# DESCRIPTION OF OPERATION OF STATIC SYNCHRONOUS MOTOR FIELD APPLICATION PANEL

For an understanding of the operation of the synchronizing input and output panels of the Static Slipsyn Control, familiarity with the NOR circuit design is all that is essential. Referring to the diagrams, transistors TR1, TR2, TR3, TR4, TR5, TR6, TR7, TR8, TR9, TR10, TR11, and TR12 are NOR circuits. These transistors are junction transistors in the common emitter configuration - not as a linear device but as a 2-position switch. In these NOR circuits, PNP transistors are used with the base biased at +20 volts and the collector biased at -20 volts. A minus pulse or signal to the input (base) sufficient to desaturate the transistor will cause it to start conducting or switch off.

Note that all the outputs of the NOR circuits using PNP transistors are minus DC voltages or pulses.

In analyzing the various circuit functions, it is highly desirable to identify on Dwg. 578-D-988 the functional blocks given in Figure 2 of I.L. 14-000-2. On the attached copy of the Schematic, this has been done.

Note: Refer to I.L. 14-000-2 for general information.

Pulse Forming Network

When the start button is pushed, energizing the control power supply, the pulse forming network generates one pulse on the 102 bus. TR12 of Memory #3 is cut off* and with no other signal to TR11, an output is obtained from TR11 to keep TR12 "cut-off" and to bias TR2N257 "on", picking up the N relay. The N relay contacts energize the M contactor which seals itself in.

The pulse generated on bus 102 is also an input to TR1, TR4, TR9. TR9 is cut off, Memory #1 is turned on (output on bus 100) to hold TR9 off. With TR9 cut off, no output is obtained from TR13 and 2N174. Thus, the field contactor (FC) is not picked up.

When the stator of the motor is energized, a voltage at rotor frequency is generated in the motor field. During acceleration of the motor, the normally closed contact of the field contactor (FC) connects the discharge resistor in shunt with the motor field. A voltage taken across a portion of the discharge resistor is the input to the voltage clipping network (bus 106 and common).

Voltage Clipping Network

In the voltage clipping network, the input voltage is impressed on Varistor 328 in series with a 2.2K resistor and in parallel with a 2.5 K pot (input) and a 4.7 K resistor.

*In this discussion, when a transistor is said to be"cut-off", it will mean that it has no output.

The tapped connection to the discharge resistor and the input pot is used to adjust the voltage to the clipping network. The Zener diode SV918 in series with a 307A diode and a 10-ohm resistor dips the negative half cycle voltage (bus 103) to 24 volts. The positive half cycle is rejected or shunted with a 307A diode in series with a 470-ohm resistor.

The speed sensing network, angle sensing network, and the zero slip sensing network all derive their input signals from the voltage clipping network (bus 103.).

## Speed Sensing Network

When the motor is energized, a negative pulse at rotor frequency from the voltage clipping network is the input to TR5 and to the RC timing circuit. From the time the start button was pushed until the motor stator was energized, TR5 was giving an output, biasing off TR4 and TR3. Also, with no output from TR3, TR2 had an output and sealed itself in by biasing TR1 off. A negative pulse to TR5 cuts it off. However, a high frequency input to the RC timing circuit maintains a charge on the capacitor; therefore, bias is maintained on TR3 to keep it cut off, maintaining an output from TR2. With an output from TR2 on bus 100, which is an input to TR9, no output is obtained from TR9, thus, the field contactor cannot be energized.

As synchronous speed is approached (1 to 10% slip, adjustable with RC timing circuit), no output is obtained from the timing circuit. Thus, when TR5 is biased off, TR3 yields an output which biases TR2 off. This is one of the conditions necessary to energize the field contactor (FC). If this were the only input to TR9, the absence of a signal on bus 100 would cause this NOR circuit to yield an output. However, buses 109, 101 and 102 also control TR9.

Angle Sensing Network

The angle sensing network puts out a pulse at the start of each negative pulse generated by the voltage clipping network. This is accomplished with TR6, and TR7 and an RC circuit. When TR6 is biased, its output ceases. Also, for a short portion of the pulse time, the RC circuit results in no bias to TR7 and thus TR7 produces a pulse which biases TR10 off. Therefore, no signal is delivered to bus 109 and to TR9. Since the field has not yet been applied, there is no signal from the Pull out circuits, or bus 101. A pulse on bus 102 decayed a long time ago. With no signals on buses 100, 101, 102, and 109, TR9 will conduct to bias TR13, the first amplifier stage. This will yield an output to 2N174, the second amplifier stage, which acts to pick up the field contactor (FC). Also, the output from TR9 cuts off TR10 to seal this condition in.

Zero Slip Sensing Network

TR8, its input resistors, a 307A diode, and a 50 volt, 35 mfd. capacitor make up the zero slip sensing network. With a negative pulse repeatedly applied to the 35 mfd. capacitor, TR8 is baised off. If the motor pulls into synchronism due to reluctance torque, the charge on the 35 mfd. capacitor will be dissipated through the 1K resistor and NOR circuit to common, thus removing the bias on TR8 and yielding an output from TR8.

As in the above case, with an input to TR10, and no signal on buses 100, 101, 102, and 109, all the conditions have been met to obtain an output from TR9 and energize the field contactor.

Applying the Field

When the field is applied, the voltage clipping network is de-energized. With no output from the voltage clipping network, there is no output on bus 100. TR1 seals this condition in. TR5 is conducting, TR4 and TR3 are cut off by the output of TR5.

Applying the field energizes the pullout circuit which is connected across a shunt (2SH-terminals 104 and 113). The output of the pullout circuit is bus 101. If the motor does not pull into synchronism, a pulse is generated after a given number of slip cycles (adjustable). This pulse is an input to TR9 and causes it to cut off. It also switches Memory #1, or TR1 and TR2, resulting in an output on bus 100 to keep TR9 cut off. Thus the field contactor drops out.

Since there is a jumper between buses 101 and 201, the pullout pulse generated on bus 101 will drive TR11 to cut off, thus dropping out the N relay which in turn de-energizes the control circuit. If this jumper is omitted, N relay does not drop out and the synchronizing circuits will again function to reapply the field, the same as discussed above.

If the motor is successfully synchronized and at some time later a sufficient number of poles are slipped due to load or system disturbances,the pullout pulse will be generated and the field removed, as discussed above.

Operation of the Pullout Network

The pullout circuit consists of Transistors TR14, TR15, TR16, and TR17 and associated circuits including the input transformer connected across shunt 2SH.

Transistors TR14 thru TR17 are PNP transistors with common emitter. TR14 is normally cut off since the resultant bias on the base is minus. TR16 base is positively biased and its output normally keeps TR17 cut OFF. When a pole slips, the resultant change in the field current results in a change or potential drop across 2SH. This results in an induced voltage on the secondary of the input transformer.

When terminal 3 is positive with respect to terminal 4, 307A diode shunts or short circuits this signal. When terminal 4 is positive with respect to terminal 3, a current flows through the 1K resistor and the 10 mfd. condenser, and the condenser assumes a charge, dependent on the circuit time constant and the strength of the signal. This charge, being positive, is sufficient to override the negative bias on TR14.

Thus TR14 conducts until the charge on the 10 mfd. condenser is dissipated, which is a function of the time constant of this RC Circuit. The RC circuit with a long-time constant consisting of the pullout pot and a 10 mfd. condenser is the load on TR14. Each time TR14 conducts due to a slipped pole, this condenser is charged a little bit more depending on the pullout pot setting. The charge on the 10 mfd. condenser increases to the point where the Zener diode ZA8 fires, thus cutting off conduction of TR16 and allowing TR17 to conduct. Since the charge on the 10 mfd. condenser is quickly dissipated, ZA8 ceases to conduct and only a short pulse is obtained on bus 101.

Other Circuits

While the motor is accelerating and before a synchronizing signal is applied, TR10 is conducting. The output of TR10 is connected through a 307A diode and a 10K resistor to bias TR15 OFF so that no pull out pulses are received on bus 101 to change the output of Memory #1 or the signal on bus 100 after synchronizing speed is obtained but before the field is applied.

Static DP Circuit

The static DP circuit input signal is taken from the same tap on the starting and discharge resistor as the synchronizing signal. The DP signal input is connected to 15 ohm 25 watt resistor in series with a wave shaping reactor.

In parallel with the reactor is a 500 ohm pot. and a Westinghouse PTC thermistor. The circuit utilizes the characteristics of the positive temperature coefficient to simulate the heating in the winding itself. The potentiometer regulates the current flow to the thermistor that gives the tripping time. The time can be varied from 6 seconds to 20 seconds or longer. The thermistor switching action is rated from 105° to 115° C. When the switching action occurs this creates a pulse that fires 320D diode and enters the 110 bus by way of Zener diode. The 110 bus carries the pulse directly to TR11 transistor which is the NOR circuit that controls the MX contactor. With no other signal present, the TR11 switches and opens MX coil circuit.

Field Loss and Incomplete Sequence

The field loss circuit protects synchronous motors against abnormal conditions arising from loss of DC excitation current. It acts to trip the line contactor supplying the motor regardless of the reason.

The current signal is taken from the same shunt as the pull-out signal. Since the field current does not flow in the shunt during the starting period, an alternate signal is fed into the circuit until the motor synchronizes. A timing circuit determines the duration of this signal.

In the timing circuit are three 50 mfd. 50 V DC capacitors in series with 1K resistor, .5 meg pot. and 100 ohm resistor. The time is regulated by the setting of the .5 meg pot. that can be regulated from a few cycles to 90 seconds.

The capacitors charge until the voltage of BB1 unijunction TR24 becomes 50% of B1-B2. At this time the transistor switches, cuasing the voltage on B2 to become more negative and thus causing TR23 and TR22 to turn on, producing a zero signal to TR21. While the capacitors were charging, the field contactor closed producing a signal to the base of TR18. With 1 on the base of TR18, we have a zero to the base of TR20, therefore, we have 1 to the base of TR21. With an input of 1 and zero the output on lead 404 would be zero. In case of field loss, the output from TR20 would be zero and would be zero and would let TR21 conduct, whereby TR11 would switch causing 2N257 to turn off, opening the MX coil circuit.

## TROUBLE SHOOTING STATIC SLIPSYN

1. When field loss and incomplete sequence are supplied and motor trips off the line before it reaches synchronous speed, remove lead 404 from input board.

2. If more than eight seconds is required to reach synchronous speed, the damper protection pot. must be increased. This pot is set for eight seconas on the test floor.

3. When field contactor closes too soon or comes out after closing, remove lead 110 at input-output board to see if stray signal is coming from damper protection circuit.

4. To test operation of TR9, TR10, and 2N174, connect lead 100 to the -20 volt term. FC should never close. In case it does close, TR9, TR10 or 2N174 is defective. Remove the connection from the -20 volt term and replace lead 100 on its proper term, if FC closes before machines get up to proper speed, the synchronous panel is defective.

5. If MX contactor opens immediately after closing or opens when FC contactor is energized, remove lead 113 from pull-out board to see if pulse is being induced thru pull-out circuit. The pulse on this circuit may be measured from the wiper term. of the P.O. pot. to com (104). A high resistance voltmeter must be used to measure the pulse. The pulse should not exceed 5 volts.

6. If lead 102 is not connected MX and FC will pick up as soon as start button is pushed. All negative leads must be secure on panel boards or MX and FC operation will be faulty. If negative and positive leads are reversed at the term boards, MX will close and drop out immediately.

7. Make sure all com (lead 104) connections are tight and secure to terminals on panel boards, a high drop on lead 104 can cause a pulse to the pull-out circuit.

8. Check the 20 volt D.C. positive and negative power supply outputs. The voltages must not exceed 21 volt D.C. These voltages may be adjusted by the primary taps on the transformer power supply.

9. In applications requiring an interposing relay on the field contactor circuit, the load on the 24 volt 2N174 transistor must be adjusted by adding a resistor to compensate for the 2 amp load normally applied by the type "M" contactor.

10. In applications requiring more pull-out time such as Ball-Mills a 2500 OHM 1 watt resistor may be added in series with the pull-out potentiometer. This increases the time range.

11. The maximum allowable ambient temperature for the static slipsyn panel is 40° C. This takes into account a 10° C rise in static slipsyn devices and total temperature cannot exceed 120°F. or 50° C. for it introduces transistor runaway and unstable operation.

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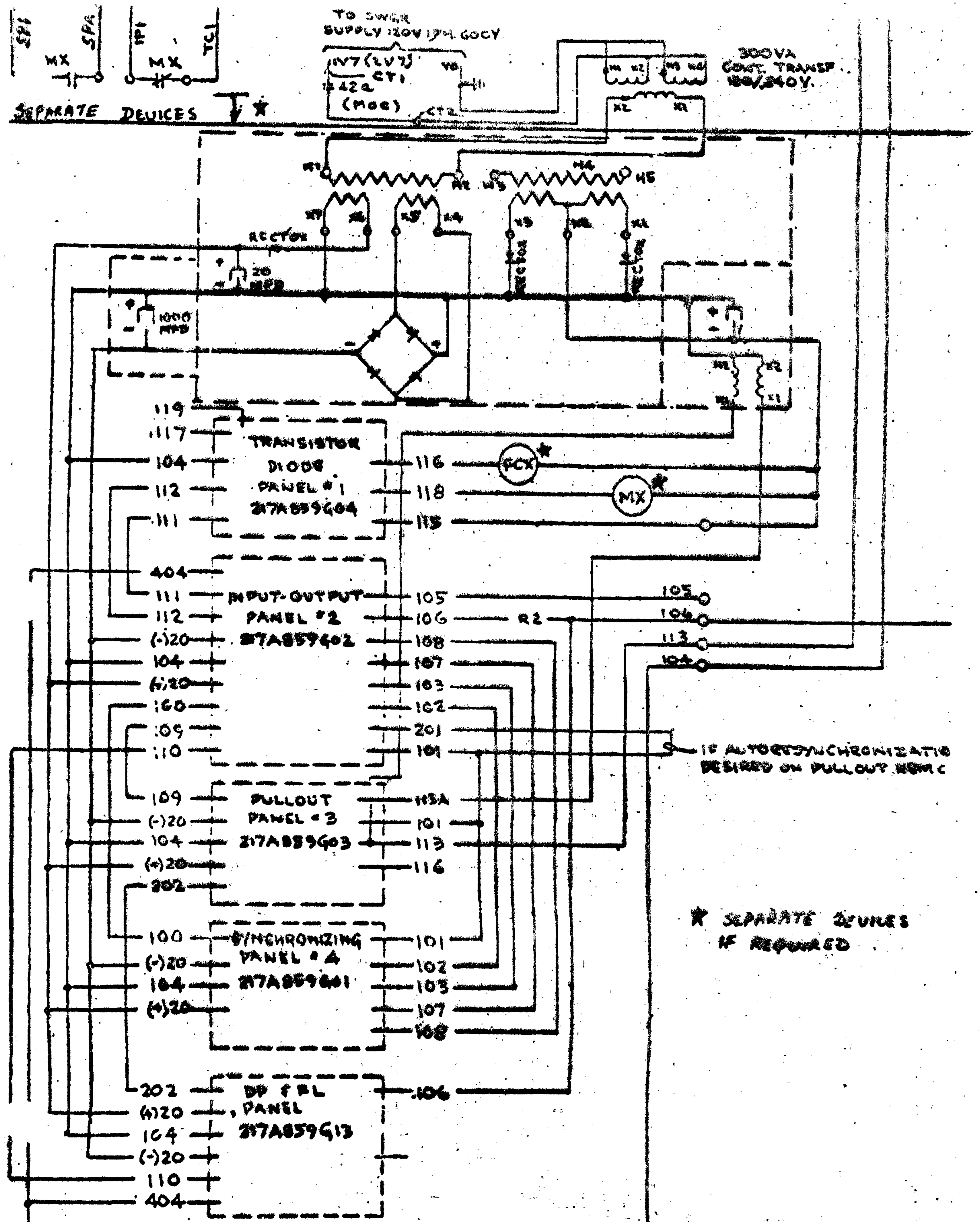


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