Technique	During the design of new (or upgrades to) motor generator set type DC drives, consider the use of solid state assemblies for control functions.

DC DRIVE — SOLID STATE CONTROL

Use solid state regulators on motor generator sets to enhance fault detection and diagnostics

Benefits	Use of solid state controls instead of magnetic amplifiers can improve system restoration time in the event of a failure. Features such as fault detection, modular construction, and packaging can be easily employed. Diagnostics for system health status and problem resolution can also be readily provided. Incorporation of these features can result in improved system performance and availability.
Key Words	Solid State Assemblies, System Restoration, Maintainability, Performance, Availability
Application Experience	National Space Transportation System Shuttle Ground Support Systems.
Technical Rationale	At KSC the 175- and 250-Ton Bridge Cranes in the Vehicle Assembly Building (VAB) were using metadynes (electromechanical rotating amplifiers) for control function. The metadyne had a long history of maintenance problems because of brush wear, contamination and corrosion. It required extensive pre-operation maintenance attention to support Shuttle processing. In addition, the metadyne units often required maintenance during processing operations impacting processing schedules. KSC replaced the metadynes with solid state controller units resulting in decreased maintenance actions including pre-operation maintenance and improved system performance and availability. Fault isolation and removal and replacement of failed components is easier and less time consuming. Since failures occur at a less frequent rate, the need for numerous operating spares is reduced. Furthermore, the "off equipment" in-shop maintenance of failed units requires much less time and money to effect a repair. Reduced maintenance and downtime allow for the crane to be ready and operating to support Shuttle processing in a more timely manner.
Contact Center	**Kennedy Space Center (KSC)**

DC Drive - Solid State Control
Technique OPS-6

The use of solid state assemblies for control functions represents a great improvement over previous control methods. Historically, the first method of obtaining adjustable speed using DC motors was the constant potential DC supply using field adjustment. This provided a small range of adjustment. This method was followed by the rotating M-G system of Ward Leonard patented in the 1890's. This drive used an AC motor driving a DC generator to convert AC to DC power. The motor and generator may be combined in a single frame and use a common shaft, or separate coupled units (See Figure 1). The output DC voltage is controlled by adjusting the field excitation of the DC generator. Depending on the accuracy required, armature voltage or a tachometer may be used as a feedback signal in a closed loop system. An important aspect of this drive is that power flow is reversible. The motor acts as a generator, driving the generator as a motor, which drives the AC motor which then pumps power back into the AC lines. This ability, called regeneration, is a useful feature in decelerating large inertias or holding back overhauling loads. This is a very important consideration when replacing the M-G with a conventional packaged silicon-controlled rectifier (SCR) drive.

In the late 1940's, electronic tube drives began to replace M-G drives. These used vacuum, thyratron, excitron, or ignitron tubes for armature circuit control. They had limited acceptance because of tube life limits and water cooling requirements on larger ratings. By the early 1960's the tubes were replace with the solid state thyristor drives. Magnetic amplifier drives were developed in the mid-1950's when silicon diodes became popular. They were never as widely used because of difficulties of reactor design and acceptable response rate. However, they were rugged and highly reliable once in satisfactory operation.

During the early 1960's the thyristor or SCR became readily available. This device is similar in operation to a thyratron tube. Today it dominates the direct current drive field. Special circuits enable the SCR to regenerate and reverse readily. Larger and less expensive SCR's have extended the range to well over 1000 HP. Figure 2 illustrates a controlled rectifier drive. Note that the gateing control and SCR bridge have replaced the M-G set of Figure 1, resulting in reduced rotating machinery.

Solid State Operation

Figure 3 shows the assemblies comprising a solid state control system for DC drives. A single phase thyristor power converter supplies up to 200 volts positive or negative at 20 amperes to the generator field. A closed-loop controller (speed regulator) provides for armature voltage with IR drop compensation or AC/DC tachometer feedback speed control and linear acceleration and deceleration. A firing circuit provides an isolated gate drive to the power converter. A bi-directional adapter used in conjunction with the firing circuit assembly provides bi-directional current to the field of a DC generator for contactorless reversing or to regulate to zero output voltage in the presence of residual magnetism of the DC generator. Protective circuitry includes a voltage sensing relay for safety interlocking and an isolator for isolated armature current feedback.

References

1. *KSC Electrical Drawing for VAB 250 Ton Cranes*, 250-69-K-L-11388.

2. *KSC Electrical Drawing for VAB 175 Ton Crane*, 175-67-K-L-11348.

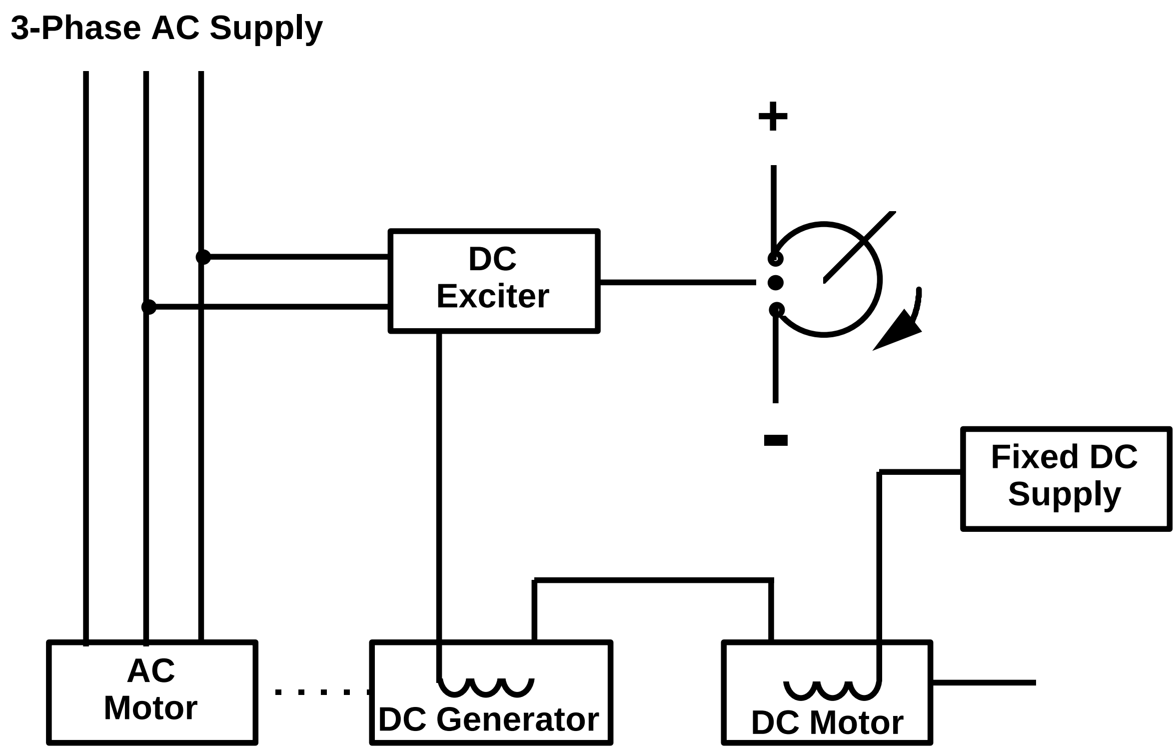

Figure 1. Rotating M-G System

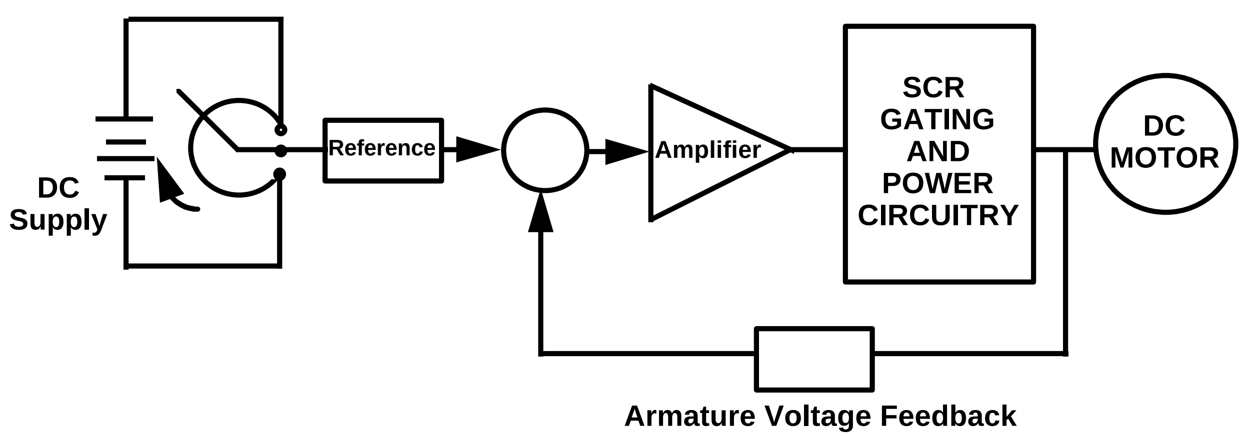

Figure 2. Controlled Rectifier Drive

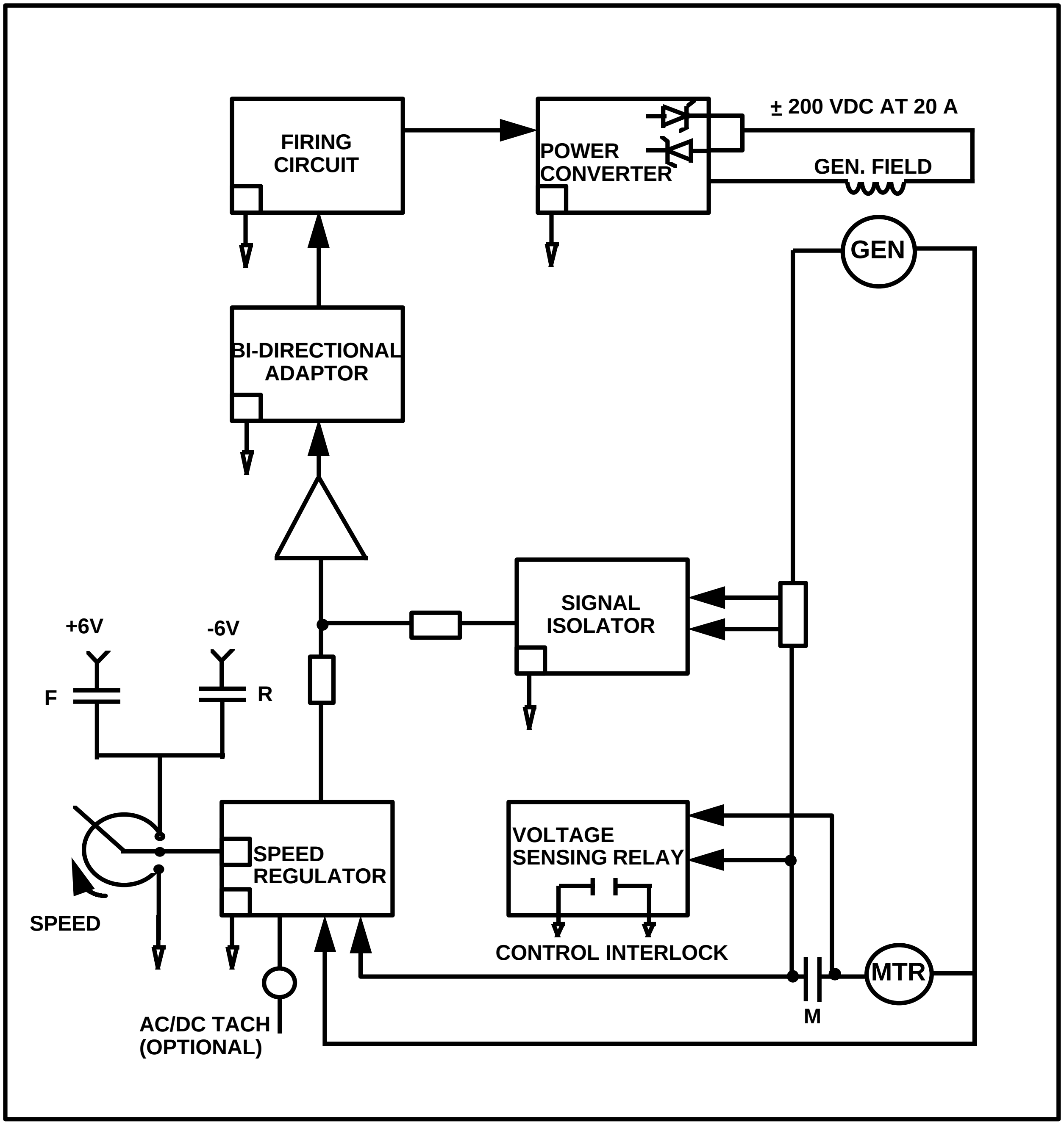

Figure 3. M-G Control-Reversing Simplified Schematic Motor Generator