4.0 THEORY OF OPERATION

4.1 OVERVIEW

The DP8 and DP9 Printers handle a large variety of documents. The two printers are identical except that the DP9 is 3.2" wider. The mechanism consists of a printhead, a carriage drive assembly and a document drive assembly. The electronics consist of a switching power supply, a Main PCB, a sensor PCB and a keypad/display assembly.

4.1.1 Carriage Drive Assembly

The carriage drive assembly positions the printhead as it prints each line of characters. The printhead is mounted on a moveable carriage that is supported by a carriage shaft. The carriage shaft is mounted to two pivot arms that allow the carriage to lift away from the platen and accommodate different thickness documents. The printhead is held against the document by the carriage shaft weight and springs. The carriage is lifted by a roller that rides across the document surface and maintains a constant printhead to document gap, thereby maintaining print quality across a wide document thickness range. An upper shaft stops the carriage from rotating around the carriage shaft.

A toothed belt clamped to the carriage is driven by a pulley mounted on the carriage stepper motor located on the left side of the metal box. The stepper motor moves the printhead in 1/120th of an inch increments along the print line. Position information is updated when the carriage is detected by an optical sensor on the Sensor PCB.

The ribbon cartridge is driven by a shaft which is in turn driven from the carriage motor shaft through a gear train which pivots so that the ribbon drive shaft rotates clockwise regardless of the direction of carriage motor rotation. The entire carriage drive assembly lifts away from the document drive and the ribbon shield and ribbon guides mounted to the carriage lower away from the printhead for easy access to the ribbon path when replacing cartridges.

4.1.2 Document Drive Assembly

The document drive assembly positions inserted documents. The document drive stepper motor mounted on the right side of the document drive is connected to the two drive rollers through toothed belts. A pinch roller is spring loaded against each drive roller providing friction feed for documents of varying thickness. Documents are fed between the drive and pinch rollers, with the spring-loaded pinch roller automatically adjusting to the document thickness. The stepper motor positions in 1/120th of an inch increments.

The presence of a document in the input tray is sensed by the frontmost of four optical sensors located above the document path. When auto alignment is active a gate is raised across the document path during document insertion. At that time the printhead moves past its normal left home position, activating an arm that raises the gate. The rising gate reduces the spring loading force on the front document drive rollers, allowing documents to rotate and align against the gate. Three optical sensors in line behind the front rollers check the leading document edge to insure that it is sensed within a programmable alignment tolerance. These sensors are also used to position the top or bottom edge of the document relative to the printhead. After alignment is verified, the printhead moves to the right, lowering the gate out of the document path and restoring normal loading force to the document drive rollers.

4.1.3 Switching Power Supply

The switching power supply is mounted to the inner front surface of the metal box. AC line voltage is wired through a power switch to the power supply. The power supply provides regulated +38VDC to the Main Printed Circuit Board.

4.1.4 Main Printed Circuit Board

The Main PCB is located in the rear of the printer and contains power supply, control and driver electronics. The regulated +38VDC is converted to +5VDC, +12VDC and –12VDC by a switching regulator on the main PCB. The +38VDC drives the printhead and stepper motors.

The control electronics are based on a 68HC12 microcontroller, a 128 Kbyte flash memory and 32Kbyte RAM. The microcontroller contains a 16-bit microprocessor, non-volatile EEPROM, timers, serial I/O communication ports and baud rate generator, multiple parallel ports and an A/D converter driven by the optical sensors. The main PCB also contains circuitry for interfacing to the keyboard/display assembly, driving the printhead and stepper motors and providing signal level conversion for the serial interface signals. The driver electronics include switching transistors that drive the printhead and 4 H-Bridge switching regulators that drive the carriage and document drive stepper motors. An optical sensor mounted on the main PCB detects opening of the cabinet.

4.1.5 Keypad/Display Assembly

The keyboard/display assembly consists of a 16 key keypad arranged in a 8 x 2 scanning matrix and a 2 line by 16 character dot matrix LCD display module. The display buffers 32 characters of data and generates the dot patterns and timing to drive the LCD.

4.2 ELECTRONICS IN DETAIL - Refer to #72135 Schematic

4.2.1 Low Voltage Supplies

The +38VDC supplied from the switching power supply is converted to +5VDC, +12VDC and –12VDC by switching regulator V1 (or alternate V2) using Schottky diode D31 and a small cube switching transformer. The 100KHz switching frequency is set by C19 & R38. The +5VDC is monitored by Q3 so that the electronics are held reset if the +5VDC is not stable.

4.2.2 Microprocessor System

The 68HC12 microcontroller U10 has a 250 nanosecond cycle time that it generates from 16Mhz crystal Y1. Each cycle the 68HC12 provides a timing pulse on TP1 for synchronizing the devices on the data bus and updates the address on pins A0-A18. The high order address lines are decoded by the 68HC12 to generate chip selects to the RAM and flash memory.

The 32 KByte RAM U9 is selected by U9 pin 20. The RAM provides workspace and buffer memory for the 68HC12. All printer, communication and service configuration parameters are stored in EEPROM internal to the 68HC12. The128 KByte flash memory U8 is selected by U8 pin 22. This memory contains the dot patterns for all printable characters and all programs that the 68HC12 executes to control the printer.

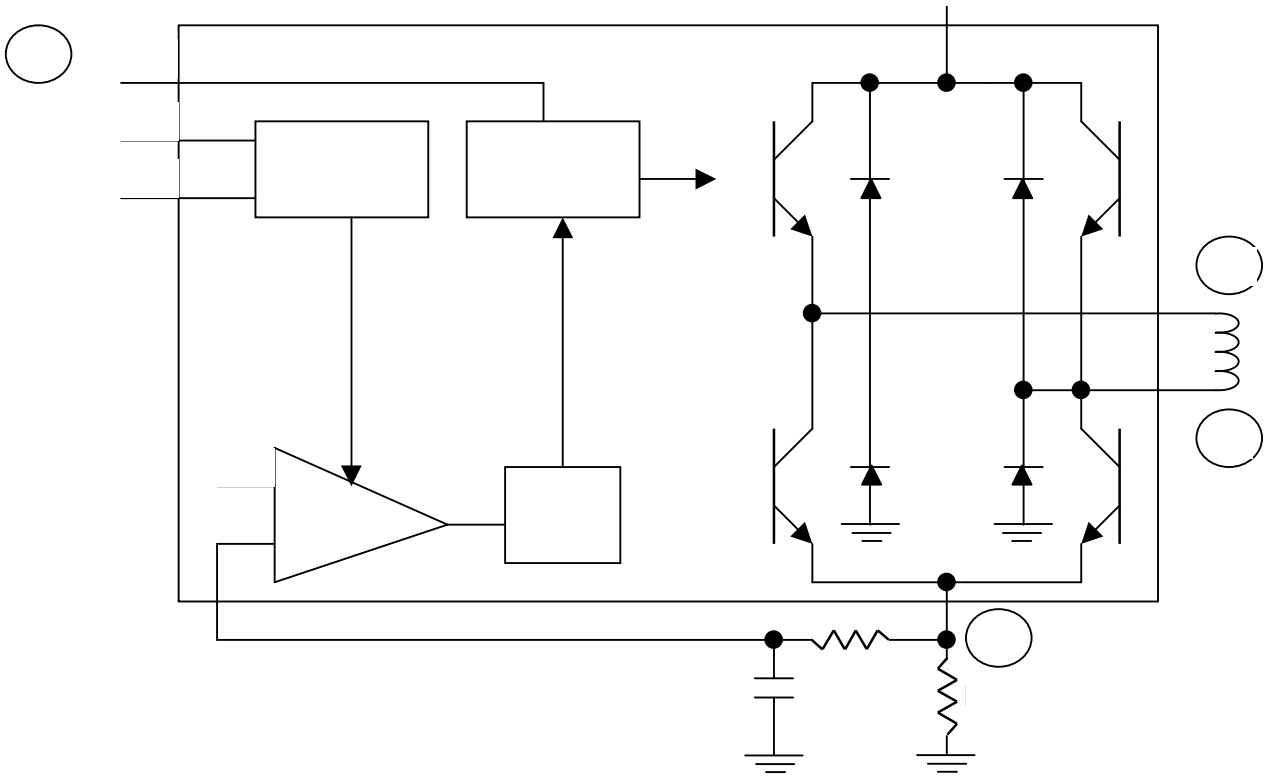
4.2.3 Stepper Motor Drivers

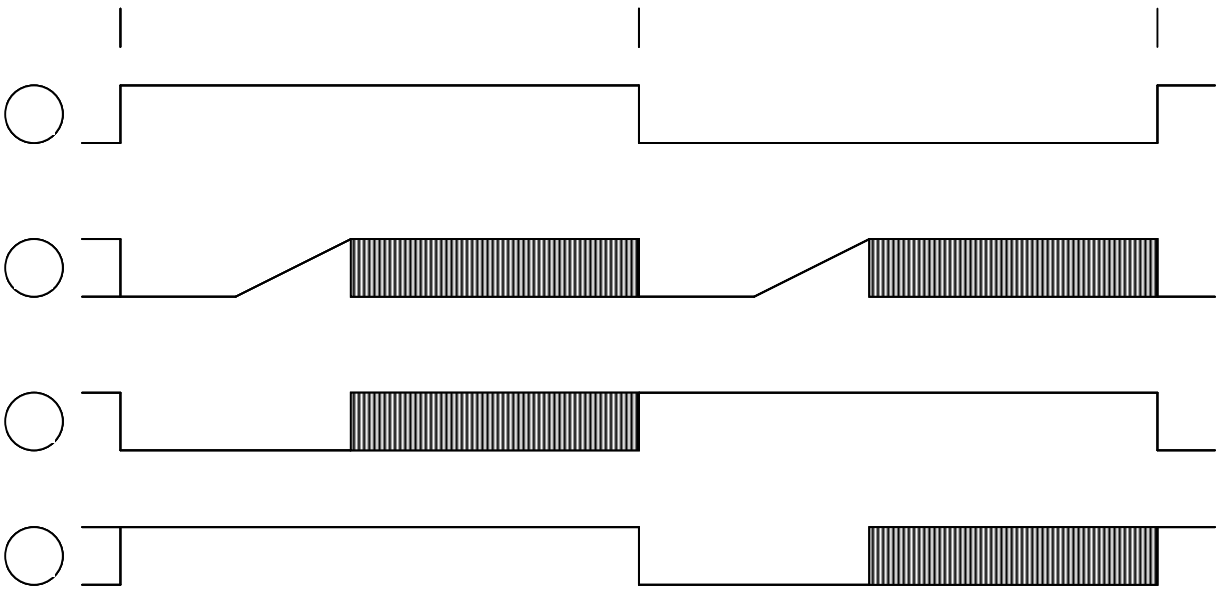
Each stepper motor has 2 stator coils, each driven by a 3718 driver U1, 2, 6 and 7. Each 3718 contains 4 transistors arranged in a H-Bridge that can apply +38 VDC to either end of the coil, a 25KHz switching oscillator and comparators that limit the coil current by sensing the voltage on an external resistor R4, 6, 29 or 32. Each 3718 is controlled by 3 signals driven from the 68HC12: a phase signal which indicates which direction current is to flow through the coil and two signals which limit the current to 0, 20, 60 or 100% of a maximum value determined by the

external resistor. 0% is used to turn off a winding, 20% is used when the motor is holding a fixed position and 60 or 100% is used when the motor is rotating. See Figure 4-1 for typical voltage waveforms on both ends of a motor coil and the external resistor. The ground plane under the 4 3718's is connected to the rear panel heat sink to reduce the temperature rise.

Motor rotation occurs by sequentially changing the phase and current signals to the two motor coils. Motor speed is controlled by how rapidly the signals are changed. Following is a state table where each state change rotates the document motor rotor 1/400 of a revolution (1/120" of document motion) and there are 8 distinct states before the pattern repeats. Direction of motor rotation can be reversed by moving up rather than down through the state table. The 2 motor windings are labeled Phase A and Phase B and the phase and 2 current level signals for each winding are shown. The state table for the carriage motor is similar but the states with 0% current are skipped so each state change rotates the carriage motor rotor 1/200 of a revolution (1/120" of carriage motion).

Phase A	I0A	I1A	Phase B	I0B	I1B	A Current	B Current	
1	0	0	1	0	0	100% Forward	100% Forward	<--
1	0	0	0	1	1	100% Forward	0% Reverse	|
1	0	0	0	0	0	100% Forward	100% Reverse	|
0	1	1	0	0	0	0% Reverse	100% Reverse	|
0	0	0	0	0	0	100% Reverse	100% Reverse	|
0	0	0	1	1	1	100% Reverse	0% Forward	|
0	0	0	1	0	0	100% Reverse	100% Forward	|
1	1	1	1	0	0	0% Forward	100% Forward	---





4.2.4 Printhead Drivers

During printing, 24 bits of print dot data are serially shifted into U3 to U5. A FIRE pulse at U5 pin 12 then transfers the 24 bits to the U3 to U5 outputs. Each high bit turns on a printwire by turning on power MOSFETS Q10 to 33. Timer U13 applies +38VDC to the other side of all printwire coils via Q5 and power MOSFET Q7.

After about 100 usec. the NO CHOP signal at D35 cathode goes high and timer U13 pin 3 begins to oscillate as an open-loop switching regulator to keep the current level in the printhead coils relatively constant. 100 to 200 usec. later the FIRE signal at D34 anode goes high which turns off U13 and Q7. On pre-revision F boards, FIRE also cleared the printwire bits from U3 to U5, turning off all transistors and discharging the coil current through D6, the coils, and diodes D7 to 30. The FIRE-EXT signal at the base of Q4 enabled a discharge path through Q8 back to +38VDC for about 40 usec. Then Q8 turned off and the remaining coil current dissipated through Q10 to 33. On revision F and later boards, the printwire bits remain set until 320 usec after FIRE began and Q8 has been jumpered to provide a direct connection between diodes D7 to 30 and +38VDC. See Figure 4-2 for typical waveforms.

4.2.5 Keypad and Display (Refer to Schematic #72135)

The keypad switches are arranged in a 8 by 2 X-Y grid. KEYSCAN0 and KEYSCAN1 at J11 pins 12 & 11 drive the grid rows and the grid columns are read into the 68HC12 on KEYBD0 through KEYBD7 at J11 pins 3 through 10.

The display is a 2 line by 16-character liquid crystal display (LCD) with integral electronics. When the 68HC12 is ready to display data, it reads status from the LCD and if the LCD is ready to accept data, the 68HC12 writes ASCII characters to the LCD. The LCD then generates and displays the corresponding character patterns.

4.2.6 Sensors

Seven optical reflective sensors are used: the left home sensor for carriage position, four document sensors for document presence, alignment and position, one document edge sensor located on the carriage, and the cabinet open sensor on the main PCB. All sensors operate in the same way: a constant current is provided to the sensor's light emitting diode (LED) through a resistor to +5 volts. If an object (carriage, document or cover) reflects the LED light onto the corresponding phototransistor, the transistor turns on, raising its emitter voltage to 2 to 4 VDC. The 68HC12 reads and digitizes the phototransistor emitter outputs via an internal A/D converter.

4.2.7 Character Printing

The carriage motor steps the carriage in 1/120" increments but dots can be printed three times per increment. Printing at 10 characters per inch (cpi) uses a 13 wide X 23 high character matrix. 13 dots are used for printing a character and 5 dots for the intercharacter space. Printing at 12 cpi uses a 11 X 23 matrix with 11 dots used for printing and 4 for spacing. Printing at 17.1 cpi uses a 7 X 23 matrix with 7 dots used for printing and 3.5 for spacing. At correspondence quality (CQ) speed half increment printing is used to double the horizontal resolution and the matrix doubles to 25 X 23 for 10 cpi and 19 X 23 for 12 cpi.

At all print speeds only every other dot position can be printed so the maximum number of horizontal dots printed is 4 for a 7 wide matrix, 6 for an 11 wide, 7 for a 13 wide, 10 for a 19 wide and 13 for a 25 wide matrix. In all print modes the upper 19 printwires are used for printing normal characters, the 20th through 23rd wires for lower case descenders and the 24th wire for underlining. Printing occurs at a maximum frequency of 1,350 Hz.

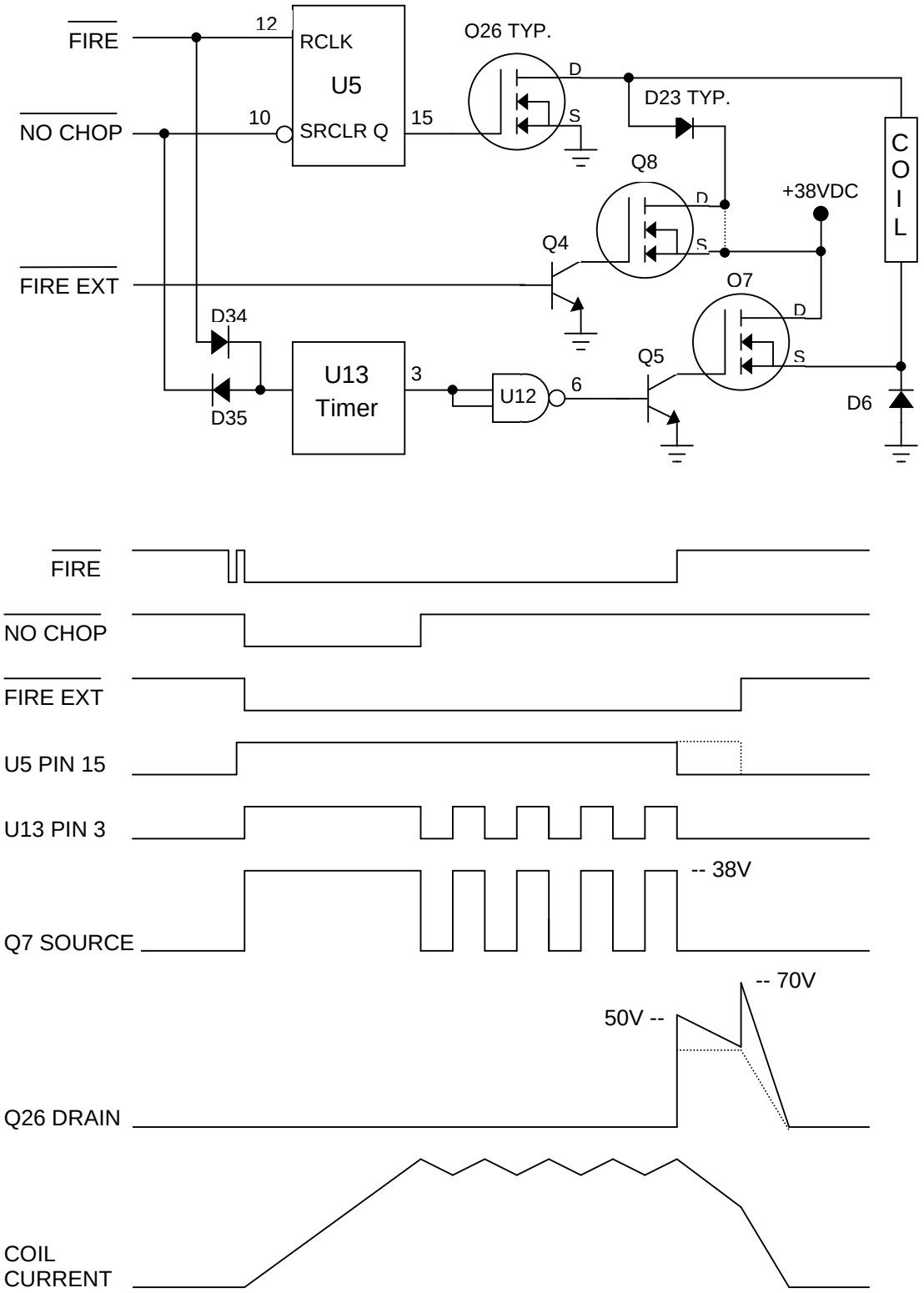


Fig. 4.2 Printhead Drive Circuit

(dashed lines are for revision F and later boards)