Power Factor at Instantaneous Load using ARC Welding Machine

T. Aarthy[1] S. Bhuvaneswari[2] M. Dhanusha Preethi[3] S. Karthika[4] Dr. S. Sumathi[5]
[1,2,3,4]UG Student [5]Assistant Professor
[1,2,3,4,5]Mahendra Engineering College, Anna University, Namakkal, India

Abstract— The thirst for new sources of energy is unquenchable, but we seldom realize that we are wasting a part of the electrical energy every day due to the lagging power factor. Hence, there is an urgent need to avoid this wastage of energy. The conventional Reed switch method is to optimize the power factor in High Tension (HT) and Low Tension (LT) industries to reduce power losses. The power factor corrective system to improve the power factor of High Tension and Low Tension industries. As the power factor correction in conventional power factor meter takes a minute. Separate capacitor banks for both load and no load conditions, to note the transformer ratings of Arc welding machine.

Key words: Reed Switch, Capacitor Bank, Contactor

I. Introduction

In recent times, power factor is the main issue for TANGEDCO and TNEB. The power losses are incurring due to the imbalance in power factor. So they are penalizing HT and LT industries. For HT industries power factor should be greater than 0.9 and for LT industries it should be greater than 0.85. The penalty is higher for HT industries. In certain factories such as fabricating industries using conventional arc welding, are in a trouble to improve the power factor because of intermittent loading condition. The automatic power factor correction meter available now takes 1 or 2 minutes to justify the system power factor and then switch to the required kVR rating.

II. Existing System

A. Power Factor Correction Equipment

The most commonly used power factor correction equipment are capacitors and industrial control equipment.

B. Capacitors

Capacitors are one of the options that can be used to improve power factor. The guide information, together with other restrictions of use, such as mounting means and special electrical connections, are detailed in the manufacturer's installation instructions furnished with the product. The Listing Mark for these products includes the product name "Power Factor Correction Unit" or "Capacitor Bank," or other appropriate product name as shown in the individual Listings. This equipment is investigated in accordance with UL 810, the UL Standard for Safety for Capacitors. UL 810 includes requirements applicable to general-use power factor correction units, consisting of one or more capacitors either with or without protective fusing or other overload protection, with or without a switch or other disconnect device, all housed within a protective enclosure.

C. Industrial Control Equipment

Power factor correction equipment is also listed under the Power Circuit and Motor mounted Apparatus (NMTR) product category. UL Guide Information for this product category is located in the UL White Book and can also be found on UL's Online Certifications Directory at www.ul.com/ database. While this category covers numerous product types, most unrelated to this subject matter, certain types of power factor correction equipment are included. The requirements of UL 810 (Capacitors) do not apply to power factor correction units containing automatic or other circuit monitoring/conditioning controls or automatic systems of multiple connected power factor correction units.

D. Drawbacks in Existing System

The existing system will improve the power factor of the industries, but the major problem is that it will take more time to adjust to the optimal power factor. Approximately it will take couple of minutes to optimize to the required power factor. This is because the variation of load and no load condition during the intermittent condition. As there is only one capacitor bank, the charge and discharge time is very less, which will have an effect on the outcome of the power factor. Sometimes there will be overlapping of charge and discharge time which will result in the damage of capacitor bank also.

E. Correction Made in our System

To overcome the problems in the existing system, we have adapted a new technique. Instead of using a capacitor bank for both the conditions, separate capacitor banks can be used for load and no load condition. This will share the charge and discharge time and also overlapping of this can be avoided. Also, the power factor will be further improved because the capacitor banks' rating will be more precise.

F. Power Factor Corrective System

The power factor corrective system's block diagram, description, circuit diagram and construction are as follows

1) Block Diagram

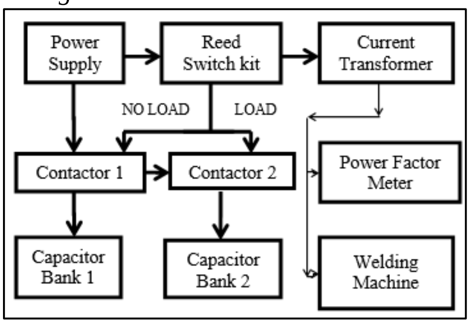

Fig. 1: Block Diagram

2) Block Diagram Description

a) Power Supply

The power supply provided here is 3ϕ, 415v, AC supply.

b) Reed Switch Kit

Reed switch is an electrical switch operated by an applied magnetic field. Here the reed switch acts as the current sensor. The reed switch conducts when the load current exceeds the rated value and provides a signal to the contactor which in turn activates the capacitor bank.

c) Current Transformer

It is used to measure very high current by stepping down the current from primary to its secondary**.** When a current is too high to measure directly or the voltage of the circuit is too high, a current transformer can be used to provide an isolated lower current in its secondary which is proportional to the current in the primary circuit. The induced secondary current is then suitable for measuring instruments or processing in electronic equipment. Current transformers also have little effect on the primary circuit. Often, in electronic equipment, the isolation between the primary and secondary circuit is the important characteristics. Here we use 30/5 current transformer. The CT step downs the current under the rated value of power factor meter and provides it.

d) Power Factor Meter

A power factor meter is a type of electrodynamometer movement when it is made with two movable coils set at right angles to each other. The method of connection of this type of power factor meter, in a 3phase circuit. The two stationary coils, S and S1, are connected in series in Phase B. Coils M and M1 are mounted on a common shaft, which is free to move without restraint or control springs. These coils are connected with their series resistors from Phase B to Phase A and from Phase B to Phase C. At a power factor of unity, one potential coil current leads and one lags the current in Phase B by 30°, thus the coils are balanced in the position. A change in power factor will cause the current of one potential coil to become more in phase and the other potential coil to be more out of phase with the current in Phase B so that the moving element and pointer take a new position of balance to show the new power factor.It is used to measure power factor directly from the circuit. Here the power factor meter is a part of the system and displays the power factor during load and no load condition. The power factor improvement can be perceived through this meter.

e) Contactor

A contactor is an electrically controlled switch used for switching an electrical power circuit, similar to a relay except with higher current ratings. A contactor is controlled by a circuit which has a much lower power level than the switched circuit. Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contactor is not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts. The physical size of contactors ranges from a device small enough to pick up with one hand, too large devices approximately a meter on a side. The purpose of contactor here is to switch to the required capacitor bank automatically through the reed switch signal.

f) Capacitor Bank

It consists of a group of capacitors connected in series or parallel which is used to correct a power factor lag or phase shift in an AC. The capacitor banks having a designed kVR rating is used here to improve the power factor during load and no load condition.

g) Welding Machine

It uses welding power supply to create an electric arc between electrode and base material to melt the metal. The welding machine is used as the source of intermittent load used for the testing of our power factor corrective system.

III. Major Components of Reed Switch Kit

A. Reed Switch

The reed switch is an electrical switch operated by applied magnetic field. It consists of a pair of contacts on ferrous metal reeds in a hermetically sealed glass envelope. The contacts may be normally open, closing when a magnetic field is present, or normally closed and opening when a magnetic field is applied. The switch may be actuated by a coil, making a reed relay, or by bringing a magnet near to the switch. Once the magnet is pulled away from the switch, the reed switch will go back to its original position. Here reed switch is wounded with a copper coil, so the input current to the reed switch is limited. When the current through it exceeds the no-load value, the reed switch gets into contact and gives the output signal.

B. Transformer

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Electromagnetic induction produces an electromotive force within a conductor which is exposed to time-varying magnetic fields. Transformers are used to increase or decrease the alternating voltages in electric power applications. Here we use a 9-0-9v transformer which converts 230v to 9v.

C. Opto-Coupler Moc3041

In electronics, an opto-isolator, also called an opto-coupler, photo-coupler, or optical isolator is a component t-hat transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Commercially available opto-isolators withstand input-to-output voltages up to 10kV and voltage transients with speeds up to 10 kV/μs. A common type of opto isolator consists of a LED and a phototransistor in the same opaque package. Other types of source-sensor combinations include LED-photodiode and lamp-photo resistor pairs. Usually opto isolators transfer digital (on-off) signals, but some techniques allow them to be used with analog signals. MOC3041 provides the output of 6v.

D. Transistor BT139

Glass passivatedtriacs in a plastic envelope, intended for use in applications requiring high bidirectional transient and blocking voltage capability and high thermal cycling performance. Typical applications include motor control, industrial and domestic lighting, heating and static switching.

E. Regulator 7805

IC 7805 is a 5V Voltage Regulator that restricts the voltage output to 5V and draws 5V regulated power supply. It comes with a provision to add a heatsink. The maximum value for input to the voltage regulator is 35V. It can provide a constant steady voltage flow of 5V for higher voltage input till the threshold limit of 35V. If the voltage is near to 7.5V then it does not produce any heat and hence no need for a heatsink. If the voltage input is more, then excess electricity is liberated as heat from 7805.

F. Capacitors, Resistors, and Diodes

The reed switch kit requires several capacitors, resistors, and diodes for the operation. The diode used here is IN4001, the capacitor required is 1000µf and resistors such as 220Ω and 150Ω are used.

G. Construction

Initially, we have selected two-phase arc welding for testing. The first step in the construction of power factor correction is to design the reed switch kit. The reed switch kit is here act as the current sensor. The input and output of the reed switch kit connected to the test kit i.e. two phase welding machine. The power factor is connected to the reed switch kit through MCB and contactor. It consists of two MCB and a contactor. Two capacitor banks of specified range are connected to them. For no load, no load capacitor is connected to an MCB and for load, load capacitor is connected to another MCB through the contactor. The current transformer is kept in the way of power factor meter. The further interconnections are made as required.

The concept of the project is we have to switch on the corresponding capacitor at the instant of the load. For the above process we require to sense the primary current initially it is 4.5 amps and at load condition, it is 15 amps. So we have selected a contactor which will be switched on between 4.5 and 15 amps. For this, we use the reed switch kit.

H. Reed Switch Kit Description

The transformer is given the input of 230v and it gives the output of 9v. The 7805 regulator gives the output of 5v. Here the capacitor is used as a filter. The optocoupler provides the output of 6v to the reed switch. The reed switch is wound with a coil. The number of turns of the coil is taken as per requires. Here we require 3 turns to make the reed switch to conduct. When reed switch conducts it sends the input to the contactor.

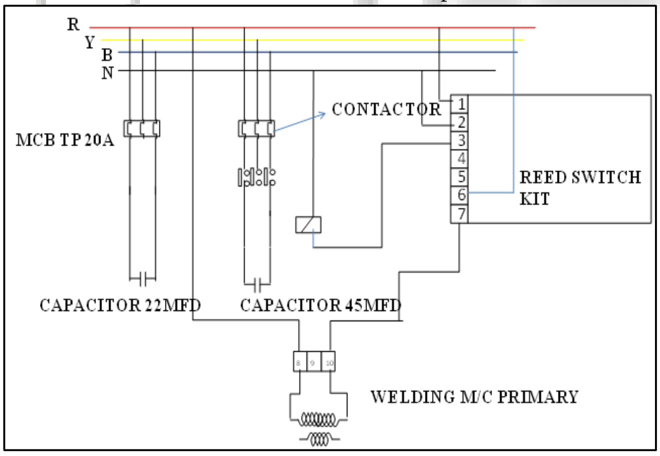

Fig. 2: Reed Switch Kit Description

I. Working and operation

1) Working

- First we take note of welding transformer capacity in KVA
- Then we measure primary and secondary voltage and the primary side no load and load current.
- From power factor meter, no load and load power factors are determined.
- Using the acquired ratings, we design the range for load and no-load capacitor banks.
- During the welding operation, power factor meter senses the power factor.
- Then the Reed Switch provides the signal to one of the contactors.
- Then the contactor actuates the capacitor bank, which in turn corrects the power factor.

J. Capacitor Rating Calculation

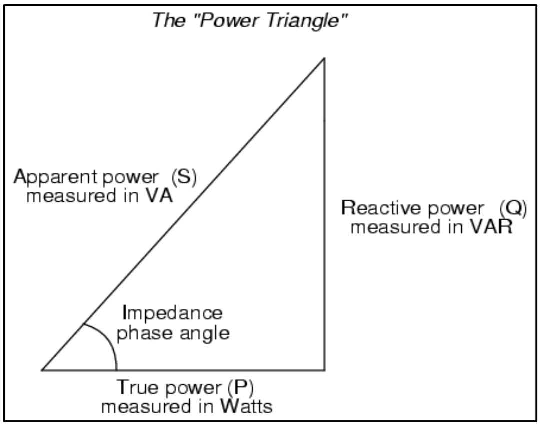

Fig. 3: Capacitor Rating Calculation

K. No Load Calculation

KW: 0.274, KVAR: 1.180
KVA: 1.352, PF: 0.227
COS θ1= 0.227, COS θ2=0.99
θ1= 77°, θ2= 7°
KVAR= (KW*tanθ1)-(KW*tanθ2)
= (0.274*4.331)-(0.274*0.122)
KVAR= 1.1526

$$C = \frac{KVAR}{2* *f*v^2}$$

C= 21.3 µF

S. No	Specifications	Values
1	KW	0.274
2	KVAR	1.180
3	KVA	1.352
4	PF	0.227
5	Cos θ1	0.227
6	Cos θ2	0.99
7	θ1	77°
8	θ2	7°
9	KVAR	1.1526
10	Capacitance required	21.3 µF
11	Capacitance Used	22µF
12	Expected Output	0.99
13	Obtained Output	0.911(min), 0.993(max)

Table 1: Specification

L. Load Calculation

KW: 2.575, KVAR: 2.889
KVA: 4.203, PF: 0.665
COS θ1= 0.665, COS θ2=0.99
θ1= 48.317°, θ2= 7°
KVAR= (KW*tanθ1)-(KW*tanθ2)
= (2.575*1.123)-(2.575*0.122)
= 2.5769

$$C = \frac{KVAR}{2* *f*v^2}$$

C= 47.65 µF

S. No	Specifications	Values
1	KW	2.575
2	KVAR	2.889
3	KVA	4.203
4	PF	0.665

Table 2: Specification

IV. Conclusions

The testing of the power factor corrective system is carried and several conclusions are made. The system can be used for long time operations of the intermittent load. Unlike the conventional power factor correction, power factor improvement can be achieved without much lag. The discharge time is shared between the capacitors so the overlapping of charge and discharge time is averted.

A. Advantages

- It optimizes the power factor better than conventional one.
- It reduces the power losses effectively.
- It reduces the damage occurring to the equipment.
- It can be used in factories for welding machine especially ARC welding.

V. Future scope of the work

The system needs further improvements such as proper capacitor rating, overall designing etc. As the system works continuously without any significant drawbacks, the product could be a notable one in the current market. If this product can be developed for the large scale industries it could be a worthy one.

Appendices

Welding Machine Ratings:

- Transformer Rating of Welding Machine 3.2 kVA
- Primary Voltage 410 V
- Secondary Voltage 42 V (No Load)
- Primary Current
  1) 3.8 A (No Load - R phase)
  2) 4.5 A (No Load - Y phase)
- Primary Current
  15 - 19 A (Full Load)
- Secondary Current
  140 A (Full Load)
- Power Factor
  1) 0.752 Lag (No Load)
  2) 0.937 Lead (Full Load)

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