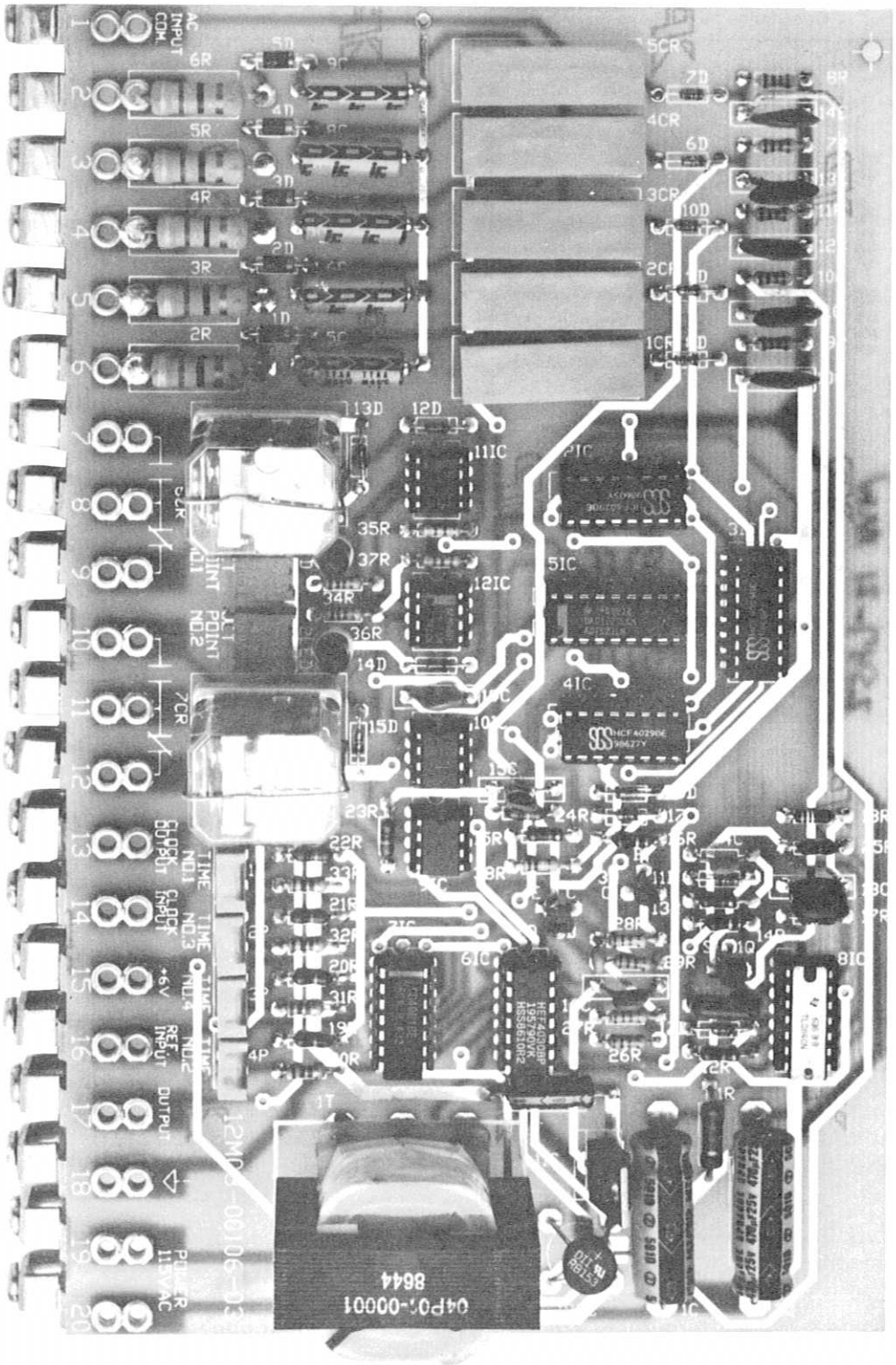
REFLEX®

# Trouble-shooting Manual
# MODEL 210
# SOLID STATE MOP
## PART NUMBER 12M03-00106-03



# REFLEX® MODEL 210 SOLID STATE MOP

**PART NUMBER 12M03-00106-03**
**SCHEMATIC DIAGRAM 12M03-00106-03**

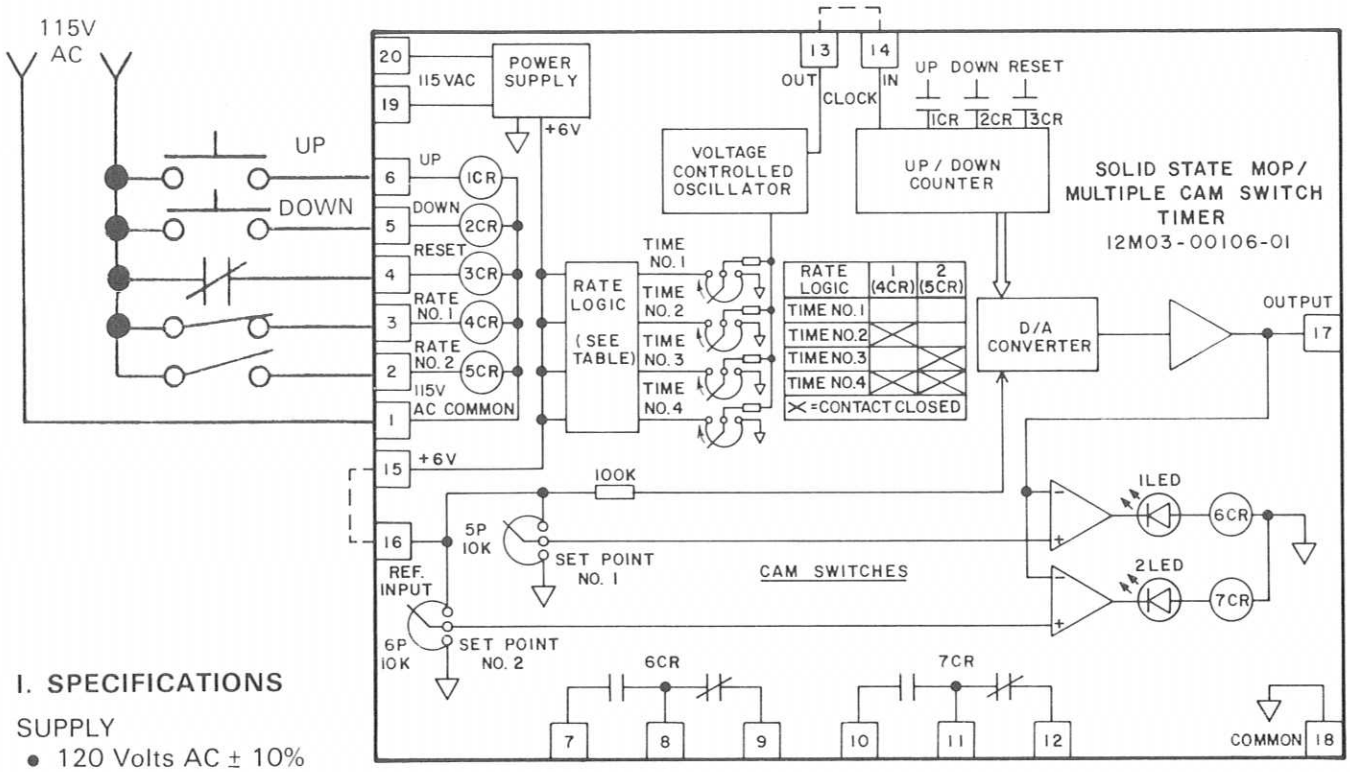



FIGURE 1. SIMPLIFIED SCHEMATIC DIAGRAM

## I. SPECIFICATIONS

SUPPLY
- 120 Volts AC ± 10%
- 50/60 Hz, single phase

AMBIENT TEMPERATURE
- 0° to 40°C (32° to 104°F)
- 50°C in cabinet

INPUTS
- 115V AC from pushbuttons, relay contacts, programmable controller or similar devices for functions of "UP," "DOWN," "RESET" and "RATE SELECT" (115V AC should be applied intermittently).*
- Analog reference, up to 10 volts either positive or negative.

ACCURACY:
- Equal to accuracy of reference used ± .02% (1% accuracy with on-board reference).

TIMING ADJUSTMENT RANGE:
- Nominally 2 to 60 seconds. Four separately adjustable times with instantaneous reset.
- Each of four times selectable by combination of two 115V AC inputs (115V AC should be applied intermittently).*

OUTPUTS:
- Analog signal, zero to a voltage equal to the reference voltage and of the same polarity (positive 6 volts with on-board reference) at 5mA.
- Relay contact closure. Two separately adjustable relays each with form C contacts. Contact rating 2A at 115V AC, 3A at 26V AC.
- Pick up or drop out point independently adjustable on each from 0 to 100% of output voltage with a differential between pick up and drop out of .05%.

RESOLUTION:
- One part in 4000

SMALLEST INCREMENT OF CHANGE:
- One part in 1000. Smaller if individual pulses are fed into "CLOCK IN" terminal.

*Intermittent operation minimizes heating but is not absolutely essential.

## II. THEORY OF OPERATION

The REFLEX Model 210 Solid State MOP is a digital-based equivalent of a mechanical motor-operated potentiometer. It allows adjustment of an analog output voltage up or down at up to four independently adjustable rates in response to external signal devices such as pushbuttons, relay contacts, a programmable controller or similar devices.

It consists of the following elements as shown in the Simplified Schematic Diagram (Figure 1):

1. Power Supply
2. Input
3. Rate Select Logic
4. Voltage Controlled Oscillator
5. Up/Down Counter
6. Digital to Analog Converter
7. Solid State Cam Switches

1. **Power Supply** – The power supply uses a center-tapped transformer with 10 volts on each side of center together with a bridge rectifier and two 470 MF capacitors to provide a nominal positive and negative unregulated 15 volts DC with respect to the transformer center-tap, which is connected to circuit common.

   Additionally, a positive 6 volt regulated voltage is obtained from the positive 15 volt supply, using regulator 1IC with a 10 MF filter capacitor. A negative 6 volt regulated voltage is obtained from the negative 15 volt supply using zener diode 1ZD.

2. **Input** – Each of five inputs consists of a rectifier, voltage divider, relay (1CR to 5CR) and filter capacitor. This network converts 115V AC to a nominal 5 volts DC to operate a reed relay. The filtering action of the capacitor allows substantial contact bounce at the 115 volt input terminals without the reed relay chattering.

   The output contact of each of these relays provides a logic level signal to the internal integrated circuits. To prevent the contact bounce of the reed relay from providing multiple pulses to the logic, an additional "debounce" network consisting of a diode, resistor and capacitor is used.

3. **Rate Select Logic** – Four independently adjustable time settings can be selected by a combination of inputs to the Rate No. 1 and Rate No. 2 (terminals No. 3 and 2 respectively) as shown in the table to the right (table 1):

   Digital logic 6IC and 7IC in conjunction with the rate relay contacts on 4CR and 5CR applies a voltage to one of the four "TIME" adjustment potentiometers 1P through 4P. The signal from one of the "TIME" potentiometers is fed to a Voltage Controlled Oscillator.

TABLE 1

| RATE LOGIC | 1 (4CR) | 2 (5CR) |
|---|---|---|
| Time No. 1 (1P) | | |
| Time No. 2 (4P) | × | |
| Time No. 3 (2P) | | × |
| Time No. 4 (3P) | × | × |
| × = CONTACT CLOSED | | |

4. **Voltage Controlled Oscillator** – A voltage controlled oscillator consisting of 8IC and associated components produces an output frequency inversely proportional to the magnitude of its input voltage . . . a nominal 2000 to 60 Hz to furnish timing pulses to the Up/Down Counter.

5. **Up/Down Counter** – A 12-bit binary up/down counter consisting of 2, 3, and 4IC, will count "UP," count "DOWN," or remain at a fixed count depending on the "UP" or "DOWN" inputs at terminals 6 and 5 respectively.

   If the "UP" terminal is activated, the counter will accumulate pulses until full unless the input is interrupted. If the "RESET" terminal 4 is activated, all three IC's are reset to zero count regardless of the inputs to terminals 6 and 5.

   The additional digital logic consisting of 6IC, 2Q and 3Q disables the Voltage Controlled Oscillator input to the Counter whenever the total count stored in the three counters is either zero or 100%. This prevents recycling of the Counter past each limit.

6. **Digital to Analog Converter** – A 12-bit multiplying digital to analog converter takes the digital outputs from the Counter IC's and provides an output voltage which has a ratio to the input reference of zero to 100% depending on the "fullness" of the UP/DOWN Counter. The converter is referred to as a "Multiplying" D/A Converter because the output is a proportionate amount of the input and will change polarity or magnitude if the input changes.

   IC's 9 and 10 work with the D/A Converter to condition input and output signals to produce an output voltage whose polarity is the same as the input, and whose magnitude is the proper percentage as determined by the Counter.

7. **Solid State Cam Switches** – 11IC and 12IC in conjunction with relays 6CR and 7CR respectively provide a relay contact opening or closing at any point from 0 to 100% of the output voltage at terminal 17.

   The "SETPOINT" potentiometers 5P and 6P determine the output level at which the relays change state. This output is a percentage of the input voltage.

For positive references the relay will be deenergized below the setpoint and will energize as the output exceeds the setpoint. For negative references the opposite is true and the relay will be energized until the setpoint is exceeded.

If additional, independently adjustable, relay operation is required the MODEL 230 Solid State Cam Switch is used in conjunction with this device to provide additional relays in multiples of five, each with individual Setpoint adjustments.

## COMPONENT LIST — ASSEMBLY #12M03-00106-03

| Symbol | Part # | Description (Acceptable Substitute) * |
|---|---|---|
| 1T | 04P01-00001 | Transformer - 120V AC PRI, two 10V SEC @ 220mA (Signal-PC20-220) |
| 1REC | 05P01-00003 | Rectifier Bridge - 50V, 1A (EDI-PF50) |
| 1-5D | 05P01-00001 | Diode - Medium Power, 1A, 400 PIV (1N4004) |
| 6-17D | 05P02-00001 | Diode - Signal, 50mA, 200 PIV (1N4148) |
| 1ZD | 05P03-00005 | Zener Diode - 6.8V, 500 mW, 10% (1N5235B) |
| 1, 2LED | 07P04-00003 | Diode - Light emitting (Litronix-RL-4403) |
| 1Q | 05P05-00001 | Transistor - N channel JFET (2N4093) |
| 2Q | 05P04-00001 | Transistor - PNP, Small Signal (2N3638A) |
| 3Q | 05P04-00002 | Transistor - NPN, Small Signal (2N3392) |
| 1IC | 05P08-00006 | +6 Volt Regulator (7806) |
| 2-4IC | 05P09-00009 | Counter - Up/Down (4029) |
| 5IC | 05P09-00010 | D/A Converter - 12 Bit (National DAC1220) |
| 6IC | 05P09-00003 | Quad Excl. Or Gate (4030) |
| 7IC | 05P09-00006 | Quad And Gate (4081) |
| 8IC | 05P08-00002 | Quad Op-Amp (TI-TL084) |
| 9, 10IC | 05P08-00005 | Precision Op-Amp (Fairchild 714) |
| 11, 12IC | 05P08-00011 | Op-Amp (LM741) |
| 1-5CR | 06P01-00011 | Relay - DIP, reed, form A contact, 500 ohm, 5V coil (Electrol-BBV1A05A10) |
| 6, 7CR | 06P01-00002 | Relay - 12V DPDT (Potter Brumfield-R10E1Y2S) |
| 1-4P | 02P04-50301-00 | Potentiometer - 50K, ½W (Beckman-72XR50K) |
| 5, 6P | 02P05-10301-02 | Potentiometer - 10K, ½W, 25T (Bourns 3299P-1-103) |
| 1, 2C | 03P01-47102-01 | Capacitor - 470MF, 25V, Electrolytic |
| 3C | 03P01-10001-00 | Capacitor - 10MF, 16V, Electrolytic |
| 4C | 03P06-22105-00 | Capacitor - 220PF, 50V, Ceramic |
| 5-9C | 03P01-10101-11 | Capacitor - 100MF, 15V, Electrolytic |
| 10-14C | 03P06-50305-00 | Capacitor - 0.05MF, 50V, Ceramic |
| 15C | 03P07-10310-00 | Capacitor - 0.01MF, 100V, Film |
| 16C | 03P06-47105-00 | Capacitor - 470PF, 50V, Ceramic |
| 17C | 03P07-22310-00 | Capacitor - 0.022MF, 100V, Film |
| 18C | 03P07-10410-00 | Capacitor - 0.1MF, 50V, Ceramic |
| 19C | 03P06-10205-00 | Capacitor - 0.001MF, 50V, Ceramic |
| 1R | 01P01-33101-02 | Resistor - 330 Ohm, ½W, 5% |
| 2-6R | 01P01-47203-02 | Resistor - 4.7K, 2W, 5% |
| 7-11R | 01P01-22300-02 | Resistor - 22K, ¼W, 5% |
| 12R | 01P01-10500-02 | Resistor - 1M, ¼W, 5% |
| 13, 15R | 01P01-10300-02 | Resistor - 10K, ¼W, 5% |
| 14, 16R | 01P01-10400-02 | Resistor - 100K, ¼W, 5% |
| 17, 18R | 01P02-49911-01 | Resistor - 4.99K, ½W, 1% |
| 19-25R | 01P02-10031-01 | Resistor - 100K, ½W, 1% |
| 26-29R | 01P01-68300-02 | Resistor - 68K, ¼W, 5% |
| 30-33R | 01P01-15200-02 | Resistor - 1.5K, ¼W, 5% |
| 34, 36R | 01P01-10200-02 | Resistor - 1.0K, ¼W, 5% |
| 35, 37R | 01P01-47500-02 | Resistor - 4.7M, ¼W, 5% |
| 38R | 01P01-22400-02 | Resistor - 220K, ¼W, 5% |

* OR EQUAL

## III. BENCH TEST

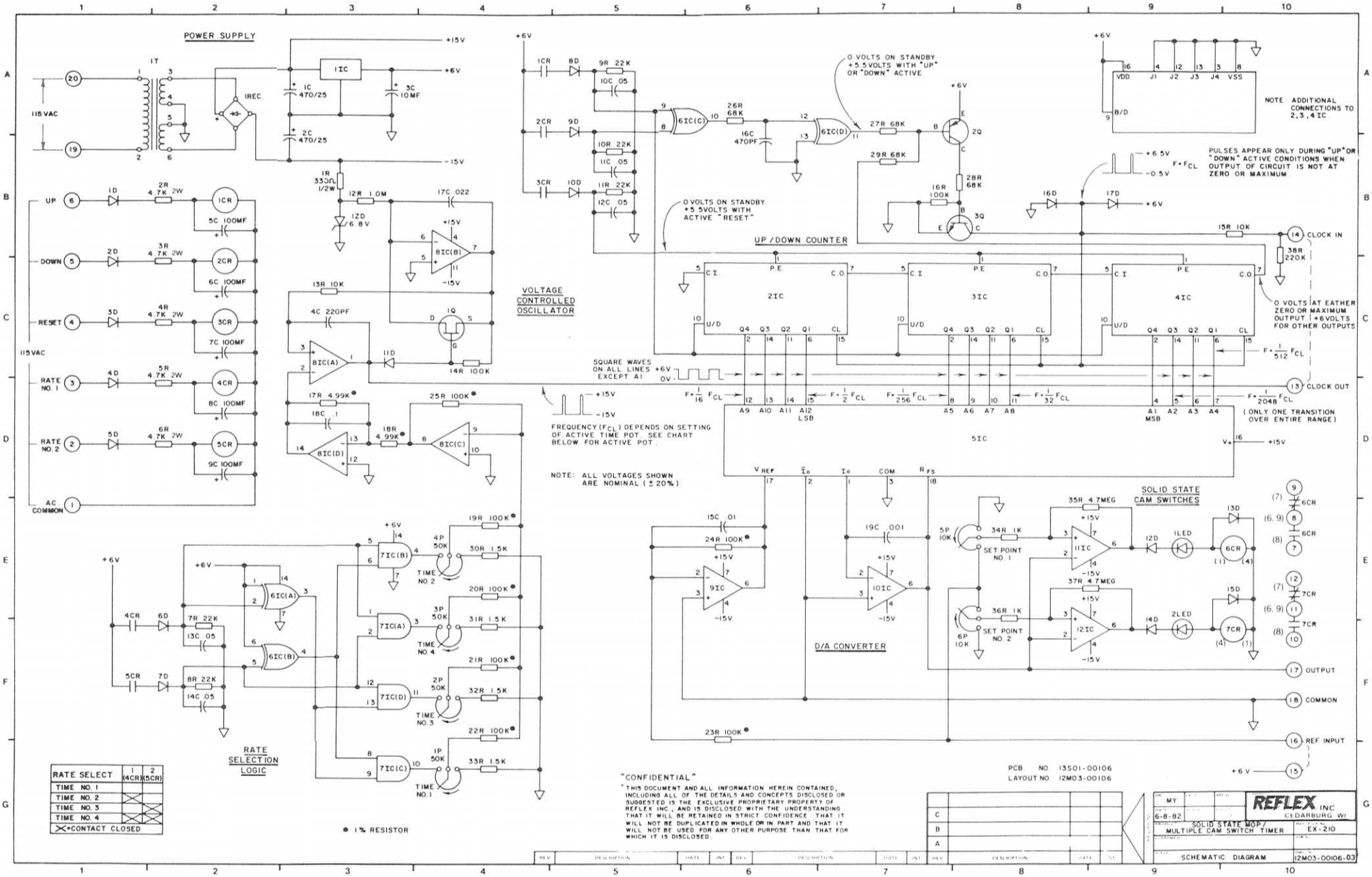
1. Adjust all potentiometers fully CCW except "Set Points" 1 and 2, which should be at about the 10% CW position. Jumper terminal 13 to 14.
2. Apply a polarity reversible 10 VDC supply to terminals 16 and 18 (common) with terminal 16 positive.
3. Monitor terminals 17 (high) and 18 (low) with a digital voltmeter (DVM) and an oscilloscope.
4. Apply 120 VAC to terminals 19 and 20.
5. Using a suitable timing device (i.e., a stop-watch or a scope with a one second per division time base), time the rise in voltage at terminal 17 when 120 VAC is applied to terminals 1 and 6. The voltage should rise smoothly to +10 VDC in approximately 3 seconds. Remove the 120 VAC from terminals 1 and 6, this should not affect the output at terminal 17.
6. At this time 1 and 2 L.E.D. should be illuminated. Using a continuity checker, measure terminals 8 to 9 and 11 to 12 and read an open circuit. Continuity should exist from terminals 8 to 7 and 11 to 10.
7. Reverse the input voltage at terminal 16 to 10 VDC negative. 1 and 2 L.E.D. should now be extinguished and the resistance (or continuity) checks of step 6 should be reversed.
8. Adjust "Set Point" potentiometers 1 and 2 to the 50% position and apply 120 VAC from terminal 1 to 5. The output should drop smoothly to 0 VDC and 1 and 2 L.E.D. should re-illuminate at about the -5 to -6 volt level.
9. Turn "Time #1" to its 50% position and apply 120 VAC to terminals 1 and 6 for 10 seconds and read the DVM at terminal 17. It should be about -2.75 VDC. Momentarily apply 120 VAC to terminals 1 and 4 ("Reset"). The output should immediately reset to 0 volts.
10. Turn "Time #2" potentiometer to its 50% position and apply 120 VAC from terminals 1 to 3 and 6 for 10 seconds. Terminal 17 should read, as in step 9, about -2.75 VDC. Repeat reset procedure (120 VAC from terminal 1 to 4) as in step 9.
11. Change the input at terminal 16 back to +10 VDC and set "Time #3" potentiometer to its 50% position. Apply 120 VAC from terminals 1 to 2 and 6 for 10 seconds. Terminal 17 should read approximately +2.75 VDC at this time. Reset as in step 9.
12. Set "Time #4" potentiometer to its 50% position and apply 120 VAC from terminal 1 to terminals 2, 3 and 6 for 10 seconds. Again, the output should rise to approximately +2.75 VDC.
13. Reset all "Time" potentiometers to the full CCW position and alternately apply 120 VAC from terminal 1 to terminals 6 and 5, allowing the voltage to swing from 0 to maximum and back again several times in approximately 3 seconds in each direction. There should be no instances of the output going from 0 to maximum or maximum to 0 instantaneously. Only applying 120 VAC to terminals 1 and 4 should cause this effect.

MATERIAL REQUIRED

1 — Oscilloscope (Tektronix 2213 or equal)
1 — Digital Voltmeter (Beckman HD-110 or equal)
1 — Power supply ± 10 VDC
1 — 120V AC line cord (plug one end, spade lugs, opposite end)
5 — Clip leads

## IV. VOLTAGE CHECKS

1. The primary voltage of 1T, leads 1 and 2 (terminals 20 and 19), should be 120 VAC.
2. The secondary voltage of 1T, leads 3 to 4 and leads 5 to 6, should be 10 VAC. These can be measured between circuit common, terminal 18 (leads 4 and 5), and each AC input to the bridge rectifier 1REC (leads 3 and 6). Voltage at the AC input to the bridge rectifier 1REC (leads 3 to 6) should be 20 VAC.
3. +15 VDC nominal between the positive end of capacitor 1C and terminal 18.
4. -15 VDC nominal between the negative end of capacitor 2C and terminal 18.
5. +6 VDC nominal (5.5 to 6.5 volts) between the positive end of capacitor 3C and terminal 18.
6. -6 VDC nominal (6.5 to 7.2 volts) between the anode of 1ZD terminal 18.
7. Use an oscilloscope to verify that the waveforms are as shown on the schematic diagram.


POWER SUPPLY
115 VAC
1T
1REC
1IC
+15V
+6V
-15V
1C 470/25
2C 470/25
3C 10MF
1R 330Ω 1/2W
1ZD 6.8V
12R 1.0M
17C .022
UP
DOWN
RESET
RATE NO. 1
RATE NO. 2
AC COMMON
1CR
2CR
3CR
4CR
5CR
5C 100MF
6C 100MF
7C 100MF
8C 100MF
9C 100MF
VOLTAGE CONTROLLED OSCILLATOR
8IC(A)
8IC(B)
8IC(C)
8IC(D)
13R 10K
4C 220PF
11D
14R 100K
17R 4.99K
18C .1
18R 4.99K
25R 100K
SQUARE WAVES ON ALL LINES EXCEPT A1
FREQUENCY ($F_{CL}$) DEPENDS ON SETTING OF ACTIVE TIME POT. SEE CHART BELOW FOR ACTIVE POT.
NOTE: ALL VOLTAGES SHOWN ARE NOMINAL (±20%)
0 VOLTS ON STANDBY +5.5VOLTS WITH "UP" OR "DOWN" ACTIVE
0 VOLTS ON STANDBY +5.5VOLTS WITH ACTIVE "RESET"
UP/DOWN COUNTER
2IC
3IC
4IC
5IC
CLOCK IN
CLOCK OUT
0 VOLTS AT EATHER ZERO OR MAXIMUM OUTPUT +6VOLTS FOR OTHER OUTPUTS
PULSES APPEAR ONLY DURING "UP" OR "DOWN" ACTIVE CONDITIONS WHEN OUTPUT OF CIRCUIT IS NOT AT ZERO OR MAXIMUM.
NOTE ADDITIONAL CONNECTIONS TO 2,3,4 IC
(ONLY ONE TRANSITION OVER ENTIRE RANGE)
D/A CONVERTER
SET POINT NO. 1
SET POINT NO. 2
SOLID STATE CAM SWITCHES
OUTPUT
COMMON
REF. INPUT
RATE SELECTION LOGIC
TIME NO. 1
TIME NO. 2
TIME NO. 3
TIME NO. 4
RATE SELECT | 1 (4CR) | 2 (5CR)
TIME NO. 1
TIME NO. 2
TIME NO. 3
TIME NO. 4
X = CONTACT CLOSED
● 1% RESISTOR
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PCB NO. 13501-00106
LAYOUT NO. 12M03-00106
REFLEX INC
CEDARBURG, WI
6-8-82
SOLID STATE MOP/ MULTIPLE CAM SWITCH TIMER
EX-210
SCHEMATIC DIAGRAM
12M03-00106-03