SECTION V

THEORY OF OPERATION

DESCRIPTION OF OPERATION

The combination of 3120 Controller, motor, and operator controls is commonly known as a drive. Figure 5-1 shows a functional block diagram of a 3120 Controller combined with the motor and operator controls to form a drive.

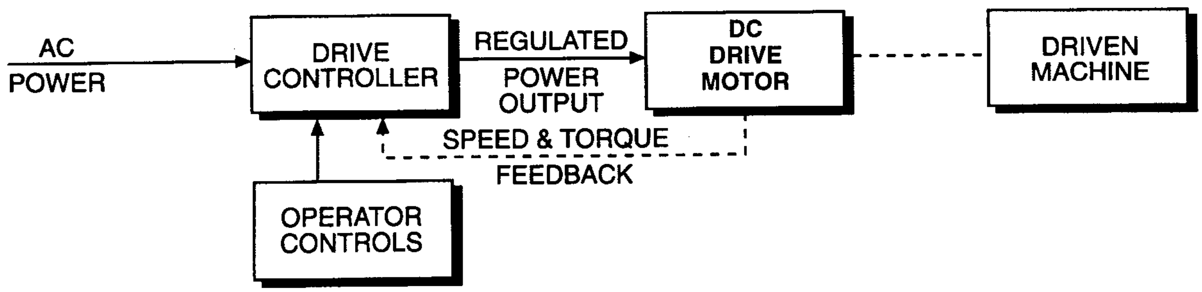

FIGURE 5-1. FUNCTIONAL BLOCK DIAGRAM

The drive provides infinitely adjustable-speed control within its operating range. While the shunt field power for the motor is provided by a constant-voltage supply, adjustable armature voltage is provided by the 3120M Module. The speed (N) of the motor is directly proportional to armature voltage, and the torque (T) is directly proportional to armature current. These two quantities are independent, as shown in Figure 5-2, page 5-2.

As a result of the controller supplying adjustable armature voltage to the motor, the drive provides constant torque operation. Thus, rated torque is provided at all speeds between zero and motor base (rated) speed, as shown by Figure 5-3, page 5-2. Since horsepower varies in direct proportion to speed, 100% rated horsepower is developed only at 100% rated speed with rated torque.

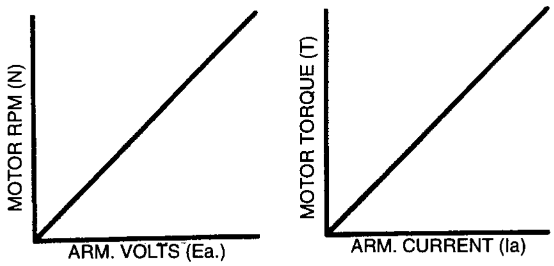

FIGURE 5-2. DC SHUNT-WOUND MOTOR CHARACTERISTICS

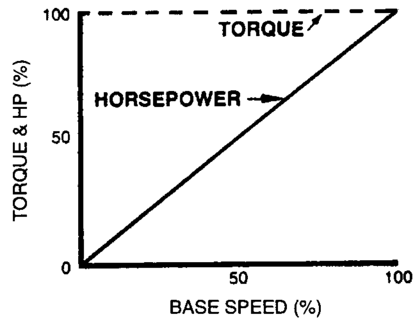

FIGURE 5-3. CONSTANT TORQUE CHARACTERISTICS

SCR DESCRIPTION

An SCR is a semiconductor with the on/off characteristics of a switch, and the ability to change AC to DC. In its static state, an SCR is like an open circuit. However, when a small positive voltage pulse is applied to its gate, with respect to its cathode, and its anode is positive, with respect to its cathode, the SCR conducts current in its forward direction, as an ordinary diode.

After being turned-on (triggered), the SCR continues to conduct until its cathode-to-anode current flow is either interrupted or reversed (i.e., the anode becomes negative and the cathode positive). The SCR then returns immediately to its nonconducting (open circuit) state until it is re-triggered.

While the anode and cathode alternately change polarity when AC is applied to an SCR, the current flow is regulated by controlling the point in the positive half-cycle of the AC when the SCR is triggered.

When the SCR is triggered late in the positive half-cycle, a small amount of current flows. Early triggering allows a larger current flow. When the AC reverses, the current flow drops to zero.

Thus, by alternately conducting/not conducting, the SCR provides pulsating DC.

SCR BRIDGE

Reference: Figure 10-1 (Page 10-2), Functional Schematic, 3120M Module

The full-converter SCR bridge consists of six SCR's (SCR1 through SCR6). The three common cathode SCR's (SCR1, SCR2, SCR3) apply positive voltage to the motor armature, and the three common anode SCR's (SCR4, SCR5, SCR6) apply negative voltage to the armature.

The SCR's are mounted in finned heat sinks and may be forced-air cooled to protect them from temperatures above their thermal ratings. Since excessive heat can cause SCR failure, an inoperative cooling fan should be replaced immediately.

Resistor-capacitor (RC) networks, located on the snubber/trigger board, and Varistors (RV1, RV2, RV3) connect across each phase of the AC supply and protect the SCR's from high voltage spikes.

Capacitors, located on the snubber/trigger board, connect from gate-to-cathode on each SCR and suppress high frequency "pickup" that could be induced into the SCR gates and cause false firing.

OPERATION THEORY

Reference: Figure 10-1 (Page 10-2), Functional Schematic, 3120M Module

When a Start command is initiated, either Relay K2 (Forward) or K3 (Reverse) pulls in on the relay/interface board. This event energizes either Contactor M1 (Forward) or M2 (Reverse), activates the field supply, enables the drivers on the control board, and lights an LED (RUN D10) on the control board. Contactor M1 (or M2) connects the motor armature to the output of the controller, and the field supply supplies rated shunt field power to the motor.

A speed reference signal is applied to the linear accel/decel board. The linear accel/decel board delays the rate of change of the speed reference signal, thereby providing an adjustable rate of acceleration and deceleration. The time span is linear and is effective whenever the speed reference is changed. A MIN SPD Potentiometer (R17) on this board allows minimum speed to be preset. For zero minimum speed, turn R17 fully counterclockwise.

From the linear accel/decel board, the speed reference signal is applied to the speed regulator on the control board. The speed regulator combines the speed reference signal with IR compensation and armature voltage feedback signals, and provides high gain for speed regulation.

IR compensation overcomes speed variations due to mechanical load fluctuations that may occur during normal operations. The IR compensator adds a current feedback signal, determined by the setting of the IR COMP Potentiometer (R111), to the speed regulator. When optional tachometer feedback is used, IR compensation is not needed and is made inoperative by the tachometer feedback board.

Armature voltage feedback provides regulation, stability, and sets maximum speed. Armature voltage is applied to an armature feedback isolator, which feeds the feedback signal through the MAX SPD Potentiometer (R131) and the feedback board to the speed regulator.

The output of the speed regulator, commonly known as an error signal, is fed to three gate drivers, each consisting of a ramp generator, comparator, driver, and gate oscillator.

The ramp generators generate sawtooth pulses. Reset is provided by the pulses from the line synchronization circuits, which are synchronized to the three-phase AC line.

The comparators compare the ramp generator outputs with the error signal from the speed regulator. As the error signal increases, the output of the comparators advance in phase which fires the SCR's in the SCR bridge earlier in the cycle, thereby increasing armature voltage to the motor.

The drivers receive the output from the comparators and provide gate pulses, and the gate oscillators provide a pulse train which fires and maintains SCR conduction.

The firing pulses from the control board are fed through isolation transformers on the snubber/trigger board to the gates of the SCR's in the SCR bridge.

Consequently, when the speed reference signal increases, conduction time of the SCR's increases which increases armature voltage which in turn increases motor speed.

As the motor rotates, it draws armature current directly proportional to the driven load. Armature current flows through a Shunt (SH1), connected in series with the armature, which causes a millivolt drop across the shunt. This potential is applied to the current feedback isolator on the control board, which provides a current feedback signal isolated from the motor armature circuit. The current feedback signal is fed to the IR compensator, current regulator, and overload circuit.

The current regulator limits motor armature current and the rate of change of current by inhibiting the error signal from the speed regulator, thereby preventing excessive current which can damage the controller and motor. Maximum allowable armature current is normally set at 150% of rated full-load armature current by the CUR LIMIT Potentiometer (R113). When armature current is being limited, an LED (CUR LIMIT D23) lights on the control board.

A current-versus-time static overload circuit is provided on the control board. If motor armature current reaches 120% of rated full-load armature current, the current feedback signal activates the overload circuit. If the overload (excessive current) is maintained for 80 seconds, the overload circuit drops out the Ø Loss, Overload Relay (K1) on the relay/interface board, which initiates a Stop function. In addition, an LED (OL D25) lights on the control board. Relay K1 remains de-energized until the controller is reset by removing and reapplying the AC supply voltage to the controller.

Relay K1 also drops out when a phase loss is detected by the phase loss circuit. Phase detection is provided by the pulses from the line synchronization circuits. In addition to dropping out K1, the phase loss circuit also disables the gate oscillator and lights an LED (Ø LOSS D11) on the control board. As when an overload occurs, K1 remains de-energized until the controller is reset by removing and reapplying the AC supply voltage to the controller.

When a Stop function is initiated, Relay K2 (or K3) drops out, which disables the drivers on the control board and drops out Contactor M1 (or M2). When M1 (or M2) drops out, the motor armature disconnects from the controller and the motor decelerates to a stop. At the same time, the field supply reduces the shunt field voltage for field economy.

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