DIGITAL DATA ACQUISITION AND CONTROL OF ELECTRICAL ENERGY IN INDUSTRY

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BACKGROUND

Like money, electrical energy is a vital resource. And it is getting costlier and scarcer. We are all keenly aware that it should be managed effectively and conserved, particularly in industries, which account for over 55% of the total electrical energy consumption in the country. And we are very much concerned about it. The issue which we now need to address seriously is: how do we do it in practice?

ELECTRICAL ENERGY MANAGEMENT SYSTEM - THE IDEAL TOOL

If we want to manage money effectively, the first thing we need is a good financial accounting system. So also, if we want to manage electrical energy effectively we need a good energy accounting system.

Unlike the older accounting systems which just kept track of inflows and outflows, modern computer based systems do a lot more. They process and analyse the data and present it in formats that can be readily used for evaluation and decision making. So let us say we have a good energy accounting system.

By merely having a good financial accounting system we do not save money. And just by having a good energy accounting system we do not save energy.

The financial accounting system and the energy accounting system are powerful tools. These bring into focus the effectiveness of various operations, indicate if they are taking us in the right direction, pin point areas that need closer attention or control and identify operational lapses, inadequacies, wastages etc. They help us to arrive at decisions on necessary control or corrective measures. And it is only when we implement these measures that savings can accrue.

Thus, to be effective, an Electrical Energy Management System should cater to three essential functions :

- Energy accounting and analysis
- Evaluation and Decision making
- implementing decisions

In all the three functions Instrumentation plays a key role.

ENERGY ACCOUNTING: MONITORING - THE FIRST STEP

Energy accounting starts with monitoring. So what should we monitor ?

Effective management requires that each operation be optimised from the energy efficiency point of view. Energy efficiency is measured in terms of the energy input into an operation in relation to the product output of that operation.

Thus, to optimise and also to assess how effective the optimisation has been, we need to monitor operational parameters as well as electrical parameters. Here we should distinguish operational parameters from process parameters - for example, temperature, pressure etc - which are primarily concerned with optimisation of the process itself.

Operational parameters to be monitored depend on the nature of operations and are specific to each industry. In general they may include :

- The product output
- Other parameters that may contribute to efficiency, as also inefficiency of the operation (eg. stoppages, idle running etc.)

Electrical parameters to be monitored should include those that contribute to the cost of electrical `energy', namely :

- Power (kW)
- Power Factor (Ratio of kW to kVA)
- Energy (kWHrs)
- Demand

While monitoring it is also desirable to include parameters that indicate the health of the electrical system, namely :

- Voltage
- Current
- Frequency (in certain cases)

LOCATION OF MONITORING NODES

Traditionally, monitoring had a limited purpose - to check the health of the electrical system. Voltmeters and Ammeters on the Incomer and the Feeders connected to it served this purpose adequately.

However, from the optimisation point of view we have to monitor each operation, as also various feeders from the energy accounting point of view. Typically, the number of nodes to be monitored may range from 20 or 30 in an industry with 1000 kVA load, to 200 or even more in a large industry. And generally these are dispersed over a vast geographical area. Fig 1 illustrates the typical dispersal of nodes.

It is not necessary that all parameters have to be monitored at all nodes. This would make the system very expensive .

The nodes can be divided into two categories.

- Major nodes monitoring large feeders, loads or energy intensive operations
- Minor nodes monitoring smaller feeders, loads and operations

Generally, at major nodes we need to monitor several parameters. At minor nodes it generally suffices to monitor only the energy parameter (kWHrs).

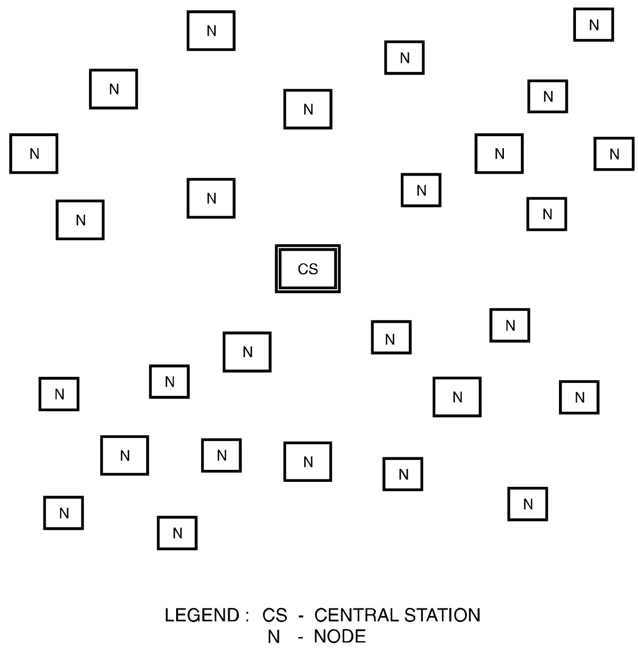

Fig. 1 - Dispersal of nodes

ANALYSIS - NEED FOR A CENTRALISED SYSTEM

Referring to Fig 1, a relatively simple arrangement is to install at each of the nodes stand-alone instruments for monitoring the necessary parameters. In fact, this has been the practice evolved over the last few years. However, when it comes to compiling the data and analysing it, use of stand alone instruments has several drawbacks:

- Readings from these instruments will generally be in the nature of raw data
- Because of the geographical spread and the resulting time lag between readings recorded manually from different instruments, the data is not correlated in real time. This can introduce large errors, for example, when assessing shift-wise performance.
- It is difficult to relate energy consumption of a particular operation to the product output, leading to large errors in assessing energy efficiencies of operations.
- Optimisation arises from control or corrective measures, and not from monitoring alone. Most of these measures have to be necessarily implemented on the basis of on line data. Data collected from stand alone instruments is essentially off line. This places a severe limitation on the extent of optimisation that can be achieved.

Therefore, for effective management and optimisation it is essential to have a Centralised System which overcomes all the drawbacks mentioned above.

A CENTRALISED SYSTEM BASED ON AN ANALOG 4 - 20 mA CURRENT LOOP

In a Centralised System, instruments installed at each of the nodes are provided with facility for communicating with a Central Station, generally PC based. The Central Station has the capability to acquire, process and analyse data from all the nodes connected to it. Fig. 2

illustrates a traditional Centralised System employing 4 - 20 mA Current Loops to transfer measured values from each node to the Central Station.

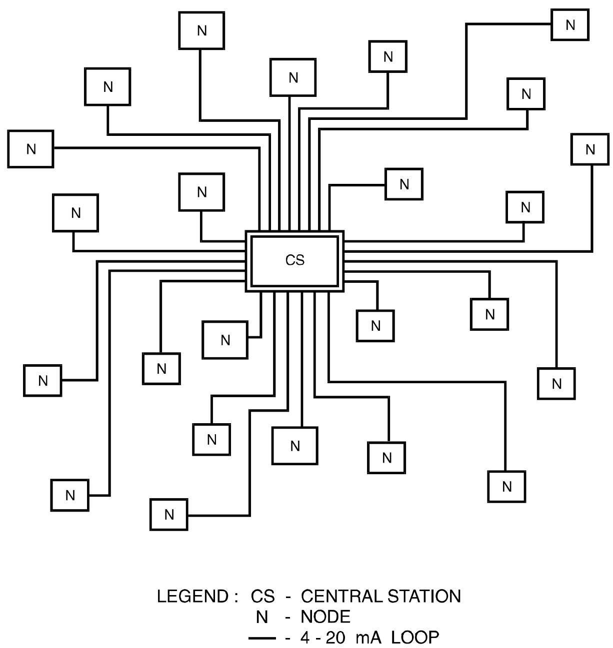

Fig. 2 - Centralised System Based on 4-20 mA Current Loop

While this type of system has been quite popular in applications confined to process data acquisition, it has many drawbacks in energy management applications :

- A separate current loop is required for each parameter. And Energy Management requires a large number of Parameters
- The cable pair carrying the current needs to be shielded.
- At the Central Station each loop needs analog ground isolation, which is expensive and adds some error to the signal.

Because of these requirements overall, cost of such a system becomes very high. Apart from that, the communication is essentially one way - from the node to the Central Station. For energy optimisation we need both way communication.

CENTRALISED SYSTEM BASED ON DIGITAL DATA TRANSFER

Modern digital techniques provide highly cost effective and reliable means of data transfer. There are two standard methods for digitally transferring data :

- Through a Pulse Train
- Through a Digital Data Packet

The Pulse Train method is highly cost effective if only one or two parameters need to be transferred from a node and the response time is not critical. In this method the node delivers a train of pulses to the Central Station such that the pulse repetition rate is proportional to the magnitude of the parameter. This method is particularly suitable for integrated parameters, for example, kWHrs. Unless the environment has a high level of electrical disturbances, a twisted telephone cable pair can be used for interconnection. Also, at the Central Station the ground isolation can be through an inexpensive opto isolator. These two features make this technique highly cost effective.

In the second method the data to be transferred is made into a digital data packet and this is transferred to the Central Station over a Serial Data Link (typically an RS 485 link) in response to a request from the Central Station. This method is very attractive when a number of parameters have to be transferred from a node to the Central Station. This method can also handle two way communication.

A MIXED DIGITAL NETWORK

A Multi-function Meter is four or five times as costly as a Digital Energy Meter with pulse train output. Therefore, in practice, the most cost effective solution is a mixed network employing Multi-function Meters with serial data output at the major nodes and Digital Energy Meters with pulse train output at the minor nodes.

Fig. 3 illustrates a typical Mixed Digital Network implemented with Conzerv products.

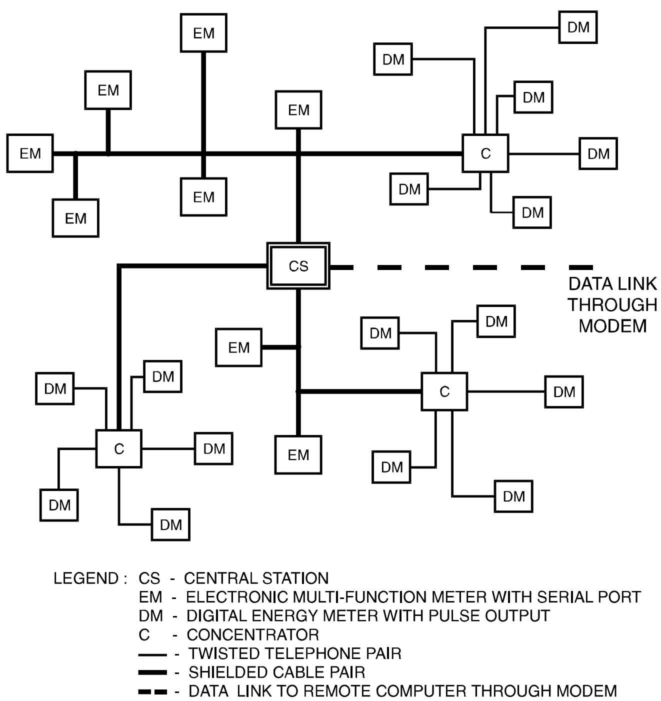

Fig. 3 - Centralised System Based on Digital Data Transfer

In this diagram the Multi-function Meters at major nodes are from the EM family and the Digital Energy Meters at minor nodes are from the DM family. The EM meters are connected to the Central Station through a network of RS 485 Multi-drop Serial Data Links. A Multi-drop link is highly cost effective. Each link comprises a single shielded pair of wires, and upto 32 EM instruments can be hooked on to it. It can also handle both way communication and is therefore suitable for control functions.

Ordinarily, for connection to the Central Station, each DM Meter requires an individual pair of wires all the way from the Meter to the Central Station. In the Conzerv implementation this is avoided. A cluster of DM Meters in a selected area are connected to a Concentrator and the Concentrator is connected to the Central Station on a Multi-drop link. There can be several such clusters in a System.

This arrangement has a number of advantages :

- The cost of interconnection comes down drastically. The individual links between the DM Meters and the Concentrator are relatively short and can be twisted telephone cable pairs. The inter-connection becomes highly cost effective.
- The link from the Concentrator to the Central Station is on the RS 485 network already established for EM Meters. Therefore there is no additional cost involved. This can handle both way communication and is therefore suitable for control functions.

CONTROL - KEY TO OPTIMISATION AND SAVINGS

Most of the control measures for optimisation have to be implemented on line. A Centralised System as described above acquires on line data and decision making is based on this data. Therefore it provides excellent support for implementing control measures.

Control measures are of two types :

- For optimisation of operations, which in turn leads to improved productivity, or savings in electrical energy costs, or both. This is best illustrated through examples in the next Para.

- For direct optimisation of electrical parameters. Demand Control and Power Factor Control are typical examples of this and are well know applications.

IMPLEMENTATION OF CONTROL MEASURES

A typical Centralised System comprises a Central Station (generally PC based), with all the nodes connected to it (through appropriate interface where necessary). A software package residing in the Central Station controls all the functions - polling the nodes, acquiring the data, filing and analysing it, presenting the analysed off line data in appropriate formats etc. The on line functions dealing with optimisation and control include setting of thresholds and time intervals, generation of alarms, acknowledging of alarms and recording of alarm conditions, tracking and recording of control operations and status etc. Actual control outputs are ideally delivered from the respective nodes which are generally close to the points of control and monitor the respective operations.

EXAMPLES OF OPTIMISATION

Example 1.

The first operation in a sugar mill is crushing sugar cane to extract juice. The sugar cane, stacked on a conveyor, is fed into the crusher. Not infrequently, because of excessive stacking the crusher rollers gets jammed. A mechanical device detects the jamming and trips the crusher motor and the conveyor. The rollers have then to be taken apart, the excessive sugar cane which caused the jamming removed and the rollers fitted back. Each time this happens, more than an hour of production is lost.
This problem is easily overcome by monitoring the kW consumption of the crusher motor, which is an accurate indicator of the loading, and using it to regulate the stacking more evenly so that jamming is avoided. Also, any possibility of jamming gets detected much before it actually occurs and can be prevented.

This is an example of using an electrical parameter to improve productivity of a mechanical operation, though there may be no saving of electrical energy as such.

Example 2.

After commissioning of the Centralised System in an industry, norms had been established for energy efficiency of various operations. The Management happened to notice that in one shift the product output of a particular operation was 80% of the norm but the energy consumption was 91%. The question was raised why this disproportionate consumption ? Investigations revealed that owing to some mismatch in loading the conveyor system was running idle for a long time. It was then that the Management realised for the first time that an idle running conveyor system guzzled so much of energy. This led to a series of questions and responses :

Q: How can idle running be detected ?
R: By monitoring the kW consumption of the conveyor motor.

Q: How much is the consumption during idle running ?
R: No idea.

It took a couple of days to find out that this was around 125 to 135 kW.

Q: What shall we take as the threshold for detecting idle running ?
R: Allowing for some margin, let us fix it at 150 kW.

Q: What should we do when idle running is detected ?
R: Trip the conveyor.

R: No. Even under normal operation the Conveyor runs idle for short periods. If it is tripped every time, it can severely disrupt production.

Q: So how long should the conveyor be allowed to run idle ?
R: Let us say 4 minutes.

Q: So what do we do after that ?
R: Trip the conveyor.

R: Not enough. The underlying condition which caused idle running may continue and it is not good for production. So let us activate an alarm after 4 minutes, and if idle running continues for another two minutes, trip the conveyor.

and so it went on

Within a week a reasonably foolproof system for optimising the conveyor operation was in place and the energy efficiency norm itself could be improved by two percent.

Example 3.

The Energy Management System can provide clear data and reports on Specific Energy Consumption. Ie, the energy Input per unit output of the shop or plant. This energy efficiency metric, apart from the above applications is also powerful in pin-pointing:

Machines due for maintenance (higher losses than norm). Eg ring-frame maintenance scheduling can be improved in a Spinning Mill, saving on down-time and maintenance cost through need-based frequency

Leaks in Air-conditioning or compressor lines (higher consumption than norm)

Optimisation of process parameters

(eg kW waveform of kiln drive in a Cement mill indicates any potential kiln rotational instability due to mis-match of feed rate)

Similarly, kW waveform of Pulp Chest stirrer drive in paper industry can give an indirect indication of the consistency of the pulp)

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