

# THE CONSIDERATIONS AND BENEFITS OF ETHERNET BASED LOW VOLTAGE MOTOR CONTROL

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Dave Holcroft  
SIEMENS Digital Factory  
Manchester  
M20 2UR

**Abstract** - This paper presents the latest concepts for motor management using intelligent electrical devices. It starts with the widely accepted concept that smart Motor Control Centres are generally more compact as well as easier to deploy, evidencing why, and builds from this point exploring how the latest generation of devices, their safety and diagnostic capabilities and networking possibilities offer the end user even more technological benefits and opportunities for commercial savings (both in OPEX and CAPEX budgets).

Using the case study of BYK Additives, UK, it explores why the user chose to adopt Ethernet connectivity within the MCC, rather than the more widely installed Fieldbus. It looks at the challenges this change of approach to networking presented (if any) and reflects these against what benefits were realised; summarising BYK's considerations and how they incorporated the lessons learnt within their strategies for smart motor management. While the paper is strongly technically biased there are some commercial examples (irrespective of origin of component manufacturer) to evidence that this shift in manufacturing principles and end user embracing of smart technology is often the most cost effective choice.

## I. INTRODUCTION

The term smart MCC, iMCC (Fig. 1) or similar is applied to the more modern iterations of the motor control centre design, which are built around the use of smart sensors and intelligent electrical devices. The principle of the design is that the components for motor starting, metering, monitoring and protection are networked, transmitting data via fieldbus cable rather than the traditional option of hardwiring the signals to a control system (via cabling termination sections of the MCC). The Intelligent Electrical Device (IED), at the heart of the iMCC concept, is now often capable of performing multiple functions, far beyond the purpose of monitoring or protection and in some instances can be viewed as a local micro controller. As such components that were originally used for

tasks (counting, timing, monitoring, metering, relay logic etc) are no longer required as their function may be found within the IED; as a result the individual component count in the motor starter compartment is often reduced.



**Fig. 1** Smart MCC example

Naturally there are tradeoffs to consider; the IED may be more expensive than the cost of the individual components, however when the cost of the wiring within the starter section is considered then the IED based offer is often the most cost effective solution.

Additional spatial and weight considerations, perhaps specific to floating production, could be that the reduced component count and reduction of associated cabling will also translate in to a weight saving per individual starter. It would not be unusual to see savings of several kilos on a single motor starter drawer as well as a more compact footprint; clients moving from a traditional 11kW hardwired solution to an intelligent motor management device (IED) based alternative could anticipate a net saving of as much as 4.5kgs, which would also see the height of the drawer to be reduced from 150 to

100mm. This reduction of height per starter allows the manufacturer to also increase the stacking density of drawers in to the MCC, which would translate in to reduction of number of tiers, which of course reduces the panel length.



**Photo 1** Networked MCC withdrawable drawer inc. IED motor starter

Traditional hardwired MCC designs would generally take the individual hardwired signals (status and other data's) to common point, such as a marshalling section, for transmission and processing by the control system. Naturally under this scenario the wiring is labour intensive but since the IED transmits the same data signals (and more) via a common network cable then individual signal wiring is no longer required, saving not only time but associated cost. If the wiring of individual signals are no longer necessary then by default the marshalling section is also superfluous; translating in to a significant weight reduction (perhaps as much as 200 kilos) as well as normally a reduction in the panel width of 400 or 600mm. Similar arguments would be equally valid if there was a local PLC with an IO section to serve the MCC. In photo 3 we can see the smart MCC minus marshalling and IO sections. Summarizing the construction of a smart MCC, in many instances the solution based on IED and networking is significantly more compact, as well as lighter in weight and occasionally is the only product that will fit in to a predetermined switch room volume.

## II. BYK ADDITIVES

BYK Additives & Instruments is one of the world's leading suppliers in the additives and instruments sector; their products are found in paints and a variety of other domestic and commercial products. As part of a recent acquisition by the Altana Group, BYK are in the process of assessing their production inventory and investing into their business to offer further

benefits to their customer base. One of their recent investments is to be found at their Widnes location in North West England (photo 2); specifically the replacement of mature, legacy MCC panels.



**Photo 2** BK Additives Chemical Plant, Widnes, Cheshire UK.

Engaging with various manufacturers BYK were keen to procure an MCC that would offer them opportunities to harvest data from IEDs, to minimise unplanned outages, to offer auto reconfiguration of new devices, to allow remote access via VPN (virtual private network) and where possible to extend the benefits of Ethernet networking into any new procured asset.



**Photo 3** New Networked MCC

It was also a key requirement to extend their fiber network into the switchroom, which offers limitless transmission as well as noise immunity benefits for the digital signals being transferred along fiber conductors.



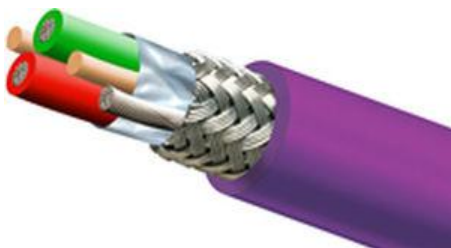
**Photo 5.** Media converter, converting Cat5 copper to Fiber

Their eventual decision allowed them to meet all of their objectives: cost effectively digitalizing their panel, minimizing constructional costs and (using a media converter (photo 5)) extend fiber into the switch room.

### III. FIELDBUS VS ETHERNET

#### Media and overview

BYK were already aware of the benefits of networked devices and networking with various media types, but wanted to explore the possibilities of Ethernet based protocols at motor starter level. The most obvious difference between fieldbus and Ethernet communications is the way that the data is transmitted. Local fieldbus generally relies on a twisted pair cable (Fig. 2) of two or four conductors and the Earth or shield to minimize EMI or noise being transferred (from adjacent power sources) to the data signals transmitting down the cables. Local Ethernet communication however tends to utilize Category 5 or 6, or industrial Ethernet cables and switches (Fig. 3).



**Fig. 2** Profibus Cable

Additional considerations with respect to the enhancements of Ethernet networking comparable to the "limitations" of Fieldbus would be the ease of cabling the network, whereby the devices are just plugged point to point, using off the shelf pre-prepared cables; this could be IED to switch (in the case of a star topology) or switch to IED to IED back to switch in

the case of a ring network. The fieldbus cable is generally a single purpose cable (for the transmission of the process data) whereas the next section will evidence that the Ethernet media is a multipurpose media, where multiple protocols, broadcasts, unicasts or multicasts coexist harmoniously on the same media.

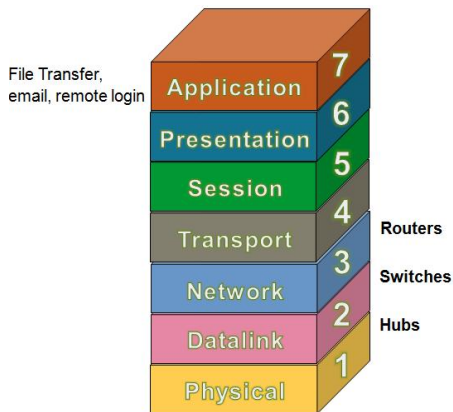


**Fig. 3** Rugged industrial Ethernet cable

Other significant advantages of Ethernet versus fieldbus is the speed of communication, not only the general update times, which in some cases can be in microsecond resolution but the way that the I/O Controller (typically a PLC) and the IO (perhaps an IED) can now simply communicate in full duplex mode, whereby stations simultaneously send and receive data; this was not possible with some older fieldbus installations (typically 2 wire systems) which could only either send or listen or send data. Ethernet networking also offers enhanced redundancy concepts (with system and media options being addressed), significantly more flexibility with respect to topology, as well as utilizing IP (internet protocol) to offer web tools and simple remote connection to IO's or IEDs. The paper will explore some of these concepts in a moderate level of detail.

#### Ethernet based protocols

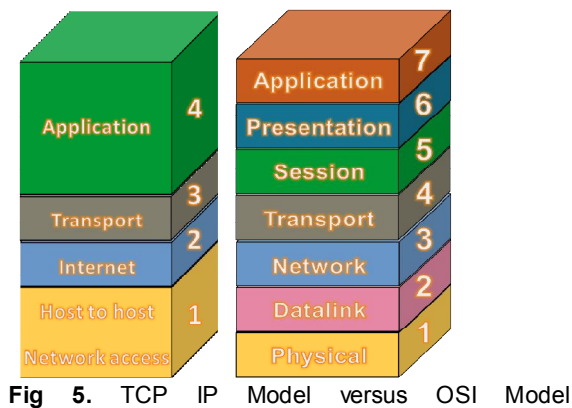
The OSI model (Open Systems Interconnection) (Fig. 4), which is based on the original TCP IP model, (Fig. 5) is accepted as a generic model for all new Protocols and thus used for networking IEDs with controller or PC. It is noticeable that the lowest layer, the Physical Layer, is concerned with the physical connection and transmission of the unstructured raw data over the media. The previous examples of Fieldbus and Cat5 cables would sit in this layer. In addition to the transmission of the data the physical layer is also responsible for Data Encoding as well as Transmission Technique (digital baseband or analogue broadband signaling). This physical level will hierarchally serve all of the higher levels



**Fig. 4** OSI Seven layer model

The paper will cover the Datalink layer at a further stage as this will be responsible for the automatic reconfiguration of a new or replacement IED, for now the focus will be on the Application layer.

The Application layer is the highest OSI layer where the user interacts with the computer. This is the layer for applications involved in a communication system and is where the Protocols such as Modbus, Profibus, Profinet and Devicenet sit. As the Application layer is at the top of the layer stack, it does not serve any of the other layers, instead the Application layer takes the help of the Transport and all layers below it to communicate or transfer its data to the remote host. During the communication process (peer to peer communications for example) the Application layer protocol communicates to its peer application layer protocol on a remote host (another communicating device, perhaps PC, PLC or IED), in order to do so it passes the data to the Transport layer. The transport layer manages the rest of the process (with the help of the lower layers).



**Fig. 5.** TCP IP Model versus OSI Model

Exploring Ethernet and Fielbus protocols specifically we can see in many cases (as with Modbus, commonly used in process environments) that the Ethernet and Fieldbus versions of a protocol are very similar but use alternative media lines and “wrap” the data in a TCP IP or IP envelope; TCP referring to Transmission Control Protocol and IP Internet Protocol being used for transferring data over the internet. That said, there are some differences which are highlighted in the telegram diagram (Fig. 6) significant differences would include the slave address (which isn’t used in Ethernet based addressing) and the Cyclic Redundancy Check element from the PDU (Protocol Data Unit). The PDU being a term used to describe transition of data as it moves from one layer to another within the stack. For a Modbus TCP IP telegram the revised RTU telegram now receives a MBAP (Modbus Application) prefix or header.

The MBAP consists as follows:

Transaction Identifier –

2 bytes set by the Client to uniquely identify each request. These bytes are echoed by the Server since its responses may not be received in the same order as the requests.

Protocol Identifier –

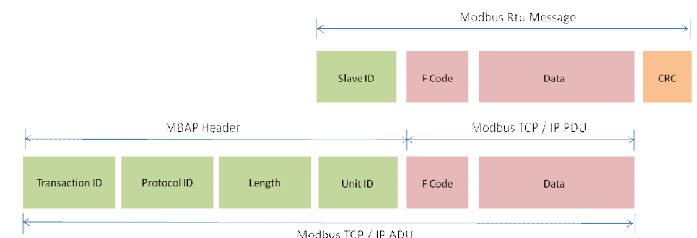
2 bytes set by the Client, which is always “00 00”

Length –

2 bytes identifying the number of bytes in the message to follow.

Unit Identifier –

1 byte set by the Client and echoed by the Server for identification of a remote slave connected on a serial line or on other buses.



**Fig. 6** Comparison of Modbus RTU & TCP messaging

Modbus RTU Request (Read Request for holding registers 40108 - 40110 from slave)		Equivalent Modbus TCP IP Request	
11 03 006B 0003 7687		0001 0000 0006 11 03 006B 0003	
Not Applicable with RTU		0001	Transaction Identifier
Not Applicable with RTU		0000	Protocol Identifier
Not Applicable with RTU		0006	Message Length (6 bytes to follow)
11	Slave ID Address (17 = 11 hexadecimal code)	11	Unit Identifier (17 = 11 hexadecimal code)
03	Function code (read analog output holding register)	03	Function code (read analog output holding register)
006B	Data address of the first requested register	006B	Data address of the first requested register
0003	Total number of registers requested (read 3 registers 40108 to 40110)	0003	Total number of registers requested (read 3 registers 40108 to 40110)
7687	Cyclic redundancy check	Not Applicable with TCP IP	

**Table. 1** Modbus Request

#### IV. ENSURING DATA RELIABILITY

With the physical media already considered (Cat5 copper Ethernet cables for example) it is important to understand how the data integrity required for process reliability is guaranteed. Profinet bases its communications on TCP, UDP and IP protocols. The primary difference between Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) is that the TCP variant guarantees sequential transmission and receipt between send and receive stations by numbering the data packets so that they may be correctly sequenced by the requesting station. Each data packet is checked for errors and tracked for correct transmission, should the recipient station not acknowledge the receipt then the data packet is resent. Examples of TCP would be loading of a social media web page where posts and comments are structured and timed, or perhaps banking where pages are loaded in a sequential order. UDP is a similar concept but as it dispenses with both the receipt request and other error checking its speed is significantly higher but it is less reliable; examples would be live event streaming – should the UDP data stream be broken then the recipient station (pc screen) will freeze and then recommence from the point where the data stream is reestablished; several seconds or minutes of content may be lost in the “downtime”. For correct process function, timing and reliability of data are paramount therefore it is essential that there is some mechanism to ensure that the data reaches its intended recipient within the most appropriate timeframe. Under these reliability constraints and with a peer to peer communication process it would be logical to assume that there would have to be some priority or weighting to the data, thus not all data communication has the same priority (as

was associated with traditional CSMA techniques, carrier sense multiple access).

As with most critical processes a degree of determinism is required, which had long been an Achilles heel for Ethernet peer to peer based communications using CSMA protocol. This determinism point was always a challenge for anything other than a master / slave control philosophy (where the master sequentially polls each slave and determines a scan or update time based on number of slaves and data content to be transferred). With CSMA each peer had similar priority on the network and listened for the network to be silent in order to send its data. In the event of simultaneous data transmission from multiple peers then they would identify “data collision” and wait a randomly assigned period of time (several milliseconds) before trying to resend the data packet. While data collision can happen on several occasions eventually the data would be successfully sent. The problem with this method is the impossibility to accurately predict a process cycle it could be 50, 100 or 150 milliseconds due to the random nature of network traffic. While this non calculable element is not a problem for some data transfer, such as an email, it had made it previously impossible to adopt peer to peer, CSMA based Ethernet communications for several processes.

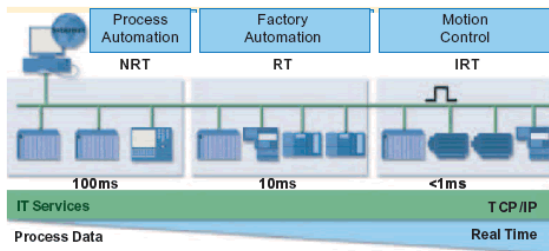
Profinet, similarly to Modbus TCP, uses or retains a master slave approach and uses the Ethernet media to transfer data. As a general statement a Profinet telegram occupies a higher priority than both TCP and UDP, this priority is defined within the standard IEEE 802.1Q and the priority code point will be defined within the Ethernet header.

Priority Code Point	Priority	Traffic Type
0	0 (lowest)	Background
1	1	Best Effort
2	2	Excellent Effort
3	3	Critical Applications
4	4	Video < 100mS
5	5	Voice < 10mS
6	6	Inter-network Control
7	7 (Highest)	Network Control

**Table 2** IEEE 802.1Q Priority Code

TCP and UDP provide merely the basis for data exchange and the Profinet telegram will be broadcast to its intended recipient on a faster, prioritised basis. This would be evidenced if the user was to utilize the same media for process communications and media streaming. The data exchange between IO controller and IO device would not be disturbed if a video stream was simultaneously pushed down the media, if ever there was a bandwidth issue then the streamed video (priority 4) would be sacrificed.

Profinet employs a variety of other means to ensure data is exchanged in a time appropriate fashion.



**Fig. 8** demonstrates the methodologies used for timing of the Profinet telegram.

Given that the Profinet telegram has a very high priority, process safety signals even higher and it is deterministic, using IEEE 802.1Q it will always be one of primary participants on the bus, ensuring that the data reaches its intended goal in a time acceptable manner. Where automation requirements demand a tighter bandwidth and timing performance, two further stages of improvement are available in the Profinet application layer; data exchange optimised for performance is called Real Time communication (RT) updates of 1mS with 100  $\mu$ s jitter and is employed for standard process data to and from the IO controller (PLC), while a deterministic and clock-synchronised communications version Isochronous Real Time (IRT) updates < 1ms with a jitter precision of <1 $\mu$ s. A pertinent example of this type of performance management of the data would be were process data

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such as electrical variables from the motor (volts, amps, power etc) were being polled by the process IO controller on a real time basis as it is not really considered as hyper-critical element, however safety critical functions, such as safe switching off, which has to be performed on an extremely fast basis, would be routed through IRT communication channel.

## V. SWITCHES AND TOPOLOGIES

Accepting the point that the Ethernet protocols are in general very similar (to those utilized on Fieldbus) and they are presented for applications across a LAN or over the internet we should now consider the connection structures possible within an Ethernet network to connect devices together and their potential benefits.

Beyond the IED we will now consider the Ethernet switch (which effectively links the IEDs together) and the topology used within the network. For performance requirements a hub would generally be dismissed as this would have no filtering capabilities for network traffic.



**Fig. 9** Ethernet switch

In contrast to a hub, which simply passes all of the data to all of its ports (impacting on networking performance), the switch, from the first time it receives a message it learns the respective MAC addresses of the devices connected to each of its ports and then broadcasts only to the intended port. Managed switches, which are commonly used in high availability systems, offer several benefits such as Quality of Service (Q.o.S), Diagnostics, Trunking, VLAN, Port Mirroring etc to prioritize frames, handle errors and improve the general management of network traffic.

Depending on the criticality of the data there are a number of topology possibilities that may be considered to connect the IED to the switch: star, tree, mesh, ring or bus are all found. The frequency of the topology deployment depends on where the data is to be sourced and used; for example within the IT business environment Star (where there is a single connection from the PC / IED to the switch) is the most commonly found for networking of PC workstations, however as the environment becomes more industrially biased and increased resilience is required then a ring topology gains in popularity. The main benefit of the ring topology offers two communications paths back to the switch. Topologies can be mixed and in Fig. 10 we can see the combination of ring and star topologies.

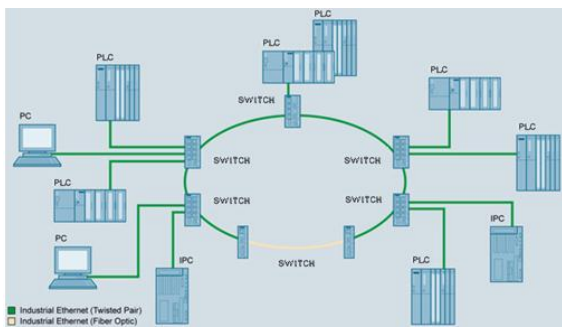


Fig. 10 Typical Industrial Ring Topology



Photo 6 Customer network topology using a Ethernet switch

**Management of traffic via broadcast, unicast or multicast.**

Having explored how, as a minimum, the switch learns the IP addresses and directs or manages the flow of network traffic it can be briefly explored how certain messaging methods can enhance this process.

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With a broadcast protocol (or message), then as with a hub, all participants on the network will receive the message, sometimes this is ideal such as site-wide or company-wide email but if the data is pertinent to only one station then the broadcast message is far from efficient and creates unnecessary burden on the network.

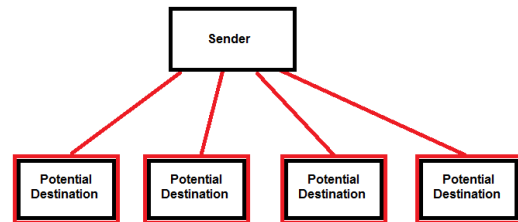


Fig. 12 Broadcast message

As discussed previously for high speed transfer of process data a hierarchal principle is adopted but this is enhanced further using the Profinet protocol, which is a Unicast based message and means that only the intended participant receives the telegram. An everyday example of this would be a mail sent explicitly to one destination, perhaps a mail containing salary details.

Clearly unicast has advantages in terms of network burden over broadcast messaging. If multiple destinations are required then, in principle, multiple unicast messages can be transmitted but with process data the PLC or IO controller will generally still sequentially send data.

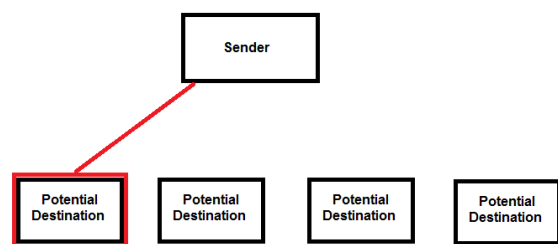
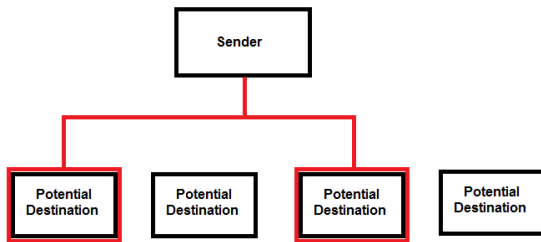


Fig. 13 Unicast message

The final option is multicast messaging, which is a hybrid of broadcast and unicast, targeting specific groups of destinations; everyday examples of this would be "group chat" where only a limited number of participants simultaneously receive the same message.



**Fig. 14** Multicast message

Potentially Multicast is a faster transmission method than unicast, however the rhetorical question would be is which Industrial processes would unicast (with microsecond resolution) be unsuitable for.

**Maximizing availability within a given topology**

In most industries downtimes are costly; not just to the loss of production time, loss of data or materials, but also the restarting costs. To mitigate this issue wherever possible the control system and network is designed to achieve the maximum uptime or availability. This is achieved by several means with common approaches being:

System redundancy – a duplicate system and even control components are deployed.

Media redundancy – with interruption in the network, communication will continue via alternative paths.

With the System redundancy concept as a minimum the control devices must be able to communicate to a standby control system (which is generally waiting to take over the process in the event of controller failure), but as highlighted above it can be that every element down to the rotating machine is duplicated. Duplication to such a level comes at considerable costs! The designer's challenge is to find the optimum balance between resilience and cost, perhaps considering redundancy at just the controller and network, rather than the individual device, especially now that many devices offer significant diagnostic, maintenance and statistical data.

Media redundancy considers how re-routing the communication path ensures that the data exchange is maintained between controller and IED. With the BYK example, Profinet protocol was utilized within the MCC and this protocol primarily relies on MRP protocol to reconfigure communications paths within 200ms. So, this means that in the event of single failure, either with a device or a single break in the network, the communication path to motor

management devices (IEDs) would be maintained.

**VI. CONSIDERATIONS AND BENEFITS OF ETHERNET NETWORKING WITHIN THE MCC**

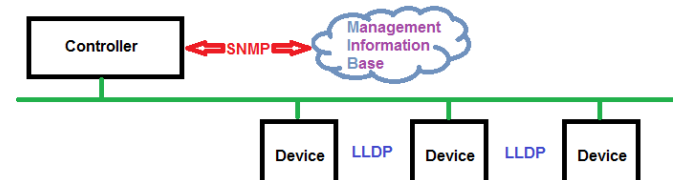
**Simple Device Replacement**

It is inevitable that devices (including IEDs) will, over time, need to be replaced and one of the benefits identified by BYK was that they wanted devices to be replaceable without the need for a computer or a programming address switch. The business driver in this instance was to minimize interaction between the IO (IED) and the plant operative; this is possible using Ethernet, or specifically Profinet protocol. The ability to replace IEDs simply by removing the drawer and inserting a pre-built spare by a technician rather than an engineer (with programming tools) is an obvious benefit.

Due to the widespread adoption of Industrial Ethernet (IE) networking there has been numerous open protocols developed to offer the consumer significant benefits with respect to the topology, diagnostics and construction of the network.

In the example (Fig. 15) the paper explores the concept of how, as desired by BYK Additives, the IED is replaced and automatically reconfigured.

Utilising LLDP (Link Layer Discovery Protocol) found in the OSI Datalink layer the IEDs display their relevant properties (such as IP address, ports, location, name, status etc) on the network. These parameters are stored within a "holder" referred to as the Management Information Base (MIB), and the controller (perhaps a PC or PLC) reads the "MIB" using Simple Network Management Protocol (SNMP), operating at the OSI Application layer. It builds up a topology map detailing the specifics of the devices and their location on the network.



**Fig. 15** Simple Device Replacement using LLDP, SNMP and DCP

Typically the I/O controller assigns IP addresses using Discovery and Configuration Protocol (DCP), also in



the OSI Datalink layer; so utilising elements of LLDP, SNMP and DCP the controller knows the location of the original device on the topology map, it then allocates the IP address to the replacement device and reconciles that the stored program within its CPU (associated with the original device) is suitable for use within the new device (a motor starter configuration with a motor starter for example) and effects the download and configuration (of the new IED).

This process takes place typically within a number of milliseconds; significantly less time than to plug in an addressing switch or laptop cable.



**Photo 7.** Replacement of a MCC starter assembly without the need for programming tools.

#### **Remote Access (Https connectivity)**

Now, it is not uncommon for many IEDs to have integrated web server functionality, therefore it is possible to remotely log in to the intelligent motor management device (with a standard web browser) and review the available data from the said device. Typically these solutions are managed via secure log on requirements (Https:) and managed through a Virtual Private Network (VPN), which offers the operator an acceptable level of security. For "log on" access to the IED it is essential to know the specific IP address of the target device, as well as the name and password. Routing via a VPN acts to hide the IP address of the operators' network as well as encrypting (via numerous means e.g. LT2P/IPsec or Open VPN) the data transferred across the web. If we accept that the data and access to the data is as secure as practicably possible then benefits of remote access are obvious; as companies rationalise their engineering teams, having various skill level technicians and managing tasks in a hierarchal manner then the capacity to immediately diagnose a problem remotely (by the relevant resource) is a significant advantage. This is an even greater benefit for remote site or where access is challenging, such as an unmanned utility plant for example.

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BYK were keen to utilise this technology, and incidentally it is gathering momentum (and adoption) in many other manufacturing market segments.

#### **Merged infrastructure**

With the first iterations of the smart MCC, as described in a previous section of the paper, the IEDs were interconnected using fieldbus. With Profibus for example, the user needed to prepare the four conductors, the shield of the cables and observe the installation rules with regards to repeaters and distances between cables. This is perfectly acceptable and a common practice, however it is a certainty that the end user or operator will also have some IT requirements on site. Typically this would be managed using an Ethernet backbone, utilising Ethernet or fiber cabling. Given that two separate media types were being used then essential spares required for robust site operation would need to include products for both fieldbus and IT networks. If the MCC or process infrastructure becomes Ethernet based then it is possible to rationalize the essential spares and dispense with those associated with the fieldbus.

#### **Topology specific to a withdrawable MCC**

There are some considerations pertinent to MRP within the MCC however, if the ring topology is utilized then potentially withdrawing a starter compartment would introduce a "break" in the ring, which itself would not be problematic, however in the event of another compartment being withdrawn or another IED failing during this time then this would be multiple breaks in the ring and communication to any IEDs within the two break points would be lost. Therefore for withdrawable panels it is essential to consider bridging solutions in the event of withdrawing compartments.

Also, with MRP there are a maximum number of 50 participants (IEDs for example) on a single ring. The reason for this 'ceiling number of participants' is that there is a finite time (<200ms) for a frame to pass around the ring and return to the master. If it does not return the ring master or manager decides that there has been a break in the network and looks to reconfigure the ring using its diagnostic tools. Further expanding the point, an IED sequentially receives, rebuilds and passes on the frame to the next device on the ring until it eventually returns to the ring manager, however there is a slight propagation delay of 2-3 milliseconds as the frame is passed from IED to IED. If the maximum number of participants is exceeded then this could reach a point where, due to

propagation delay, the frame no longer returns in the expected time and the manager interprets this as a break.

Thus single rings need to be limited to a maximum number of participants, perhaps multiple rings within the MCC, and ring bridging solutions need to be considered.

## VII. CUSTOMER PANEL

The BYK MCC was procured via a local UK based manufacturer, and as with any panel produced the price of the product quoted to BYK typically consists of several elements: component pricing, labour and engineering pricing as well as raw materials (copper, steel, paint finish etc). During the sales process it was clear that BYK were keen to realise the benefits detailed in the above technical paper, however a commercial evaluation needed to be undertaken to see whether incremental costs associated with Ethernet networking outweighed the benefits the solution offered.

In the panel there were approximately 90 networked motor starters and the incremental cost to enhance these IEDs to incorporate Ethernet on each of the IEDs was approximately 12.5%. In addition to the IED costs there were several Ethernet switches to manage the Ethernet network. The total uplift in price for the infrastructure (IEDs, switches etc) was approximately £3,500 across the 90 circuits. In a very price sensitive market while the uplift in cost of components was only one element of the overall panel costing; steel, copper etc remaining constant (reducing the overall percentage price increase) initial indications on components alone suggested that there could be a price premium to switch to Ethernet technology within the MCC, which if it was the overall commercial summary may be unacceptable to the client.

The network creation of course includes routing of cables, topology configuration, termination etc and for the BYK assembly conventionally there would have been 5 Profibus networks. There is a ceiling to the number of slaves on a single Profibus network, there are also considerations with regards to cable lengths and Profibus repeaters, as such the time to deploy the networks using Profibus DP equated to 85 hours with an additional 12 hours testing. These timings when using plug-and-play, point-to-point Profinet communications reduced the time from 85 to 24 hours, which was a 70% reduction. Using the local

hourly rate for wiring costs it was proven that this productivity saving translated in to a cost reduction that would completely offset the costs of Ethernet IEDs and switches! Therefore the headline message to BYK was that the total panel cost was marginally lower using Ethernet.

## VIII. CONCLUSION

As adoption of Ethernet gathers pace Oil and Gas operators and end users in other markets will be increasingly faced with the question of when is the right time to embrace this technology. The paper covers many of the benefits; merging process and IT infrastructure, simple device replacement, remote services, speed, flexibility of topology for example but it also evidences that the adoption of such technology should not necessarily come as a price premium.

While users tend to extend existing networks by adding additional fieldbus devices, they can also adapt their existing structures by utilising proxies to blend fieldbus and Ethernet technology so no longer is it only the Greenfield sites or new assets where Ethernet technology can add value and still be commercially viable.

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## X. VITA

The author is the European Business Development Manager for SIEMENS DF PD business for smart motor management devices. He has worked in the industry for 25 years and held a number of portfolio management and development roles both in SIEMENS UK & Germany. He has presented to all elements of the Oil and Gas supply chain in several countries.