ELECTRONIC DEVICE FOR OVERLOAD PROTECTION OF THE ROTARY DRUM AGGREGATES

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Abstract: In case of a sudden shutdown and for a long time of the rotary drum, the superior part of the shell is cooling down faster then the inferior part which is in contact with the processed material. To avoid the sudden shutdown because of an eventually overload, the rotary drum is equipped with a power supply supervisory.
The paper describes such an electronic device.

Keywords: rotary drum, power supply, overloads protection

1. INTRODUCTION

The rotary drum aggregates are very large equipments with lengths till 30m and diameters till 8m. in these conditions, driving these equipments give serious technical problems and sudden shutdown leads to important material loss.

The power unit has two parts:

1. The main power unit;
2. The secondary power unit which, in extreme conditions, has to supply power for furnace rotation.

If, for instance, the main engine broke or the electric power turns off, then, the secondary power unit automatically turns on and supply energy for a second engine from a safety network. If this safety network can not supply the electric power needed, then an additional power unit with an internal-combustion engine is turned on.

These two auxiliary power units are absolutely necessary, because, in case of a sudden shutdown for a long period of tome, a temperature difference is created between the superior part and inferior part of the rotary drum, which may lead to the bending of the rotary drum, which is functionally inadmissible.

The auxiliary power unit spins the drum with low speed, preventing the warming of the inferior part of the drum.

It is obvious that, for this type of equipments, sudden shutdown can occur because of an overload. To avoid this to happen, we use a power supply supervisory.

2. THE CROWBAR TECHNIQUE

One of the simplest and most effective methods of obtaining overvoltage protection is to use a crowbar" SCR placed across the equipment's dc power supply bus. As the name implies, the SCR is used much like a crowbar would be, to short the dc supply when an overvoltage condition is detected. Typical circuit configurations for this circuit are shown on Figure 1. This method is very effective in eliminating the destructive overvoltage condition. However, the effectiveness is lost if the OVP circuitry is not reliable.

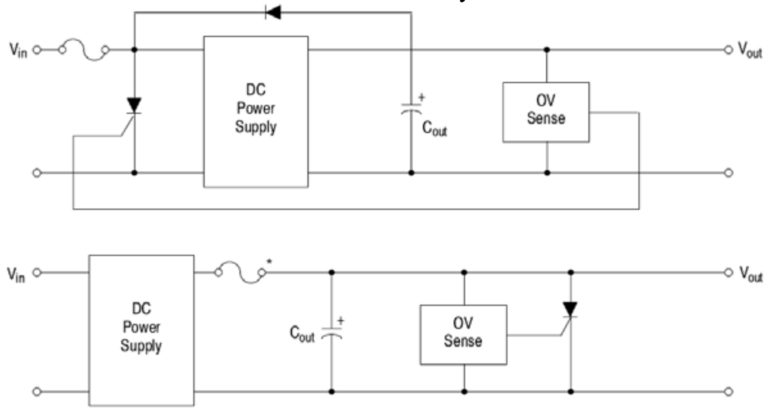

Figure 1 Typical Crowbar OVP Circuit Configurations

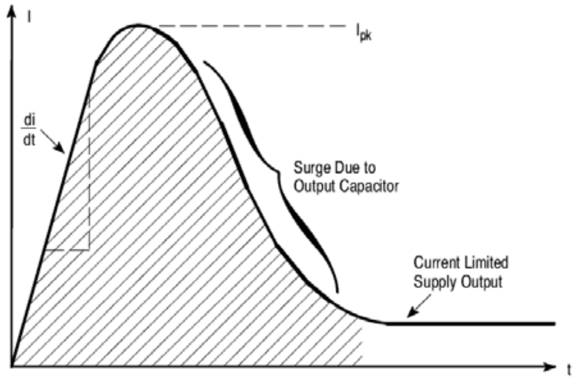

Figure 2 Crowbar SCR Surge Current Waveform

Referring to Figure 1, it can easily be seen that, when activated, the crowbar SCR is subjected to a large current surge from the filter and output capacitors. This large current surge, illustrated in Figure 2, can cause SCR failure or degradation by any one of three mechanisms: di/dt, peak surge current, or I2 t. In many instances the designer must empirically determine the SCR and circuit elements which will result in reliable and effective OVP operation. To aid in the selection of devices for this application, ON Semiconductor has characterized several devices specifically for crowbar applications. This significantly reduces the amount of empirical testing that must be done by the designer. A good understanding of the factors that influence the SCR's di/dt and surge current capability will greatly simplify the total circuit design task.

1. di/dt — As the gate region of the SCR is driven on, its area of conduction takes a finite amount of time to grow, starting as a very small region and gradually spreading. Since the anode current flows through this turned–on gate region, very high current densities can occur in the gate region if high anode currents appear quickly (di/dt). This can result in immediate destruction of the SCR or gradual degradation of its forward blocking voltage capabilities, depending upon the severity of the occasion. The value of di/dt that an SCR can safely handle is influenced by its construction and the characteristics of the gate drive signal. A center–gate–fire SCR has more di/dt capability than a corner–gate–fire type, and heavily overdriving (3 to 5 times I_{GT}) the SCR gate with a fast <1.0 µs rise time signal will maximize its di/dt capability. A typical maximum di/dt in phase control SCRs of less than 50 A rms rating might be 200 A/µs, assuming a gate current of five times IGT and <1.0 µs rise time. If having done this, a di/dt problem still exists, the designer can also decrease the di/dt of the current save form by adding inductance in series with the SCR, as shown in Figure 3. Of course, this reduces the circuit's ability to rapidly reduce the dc bus voltage, and a tradeoff must be made between speedy voltage reduction and di/dt.

2. Surge Current — If the peak current and/or the duration of the surge is excessive, immediate destruction due to device overheating will result. The surge capability of the SCR is directly proportional to its die area. If the surge current cannot be reduced (by adding series resistance, see Figure 3) to a safe level which is consistent with the system's requirements for speedy bus voltage reduction, the designer must use a higher current SCR. This may result in the average current capability of the SCR exceeding the steady state current requirements imposed by the dc power supply.

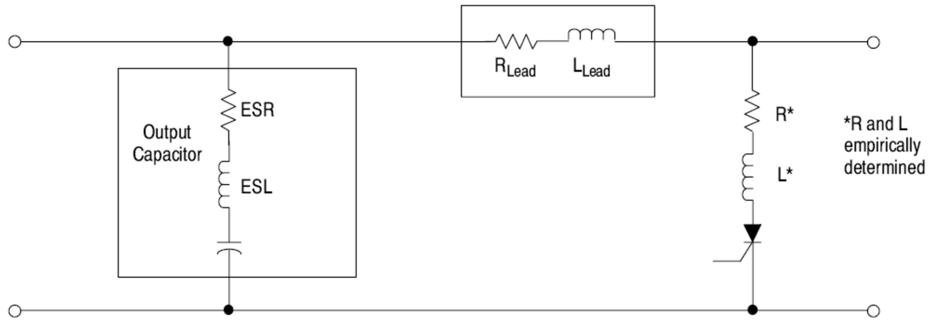

Figure 3 Circuit Elements Affecting SCR Surge & di/dt

3. THE SENSE AND DRIVE CIRCUIT

In order to maximize the crowbar SCR's di/dt capability, it should receive a fast rise time high–amplitude gate–drive signal. This must be one of the primary factors considered when selecting the sensing and drive circuitry. Also important is the sense circuitry's noise immunity. Noise immunity can be a major factor in the selection of the sense circuitry employed. If the sensing circuit has low immunity and is operated in a noisy environment, nuisance tripping of the OVP circuit can occur on short localized noise spikes, which would not normally damage the load. This results in excessive system down time. There are several types of sense circuits presently being used in OVP applications. These can be classified into three types: zener, discrete, and "723."

1. The Zener Sense Circuit — Figure 4 shows the use of a zener to trigger the crowbar SCR. This method is NOT recommended since it provides very poor gate drive and greatly decreases the SCR's di/dt handling capability, especially since the SCR steals its own very necessary gate drive as it turns on. Additionally, this method does not allow the trip point to be adjusted except by zener replacement. **2. The Discrete Sense Circuit —** A technique which can provide adequate gate drive and an adjustable, low temperature coefficient trip point is shown in Figure 5. While overcoming the disadvantages of the zener sense circuit, this technique requires many components and is more costly. In addition, this method is not particularly noise immune and often suffers from nuisance tripping.

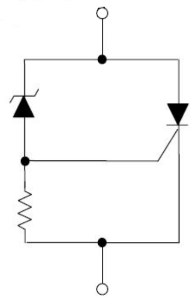

Figure 4 The Zener Sense Circuit

3. The "723" Sense Circuit — By using an integrated circuit voltage regulator, such as the industry standard "723" type, a considerable reduction in component count can be achieved. This is illustrated in Figure 6. Unfortunately, this technique is not noise immune, and suffers an additional disadvantage in that it must be operated at voltages above 9.5 V.

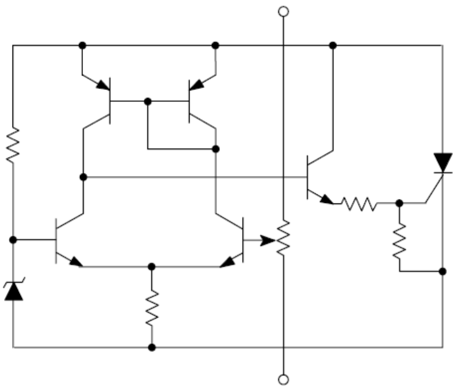

Figure 5 The Discrete Sense Circuit

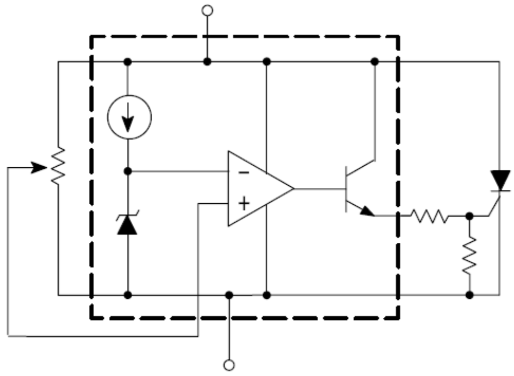

Figure 6 The “723” Sense Circuit

4. The MC3423 — To fill the need for a low cost, low complexity method of implementing crowbar overvoltage protection which does not suffer the disadvantages of previous techniques, an IC has been developed for use as an OVP sense and drive circuit, the MC3423. The MC3423 was designed to provide output currents of up to 300 mA with a 400 mA/µs rise time in order to maximize the di/dt capabilities of the crowbar SCR. In addition, its features include:

1. Operation off 4.5 V to 40 V supply voltages.
2. Adjustable low temperature coefficient trip point.
3. Adjustable minimum overvoltage duration before actuation to reduce nuisance tripping in noisy environments.
4. Remote activation input.
5. Indication output.

5. Block Diagram — The block diagram of the MC3423 is shown in Figure 7. It consists of a table 2.6 V reference, two comparators and a high current output. This output, together with the indication output transistor, is activated either by a voltage greater than 2.6 V on Pin 3 or by a TTL/5.0 V CMOS high logic level on the remote activation input, Pin 5. The circuit also has a comparator–controlled current source which can be used in conjunction with and external timing capacitor to set minimum overvoltage duration (0.5 µs to 1.0 ms) before actuation occurs. This feature allows the OVP circuit to operate in noisy environments without nuisance tripping.

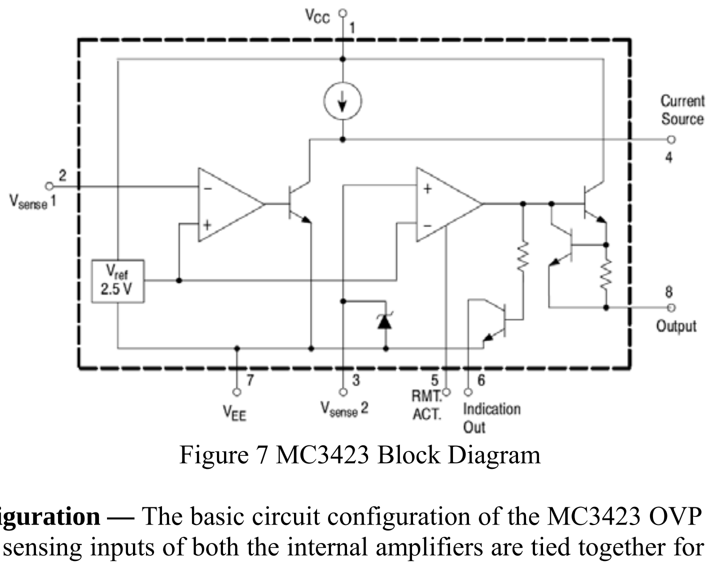

Figure 7 MC3423 Block Diagram

6. Basic Circuit Configuration — The basic circuit configuration of the MC3423 OVP is shown in Figure 8. In this circuit the voltage sensing inputs of both the internal amplifiers are tied together for sensing the overvoltage condition. The shortest possible propagation delay is thus obtained. The threshold or trip voltage at which the MC3423 will trigger and supply gate drive to the crowbar SCR, Q1, is determined by the selection of R1 and R2. Their values can be determined by the equations given in Figure 8 or by the graph shown in Figure 9. The switch (S1) shown in Figure 8 may be used to reset the SCR crowbar. Otherwise, the power supply, across which the

SCR is connected, must be shut down to reset the crowbar. If a non current–limited supply is used a fuse or circuit breaker, F1, should be used to protect the SCR and/or the load.

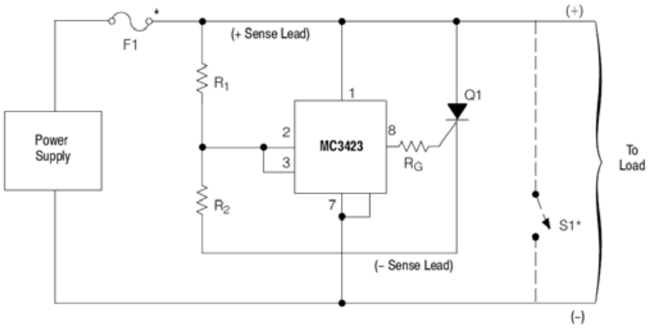

Figure 8 MC3423 Basic Circuit Configuration

7. MC3423 Programmable Configuration — In many instances, MC3423 OVP will be used in a noisy environment. To prevent false tripping of the OVP circuit by noise this would not normally harm the load, MC3423 has a programmable delay feature. To implement this feature, the circuit configuration of Figure 10 is used. Here a capacitor is connected from Pin 3 and Pin 4 to VEE. The value of this capacitor determines the minimum duration of the overvoltage condition (tD) which is necessary to trip the OVP. The value of CD can be found from Figure 14–11. The circuit operates in the following manner: when VCC rises above the trip point set by R1 and R2, the internal current source begins charging the capacitor, CD, connected to Pins 3 and 4. If the overvoltage condition remains present long enough for the capacitor voltage, VCD to reach V_{ref}, the output is activated. If the overvoltage condition disappears before this occurs, the capacitor is discharged at a rate 10 times faster than the charging rate, resetting the timing feature until the next overvoltage condition occurs.

8. Indication Output — An additional output for use as an indicator of OVP activation is provided by the MC3423. This output (Pin 6) is an open–collector transistor which saturates when the MC3423 OVP is activated. It will remain in a saturated state until the SCR crowbar pulls the supply voltage, VCC, below 4.5 V as in Figure 10. This output can be used to clock an edge triggered flip–flop whose output inhibits or shuts down the power supply when the OVP trips. This reduces or eliminates the heat sinking requirements for the crowbar SCR.

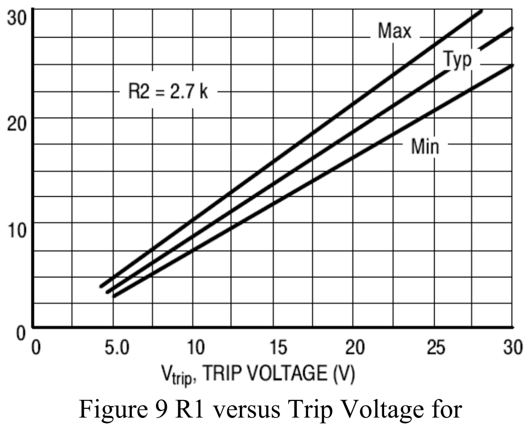

Figure 9 R1 versus Trip Voltage for the MC3423 OVP

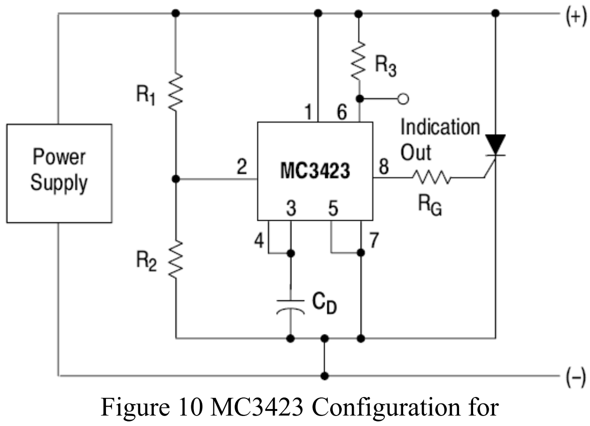

Figure 10 MC3423 Configuration for Programmable Minimum Duration of Overvoltage Condition Before Tripping

9. Remote Activation Input — Another feature of the MC3423 is its Remote Activation Input, Pin 5. If the voltage on this CMOS/TTL compatible input is held below 0.7 V, the MC3423 operates normally. However, if it is raised to a voltage above 2.0 V, the OVP output is activated independent of whether or not an overvoltage condition is present. This feature can be used to accomplish an orderly and sequenced shutdown of system power supplies during a system fault condition. In addition, the Indication Output of one MC3423 can be used to activate another MC3423, if a single transistor inverter is used to interface the formers Indication Output to the latter's Remote Activation Input.

4. CONCLUSIONS

The use of SCR crowbar overvoltage protection (OVP) circuits has been, for many years, a popular method of providing protection from accidental overvoltage stress for the load. In light of the recent advances in LSI circuitry, this technique has taken on added importance. It is not uncommon to have several hundred dollars worth of electronics supplied from a single low voltage supply. If this supply were to fail due to component failure or other accidental shorting of higher voltage supply busses to the low voltage bus, several hundred dollars worth of circuitry could literally go up in smoke. The small additional investment in protection circuitry can easily be justified in such applications.

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