PLANNING SOLUTIONS TO VOLTAGE DIP PROBLEMS.

by GJ Coetzee

1 EACH PLANT WILL HAVE ITS OWN UNIQUE SOLUTION

It is not possible to find a solution which would be suitable to all industrial, mining and manufacturing plants. The supply systems and processes are not identical and the solution best suited for a plant must be found. The following minimum information must be available before the best counter measure to voltage dips can be selected.

1.1 UNDERSTAND THE PROCESS OF THE PLANT

The processes of the plant must be fully known. The important parts are the essential processes & the systems / subsystems that are critically susceptible to voltage dips.

1.2 KNOW TYPES OF DIPS TO BE EXPECTED.

Voltage dips, due to short circuits can occur on any electrical system; voltage dips due to temporary disconnection of supply to a plant are unusual but can occur in some cases. An electrical system where there is change from one supply to another, where the supply will be disconnected, must be identified. A plant with a high "plant inertias" can be designed to ride trough the dead time of line Auto Re-closures (ARC).

2 DROPOUT OF CONTACTORS vs HOLDING CONTACTORS CLOSED

The problem of low voltage contactors dropping out during a voltage dip can be solved in two basic ways namely:

- secure the supply to hold the contactor closed during a voltage dip
- trip the contactors in a controlled manner when a voltage dip is detected and then re close the contactors after voltage restoration.

2.1 ADVANTAGE OF HOLDING CONTACTORS CLOSED

The advantages of holding the contactors closed during a voltage dip are as follows:

- MINIMUM DISTURBANCE TO THE PLANT PROCESS

  The disturbance to the plant processes are minimized. This is essential to plant processes having system(s)or sub-systems with low "plant inertias".

- MULTIPLE VOLTAGE DIPS

  By holding the contactors closed, the disturbance to the plant process are minimized and the recovery of the process after voltage recovery is relatively quick. This increases the possibility of plant being able to ride through multiple voltage dips without a stoppage.

- SOLUTION COULD BE SIMPLE

  In general, the implementation could be very simple depending on the configuration of the plant.

- LOW CAPITAL OUTLAY

  The capital outlay required to implement this type of counter measure generally will be relatively low.

2.2 DISADVANTAGE OF HOLDING CONTACTORS CLOSED

The disadvantages of holding the contactors closed during a voltage dip are as follows:

- RESTARTING CURRENTS OF MOTORS

  The restarting currents drawn by the motors could become high if the duration of the fault is long. Power supply equipment such as the supply transformer may be overloaded. However, this depends on the ratio of the supply equipment rating and the size of the total amount of rotating machines on the plant and is not necessarily a problem in all cases.

2.3 ADVANTAGE OF TRIPPING AND RECLOSING, CONTACTORS

The advantages of tripping and re closing the contactors during a voltage dip are as follows:

- CONTROL OF THE RESTARTING CURRENTS DRAWN BY MOTORS

  On a plant with a weak supply and large rotating machines, the restarting current can be controlled by starting the motors sequentially.

2.4 DISADVANTAGE OF TRIPPING AND RECLOSING CONTACTORS

The disadvantages of tripping and re closing the contactors during a voltage dip are as follows:

- DISTURBANCE TO PROCESS

  Once an induction motor has been disconnected from the supply, re-closing can only be carried out safely once the flux in the motor has decayed below approximately 36% of its nominal value. This decay time is the motor open circuit time constant and can be as high as 1.5 seconds for large low voltage motors. Motors with high inertia loads will decelerate quickly and their restarting times will be long. The motors are then restarted in sequential groups preventing overloading of the supply equipment. The disturbance to the processes an the plant is thus very high when compared to the method of holding the contactors closed. This method is difficult to apply when dealing with systems with low "plant inertias" and/or when multiple voltage dips occur.

- TRIPPING CONTACTORS BEFORE DROP-OFF

  Where the motors are controlled by a complex process control system, contactors must be opened in a controlled manner such that they can be re closed. This must be done to ensure that the control system has continuous control over the plant. The dropout time of the contactors is very fast and they are likely to open due to the voltage dip before a controlled shutdown can be performed.

- COMPLEX CONTROL SYSTEM

  Tripping and re-closing of contactors requires acomplicated control system to perform this function satisfactory.

- HIGH CAPITAL OUTLAY

  The capital outlay on a automatic re closing system could become relatively high. The engineering time to implement such a system is also high.

3. METHODS OF HOLDING CONTACTORS CLOSED

There are many ways to secure LV contactor control supply or holding the contactor closed during a voltage dip. An appropriate solution would depend on the number of contactors to be held closed and the types of voltage dips expected. Some of the options are discussed. below:

3 .1 CAPACITOR PER CONTACTOR

The supply to the contactor can be rectified and energy stored in a capacitor to slug the dropout time of the contactor. The the contactor coil must be chaged to one that is DC operated. This solution would be expensive and result in the following problems:

- The contactor will be slow to open when tripped. This problem can be overcome by placing additional auxiliary-contacts in the control circuit.
- The reliability of DC operated control coils is not as good as AC operated coils.
- The capacitor will be carrying high ripple currents and is likely to fail. Failure of capacitors can result in major contamination of the panel unless the capacitors are well enclosed.

3.2 SLUGGING OF CONTACTORS

The mechanical mechanism of the contactor can be arranged in such a manner that the opening action of the contacts is slugged by dampers. The problems associated with this type of solution are:

- mechanical system becomes complicated and would either be expensive or unreliable.
- The contactor will be slow to open when tripped. This problem can be overcome by complex mechanical interlocks which will increase cost and may introduce reliability problems.

3.3 LARGE CENTRALIZED UPS

Most Uninterrupted Power Supplies (UPS) have passive filters on their output circuits and cannot supply loads with a low power factor. Unless some other form of load is placed in parallel on the UPS output to improve the overall power factor, the output filter and inverter can not function correctly when supplying highly inductive control circuit loads. It would not be advisable to connect sensitive computer/ control equipment and low voltage contactor control supply to the same UPS output as high switching surges can be generated when switching the highly inductive loads.

3.4 LATCHED CONTACTORS

Mechanically latched contactors can be used to control small low voltage drives. The contactors mould obviously not open during a loss of control supply but serious problems may arise when a complete loss of supply occurs as it would not be possible to open (unlatch) the contractor.

3.5 DC SUPPLY CONTACTORS

The contactors can be held closed by DC supply from a battery. Unless a battery already exist on the plant, the maintenance on the battery will be high. Also the load drawn by DC contactors are high and the size of the batteries will have to be significant. A further problem is the reliability of DC operated contactors. However, a combination of latched contactors, controlled by a battery supplied DC system is an attractive but expensive solution.

3.6 MG SETS

An AC Motor driven AC Generator set (MG) with a large fly wheel can be used to secure the control supply. The disadvantage is the frequent maintenance required on the mechanical rotating system.

3.7 Dip Proofing Inverter (DPI)

An off line UPS referred to as a DPI is a feasible solution to secure the control supply to contactors. The DPI should be designed such that if it fails:

- the possibility of losing the output should be minimized.
- self monitoring circuits shall, where possible, give a failure alarm.

4 METHODS OF RE CLOSING CONTACTORS

An automatic contactor re closing control system must have the following minimum features:

4.1 INTELLIGENT CONTROL

The control system must be intelligent and equipment such as a PLC can be utilized.

4. 2. PRE-MEMORY OF RUNNING MOTORS

The re closing system must monitor, on a continue basis, the motors that are running on the plant as only the motors which were running prior to the voltage dip must be re closed when the voltage recovers.

4.3 CONTROLLED OPENING OF CONTACTORS

The contactors must be opened in a controlled manner shortly after the voltage dip occurs. Unless the contactors are opened in a controlled manner, control is lost and the re closing may not be successful. A further problem is that the contactors can start to chatter during partial voltage loss. This chattering can lead to failure of the main contacts of the contactor and contactors should thus be opened shortly after the initiation of the voltage dip.

4. 4 SEQUENTIAL RESTARTING

Due to the relatively long outage of the motors after tripping, the restating currents may be higher and will last longer than the re-starting re-accelerating currents when holding the contactors closed. The motors must then be started sequentially in groups to prevent thermal overloading of the supply system equipment and in accordance with plant operating and interlocking requirements.

5 REDUCING FAULT CLEARING TIMES

Reducing the fault clearing time on the supply system as well as on the plant internal distribution system can make a remarkable difference to the ability of the plant to continue normal operation after a voltage dip. As an example, installing instantaneous over current relays on the internal distribution feeders can shorten fault durations and the motors will then be in a better position to recover to nominal speed after a voltage dip, if the contactors are held closed.

6. MODIFICATIONS TO "PLANT INERTIA"

On a plant where a system or sub system has a short process inertia constant, a possible solution is to increase the "plant inertia" by modifying the plant. As an example, a gravity fed conservator tank can be installed on a lubrication oil feeding system. This type of solution could become very costly unless it is identified during the initial design phase of the plant.

CONCLUSION

Once the process of the plant, condition of power supply to plant and the types of voltage dips expected are known, a solution can be engineered.

Paper: **Planning solutions to voltage dip problems.**

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