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Embedded based Maximum Power Demand Indicator and Controller for Efficient Power Management using Proteus

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Abstract— **The demand for energy is increasing as a result of the growth in both population and industrial development. To improve the energy efficiency, consumers need to be more aware of their energy consumption. In recent years, utilities have started developing new electric energy meters which are known as smart meters. A smart meter is a digital energy meter that measures the consumption of electrical energy and provides other additional information as compared to the traditional energy meter. The aim is to provide the consumer and supplier an easy way to monitor the energy. Smart energy meter can also store and review our consumer energy.**

Keywords— ***MDI, Power factor, Penalty, Load management***

I. INTRODUCTION

Power is measured in momentary amounts, while energy is the vital of power over the long run. For instance, a 100 W light retains 100 W of power. On the off chance that worked for one hour, that light ingests 100 W - hours of energy. Greatest demand is the most extreme quick power devoured over a detailed window of time. On account of that 100 W bulb, as it is exchanged on and off, the immediate demand goes from zero to 100 W to zero, and so on. Not exceptionally intriguing. At the same time if that bulb is worked in parallel with a second 100 W light that is left on constantly, the demand will switch promptly between 100 W and 200 W, and the greatest demand of the blend will be 200 W. Presently, the way this is connected is that electric appropriation utilities frequently incorporate demand as one of the components used to focus the charge the buyer gets. Notwithstanding measuring incorporated energy utilization over the charging period (regularly a month), they additionally measure demand. Instead of measure genuinely immediate qualities, they really measure energy over a short window of time, and after that partition the energy devoured amid that interim by the length of the interim to touch base at successful peak esteem for the interim.

The best normal estimation of the power, apparent power, or current devoured by a client of an electric power system, the midpoints being assumed control progressive time periods, normally 15 or 30 minutes long and It is the best demand of burden on the power station amid a given period, i.e., the most extreme of every last one of demands that have happened amid a given period (may be a day, may be an hour, and so forth).

- Need of maximum demand in Electricity bill?

When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed, it is called two-part tariff.

- In this total charge is divided into two.

1. Fixed charge depends on maximum demand of consumer.
2. Running charge depends on no. of units consumed. It is measuring by installing maximum demand meter. Charges are made on the basis of maximum demand in KVA and not in kW.

It is important to note that while maximum demand is recorded, it is not the instantaneous demand drawn, as is often misunderstood, but the time integrated demand over the predefined recording cycle.

As example, in an industry, if the drawl over a recording cycle of 30 minutes is:

2500 KVA for 4 minutes

3600 KVA for 12 minutes

4100 KVA for 6 minutes

3800 KVA for 8 minutes

The MD recorder will be computing MD as: (2500 * 4 + 3600 * 12 + 4100 * 6 + (3800 * 8)/

30
= 3606.7 KVA

As can be seen from the Figure 1 below, the demand varies from time to time. The demand is measured over predetermined time interval and averaged out for that interval as shown by the horizontal dotted line.

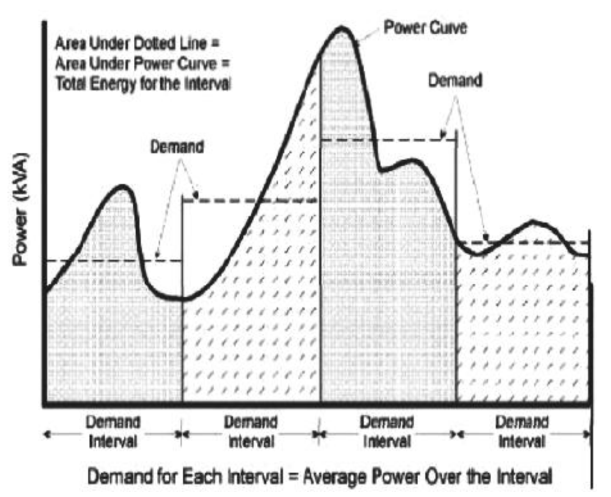
I. MDI PENALTY

The MDI penalty can be avoided by improving the power factor and by using more efficient appliances.

The MDI penalty can be avoided by improving the power factor and by using more efficient appliances. Another option of avoiding MDI penalty is by shifting your peak load to a time of day when your load is less.

There are 2 methods of calculating MD (Maximum Demand):

Figure 1: Power and Demand Curve



III. NORMAL OR BLOCK METHOD

Toward the end of each one fix integrating period, normal power for that period is ascertained. On the off chance that this quality is more noteworthy than officially existing esteem then this is put away as the MD.

IV. SLIDING WINDOW METHOD

Toward the end of a sub incorporating period the average power is ascertained for one coordinating period. In the event that this quality is more prominent than the officially existing esteem than this is put away as MD. The incorporating period slides by a window of the sub incorporating period (Capasso and so forth every one of the., 1994; and World Bank, 2012).

MO No.	MO No.	MO No.	MO No.
MD 1	MD 1	MD 1	MD 1
MD 2	MD 2	MD 2	MD 2

Assume a load pattern of following type:

$T = 09.00$, $T = 09.15$, $T = 09.30$, $T = 09.45$, $T = 10.00$

20 KVA, 30 KVA, 30 KVA, 20 KVA

15 mins, 15 mins, 15 mins, 15 mins

For MD 1 (Sliding window method) Demand – 09.00 to 09.30 block

$$\frac{(20 * 15 + 30 * 15)}{30} = 25KVA$$

Demand - 09.15 to 09.45 block

$$\frac{(30 * 15 + 30 * 15)}{30} = 30 \text{ KVA}$$

Demand - 09.30 to 10.00 block

$$\frac{(30 * 15 + 20 * 15)}{30} = 25 \text{ KVA}$$

MD 1 at the end of 10.00 = 30 KVA.

For MD 2 (Block method)

Demand - 09.00 to 09.30 block

$$= \frac{(20 * 15 + 30 * 15)}{30} = 25 \text{ KVA}$$

Demand - 09.30 to 10.00 block

$$= \frac{(30 * 15 + 20 * 15)}{30} = 30KVA$$

MD 2 at the end of 10.00 = 25 KVA Normally MD is reset on the first of every month, i.e., on a Monthly basis.

V. MICROCONTROLLER BASED MDI

The conventional greatest demand metering utilized conventional meters with current transformers and the meter dealt with a 15 moment normal with a pointer which showed the most extreme arrived at since the last time the pointer was reset.

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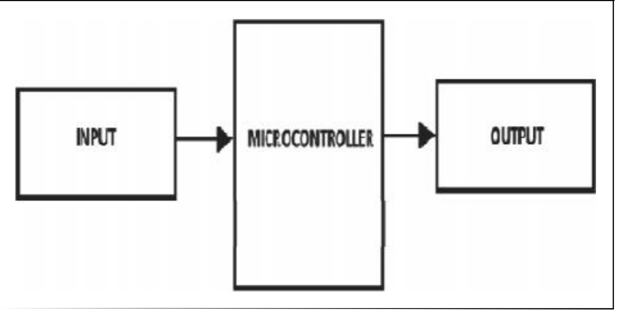
It has several drawbacks, as:

The meter did not correspond precisely to the supply authority's meter values because of differences in the averaging times and differences in reset time.

This meter couldn't be monitored continuously and high greatest demand values were regularly recorded when problems happened on the factory and the administrator had neglected to recognize the excessive most extreme demand.

Figure 2: Microcontroller Based MDI



• It was very difficult to discover exactly when the maximum demand had been exceeded due to a lack of any recording.

• It was difficult to predict the effects of adding or removing load.

In addition to the measurement of the MDI this project has a capability of f detection and indication as there is a close relationship between the frequency and the power (demand/supply) which is shown in Figure 3 below.

VI. ELECTRICAL LOAD MANAGEMENT

Need for Electrical Load Management

In a macro perspective, the growth in the electricity use and diversity of end use segments in time of use has led to shortfalls in capacity to meet demand. As capacity addition is costly and only a long time prospect, better load management at user end helps to minimize peak demands on the utility infrastructure as well as better utilization of power plant capacities.

VII. MAXIMUM DEMAND CONTROL

Step By Step Approach for Maximum Demand Control:

A. Load Curve Generation

Presenting the load demand of a consumer against time of the day is known as a 'load curve'. If it is plotted for the 24 hours of a single day, it is known as an 'hourly load curve' and if daily demands plotted over a month, it is called daily load curves.

These types of curves are useful in predicting patterns of drawl, peaks and valleys and energy use trend in a section or in an industry or in a distribution network as the case may be.

B. Rescheduling of Loads

Rescheduling of large electric loads and equipment operations, in different shifts can be planned and implemented to minimize the simultaneous maximum demand. For this purpose, an operation flow chart and a process chart are prepared. Analyzing these charts and with an integrated will help to improve the load factor which in turn reduces the maximum demand approach.

C. Storage of Products/in Process Material/Process Utilities like Refrigeration

It is possible to reduce the maximum demand by building up storage capacity of products materials, water, chilled water and hot water, using electricity during off peak periods.

D. Shedding of Non-Essential Loads

When the maximum demand tends to reach preset limit, shedding some of non- essential loads temporarily can help to reduce it. Sophisticated microprocessor controlled systems are also available, which provide a wide variety of control options like:

• Accurate prediction of demand.

• Graphical display of present load, available load, demand

E. Operation of Captive Generation and Diesel Generation Sets

When diesel generation sets are used to supplement the power supplied by the electric utilities, it is advisable to connect the DG sets for durations when demand reaches the peak value. This would reduce the load demand to a considerable extent and minimize the demand charges.

F. Reactive Power Compensation

The maximum demand can also be reduced at the plant level by using capacitor banks and maintaining the optimum power factor. Capacitor banks are available with microprocessor based control systems. These systems switch on and off the capacitor banks to maintain the desired Power factor of system and optimize maximum demand thereby (Calcutta *et al.*, 1998; and Collabus, 2003).

VIII. POWER FACTOR IMPROVEMENT AND BENEFITS

A. Power Factor Basics

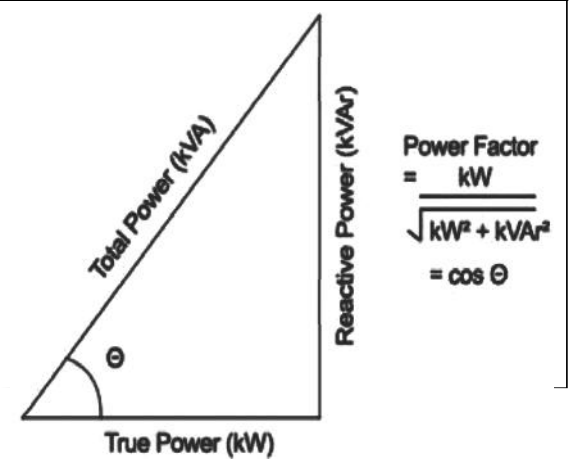
In all industrial electrical distribution systems, the major Loads are resistive and inductive. Resistive loads are incandescent lighting and resistance heating. In case of pure resistive loads, the voltage (V), current (I), resistance (R) relations are linearly related,

Active power is measured in kW (Kilo Watts). Reactive power is measured in KVAR (Kilo Volt-Amperes Reactive).

The vector sum of the active power and reactive power make up the total (or apparent) power used. This is the power generated by the SEBs for the user to perform a given amount of work. Total Power is measured in KVA (KilloVolts-Amperes).

The active power (shaft power required or true power required) in kW and the reactive power required (KVAR) are 9 0° apart in a pure inductive circuit,

Figure 5: Power Triangle



The active power (shaft power required or true power required) in kW and the reactive power required (KVAR) are 90° apart vector in a pure inductive circuit, i.e., reactive power KVAR lagging the active kW. The vector sum is called the apparent power or KVA, as illustrated above and the KVA reflects the actual electrical load on distribution system (Brown, 2008).

The ratio of kW to KVA is called the power factor, which is always less than or equal to unity. Theoretically, when electric utilities supply power, if all loads have unity power factor, maximum power can be transferred for the same distribution system capacity. However, as the loads are inductive in nature, with the power factor ranging from 0.2 to 0.9, the electrical distribution network is stressed for capacity at low power factors.

B. *Improving Power Factor*

The solution to improve the power factor is to add power factor correction capacitors to the plant power distribution system.

They act as reactive power generators, and provide the needed reactive power to accomplish kW of work. This reduces the amount of reactive power, and thus total power, generated by the utilities.

IX. ADVANTAGES OF PF IMPROVEMENT BY CAPACITOR ADDITION

- Reactive component of the network is reduced and so also the total current in the system from the source end.

- 12R power losses are reduced in the system because of reduction in current. Voltage level at the load end is increased.

- KVA loading on the source generators as also on the transformers and lines up to the capacitors reduces giving capacity relief. A high power factor can help in utilizing the full capacity of your electrical system (Calcutta *et al.*, 1998; and Mc Donald, 2003).

X. COST BENEFITS OF PF IMPROVEMENT

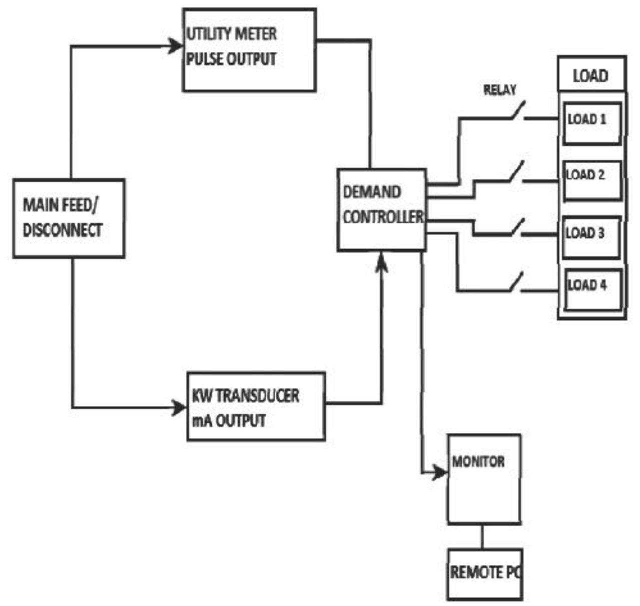
While costs of PF improvement are in terms of investment needs for capacitor addition the benefits to be quantified for feasibility analysis are:

- Reduced KVA (Maximum demand) charges in utility bill.

XI. MAXIMUM DEMAND CONTROLLER

High-Tension (HT) consumers need to pay a maximum demand charge notwithstanding the usual charge for the number of unit s expended. This charge is generally taking into account the most astounding measure of force utilized amid some period (say 30 minutes) amid the metering month. The maximum demand charge regularly speaks to an extensive extent of the total bill and may be in view of one and only segregated 30 moment episode of high power utilization.

Figure 6: Demand Controller



XII. CONCLUSION

A good record of the load pattern is obtained which enables accurate predictions and better load distribution. The capital outlay for maximum demand control is low. With good maximum demand indication, it is possible to create awareness of where and when power is used and consequently gets greater power utilization. The data obtained from the MDI controller may be used for the design and development of Smart Grid and helpful for prediction of estimated load in large load dispatch centre.

Proper utilization of electrical power during off peak period and the data obtained from the MDI controller is useful for the automation of Distribution system.

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