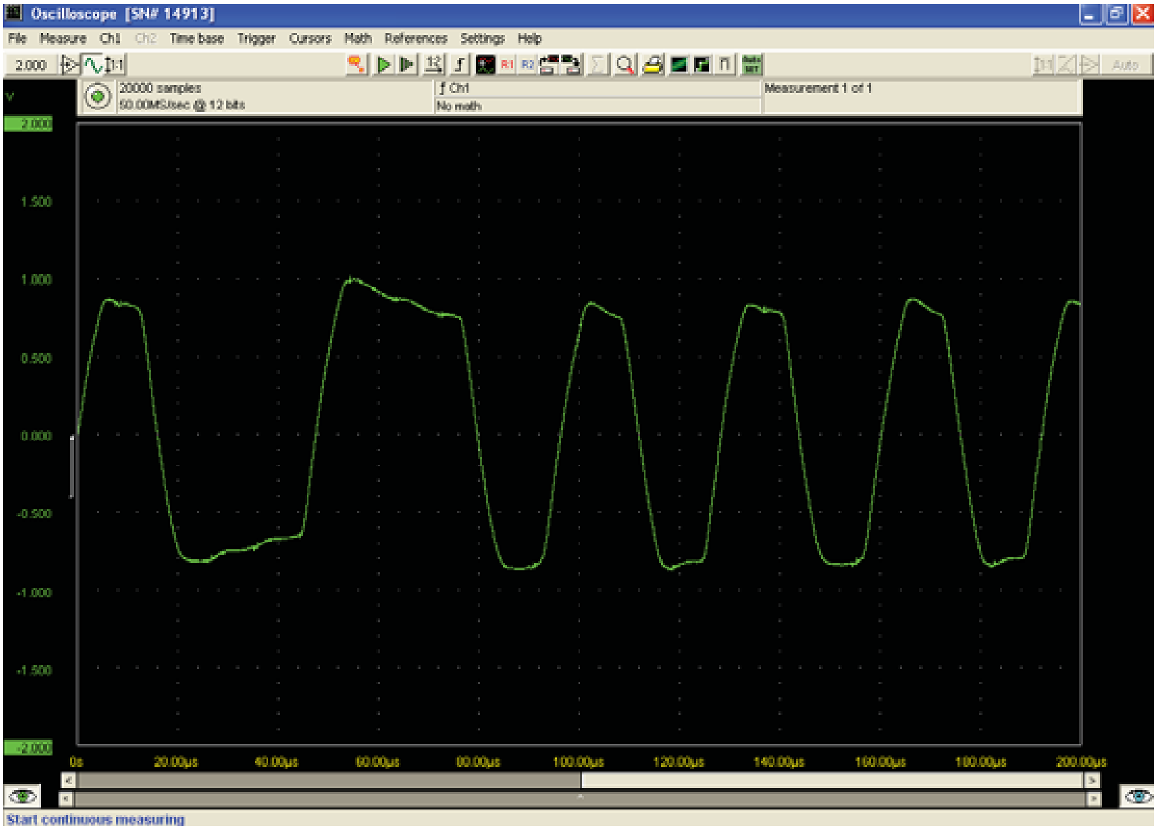

Figure 6: Waveform when missing one terminator.

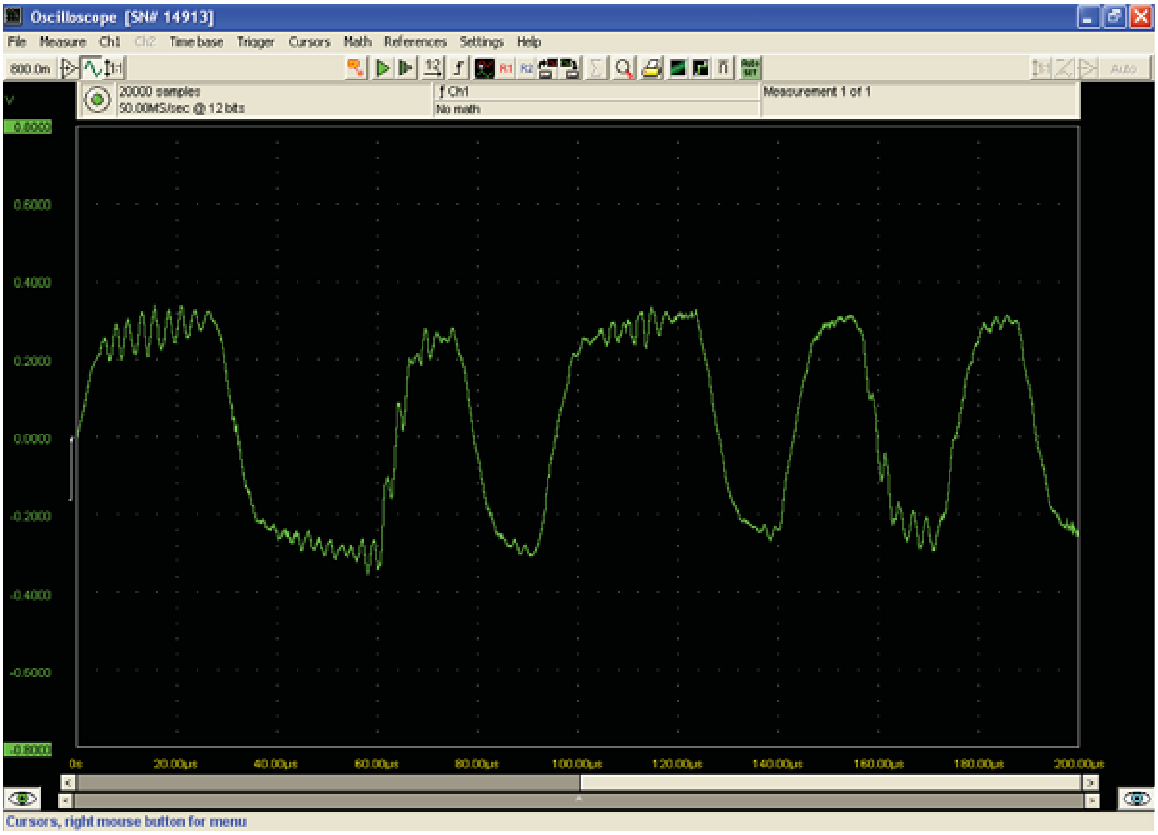

Fig. 8: Segment 1.

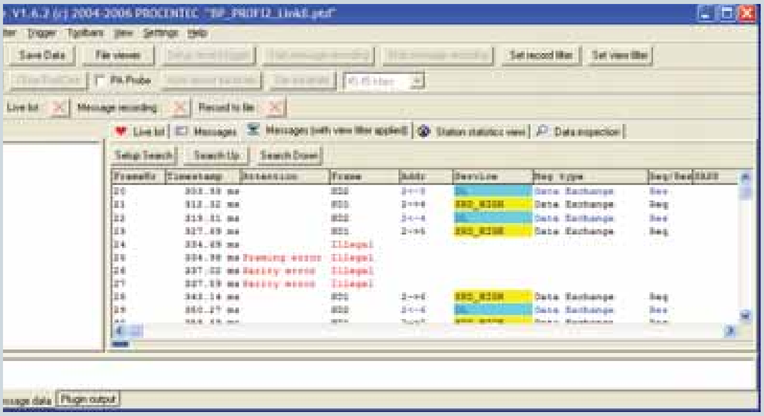

Fig. 9: Trace from Segment 1: showing framing errors and illegal messages

Fig. 10: Temperature transmitter incased in water

ported this. Had this been a non-IS environment with long wire runs, then this wire practice would have been a problem. The ultimate solution would have been to switch out the T-connectors for Profibus PA junction boxes.

Problem 2

Figure 8 shows the waveform from segment 1.

When we looked at this, we figured that there were interferences from power cables or Variable Frequency Drives (VFD). However, when we traced the wire runs, we could not find any sources for electrical noise. During our wire tracing procedure, we opened the cabinets that held the T-connectors with the M12 connectors. These cabinets were not sealed correctly and had water dripping from the M12 connectors (Figure 7). Also, the M12 connectors were connected with only a half turn. A tight connection requires several complete turns, and these connectors were just barely touching. After we dried tightened the connectors the waveform cleaned up.

Problem 3

On this same segment, we were also having trouble communicating to a Siemens radar level transmitter (Sitrans LR250). We connected the Profibus bus monitor program and saw Figure 9.
Given the waveform shown in figure 8, it was natural to assume that it was the electrical noise that was causing this problem. However, once we solved that problem by drying the connectors and tightening them, the communication problem with the Sitrans LR250 did not correct it self. From prior experience, we know that another cause of the framing errors and illegal messages could be two devices with the same address. So we went up to each field device and verified the address. We found two devices with the same address. The solution was simple to change the address in one of the devices to the address that it was supposed to have. Once we did this, the bus errors disappeared.

Problem 4

On segment 10, we had the power light on the Profibus DP/PA Coupler blinking. Since we had only ever seen this light as a solid green, we checked the manual. The manual said that this indicated that the segment was drawing too much power and the current was being limited. On this segment we had a number of Sitrans LR250 level and Sitrans TH400 temperature transmitters. We were communicating to the level devices but had lost communications to some of the temperature transmitters. Therefore, we thought we were probably dealing with an overloaded segment – too many devices and/or too long.

When we opened one of the temperature transmitters, water started to shot out from around the seal and we saw what the problem was (Figure 11). The unit was installed correctly except that where the conduit ended it was not sealed (Figure 12). Water collected via the conduit until the temperature transmitter was completely under water.

To our amazement we could still communicate to all the radar devices on this segment and it was in full data exchange. When we tried to do a download with Simatic PDM, we received communications errors on the long messages, but given that several of the instruments were underwater, we would not have expected any communications at all.

These were also the instruments that the customer was reporting losing connection with – not a big surprise. Once the instruments that were underwater were replaced and the conduits were properly sealed, this problem disappeared.

Conclusions

This site visit definitely showed how robust Profibus is. With the site installation issues we found, the network should not have even worked. Yet the operators were getting data which met their update requirements.

The systematic troubleshooting method that we followed worked very well. However, interpreting the data required some

Fig. 11: Conduit open at the top for rain

art. A test result can have more than one cause. Noise on the waveform that can be caused by electrical noise, can also be caused by a combination of poor connections and water. A waveform that looks like there is a missing terminator can be caused by mixing cable types. Bus errors that can be caused by a noisy line, can also be caused by having two devices with the same address. A segment that is in overload condition can be caused by having too many devices, and can also be caused by having a device with water problems.

Things are not always as they first appear. However, once you fully investigate a problem methodically, the real cause is not hard to find.

Reference:
'A Guide to Troubleshooting Profibus PA Networks', James Powell, P.Eng.

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