Static SLIPSYN® Synchronous Motor Control

OPERATION

A synchronous motor is started as an induction machine with the field connected across the starting and discharge resistor. The purpose of this resistor is to limit the external induced field voltage and to provide optimum starting torque. The DC field voltage should be applied when the motor has reached the proper speed and rotor position. This is the basic function of the static SLIPSYN ® control. Protective features such as damper winding, pull-out, and field loss may also be included.

The transistor logic and amplifier circuits all operate on DC voltage which is furnished by the power supply mounted on top of the sheet steel enclosure. A single phase transformer with primary ratings of 220, 440, or 550 volts, 60 cycles is provided on standard units, although a different transformer is used for other voltages or frequencies. Several DC voltages are supplied by separate secondary windings on the transformer. The -20 volts is the main supply and uses a full wave rectifier bridge with a 1000 mfd. filter capacitor. The 20 volts is a bias supply using a half wave rectifier with a 50 mfd. filter capacitor. The -24 volt supply furnishes power to the relay and contactor coils. It uses a center tapped full wave rectifier and a 500 mfd. filter capacitor.

The logic, switching, and amplifying functions are all performed by transistors. Output circuits are provided to energize the AC line contactor interposing relay (MX) and the field contactor (FC). Magnetic cores are used in the pull-out and damper protection networks. The wire-wrap process is used for assembling and inter-connecting the components on the five circuit boards. Wire is wrapped around a rectangular post for a solderless connection.

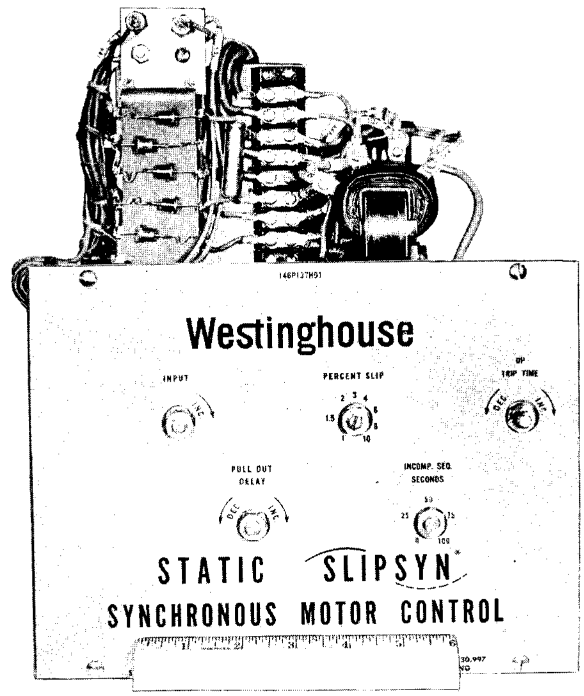

Fig. 1 SLYPSYN® *Control Panel*

Refer to the block diagram, Fig. 2, for the following description of operation. Pushing the start button energizes the power supply and causes a pulse on lead 102. This pulse turns off MEMORY #1 and #2 to insure that the field contactor remains de-energized. At the same time it turns on MEMORY #3. This output is amplified to energize relay MX, whose contacts are used to energize the line contactor or circuit breaker. MX remains closed until the power supply is de-energized, or until a protective circuit functions.

The synchronizing input signal is taken across the starting and discharge resistor or a portion of it. This voltage has a frequency inversely proportional to motor speed. The magnitude is adjusted by means of the input potentiometer, and the voltage clipping network limits the negative half cycle of the input voltage to -24 volts. The

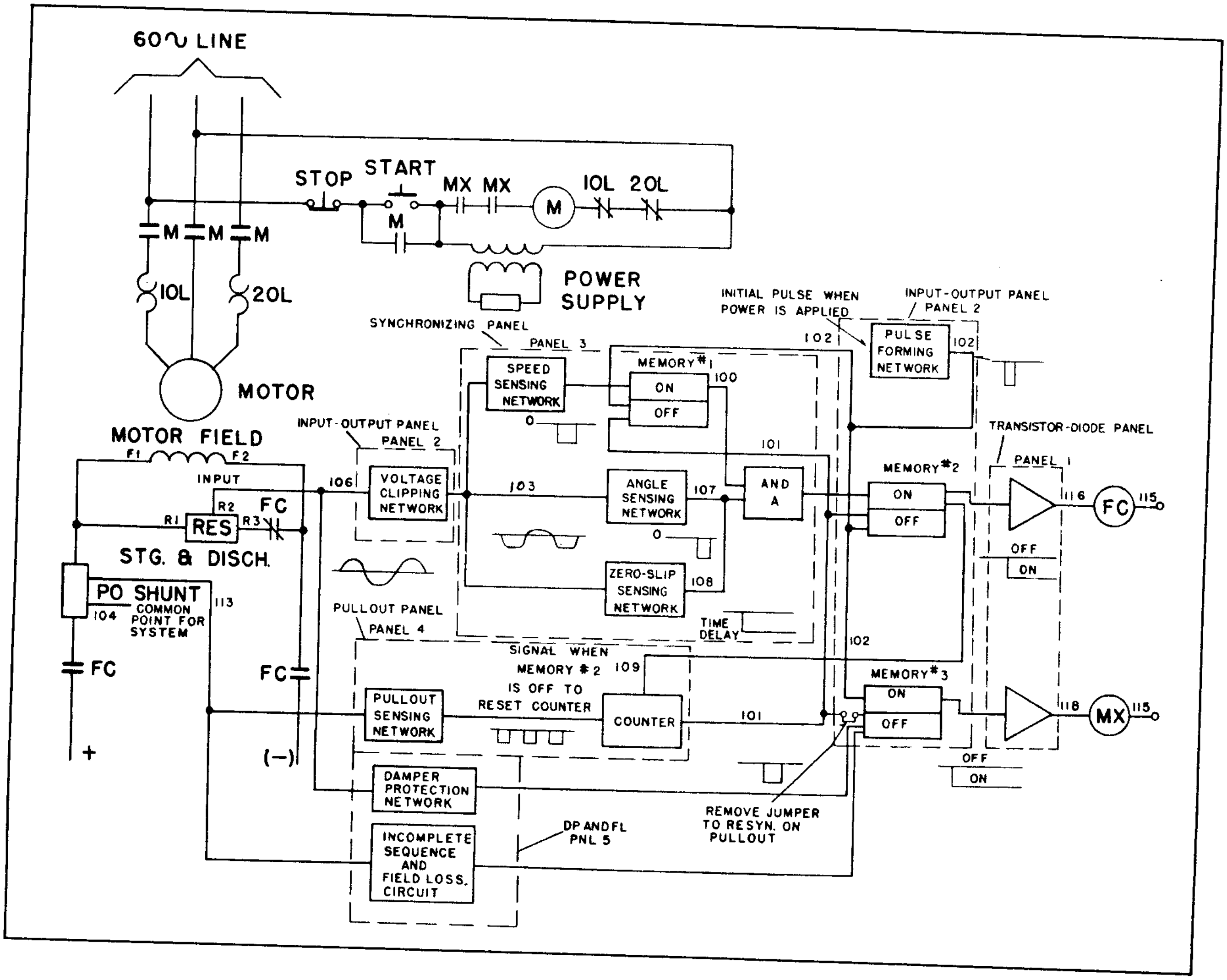

Fig. 2 *Block Diagram*

positive half cycle of input is not used in the control but is limited to a low value. The clipped negative half cycle (pulse) is then fed into 30 separate circuits which determine the proper conditions for synchronization.

The interval between negative pulses gradually increases due to the decreasing slip frequency. In the speed sensing network each pulse resets a timing circuit. When the interval between pulses exceeds the delay of the timer an output signal turns on MEMORY #1. This output is one of the 2 signals required to turn on AND A. It indicates that the motor is at the proper speed.

The other requirement for a good synchronization is that the field be applied when the induced field current is opposite that of the steady state field current. Assuming a positive steady state field current, a short pulse is generated in the angle sensing network at the beginning of each negative pulse. The first of these pulses to occur after MEMORY #1 has turned on will turn on AND A. This turns on MEMORY #2 which energizes the field contactor coil through an amplifier.

It is possible for some lightly loaded motors to pull into step due to reluctance torque. In this case no angle pulse would be generated after the speed sensing signal is received and therefore, the field contactor would not close. To prevent this, a zero speed network is provided to give an alternate signal and to turn AND A on after a short delay.

In addition to the synchronizing function, the static SLIPSYN® control contains circuits which will protect the motor against certain abnormal conditions. A pull-out may occur when the motor has been loaded too far beyond its rated torque. The motor slows to less than synchronous speed and an AC current is super-imposed on the DC field current. A shunt in the field circuit is used to pick up this signal which is then fed to the pull-out network. Each pole slipped produces a pulse which is fed into a counter. This is adjustable from 1 to 8 poles slipped and can be set to suit the application. A higher setting will reduce false tripping due to random load or line transients. The controller will normally be set to shut down completely on pull-out, but a jumper can be removed to allow the motor to re-synchronize.

Most units also contain a damper protection network. Should the motor fail to accelerate, or if it accelerates too slowly, there is danger of damaging the damper winding. Although this winding is limited to rather short locked rotor time, it is capable of longer operation at higher rotor speeds. The input is taken from the same starting and discharge resistor tap as the synchronizing signal. The duration of this input signal is compared with a preset time period which automatically increases as the slip frequency decreases. The overall effect is to provide optimum protection while making full use of the motors accelerating ability. The potentiometer is preset and sealed with paint at the factory to provide a trip time of 7 to 8 seconds at 60 cycle slip frequency. This calibration is made with an input signal of 100 volts, therefore, the actual input voltage should be checked at startup as noted below, to provide a signal within ± 10% of this value.

The field loss circuit is an optional feature and it will not be found on all units. It acts to shut down the motor if the field current stops flowing, regardless of the reason. The signal is taken from the pull-out shunt on leads 104 to 113. Since the field current does not flow through this shunt during the starting period, it is necessary to inject an alternate signal which is removed after the motor has synchronized. A timer which is adjustable to 90 seconds determines the duration of the signal. If the motor has not synchronized when this time has expired, it will shut down. This is known as incomplete sequence.

START - UP

After making all the necessary control and power connections, the unit is ready for starting. Care should be taken that the DC connections are as shown in the diagram, since the common for the static control should be connected to the plus side of the DC line. Improper connection will cause the field contactor to close during the half cycle of induced field current most likely to cause pole slippage before synchronization. The input and DP adjustments are made at the factory before shipping, and should be satisfactory. The percent slip potentiometer should be adjusted for the desired synchronizing speed. In general, the lower percent slip settings are required only for high inertia loads. The pullout potentiometer should be set for the protection desired. If the field loss function is included, the incomplete sequence pot should be set at maximum.

Remove the cover from the static SLIPSYN® shown in Fig. 1. Pushing the start button will apply the AC power and the motor will accelerate. <u>ON THE FIRST START</u>, and while the motor is accelerating, measure the input voltage between terminals R2 (106) and common with an AC voltmeter. This should be 100 V ± 10% to provide accurate damper winding protection. Reset this tap if necessary.

If the motor trips off the line before it has synchronized, first make sure that the incomplete sequence potentiometer is set at the maximum position. If this is already at maximum, or if the motor still trips on a

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subsequent start, the cause is an output from the DP board. A high signal voltage from the starting and discharge resistor will cause a premature trip. If the reading taken on the first start was high, then readjust the tap in line with the indicated tolerances. It is also possible that the accelerating time is longer than the trip time as determined by the pot setting. The motor may actually be capable of this longer acceleration time, and increasing the pot setting will compensate for this. However, the motor manufacturer should be consulted to ascertain that its rating is not being exceeded, resulting in damage to the damper winding. Although the DP circuit does not measure the heat retained in the winding after a start, its reset time requires 5 to 6 minutes before accurate repeatability can be achieved.

CAUTION: Do not start the motor successively without allowing time for the damper winding to cool.

If the field contactor does not close at all, the motor does not have enough torque to accelerate to the speed set on the percent slip potentiometer. Increase this setting until the field contactor closes on a subsequent start. If the field contactor closes too soon, the most likely trouble is low input. To adjust this connect a DC 10 milliamp ammeter between terminal 105 and common, and again start the motor. Increase the Input potentiometer adjustment until the needle moves slightly. This adjustment must be made before the motor reaches synchronous speed. There is another condition which may arise after the stop button is pushed, and, before the motor has stopped rotating, the start button is again pushed. The field contactor may close immediately, causing the pull-out circuit to trip the motor off the line. This also indicates that the input signal voltage is still too low. Readjust as indicated above. Finally, set the Incomplete Sequence potentiometer at a value just greater than the time required for the motor to synchronize. Make sure there is enough time delay for the current to build up in the motor field.

If the motor trips off the line any time after it has successfully synchronized, this is probably due to an output from one of the protective circuits, or to an overload relay tripping. It may be necessary to raise the setting of the pull-out potentiometer to over-ride line or load transients.

To check the pull-out circuit, start the motor and after it has synchronized, remove one lead to the field contactor coil. When the field has been removed the motor should slow to something less than synchronous speed. Reclosing the field contactor will simulate poles being slipped and the motor will be removed from the line. If this does not occur, it is possible the motor is too lightly loaded to slow below synchronous speed when the field is removed.

To check the field loss circuit remove one lead from the field contactor coil after the motor has synchronized. This interrupts the field current and the motor will be de-energized. Incomplete sequence can be checked by setting the pot to less than the actual time required for the motor to synchronize. An alternate method is to remove a lead from the field contactor coil before starting the motor. In either case, the motor will shut down before synchronizing.

To check the DP circuit, a separate well-regulated 100 volt 60 cycle source must be used. Disconnect a lead from the line contactor coil to prevent the motor from starting. It is advisable to open the circuit to the tap on the starting and discharge resistor to prevent excessive current drain on the separate source. Press the start button and at the same time apply the separate source to the common (104) and R2 (106) terminals on the static assembly. The interposing relay (MX) will trip in 7 to 8 seconds (factory setting). The pot may be reset to agree with the "maximum locked-rotor time" of the particular motor. To prevent damage to the circuit board, REMOVE THE SEPARATE SOURCE AFTER THE RELAY HAS TRIPPED, OR AFTER A MAXIMUM OF 20 SECONDS.

TROUBLE SHOOTING

If, after making the adjustments under start-up, the controller does not function properly, Table No. 1 can be used to locate the trouble. Since all the transistors are operated as switches, an incorrect signal can easily be found. An (X) indicates a negative voltage of approximately 10 volts should be present. An (0) indicates zero voltage. Other voltages are indicated. All voltages are measured to the common (104) of the static SLIPSYN® control. Do not measure to ground.

The three conditions used for trouble shooting, as listed in the table, are:

A. Power to control circuit but coil of motor contactor (M) disconnected. Use jumper around M interlock in pushbutton circuit.

B. Line contactor coil connected, but measurement must be taken before motor reaches synchronous speed.

C. Field contactor closed.

The fifth column indicates the board most likely to be causing trouble. These are indicated in the order of their position in the assembly, starting at the left.

1. Transistor Diode Panel - S# 217A859G04
2. Input-Output Panel - S# 217A859G02
3. Pull-Out Panel - S# 217A859G03 or - S# 217A859G06 (when F.L. included in assembly.)
4. Synchronizing Panel - S# 217A859G01
5. Field Loss Panel - S# 217A859G05 or - S# 217A859G13 (when DP included in assembly.)
6. Damper Protection Panel - S# 217A859G12

TABLE NO. 1

TERMINAL MARKING	A	B	C	BOARD MOST LIKELY TO BE CAUSING TROUBLE	REMARKS
-20	-20	-20	-20	Power Supply	
+20	+20	+20	+20	Power Supply	
Common	0	0	0	Power Supply	
100	X	X	0	2 - 4	
101	0	0	0	3	Pull-out ckt. output
102	Pulse	0	0	2	Short pulse when power is applied
103	0		0	2	Clipped input
105	0	d-c ma	0	4	Input adjustment ckt.
106	0	100 volts	0	Input	Input from starting and discharge res.
107	0	Pulses	0	2	Pulse every negative half cycle
108	X	0	X	2	Reluctance pull-in signal
109	0	0 then X	0	4	
111	0	0	0	1 - 2	MX signal
112	0	0	0	1 - 2	FC signal
113	0	0	0.2 V DC		Input to P.O. ckt.
115	-24	-24	-24	Power Supply	
202	X	X	0	5	Field loss only
404	0	0	0	5	Field loss only

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