Title: Leveraging Field Bus advantages in Up-stream Oil Industry applications.

Introduction:

In current industrial scenario, the pressure is overwhelming to perform, produce, deliver faster, better and cheaper. As technology has reshaped the speed of business and the quality movement has focused on the customer, customer expectations have changed. To thrive and effectively compete in this kind of environment, there is a continuous need to explore new ways to improve industrial performance and the concept of continual improvement has become the buzzword in industry.

The persistent high price of oil & gas in International market has prompted leaders in up-stream oil industry to apply more thrust on enhancing the efficiency and pace of exploration and production activities. Use of information technology has become a focus subject in respect of activities like – Data acquisition, data processing, Data interpretation, Optimization of production level, maintaining health of reservoir, remote monitoring of drilling activities and offering of-line solution for augmenting the operation etc.

In order to ensure seamless integration of well head data and drill site data with it’s actions at installation level as well as decision making activities at asset level and at Corporate Head quarter, ONGC has embarked upon a project for – “Enterprise wide SCADA system for production and Drilling facilities”. The scope of this project is to capture data from both off-shore and on-shore assets which covers 157 offshore platforms, 10 offshore rigs, 247 nos onshore installations, interconnecting pipeline, 5 on shore process plants and 65 onshore rigs.

The information data base from SCADA network is further integrated to it’s business information system (ICE) and scientific data base(EPINET) for sub-surface activities.

The entire SCADA project has been conceived as three Tier system.

Tier-I has been confined to - data acquisition at field installations covering day to day operations in production installations and drilling rigs. This facilitates access of all critical production data - like well head parameters, well test data, instantaneous and cumulative fluid production rates, their trends, custody transfer

<table>
<thead>
<tr>
<th>172 x Tier 1 Onshore (Typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Remote Low Power RTUs</strong></td>
</tr>
<tr>
<td><strong>Polled via two Tier 1 sites</strong></td>
</tr>
</tbody>
</table>

**Legend**
- GGS, GCP, ETP
- 12 High Prod. Wells
- 12 Tier 1 sites
- Redundant LAN
- R T U
- Terminal Server
- Spread Spectrum Radio
- Workstation Multi-purpose
- Event
- Laser
data as well as inventory levels in each installations. Similarly from drill sites, many important parameters like – mud parameters, ROP, depth, pump parameters, rotary parameters, hook load etc shall be captured.

**Tier-II** level has been envisaged as the centre of conglomeration of all Tier-I data from all production installations and also for Drilling SCADA for the particular asset and the same is available at Asset collaboration centre for asset level monitoring and assessment through radio and microwave links.

**Tier-III** level control centre at corporate HQ, Delhi shall further integrate the data from all Tier-II collaboration centre situated at individual assets through lease network. Data base at Tier–III control room is further interfaced with EPINET and ICE system to facilitate business applications and MIS reporting.
Tier –I Instrumentation and network:

The types of parameters to be monitored at installation level are of wide variety and in some cases fluids are not consistent in nature. So, it is of paramount importance to select right types of devices to ensure reliable, consistent and trouble free operation of the devices in longer time horizon. The types of fluid to be handled for measurement again varies from installation to installation apart from varying operating ranges from time to time. Some of the typical parameters which have been considered in general for all such production installations are as listed below along-with types of devices selected:

<table>
<thead>
<tr>
<th>Serial no</th>
<th>Parameters &amp; application</th>
<th>Instrument device</th>
<th>Type of device</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Well head pressure / temperature</td>
<td>Pressure /Temperature transmitters with Radio telemetry</td>
<td>Radio transmitters powered with solar cell.</td>
</tr>
<tr>
<td>02</td>
<td>Flowing status of wells /flow rate</td>
<td>Clamp on Ultrasonic flow meters</td>
<td>FF / MODBUS device</td>
</tr>
<tr>
<td>03</td>
<td>Gas flow to dispatch header / gas flow from individual gas wells</td>
<td>Orifice meters (senior orifice fittings) with multiple sensors</td>
<td>FF device</td>
</tr>
<tr>
<td>04</td>
<td>Tank level indicators</td>
<td>Guided wave Radar type level indicators</td>
<td>MODBUS</td>
</tr>
<tr>
<td>05</td>
<td>Line temperature of oil &amp; gas line</td>
<td>Strip type RTD device with filed transmitter</td>
<td>FF type</td>
</tr>
<tr>
<td>06</td>
<td>Water injection header flow rate</td>
<td>Orifice meter /DP transmitters</td>
<td>FF type</td>
</tr>
<tr>
<td>07</td>
<td>Gas lift header pressure</td>
<td>Pressure transmitter</td>
<td>FF type</td>
</tr>
<tr>
<td>08</td>
<td>Gas lift finger flow rate</td>
<td>DP transmitter with P&amp;T compensation</td>
<td>FF type</td>
</tr>
<tr>
<td>09</td>
<td>Test gas flow rate</td>
<td>Senior orifice meter</td>
<td>FF type</td>
</tr>
<tr>
<td>10</td>
<td>Effluent water dispatch meter</td>
<td>Magnetic flow meter</td>
<td>FF type</td>
</tr>
<tr>
<td>11</td>
<td>Mass flow meter for stabilized oil</td>
<td>Coriolis meter</td>
<td>MODBUS</td>
</tr>
</tbody>
</table>

As per strategy adopted, all new additional devices has been opted for having FF interface except for some typical applications where special type of instruments have been necessary and the manufacturers are yet to develop models with FF interface. Moreover, wherever existing electronic devices are already in existence and in operation , the signals have been interfaced either HART protocol or through RTU and MODBUS link with HOST system. All digital inputs like – level switch, pressure switch, flow switch etc have been first interfaced with Digital I/O module and then to HOST controller through Profibus interface. Accordingly, host system at installation control room have the provision for all types of interfaces like – FF, Profibus, MODBUS, HART & serial input.

For data from Drilling Rig, parameters like - are captured from Rig sensor module to RTU through BITSML protocol. These data is first received at nearby production installation through radio link and then from installation control room to asset control centre through microwave link.

Strategy for Fieldbus devices and architecture:

Although the Host system has been designed to support a hybrid network to accommodate devices with 4-20 ma signal, HART signal, profibus DP and FF signal, most of the filed devices (around 90%) are with FF interface. Typically, within Ankleshwar asset which has 32 production installations, out of total 1752 new field devices introduced against SCADA project, 1126 devices are FF type. Further, since all filed devices are installed in hazardous area, all the loops have been engineered with FieldBus Intrinsically Safe
Concept (FISCO) for intrinsic safety by using field barrier. Each H1 segment has been assigned to support maximum 4 such Field barrier with each Field barrier supporting maximum four FF devices. However, care has been taken not to load each segment more than 75% of their maximum capacity. Spur lengths for each device in general varies from 20 to 50 meters and main trunk cable length ranges from 100 to 250 meters. Thus, the maximum cable length for extreme location is within 850 meters.

Typical FF network is as shown below:

List of control hardware (at Tier-I control room):

- Redundant controller: AC800F consisting of
- CPU board PM803 F
- Power supply module: SD 812F
- FF Module (4slot): FI 840F
- Profibus module: FI 830F
- Ethernet module: EI 813F
- Serial Module (MODBUS): FI 820F
- Redundancy Link Module: RLM 01 (for Profibus DP inputs)
- Analog Input module: AI 845 / AI 810 / AI 830 (for RTD input)
- Digital input module: DI 810
- Digital output module: DO 810
- Field bus communication interface: CI 840

List of field hardware:

- Field barrier: P&F
- Surge protector
- Field Terminator
Why to opt for FF devices?

1. **Versatile Diagnostic coverage:**
   In view of large no. of field devices installed at various filed installations and all the devices are being installed in remote and scattered locations, it is a mammoth task to maintain the devices in case of trouble. It is not feasible to depute qualified instrumentation engineers at each and every location on regular basis. But, at the same time, ONGC cannot afford to keep the devices out of order for long. Hence, it has been mandatory and very important to have self diagnostic routine checks on each field device to specify the health status of the device and communicate rest of the system whether the data coming out of the device can be trusted or not. It enables detection of device failure and instantly communicates to operator. In any specific application, even this type of “device failure” situation can enable user to pre-configure the interlock to fall back on most safe situation as per outcome of HAZOP study. Although the internal diagnostics within each device is to some extent vendor specific depending on sensing technology adopted, as part of field bus protocol the same is incorporated within DD files in standard format so that HOST can read it equally well. The typical screen display in operator console for such diagnostic alarms are as shown in fig 4.

2. **Lesser hardware and variety:**
   With field bus technology, reduction in hardware is achieved both in field instruments (allows multiple inputs with one transmitter) as well as in control stations (as it eliminates the need of I/O subsystem thus smaller size system cabinets are required).

3. **Faster erection and commissioning:**
   Reduction in panel hardware means – less marshalling, termination, power supply and elimination of tedious task of verification process for each I/O loops. Total verification process is significantly reduced as a single check for communication to verify the integrity of communication port is good enough. Moreover, since the values are transmitted in engineering units there is no pressing need to establish consistency of scaling between devices, controllers and work stations. Use of multi-variable devices reduces again the no. of total device, it’s installation requirements and also facility for remote diagnostics reduces the hassles for accessing the instruments for maintenance. This allows the devices to be installed even in difficult location without much thought on access problems. The types of cables to be used are significantly reduced including individual loop integrity check.
   Unlike a traditional system, for which commissioning is a very manual and labour intensive task, devices in a field bus network can be commissioned from the work station in the control room itself. It has been observed that – once host is connected to the field bus network, all field devices in the network are automatically detected in one shot and the tags are identified in the Host’s live list for each network. As a result, practically the commissioning time has been reduced to almost 6-8 hours for any particular installation. This save lot of time and resources.

4. **Network enabled asset management:**
   The field bus technology enables simultaneous transfer of I/O data related to process parameters as well as many system configuration data like – configuration download, remote operation, tuning, and asset management functions. As a result, any asset management software meant for functions like - having information for Tag details, instrument specifications, ranges, calibration records, material of construction or reconfiguration of the existing device etc. can directly talk with the devices throughout the plant. Operator while monitoring the desired process parameter can at the same time have details on the health of the device and remain confident on reliability of data.

5. **Interoperability feature** – the ability of a device to work together with other devices.
   Just as the field level network standard gives site to select field instruments, the open host level network lets sites to mix and match subsystems from different manufacturers. It has been possible for subsystems
to use different field level networks but be integrated with each other through the same Host level protocol.

6. **Graphical programming Language:**
   Since the programming language is graphical using function block diagram rather than textual, the control strategy can be built by selecting the function blocks and linking them together. This enables equipments from different suppliers to be configured in the same basic way.

7. **Faster system engineering enabler:**
   The simpler hardware architecture and reduced complexity of field bus system greatly simplifies project engineering and design work from the conceptual design stage to detailed engineering as well as documentation phase.

**Threats perception and it’s mitigation:**
1. The very basic concept of running nearly 12 devices under one common H1 bus has inherent apprehension on one’s mind on the consequence of failure of the trunk cable, wherein data for all 12 devices are lost since there is no redundant cable. But, since in reality - the probability of failure of a trunk cable is very less (cable being a passive device and have enough protection from mechanical damage), the other possibility of link failure is due to short circuit or open circuit scenario during maintenance activities. In order to prevent total segment failure, nowadays devices like - Field barriers or power conditioners are having provision to isolate the faulty device or spur and maintain operation in balance devices. Now, since failure is still not overruled, the risk associated with loss of critical parameters in control application can be further minimized by assigning not more than one critical control loop under one segment. However, there is still one positive aspect in the fact that as soon as there is failure of any device or spur or segment, the diagnostic is powerful enough to report the failure instead of leaving it undetected.

2. Another type of apprehension arises from the concept of using FCS architecture wherein PID algorithm is executed within valve positioner itself and the consequence when valve positioner fails. The situation invariably creates the obvious consequence of loop failure. But, a little close introspection shall reveal that – the situation is no way worse than the failure of a valve positioner in conventional system wherein, by default the valve goes to its fail safe position.

3. The data transmission in H1 network is managed by Link active scheduler (LAS). Generally, Foundation H1 data link layer recognizes three device types lie – Basic, Link Master and Bridge. Out of these three, mostly the host interfaces are Link masters devices and are able to become LAS. Whereas, basic devices like transmitters and valve positioners can not become LAS. So, when the Link master devices fail, there is scenario of communication failure in the segment. To overcome such scenario, nowadays trend is to configure some of the field devices also to take over as LAS in case of failure of link masters.

**Conclusion:**
Although majority of FF devices used against the SCADA project are for open loop application and control of process is not envisaged, the most important benefit realization comes out of the fact that by using field bus technology, we can have right information from the device at right time to make the maintenance much more simple but efficient.

Devices based on field bus technologies have wide diagnostic coverage although it varies from manufacturer to manufacturer. But, it has been the trend to use additional sensors, separate electronics and self diagnostics firmware algorithm which generates several error messages to identify the type of failure and in turn helps in identifying the failed component easily.

Overall, we can conclude that advent of field bus technology has enabled users to leverage with more and more useful information on device hardware used for sensing as well control to ascertain it’s health status before failure and also adequate guidance for recovery from failure status. To be more precise, it’s a good start with right step but yet miles to go.
**Profile of Author:**

Sh Ajeykumar Rout is currently working as Dy. General Manager (Instrumentation) in ONGC Ltd, India. He has more than twenty-five years of experience in the field of control & Instrumentation systems for Oil & Gas industry and is currently assigned for various Automation projects in ONGC. On the academic front, he did his M.Tech in Measurement & Instrument Technology from Calcutta University, India before starting his professional career in ONGC.

Sh Rout has been involved in Basic Engineering, Technical evaluation, Review of Engineering documents and Commissioning of a large number of grass root projects in Oil & Gas processing applications in ONGC. He has successfully implemented advanced process Control schemes for process plants within ONGC and is currently steering various control system up-gradation projects within ONGC in order to introduce new technology.