**Abstract** - Is “smart” the modern trend to use or should MCCs be based on traditional designs? Based upon over 15 years experience in applying IMCS designs, guidelines & selection criteria allowing end-users to choose the right type of MCC for their application will be presented together with financial comparisons.

**Index Terms** — LV Intelligent Motor Control System, LV conventional Motor Control Center.

I. INTRODUCTION

Motor Control Centers are used for control of motors. When I have to explain to my 6 and 10 year old daughters what daddy is doing during the day I'm always referring to the distribution board we have in our house to distribute the electrical energy to the outlet sockets in the various rooms…

From the utilities the electrical energy is distributed to plants. On plant level the high voltage is transformed to low voltage level.

This is a typical HV/LV single line showing an MCC that has 2 sections : 2 incoming breakers, 1 buscoupler and several outgoing units, feeders and motorstarters.

LV Motors in the process industries are most often three-phase induction motors. Each motor requires a motor starter.

The motor starters are grouped in a LV MCC. This MCC interfaces with the operators (signal lamps, pushbuttons, meters), interfaces with the process control equipment (for automated process control) and offers a safe environment to personnel and equipment in case of abnormal conditions (faults).

Similar to the distribution board at home, the MCC consists off one (or more) incomer(s), a busbar system and several outgoing units.
A motor starter comprises of a short circuit protective device, a contactor for switching on/off and a thermal overload protection to protect the motor in case of overload.

Similar to the distribution board at home you will have a big incomer, a busbar system and several outgoing units.

**Basic Motor starter functionality:**
- Overload protection
- Single phase protection
- Earth leakage protection (> 30 kW)
- Under voltage protection
- Start/stop indication and control
- Amps indication
- Communication of signals

**Enhanced Motor starter functionality:**
- Restarting after voltage dips
- Energy measurement
- Condition monitoring motor windings (windings too hot or wet).
- Condition monitoring motor bearings
- Low amps (=low flow) protection

In industrial applications we have an automated approach to start/stop motors. The programs for this are put in DCS (Distributed Control Systems) or PLCs (Programmable Logic Controllers).

A conventional MCC is a MCC with individual devices per function. Conventional MCCs are connected to process controllers by means of multi-core cables. This allows the exchange of control and status information and some measurement information.

Any requirement to exchange more data between the process controller and MCC leads to an increased amount of cabling being installed together with associated interface panels.

By replacing these multi core cables with communication cables costs could be saved on cabling costs.

Reducing the number of pieces of equipment per motor starter leads to integration of measurement and protection using the power of a micro-processor.

In this way the Intelligent MCC was born.
II. ADVANTAGES AND DISADVANTAGES OF IMCS

A. Advantages of Intelligent Motor Control Centers

1) Late point definition of DCS I/O:
   Allows for more time during project development. You don’t have to determine all
details to allow the MCC to be built, cabling to be ordered or installation drawings to be completed.
2) Plug and play:
   The same unit is used for all kW-ratings. It is independent of compartment height.
3) Significant reduction of external cabling and associated checking during commissioning
4) Simplification of typical motor schematic diagrams
5) More compact compared to conventional (less devices, A-meter, hr-counter, …)
6) Less devices is also a cost benefit!
7) All signals are available. If needed in the future it is available. If for analysis purposes currents
   have to be trended it is possible without adding additional devices.
8) Less maintenance needed.
9) No need for current injection to check EXE motor-protection functions (however watch dog
   is not sufficient for A/D converter verification, so still need to check analogue signals against
   external reference e.g. local ammeter).
10) Inhibiting restarting until the motor has cooled sufficiently helps prevent operator abuse of
    equipment

B. Disadvantages of Intelligent Motor Control Centers

1) When different models of relays are available some engineering must be done before ordering
   the MCC to assure the right functions are available.
2) Are much more complex and hence need much more configuration than simply entering motor
   FLC. A much larger amount of setting information has to be kept and be retrievable.
3) Lifetime of devices can be less than conventional devices (components)
4) What if IMCS is obsolete and needs to be replaced? Is it compatible, does it fit in the same space?
5) May need to purchase of additional spare parts to guarantee lifetime matching that of the rest of
    the MCC

III. EXPERIENCES WITH IMCS

A. Examples of bad IMCS integration

1) During use only limited information was exchanged with DCS:
   Only running / tripped / available / load (A)'s were communicated, Emergency stop was
   hardwired.
   In this project there would have been less cable costs savings because cables are still run
   between control room and substation.
2) Engineering Workstation local to the switchboard
   After a number of years in service (when the historical data would have been useful to aid
   maintenance), there was no one available who could remember how to operate it because no
   one had been using it regularly during the intervening interval.
3) “Old” IMCS was not serviceable after a number of years. Needed to be upgraded with newer
   version. Newer IMCS was not compatible. Didn’t fit in the same space and did not use the same
   communication protocol. However the switchgear had a minimum of at least 15 years lifetime left.
4) Generally the IMCS provides (little) information to the DCS for process control and (more)  
   information to the electrical maintenance staff. In most plants process control is independent from 
   maintenance. The IMCS has to serve both parties. Both parties have different responsibilities and are using the same system.
   In practice this can create for communication conflicts between the two parties. In an ideal
   world relevant maintenance information would be passed directly to the Maintenance Management System and hence directly affect
   scheduling of tasks based upon condition monitoring rather than purely on an elapsed time basis.
5) Cost of providing serial links in DCS and separated routes for dual communication link
   cables between DCS and IMCS can be high for some installations and can significantly reduce
   perceived cost benefits of a reduced number of cables.
6) Reliability of hot standby links (to provide a robust communication solution) has been found
   in practice to rarely achieve the predicted performance.

B. Examples of good IMCS integration

1) Project with complex process control (loading terminal)
   Lots of stands, lots of products, lots of pumps with product dependant functionalities
   Intelligent MCC was communicating to the process control PLC.
   The control PLC determined the amount of MCC I/O needed.
   Flexibility of system to be reconfigured easily to adapt to changes in pump selection, loading
   rates etc reduced engineering and installation costs
2) Loading data (amps/kW) from pumps used in DCS control to help optimize energy use on a
   plant against flow rates & production targets
3) Project timescales reduced by allowing and element of concurrent engineering between final
   detailed design and manufacture of MCC
IV. CONVENTIONAL OR INTELLIGENT, THE FINANCIAL COMPARISON

A model was developed to be able to determine the financial differences between a conventional and intelligent MCC.

### CONVENTIONAL MCC VERSUS INTELLIGENT MCC USING 100 MOTOR STARTERS

<table>
<thead>
<tr>
<th>TOTAL NUMBER OF DEVICES</th>
<th>100</th>
<th>MD. OF 500 MOTOR STARTER</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISTANCE BETWEEN DCS &lt;&gt; IRP (mtr)</td>
<td>50</td>
<td>MD. OF 500 MOTOR STARTER</td>
<td>1</td>
</tr>
<tr>
<td>DISTANCE BETWEEN IRP &lt;&gt; MCC (mtr)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RATES TO INSTALL CABLE</td>
<td>30</td>
<td>No Premium</td>
<td></td>
</tr>
<tr>
<td>INSTALLATION TIME PER MTR. FOR 2 CORE CABLE</td>
<td>0.2</td>
<td>Hours</td>
<td></td>
</tr>
<tr>
<td>INSTALLATION TIME PER MTR. FOR 30 CORE CABLE</td>
<td>0.3</td>
<td>Hours</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MATERIAL UNIT PRICE</th>
<th>MATERIAL REQUIRED</th>
<th>DAY</th>
<th>MATERIAL COST</th>
<th>INSTALLATION COST</th>
<th>INSTALLATION COST SAVINGS FROM INT. MCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIGITAL INPUT (DI)</td>
<td>62.5</td>
<td>200 pc.</td>
<td>12,500.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANALOG INPUT (AI)</td>
<td>18.75</td>
<td>100 pc.</td>
<td>1,875.00</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>DIGITAL OUTPUT (DO)</td>
<td>62.5</td>
<td>100 pc.</td>
<td>6,250.00</td>
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<tr>
<td>RS 485 CABLE</td>
<td>5</td>
<td>55 mt.</td>
<td>275.00</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NUMBER OF DI PER MOTOR STARTER</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NUMBER OF AI PER MOTOR STARTER</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NUMBER OF DO PER MOTOR STARTER</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Financial Comparison

- **Cabling costs** (material and labour) for communication cable
- **Intelligent module** (and other materials needed to convert a conventional starter to an intelligent starter)

This model assumes that customers are choosing only between hardwired or serial wired control/signaling. In practice customers are also using “hybrid” systems with a mix of both to allow for redundant control/signaling (necessary for safeguarding stop commands). This will substantially increase the overall cost of an intelligent MCC.

V. CONVENTIONAL OR INTELLIGENT, THE SELECTION CRITERIA

In general conventional MCCs are a better choice when:
- limited number of MCC info has to be exchanged with the DCS.
- Only Standard starter functionality is required
- Workforce in target location would need extensive training to handle more complex equipment
- There is no component obsolescence, which can lead to major expenditure being required after 12-15 years to upgrade to latest versions.
- Robust solution required with vulnerabilities to voltage pick up or EMC issues understood and mitigating actions well known

In general intelligent MCCs are a better choice when:
- Extensive amount of MCC info is communicated with the DCS. For example in remotely operated facilities more information made be needed regarding reasons for trips than a facility which can be readily visited in person.
- More than the standard starter functionality is required (The greater the number of additional functions the greater the benefit over a conventional solution)
- It is expected that a significant number of changes to controls will be required over the lifetime of the MCC (simplified engineering and field modifications)
- It is wished to use data such as loading, number of starts and running hours to assist in deciding on maintenance strategies

Often in making such comparisons there are compromises to be made, as rarely in practice are there only benefits and no dis-advantages in choosing one solution over the other.

The main driver in choosing between the technologies is “which approach gives an lower overall cost to the project?” Often this is influenced by the ability to allow process engineering and electrical design to overlap and thereby contribute to reducing or at least holding the
project duration. Benefits of early completion or achieving planned completion dates can be very, very large and far outweigh the difference in equipment costs.

VI. INTELLIGENT MCC, FUTURE DEVELOPMENTS

- Compartment temperature measurement (i.s.o. IR scanning)
- Communications suitable for safety bus (no ESD relays needed). This implies a need to comply with additional requirements to achieve a suitable SIL rating. Will users be happy to discard hard wiring for emergency stop signals?
- Make re-start scheme’s work reliably. Currently settings are not recorded (communicate them and make the scheme visible). When restarting relays are used they can have unrevealed failures (they are not telling that they are fault)
- Eliminate interposing relays
- Reduce amount of wiring (e.g. communication over mains power or auxiliary power supplies)
- Better Data management. Record settings in the field. Make it visible what changes have been made in the field compared to “released” settings (approved by site management).
- Allow web browser functionality: no special software is needed on your PC. Just hook-up the laptop using an Ethernet or USB connection.
- Allow next to local monitoring / parameter setting optionally for remote monitoring / parameter setting through Internet.
- Allow for integration of normal (low cost) multi-meters with the IMCS
- Event recording on functional unit level for use within Sequence of Event Recording (requires time synchronisation)
- Wireless communications? Security is a big issue! Reliability is a big issue in high EMC environments.
- Thermal overload should reset automatically. Trip history should be available.
- How to deal with emergency stops and safety switches (interlocks).
- In substations with both MV and LV MCC’s or switchboards different standards exist for communication protocols for MV and LV equipment.
- Is IEC 61850 the way to go for communication between MCC starter devices and the outside world so that there is a single protocol used?

VII. CONCLUSIONS, ARE THE BENEFITS OF IMCS REALIZED IN PRACTICE?

In practice we have seen a strong tendency for more and more MCC’s to be specified with intelligent devices. There is a greater amount of data requested to be made available to DCS or SCADA systems. Whether this is as a result of a real need or merely response of designers to the capability being available is not wholly clear.

Intelligent MCCs offer lower installation costs when a reasonable of MCC information has to be communicated with the Process Control system.

Intelligent MCCs offer a high degree of flexibility with regard to information available to be communicated now or in the future. If certain functionality is not needed today but needs to be added in the future most intelligent MCCs can handle this without major changes.

Also important for low maintenance costs is the lifetime of the Intelligent MCCs. Software and electronics tend to change with a more rapid pace than the MCC main components. In the past, suppliers of intelligent devices have not given backward compatibility and upgrade paths sufficient thought. Users are now being faced with complete system replacements and major upgrade costs after only 12-15 years of operation.

It has been an article of faith in the past by many users that “smart” devices were the way to go in the future. However Intelligent Motor controls have not yet fully delivered on their promise.

Areas for improvement are:
- Emergency stop signals are still hard wired meaning not all cost savings are realized,
- Setting up the devices requires significantly more effort than for conventional devices and the number of settings creates issues in storing the data,
- Differences in the version of the firmware used in the devices creates problems for users where they have nominally identical devices bought at different times,
- Lifetime of the units is often “short” compared to users expectations and upgrade paths are not clearly thought through
- Bespoke communication solutions are used rather than true standards so interoperability is only achieved with considerable effort

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VIII. REFERENCES

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[2] IEC 61850 : What you need to know about functionality and practical implementation (Dave Dolzilek, Sweitzer Engineering Laboratories, Inc. Pullman, WA USA)

IX. VITA

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Graduated in 1985 from the HTS Hilversum, the Netherlands with a bachelor degree (ing.) in Electrical Engineering specialization Telecommunications. From 1987 he worked for Rosmark Watertreatment as a process automation engineer and later he managed the process automation department. In 1997 he joint Eaton Electric in the role of application engineer/SCADA specialist. After changing positions to Project Manager and Export Customer Support Manager his current position is Product Manager being responsible for the marketing of LV MCC and Motor Management Systems.

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