CITIZEN

Specifications

LINE THERMAL PRINTER MECHANISM
MODEL MLT-288

Rev.1.00 First created,June.2000

Japan CBM Corporation

REVISION

Rev.No.	Date	Content
Rev. 1.00	June. 19, 2000	First created

<Cautions>

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<Safety Cautions>

1. Temperature rises on thermal head:
The thermal head is heated up to a dangerously high temperature while it is in use or immediately after use. The equipment designer should design the enclosure so the user is unable to gain direct access to the thermal head. Also use an appropriate warning indicator on the equipment. The enclosure should also be designed to ensure maximum heat dissipation effect to limit temperature rise on the thermal head.

2. Head cleaning:
Wait for the appropriate indicator to display(showing that the head temperature has lowered to a safe level) before performing thermal head cleaning.

3. Thermal head overheating:
In case a thermal head runaway (due to CPU runaway, etc.) occurred, the consequent overheating may cause a smoke, fire, or a burn injury if the user inadvertently touches the head. Be sure to use a hardware facility to detect thermal head failures so the head is shut down in the event of failure.

4. Temperature rise on paper feed motor:
Part of the paper feed motor structure protrudes from the printer frame. The equipment designer should design the enclosure so the user is unable to gain direct access to that part of the motor which is heated up to a high temperature while in normal use. Also use an appropriate warning indicator on the equipment. The enclosure should also be designed to ensure maximum heat dissipation from the paper feed motor since the motor is equipped without such temperature sensors as thermistors.

5. Overheating on the paper feed motor:
In case of paper feed motor failure (due to CPU runaway, etc.), the consequent overheating may cause a smoke, fire, or a burn injury if the user inadvertently touches the motor. Be sure to use a hardware facility to detect motor failures so it is shut down whenever a failure is detected.

6. Enclosure design around paper feed gears:
Part of the paper feed gear assembly protrudes from the printer frame. The equipment designer should design the enclosure so the user is unable to gain direct access to that part of the paper feed gear ass'y.

7. Other cautions:
The equipment's enclosure should be designed to prevent liquid or any metallic foreign matter from being spilled or dropped into the printer mechanism as it may cause a smoke, fire, or other serious hazard due to internal short circuit.
The equipment designer should design the enclosure so the user is unable to gain direct access to any sharp edge on the printer structure.

CONTENTS

1. OVERVIEW

The MLT-288 is a compact thermal line printer employing the thermal dot printing mechanism. It is designed primarily for use in POS terminals, measuring and analyzing instruments, medical equipment, communications devices, portable data terminals, and other similar data devices.

1.1 Features

(1) Compact, light-weight design
(2) High printing speed: 500 lines/sec. max.
(3) High resolution: 8 dots/mm
(4) Long operating life print head
(5) Head drive: Single 5 V supply or 2 Lithium-ion batteries
(6) Simple, reliable mechanism design

2. GENERAL SPECIFICATIONS

Table 2-1 General Specifications

	Item	Specifications	Remarks
1	Printing method	Thermal dot line printing	
2	No. of overall dots	384 dots/line	
3	Dot density	8 dots/mm	
4	Effective printing width	48 mm	
5	Printing speed	200 dot lines/sec	5 V, head temperature=no less than 40˚C, within 64 dots
		420 dot lines/sec	7.2 V, head temperature=no less than 30˚C, within 64 dots
6	Feeding pitch	0.125 mm	Motor's 2 stepping span
7	Detection method		
	Head temperature detection	Thermistor	
	Paper end detection	Photointerruptor	
	Head-Up detection	Mechanical switch	
8	Operating voltage range	VH DC 4.2~8.5 V	Ni-Cd or Li-Ion, normally 7.2 V MAX 8.5 V is only allowed just after battery charging; not allowed for normal use.
		Vdd DC 4.75~5.25 V	
9	Current consumption Head(VH)	1.7 A MAX	VH=5V, 64 dots, 25˚C
		2.4 A MAX	VH=7.2V, 64 dots, 25˚C
	Motor(VH)	0.5 A MAX 0.3 A mean current	VH=7.2V, 840PPS
10	Recommended paper		The outer surface of the roll paper must be the printing surface.
	Paper width	58^{0}_{-1} mm	
	Paper thickness	60~72 µ	The paper should not be bonded to the roll core.
	Recommended supplier & model	Nippon paper : TF50KS - E2C	Roll diameter: No more than 60 mm ø
11	Feeding force	More than 0.49N	
12	Paper retention force	More than 0.78N	
13	Reliability Life of head	6 million lines	normal temperature (25˚C), normal humidity, 12.5% printing ratio, rated energy, and on the recommended print paper
	MCBF	15 million lines	
	Life of head Pulse stress resistance	No less than 50 million pulses	
	Wear resistance	50 km or more	
14	Environmental Conditions		
	Operating conditions	Temperature : 0~45˚C Humidity : 35~85% RH	Guaranteed range 5~40˚C with no dew condensation
	Storage conditions	Temperature : –20~60˚C Humidity : 10~90%RH	Head-up position in storage
15	Anti-vibration property	6G, Frequency 10~55 Hz 3 perpendicular axes, 1 hour	
16	Anti-shockness property	60G 11ms 6 directions, one impact in each direction	
17	External dimension	72.7(W) x 38(D) x 13(H) mm	Excluding the head-up lever, connectors, and other projections
18	Weight	Approx. 45g	

3. THERMAL HEAD

3.1 Thermal Head Specifications

Table 3-1 Thermal Head Specifications

	Item		Specifications	Remarks
1	Effective printing width		48 mm	
2	Overall No. of dots		384 dots/line	
3	Dot density		8 dots/mm	
4	Dot centers		0.125 mm	
5	Mean resistance value		130 Ω	
6	No. of strobes		6	
7	Data transfer method		1 DATA input	
8	Driver configuration		6 drivers	64 dots each
9	Voltage supply	VH	DC 4.2~8.5V	Max. normal voltage: 7.2 V MAX 8.5 V is only allowed just after battery charging; not allowed for normal use.
		Vdd	DC 4.75~5.25V	

3.2 Thermal Head Equivalent Circuit

The thermal head is comprised of heating elements and the head drivers that drive the heating elements (see Fig. 3-1). Serial print data, fed to the SI input, is shifted into the shift register synchronized with the Shift clock, then is latched into the latch register at the active edge of the LATCH signal. The Head Drive signal (Print commands STR1-6) opens the gate to energize the heating elements reflecting the print data.

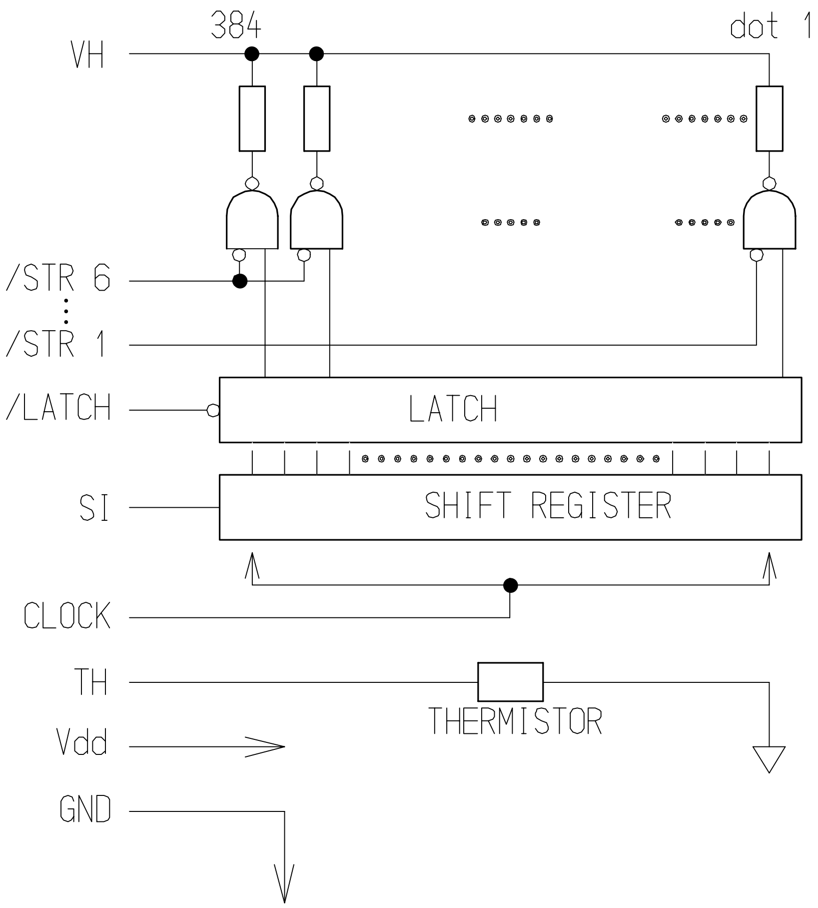


Figure 3-1 Themal Head Equivalent Circuit

3.3 Head Dividing Process

There are six strobes on the thermal head which can be divided into six cycles at maximum for printing. Table 3-2 lists the heating element positions in relation to the strobes.

Table 3-2 Strobe Pin vs. Heating Elements

STR.No	Heating Element No.	Dot No./STR
1	1~64	64
2	65~128	64
3	129~192	64
4	193~256	64
5	257~320	64
6	321~384	64

3.4 Printing Data and Printing Position

Print data of 384-bit length, transferred by SI, is printed in the arrangement as shown in Figure 3-2.

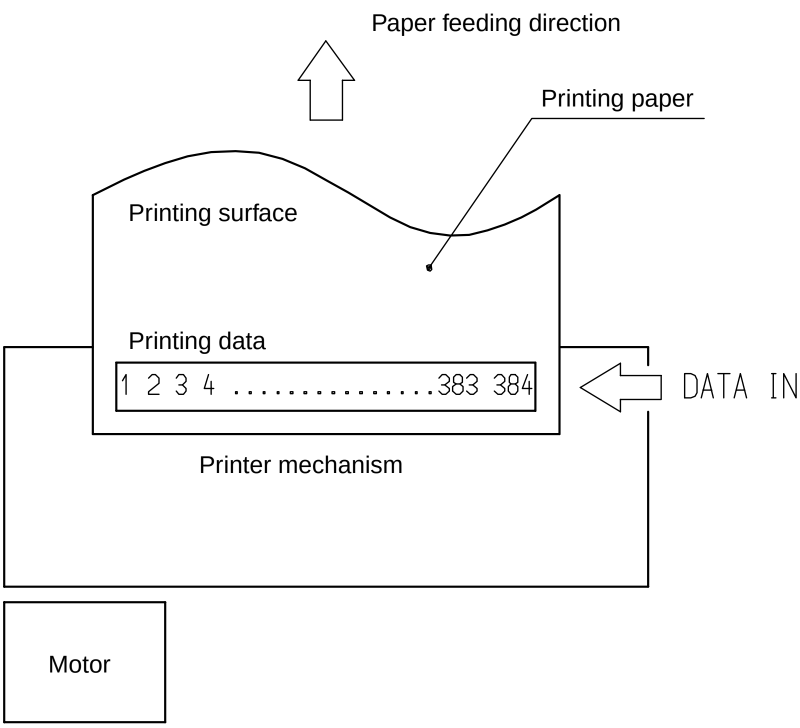


Figure3-2 Printing Data and Printing Position

3.5 Driving Pulse width

3.5.1 Compensating Pulse Width for Driving Voltage

Pulse width should be controlled according to the head driving voltage so as to secure constant print toning. The pulse width can be calculated with the following formula:

$$\mathrm{Ton}(25) = \mathrm{Eo} \times \frac{(\mathrm{N} \times \mathrm{Rcom}+\mathrm{Rav}+\mathrm{Ric})^2}{\mathrm{V}^2 \times \mathrm{Rav}}$$

Ton(25) : Driving pulse width 25°C operating temperature (ms)

Eo(*) : Typical energy applied 0.25 (mJ)

V : Calculate V from the following formula:

$V = -0.0321(VH)^2+1.8455(VH)-3.8783$

VH : Supply voltage (V)

Rav : Mean resistance value 130 (Ω)

N : Number of simultaneously driven dots

Rcom: Common line resistance 0.65 (Ω)

Ric : Driver' ON resistance 18 (Ω)

(*) The typical energy only applies to the specified thermal print paper, TF50KS-E2C.

Table 3-3 Example of Driving Pulse Width Calculation

Supply voltage(VH)	Pulse width
4.2 V	6.32 ms
5.0 V	3.34 ms
6.0 V	1.90 ms
7.2 V	1.15 ms

1. Temperature 25˚C
2. Simultaneously driven dots 64
3. Resistance value 130 Ω

3.5.2 Compensating Driving Pulse Width for Temperature

Driving pulse width should be controlled according to ambient temperature which is detected with the thermal head's built-in thermistor.
The thermal head must be shut down if the thermistor temperature exceeds 65°C. Use the following formula to determine driving pulse width:

$$tx = t25 \times \left[1 + \frac{(T25 - Tx) \times C}{100} \right]$$

tx : Driving pulse width (ms) at the operating temperature (Tx)
t 25 : Driving pulse width (ms) at 25°C operating temperature
T25 : Room temperature (25°C)
Tx : Operating temperature (°C)
C : Temperature compensation coefficient: C=1.5 (less than 25°C)
C=1.2 (more than 25°C)

3.5.3 Driving Pulse Width Calculation Example

Table 3-4 Thermistor's Temperature Characteristic and Relationship of Driving Pulse Width vs. Temperature

Temperature (°C)	Thermistor resistance value(kΩ)	Pulse width(μsec)			
		VH = 4.2 V	VH = 5.0 V	VH = 6.0 V	VH = 7.2 V
0	100.86	8.69	4.60	2.61	1.58
5	77.77	8.22	4.35	2.46	1.50
10	60.52	7.75	4.10	2.32	1.41
15	47.51	7.27	3.85	2.18	1.33
20	37.61	6.80	3.59	2.04	1.24
25	30.00	6.32	3.34	1.90	1.15
30	24.11	5.94	3.14	1.78	1.08
35	19.52	5.56	2.94	1.67	1.01
40	15.90	5.18	2.74	1.55	0.94
45	13.04	4.81	2.54	1.44	0.88
50	10.77	4.43	2.34	1.33	0.81
55	8.94	4.05	2.14	1.21	0.74
60	7.46	3.67	1.94	1.10	0.67
65	6.26	3.29	1.74	0.99	0.60

3.6 Thermistor Specifications

1. Electrical characteristics

(1) Resistance value : 30 kΩ ± 5% at 25°C
(2) B constant : 3950 K ± 2%

2. Max.rate

(1) Operating temperature range : – 40 ~ + 125°C
(2) Heat dissipation constant : 1.5 m W/°C
(3) Thermal time constant : 5 sec
(4) Max. rated output power : 400 m W at 25°C

3. Relationship between the thermistor resistance value and temperature

$$Rx = R25 \times EXP\left\{ B \times \left(\frac{1}{Tx + 273} - \frac{1}{298} \right) \right\}$$

Rx : Thermistor resistance value at temperature Tx (°C)
R25 : Thermistor resistance value at 25°C (30 kΩ ± 5%)
B : 3950 K ± 2% (Constant)
Tx : Temperature (°C)
EXP(X) : Xth power of the exponents

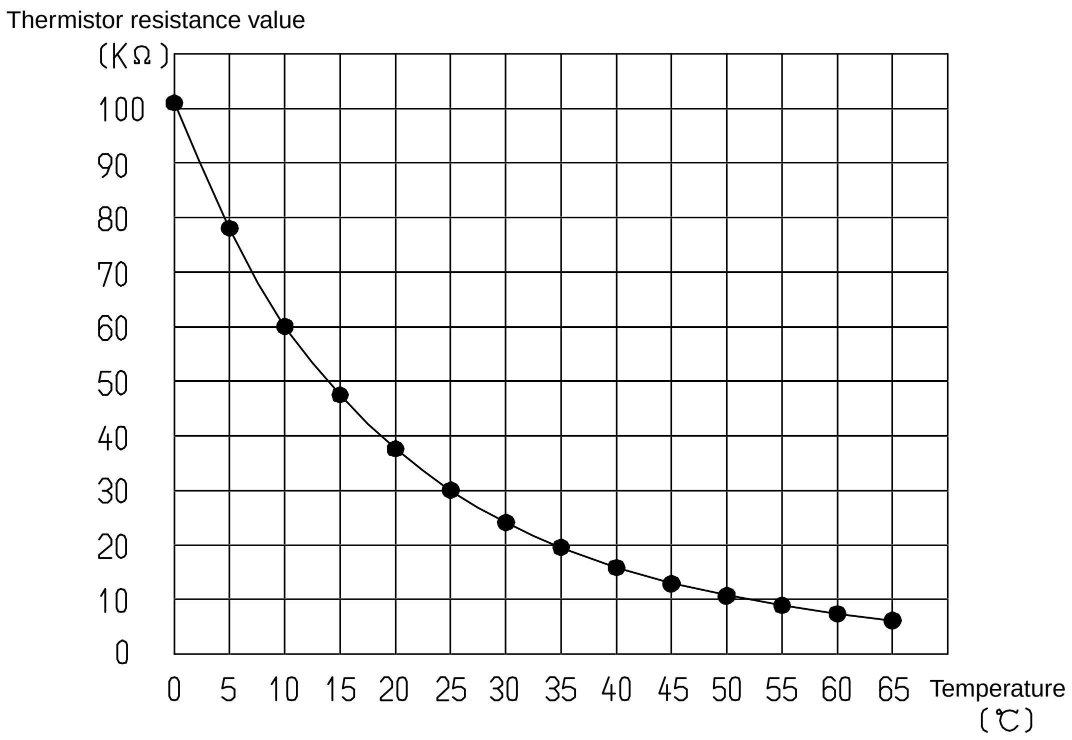


Figure 3-3 Temperature Characteristics of Thermistor

3.7 Electrical Characteristics of the Thermal Head

Table 3-5 Electrical Characteristics of the Thermal Head

T=25˚C

Item		Signal	Rating				Remarks
			min	typ	max	Unit	
Mean resistance value		Rave	125	130	135	Ω	
Supply voltage		VH	4.0		8.5	V	Typical printing condition
Circuit power voltage		Vdd	4.75	5.0	5.25	V	
Circuit power current		Idd			42	mA	ALL-HIGH
Input voltage	H	Vih	0.7 Vdd		Vdd	V	
Input voltage	L	Vil	0		0.3 Vdd	V	
Data input current	H	Iih			0.5	μA	Vih = Vdd = 5.0 V
Data input current	L	Iil			0.5	μA	Vil = 0,Vdd = 5.0 V
Driver's output leakage current		I1			3.8	mA	ALL-LOW
Max. operating frequency		t1			8	MHz	See figure 3-4
CLOCK pulse width		t2	70			ns	
Data setup time		t3	40			ns	
Data hold time		t4	10			ns	
Latch pulse width		t5	100			ns	
Latch setup time		t6	100			ns	
Latch hold time		t7	50			ns	
STR-DO propagation delay		t8			3.0	μs	
DO rising time		t9			3.0	μs	
DO falling time		t10			3.0	μs	

3.8 Timing Chart Diagram

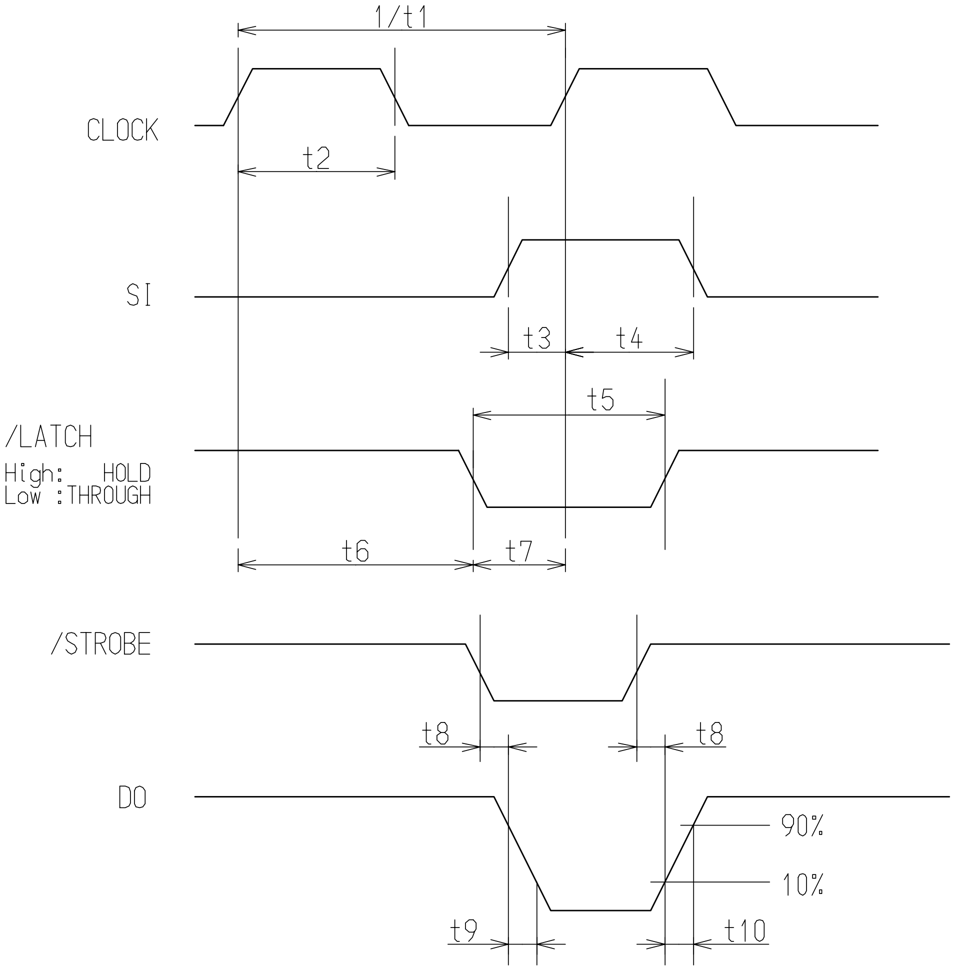


Figure3-4 Timing Chart Diagram

3.9 Peak Current

The peak driving current depends on the number of simultaneously activated dots as given in the following example. Care should be exercised for voltage drops along the head drive wirings at the peak drive current.

Table 3-6 Example of Peak Current

VH	Number of simultaneously driven dots	Peak current (theoretical value)	Remarks
5 V	64	1.7 V	Resistance value130 Ω
7.2 V		2.4 V	25 °C

3.10 Caution When Using the Thermal Head

(1) Where the application demands continuous printing at a high printing ratio, the head driver should be designed so the thermal head is shut down whenever thermistor temperature exceeds 65°C. If printing is continued with thermistor temperature exceeding 65°C, the thermal head's operating life may be shortened significantly.

(2) If a CPU runaway occurs on the host system, the software fault detection may fail to detect it, causing unrecoverable damage to the thermal head. Be sure to use hardware fault detection to protect the thermal head from possible damage.
On fault detection, immediately shut down the power supply to the thermal head. The thermal head should be re-energized after the cause of the fault is removed.

(3) The driver should be designed so the maximum energy applied to the thermal head does not exceed 0.37 mJ/dot. If this limit is exceeded, the head's operating life may be shortened significantly.

(4) Adhere to the following power On/Off sequence to protect the heating elements from possible damage:
Power on: Vdd first, followed by VH
Power off: VH first, following by Vdd

(5) Whenever the thermal head is turned on or off, the STR signals must be left inactive.

(6) Do not apply physical impact (including ingress of foreign matter) to heating element surfaces.

(7) Avoid applying an excessive pulling force (20 N or more) to the thermal head's FFC cable. Also avoid physical contact with FFC cable plugs' pin contacts. A total number of mating cycles should not exceed 10.

(8) If noise bypassing capacitors are required, use 0.1 μF/16 V capacitors across Vdd and GND. To stabilize the COM potential to ground, use a large capacitance. It should be noted, however, that a large capacitance, if used with a lithium-ion battery, may cause the protection circuit to trip off.

(9) While the printer is left inactive, leave the VH supply to the thermal head turned off (all potentials held in capacitors must be discharged).

4. PAPER FEEDER

- The paper is fed forward if the paper feed motor is rotated counterclockwise as viewed from its gear side.
- The stepping motor should be driven in 2-2 phase excitation mode. Two steps of motor driving signal feeds the paper by a 0.125 mm span (equal to dot centers).
- Whenever the paper feed motor is to be started up from stop (unexcited) state, first drive it backward by 20 steps, and then forward by the same steps, so as to prevent paper feed mechanism's backlash that may cause lowered print quality.
- While printing, the driving frequency must be controlled in real time according to print conditions (drive voltage, head temperature, number of energized dots, etc.).
- To prevent the paper feed motor from overheating, leave it unexcited in any state other than paper feed or print operation. After the motor is driven for t seconds, allow a stationary interval of 2t seconds or more ($t < 180$ sec.).
- Do not drive the paper feed motor intermittently by alternately starting and stopping it repeatedly, as it may cause uneven paper feed spans that will lead to lowered print quality.
- The motor driver should have a fine driving voltage regulation (around 0.3 V).

4.1 Characteristics of the Stepping Motor

Table 4-1 General Characteristics of the Stepping Motor

Item	Rating
Type	Permanent magnet type
No. of phases	4 phases
Driving system	Bipolar chopper driving
Excitation	2-2
Winding resistance/phase	18 Ω / phase
Rating voltage	7.2 V
Driving current	Approx. 0.5 A
Driving frequency	To be determined by driving voltage

4.2 Excitation Sequence

The motor is driven in the forward direction if its excitation phases are switched as per the following steps:

Table 4-2 Excitation Sequence

Sequence	Signal			
	ϕ 1 ($\overline{B}$)	ϕ 2 (B)	ϕ 3 ($\overline{A}$)	ϕ 4 (A)
step 1	High	Low	Low	High
step 2	High	Low	High	Low
step 3	Low	High	High	Low
step 4	Low	High	Low	High

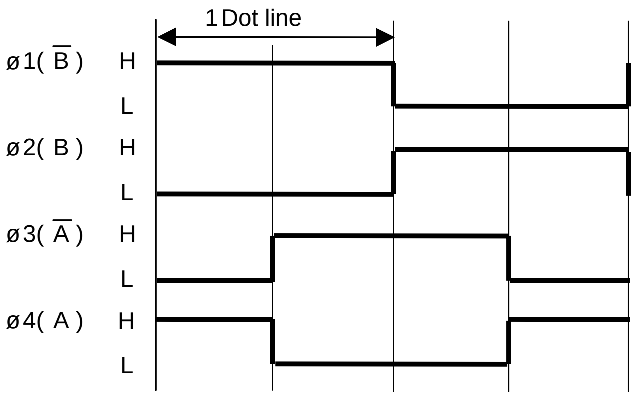


Figure 4-1 Excitation Voltage Waveforms

4.3 Example of the Drive Circuit

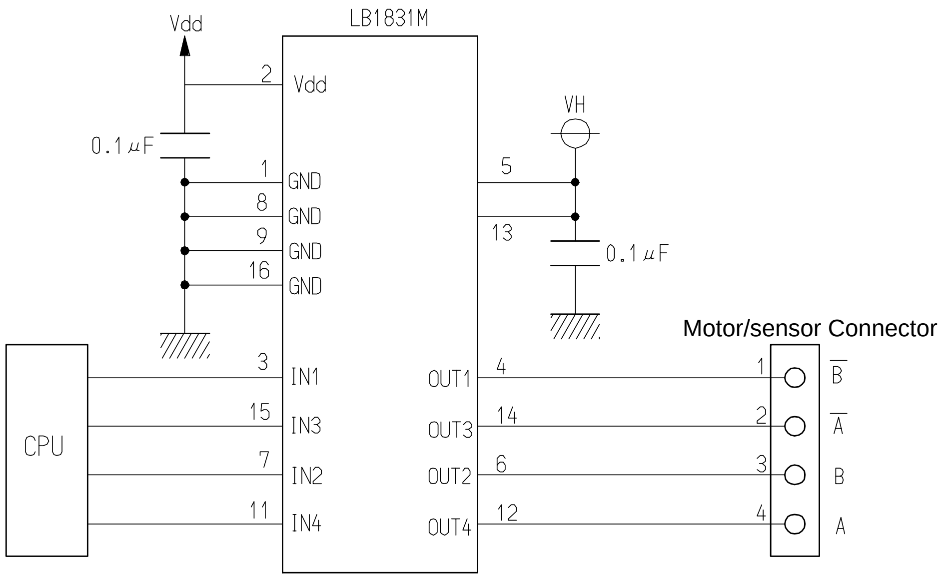


Figure 4-2 Example of the Drive Circuit

4.4 Motor Start/Stop Timing

1. Stopped

When stopping the motor, excite the same phase as the last one in the priting steps for 50 ms.

2. Stop mode

To prevent the stepping motor from overheating, set the Stp (Stop) signal to High to suppress excitation whenever the motor is in Stop mode.
While the motor is left unexcited, the paper won't be dislocated due to stepping motor's retention torque and platen pressure.

3. Activated

(1) The motor should immediately enter the print steps after it restarts from pause mode.
(2) When starting the motor, excite the same phases as those excited in the stopping step for 1 step, before proceeding with print step sequence. To absorb paper feed mechanism's backlash and consequent poor print quality, first drive the motor 10 dot rows (20 steps) backward, and then another 10 dot rows (20 steps) forward.

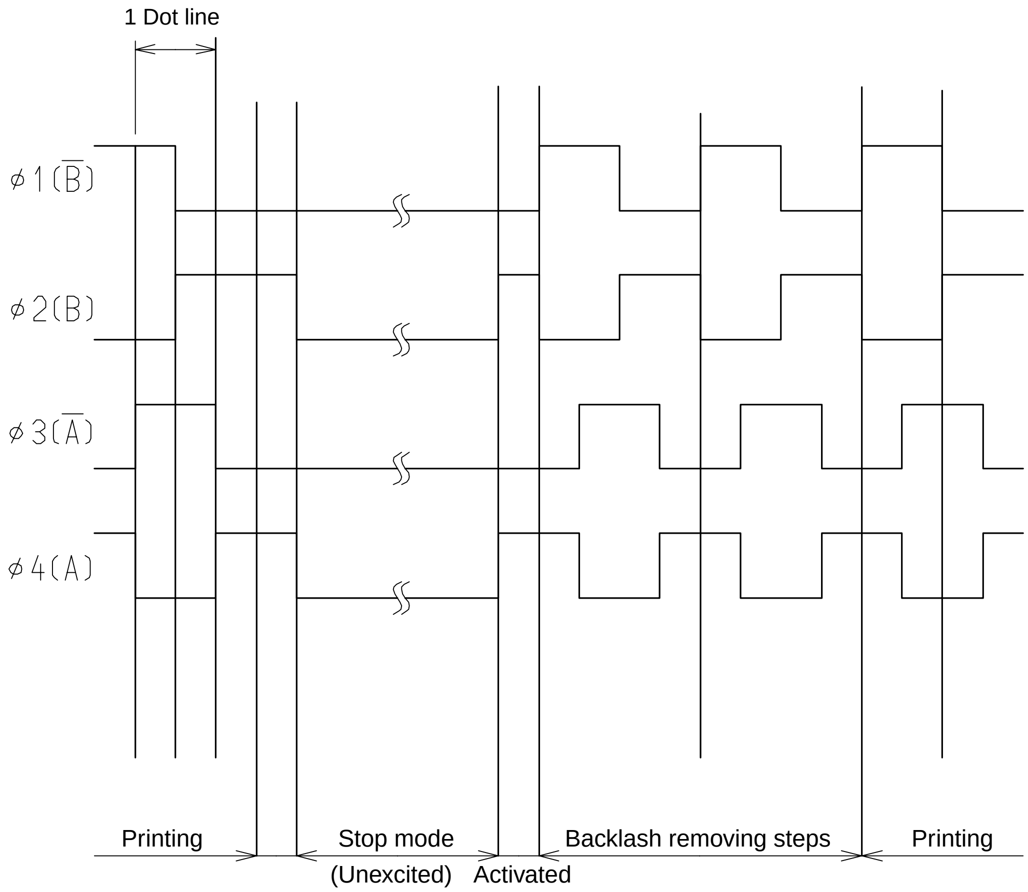


Figure4-3 Motor Start/Stop Timing

4.5 Cautions for Motor Driving

1. Motor driving pulse rate

Motor driving speed varies with driving voltage. It is determined with the following formula:

Motor driving speed (pps) = 200 x (VH) - 600

e.g.) When VH=7.0 V:

800 pps = 200 x (7) - 600

During auto loading, the motor driving rate should be reduced to a value not exceeding one fourth (1/4) the above speed.

> **Note**
> If a low temperature or low driving voltage condition exists during auto loading, the platen may fail to rotate properly or may not rotate at all.

2. Motor current control

If the stepping motor is driven at a very low rate or held up for a prolonged time span, it may produce unusual noise or heat. To prevent this, motor driving current must be PWM-controlled.

PWM control is activated when a single step period is equal to or more than the motor driving pulse width T1 as given in formula (1).
(e.g. pulse width at 7.0 V = 1/800 = 0.00125 sec. = 1.25 ms)
where T1 is the timing to start PWM control, that is, PWM control is initiated when time T1 has elapsed after an active driving step pulse is applied to the motor.
The PWM frequency should be set between (and including) 10 kHz and 20 kHz.

$$\frac{T3}{T2+T3}=D \quad (D = 0.65) \qquad \frac{1}{T2+T3}=10 \text{ to } 20\text{ kHz}$$

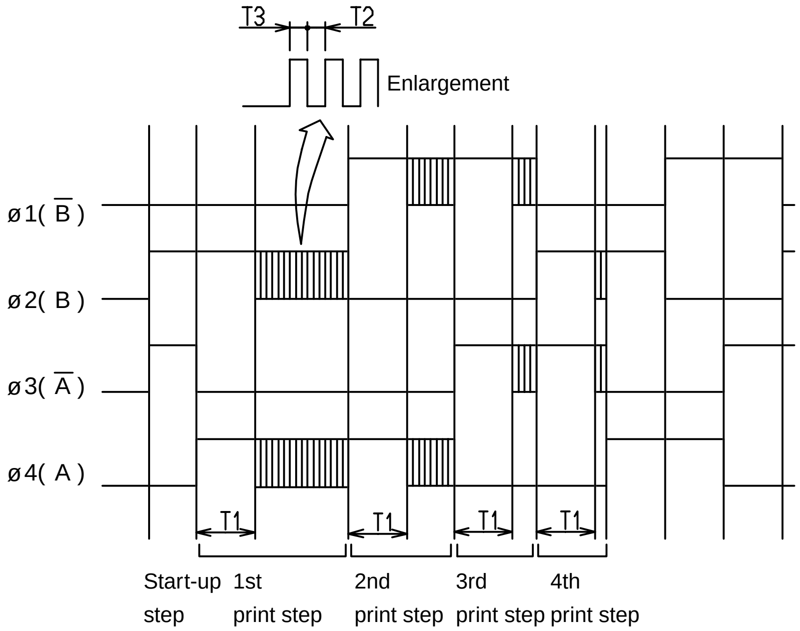


Figure 4-4

3. Acceleration Control

When the motor is heavily loaded during start-up or any other occasion, it must be driven under controlled acceleration scheme to secure the specified paper feed power. Individual acceleration tables are used for different driving voltage ranges. Gradually accelerate the motor until the driving frequency given in formula (1), motor driving speed, is reached while looking up the acceleration table prepared for the pertinent driving voltage.

The acceleration steps are described below:

1. Activate the start-up step for the time period for acceleration step 1 (t0).
2. Drive the 1st step for the time span specified for acceleration step 1(t0).
3. Drive the 2nd step for the time span specified for acceleration step 2(t1).
4. Subsequently drive the n'th step for the time span specified for acceleration step n .
5. The motor reaches a constant speed when it is accelerated at the pulse width derived from the frequency given by formula (1), motor driving speed.

The printer is available even if it is in an acceleration process.

Table 4-3 Acceleration Step

Step No.	VH=4.2~4.7		VH=4.8~5.5		VH=5.6~6.5		VH=6.6~7.5		VH=7.6~8.5	
	Step time (ms)	Motor Drive Speed (pps)	Step time (ms)	Motor Drive Speed (pps)	Step time (ms)	Motor Drive Speed (pps)	Step time (ms)	Motor Drive Speed (pps)	Step time (ms)	Motor Drive Speed (pps)
t0	13.33	75	8.85	113	6.41	156	4.44	225	3.47	288
t1	10.91	108	7.30	161	5.26	224	3.78	305	2.99	382
t2	8.27	134	5.57	198	4.00	276	2.98	367	2.39	456
t3	6.94	155	4.69	229	3.36	319	2.54	421	2.05	520
t4	6.09	173	4.13	256	2.96	358	2.25	468	1.82	577
t5	5.50	190	3.37	280	2.67	392	2.04	511	1.66	629
t6	5.05	206	3.43	303	2.45	424	1.88	551	1.53	677
t7	4.70	220	3.19	324	2.28	453	1.76	588	1.43	722
t8	4.41	233	2.99	344	2.14	481	1.65	623	1.35	764
t9	4.17	246	2.83	362	2.02	507	1.56	656	1.28	804
t10	3.96	258	2.69	380	1.92	532	1.49	687	1.21	842
t11	3.79	270	2.57	397	1.84	556	1.42	717	1.16	878
t12	3.63	281	2.47	413	1.76	579	1.37	746	1.12	913
t13	3.49	292	2.37	429	1.70	601	1.32	774	1.07	947
t14	3.37	302	2.29	444	1.64	622	1.27	801	1.04	980
t15	3.26	312	2.22	459	1.58	642	1.23	827	1.00	1011
t16	3.16	322	2.15	473	1.53	662	1.19	852	0.97	1042
t17	3.07	331	2.08	487	1.49	681	1.16	876	0.95	1071
t18	2.98	340	2.03	500	1.45	700	1.13	900	0.92	1100

5. HEAD-UP DETECTION

The printer incorporates the head-up sensor that detects the head position (up or down). If the thermal head is activated when it is in the Up position, it may be damaged or the operating life may be shortened significantly. The driver should be designed to detect the head-up sensor signal so the thermal head is never energized when it is in the Up position.

5.1 Specifications

Type	Mechanical switch Head-up : CLOSE Head-down : OPEN
Max. Rate	DC 15V, 1A
Contact resistance	less than 70 mΩ

5.2 Example of Head-Up Detection Circuit

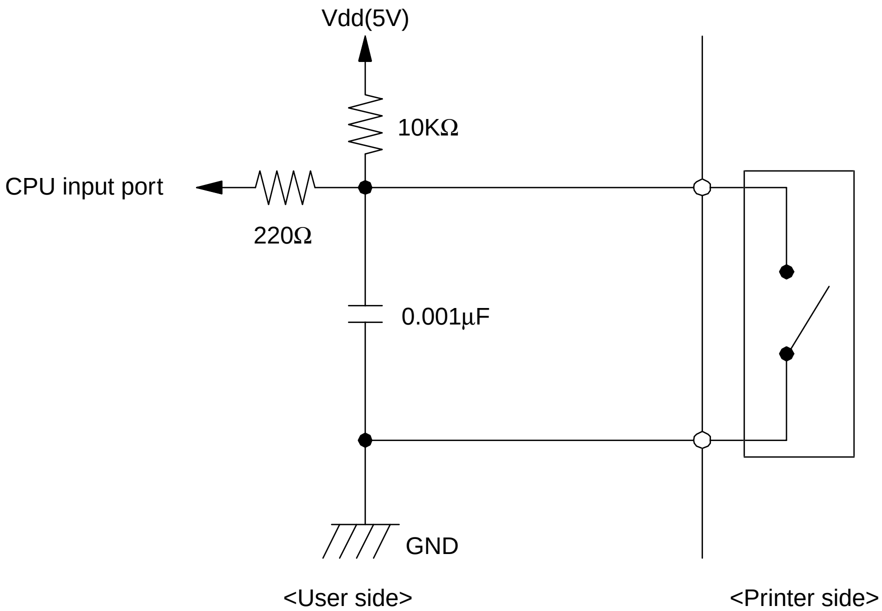


Figure 5-1 Example of Head-Up Detection Circuit

To prevent malfunction from chattering, use a capacitor in parallel with the switch contacts.

6. PAPER END DETECTION

The printer incorporates a paper sensor (reflective photointerruptor). If the thermal head is energized with no roll paper loaded in the printer, the head may be damaged or its operating life may be significantly shortened. The driver should be designed so the thermal head will never be energized if no roll paper is loaded in the printer.

6.1 Specifications

Table 6-1 General Specifications for the Paper End Sensor

T=25˚C

Item		Signal	Rating	Unit
Input	Forward current	I_F	50	mA
	Reverse voltage	V_R	6	V
	Allowable loss	P_D	75	mW
Output	Voltage between collector and emitter	V_{CEO}	35	V
	Voltage between emitter and collector	V_{ECO}	6	V
	Collector current	P_C	75	mW
	Collector loss	I_C	20	mA
Operating temperature		Topr	–25 ~ +85	°C
Storage temperature		Tstg	–40 ~ +100	°C

Table 6-2 Electrical Characteristics of Paper End Sensor

T=25˚C

Item		Signal	Condition	Min.	Normal	Max.	Unit
Input	Forward voltage	V_F	I_F=20mA		1.2	1.4	V
	Reverse current	I_R	V_R=3V			10	μA
Output	Collector cutoff current	I_{CEO}	V_{CE}=20V			100	μA
Transmitting characteristics	Collector output current	I_C	V_{CC}=2V , I_F =4mA	23		160	μA
	Leak current	I_D	V_{CE}=2V , I_F =4mA			100	nA
	Response time	t r	V_{CC}=5V I_C=0.1mA R_L=1KΩ		30		μsec
		t f			40		μsec

6.2 Example of Circuit for Detecting End of the Paper

The following paper sensing electronics is recommended to ensure error-free paper sensing:

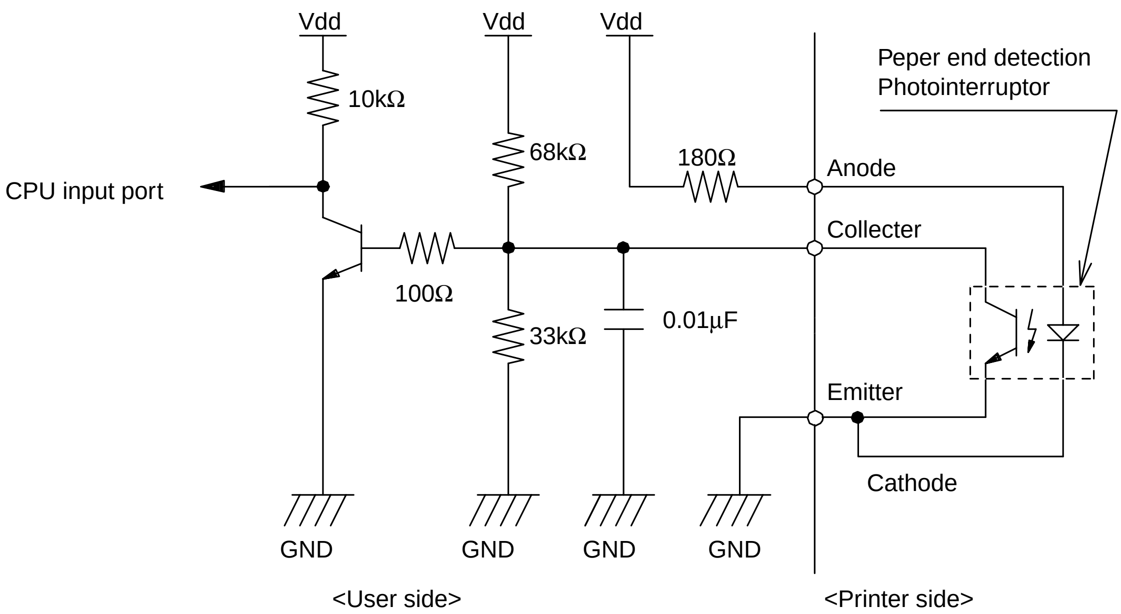


Figure 6-1 Example of Circuit for Detecting End of Paper

7. CONNECTION TERMINALS

The printer has 2 interface connectors with the following functions:

Table 7-1 Connector Specifications

No.	Connector	No. of Pin	Maker, Type	Recommended Mating Connector
1	Thermal head connector	24	FFC Cable (Pitch = 1mm)	
2	Head-up sensor Paper end sensor Motor	9	Molex Japan Inc. 51021-0900	Molex Japan Inc. 53047-0910 53048-0910

7.1 Thermal Head Connector

Figure 7-1 shows thermal head connector's pin arrangement.

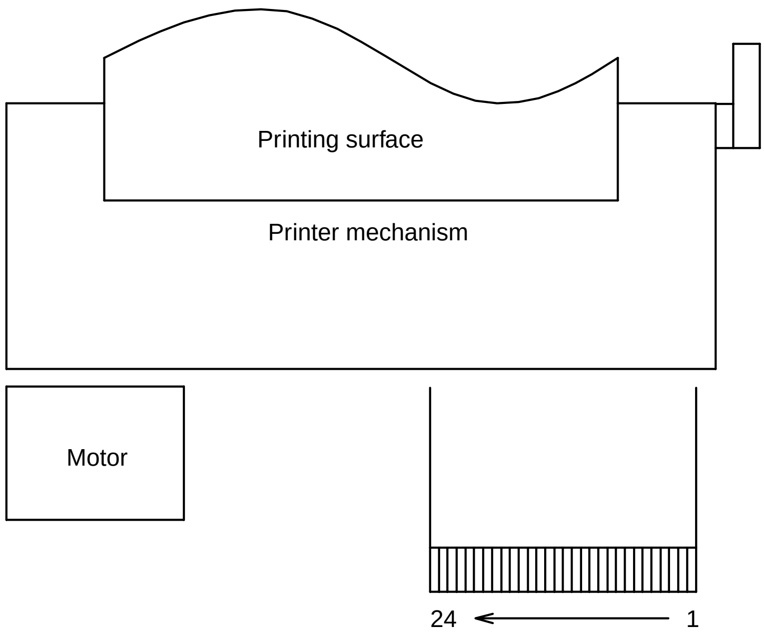


Figure 7-1 Thermal Head Connector's Pin Allocations

Table 7-2 Thermal Head Connector's Pin Allocations

Pin No.	Signal
1	VH
2	VH
3	SI
4	GND
5	TM
6	/STROBE1
7	/STROBE2
8	Vdd
9	/LATCH
10	GND
11	/STROBE6
12	CLOCK
13	GND
14	/STROBE5
15	/STROBE3
16	GND
17	GND
18	/STROBE4
19	GND
20	GND
21	GND
22	VH
23	VH
24	VH

Caution

All the GND pins must be connected to the host system's signal ground.

7.2 Motor/Sensor Connector

Figure 7-2 contains the sensor/motor connector pin assignments.

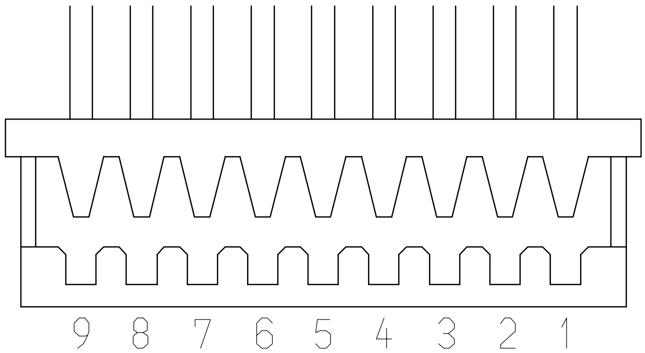


Figure 7-2 Motor/Sensor Connector's Pin Diagram

Table 7-3 Motor Connector's Pin Allocations

No.	Signal	Remarks
①	$\overline{B}$	Motor
②	$\overline{A}$	
③	B	
④	A	
⑤	Photointerruptor Collecter	Paper end sensor
⑥	Photointerruptor Emitter + Cathode	
⑦	Photointerruptor Anode	
⑧	Head-up sensor output	Head-up sensor
⑨	Head-up sensor output	

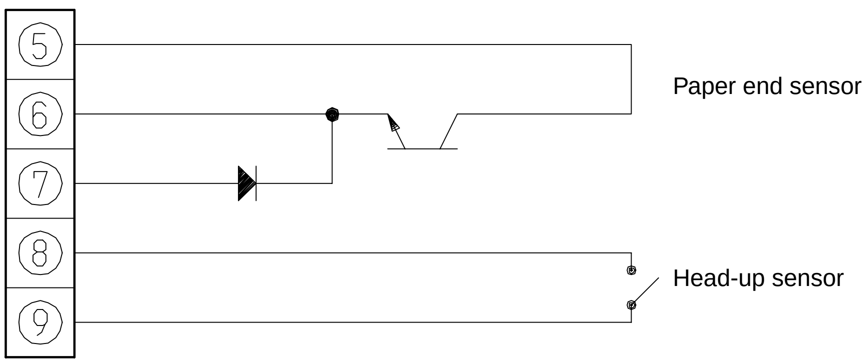


Figure 7-3 Example of Sensor Connector Circuit

8. CONTROL SYSTEM

8.1 Example of Driving Method

Figure 8-1 contains the timing charts for a line divided into 2 dot rows. The following provides step-by-step description of the timing charts:

1. Stop state:

The printer is in Standby mode, with the motor left unexcited.

2. Motor starts up:

Apply, to the motor, the driving phase for acceleration step 1 (t0) or the driving phase applied just before the motor stopped last.
The backlash removing steps must be executed at this point.
A single line of print data is transferred to the thermal head, where it is latched into the register.

3. The thermal head is activated to print the 1st dot row:

The paper feed motor steps a single step forward to be ready for printing the 1st dot row. Stepping time refers to the driving pulse width at the driving frequency given by formula (1), motor driving speed, in Section 4.5.
The thermal head is activate at the STB signal (1 to 6) timings each strobing 64 dots of print data. If the driving pulse width exceeds T1 (PWM activation timing), hold (PWM control) the motor driving signal until all the head driving pulses are transferred to the head.

4. The motor steps forward:

When the 1st dot row is printed, the paper feed motor steps a single step forward.
If the head driving pulse width exceeds the paper feed motor driving pulse width, the motor should be driven with the longer out of the following 2 driving pulse widths: i.e. one with an acceleration step shorter than the head driving pulse width obtained from the acceleration table in Table 4-3, and the other at the driving frequency given by formula (1), motor driving speed, in Section 4.5.

5. The thermal head is activated to print the 2nd dot row:

The paper feed motor steps a single step forward to be ready for printing the 2nd dot row.
If the head driving pulse width exceeds the paper feed motor driving pulse width, the motor should be driven with the longer out of the following 2 driving pulse widths: i.e. one with an acceleration step shorter than the head driving pulse width obtained from the acceleration table in Table 4-3, and the other at the driving frequency given by formula (1), motor driving speed, Section 4.5.
The thermal head is activate at the STB signal (1 to 6) timings each strobing 64 dots of print data. If the driving pulse width exceeds T1 (PWM activation timing), hold (PWM control) the motor driving signal until all the head driving pulses are transferred to the head.

6. The motor steps forward:

When the 2nd dot row is printed, the paper feed motor steps a single step forward.
If the head driving pulse width exceeds the paper feed motor driving pulse width, the motor should be driven with the longer out of the following 2 driving pulse widths: i.e. one with an acceleration step shorter than the head driving pulse width obtained from the acceleration table in Table 4-3, and the other at the driving frequency given by formula (1), motor driving speed, in Section 4.5.

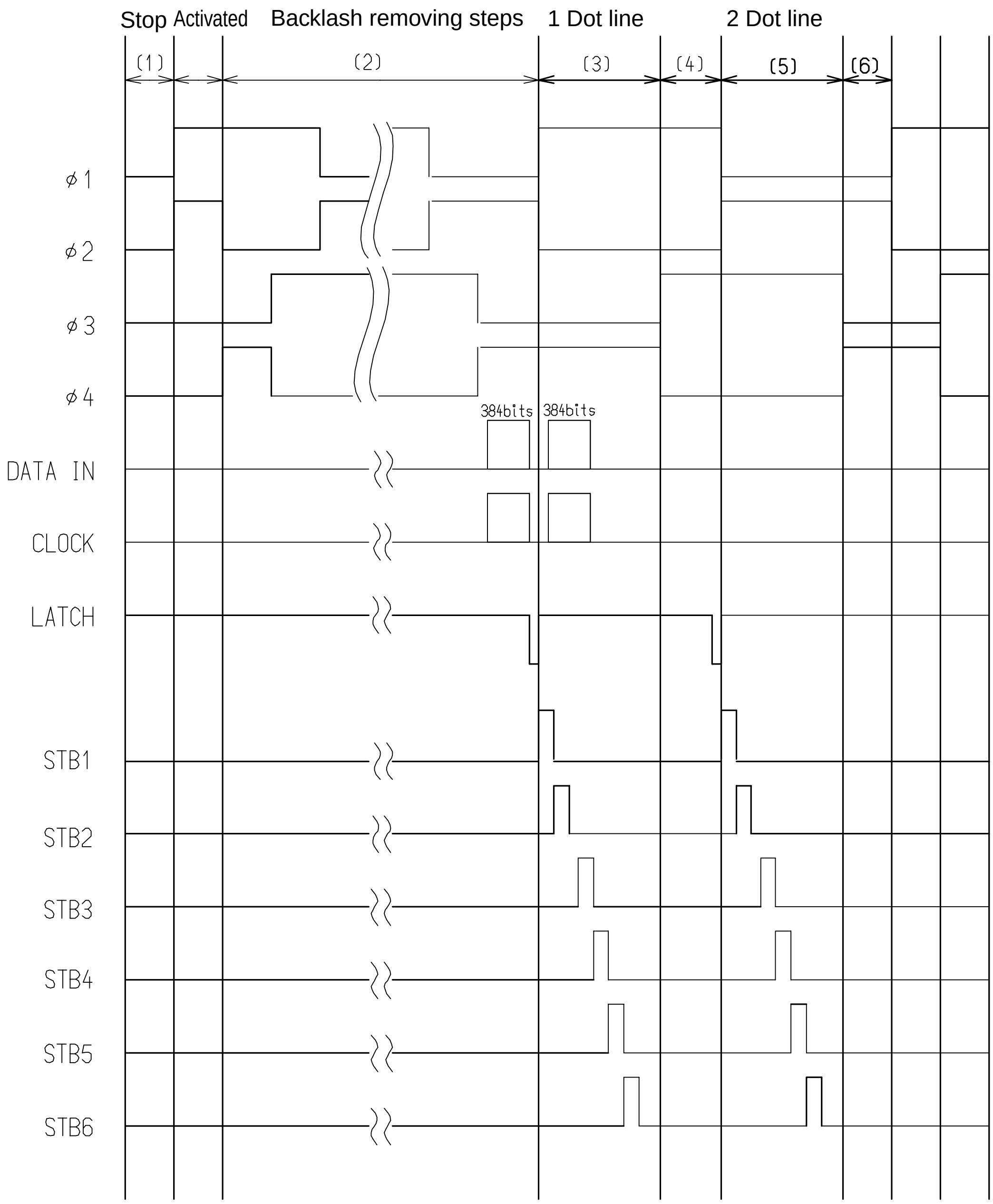
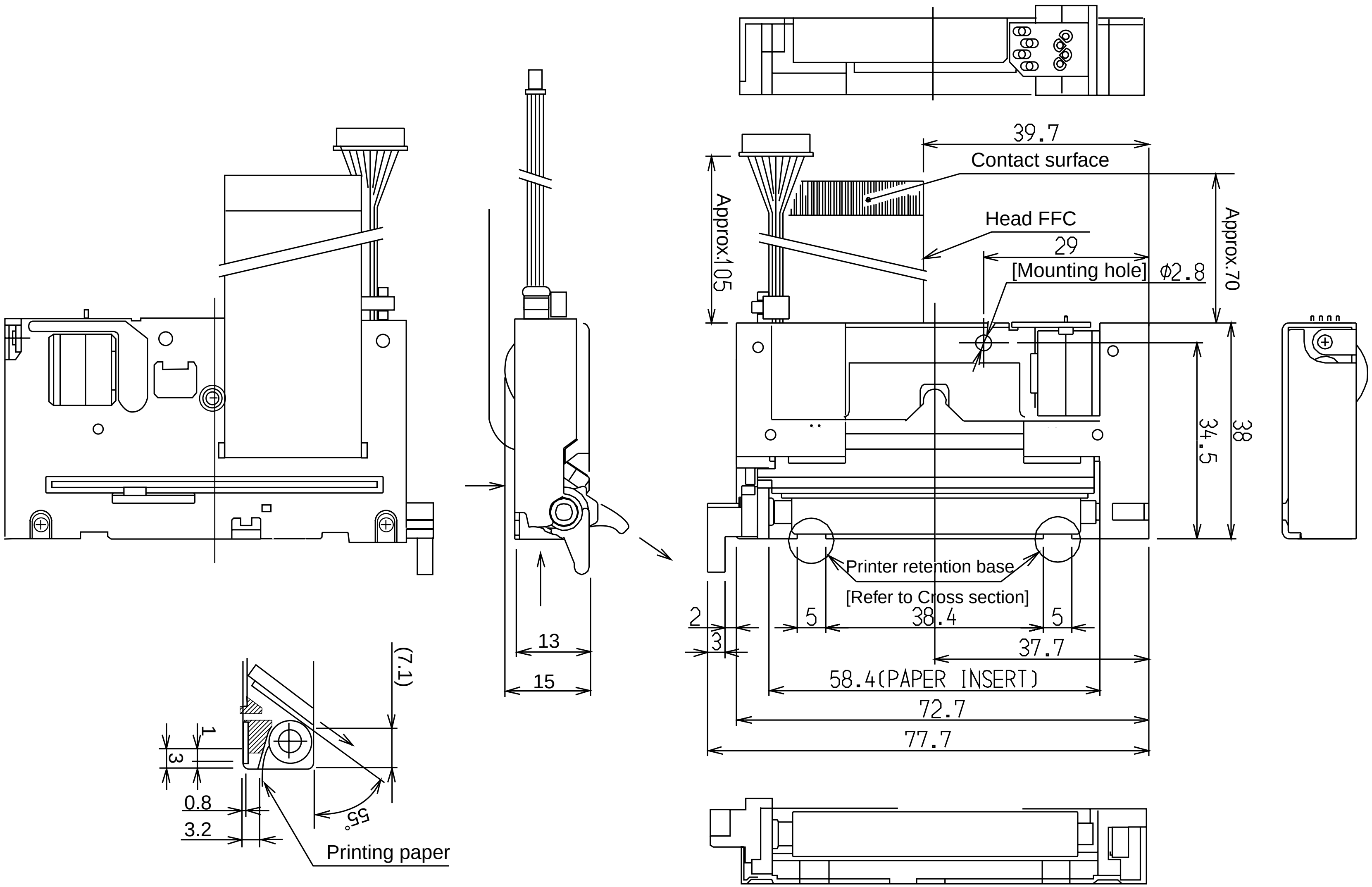

Stop
Activated
Backlash removing steps
1 Dot line
2 Dot line
(1)
(2)
(3)
(4)
(5)
(6)
φ1
φ2
φ3
φ4
384bits
384bits
DATA IN
CLOCK
LATCH
STB1
STB2
STB3
STB4
STB5
STB6

Figure 8-1

9. EXTERNAL APPEARANCE



Cross section
(printer retention base and paper exit)

10. CAUTIONS FOR PRINTER ENCLOSURE DESIGN

10.1 Securing the Printer

(1) Use the mounting screw hole (ø2.8) and 2 printer retention holes to secure the printer mechanism within the enclosure. The enclosure's 3 mounting surfaces should be on a horizontal plane with an error not exceeding 0.1 mm. Any part of the enclosure, other than the 3 mounting surfaces, should not interfere with the printer mechanism. Mounting surfaces, if not on a single horizontal plane, may cause a deforming or torsional stress to the printer mechanism, possibly resulting in a mechanical failure. (For the locations of mounting holes, see Section 9, "Outline Drawings."
(2) The screw used in the mounting hole (ø2.8) should have a screw head diameter of ø4.5 mm or less. When screwing, exercise care not to bite the motor cables. Also exercise care so the printer's FFC cable or other lead wires are not wedged between the printer and enclosure wall.
(3) It is advisable that vibration-proof rubber feet be used at the printer retention holes to lower audible noise.

10.2 Connection to Frame Ground

To prevent ESD damage to the thermal head or other printer electronics, ground the printer's chassis to the frame ground.

10.3 Paper Insertion Port

The paper insertion port is user-specifiable: either the rear or the bottom port. These ports are available on separate models.

10.4 Roll Paper Holder

(1) The roll paper in the paper holder must be held in a horizontal position, with its core axis properly aligned with the platen axis.
(2) The roll paper must be held in its core center. If it is held on the outer surface, irregular line spacing may occur.
(3) Paper take-up load on the printer should not exceed 0.49 N.

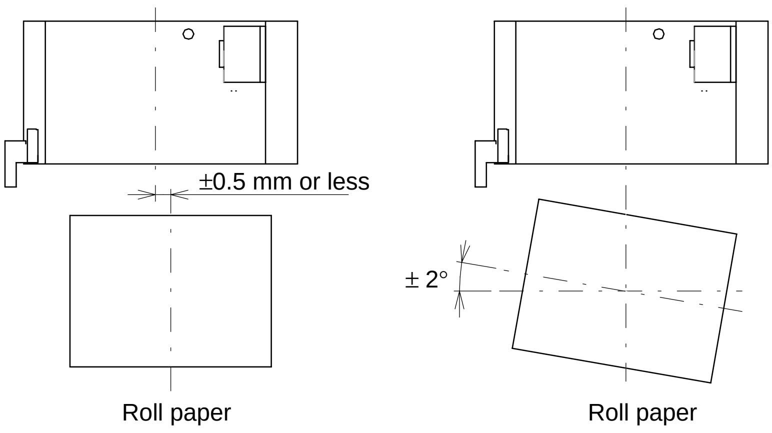


Figure 10-1 Roll Paper Positioning

10.5 Miscellaneous

(1) When using the paper cutter, design its layout so the paper end does not interfere with the cutter.
(2) Depending on the enclosure design, the printed paper end may be entangled into the paper insertion port or the tail end of the roll paper may be entangled with the platen roller. The enclosure should be carefully designed to prevent the problems as such.

11. CAUTIONS FOR DESIGN AND HANDLING

11.1 Cautions on Driver Design

(1) The thermal head driver should be carefully designed by referring to Section 3.11, "Cautions for Thermal Head Driving"
(2) To prevent ESD damage to the thermal head, ground the printer's chassis to the frame ground.
(3) The cables and wires that connect the power supply to the head FFC or motor connectors should be routed as short as possible.
(4) Never energize the thermal head with no paper loaded in it or the head left in the Up position. Otherwise lowered print quality or damage to the head may result. Use the paper and head-up sensors for adequate interlock control.
(5) Use the appropriate measure to prevent static electricity buildup in the paper feed path from entering control signal terminals.
(6) Special care should be exercised to prevent paper fragments or debris from getting into the paper feed gear assembly.

11.2 Cautions for Handling

(1) If a roll paper outside the recommended paper specifications is used, the specified print quality or printer's operating life may not be guaranteed. Also be sure to use roll paper with its width not exceeding the specified range of paper width.
(2) Do not apply physical impact (including foreign matter) on the head substrate (heating element surfaces).
(3) To prevent ESD damage to the heating elements and driver ICs, use the appropriate anti-static measures including wrist band.
(4) The heating element and platen roller surfaces should be cleaned with a cotton swab slightly dampened with methanol or isopropyl alcohol.
(5) If the thermal head gathers dew drops, thoroughly dry it off before using the printer again. If the thermal head is energized with dew drops left on it, the head may be damaged.
(6) Do not pull or bend the FFC cable as it may apply an excessive tensile or bend stress to the thermal head connector.
(7) If the printer is used in a low temperature, humid atmosphere, the print paper may be contaminated or the printer may gather dew drops due to water vapor emitted from the print paper (especially when an all-black or checker pattern is printed).
(8) Cables should be connected or disconnected with the power to the printer left turned off.
(9) The MLT-288 Printer has no drip-proof construction. Do not get it wet or operate it with wet hands.
(10) The MLT-288 Printer has no dust-proof construction. Avoid using it in a dusty atmosphere.
(11) While no paper is loaded in the printer, keep its paper sensor from ambient light as it may cause malfunction.

11.3 Inserting the paper/Removal of the paper

1. Inserting the paper

- Use the head-up lever to keep the head off the platen when inserting the paper.
- Align the edge of the paper with inserting position.
- Do not insert the paper whose edge is bent or fluffy.
- Pull the edge of the paper, which is just come out of the thermal head to check if the patter is set straight, then release the head-up lever to lower the head.

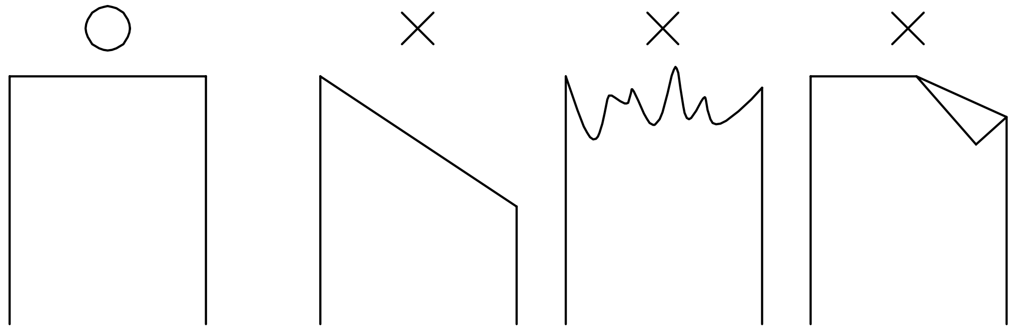
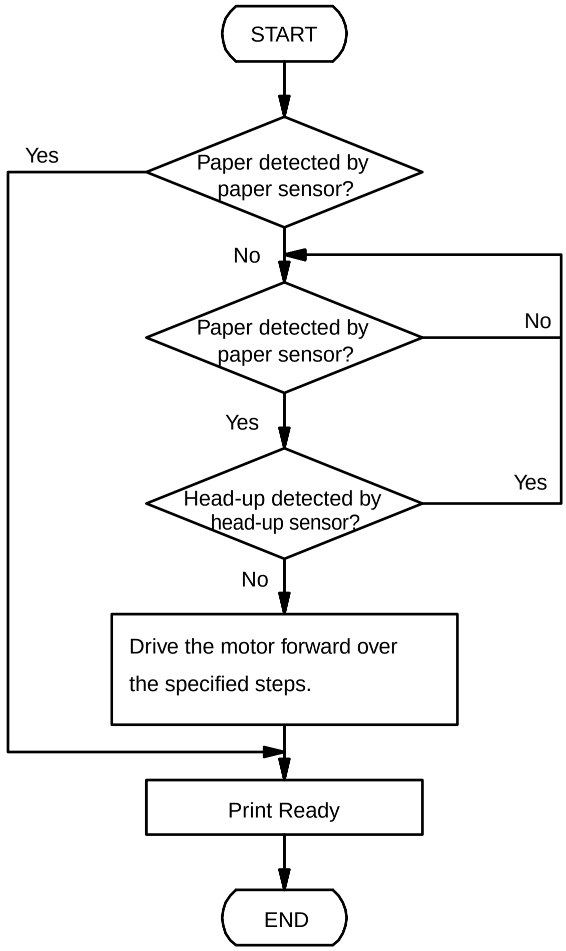


Figure 11-1 Condition of the Edge of the Paper

2. Auto paper loading sequence

The print paper can be automatically loaded by utilizing the paper and head-up sensor signals. The auto loading sequence is shown in Figure 11-2.



Note

(1) The motor should be driven at a frequency lower than one fourth (1/4) the driving frequency for paper feed (see Table 4-2).

(2) The driving step rate should be determined by taking into account the dispersion of paper-platen friction and the distance to the paper exit.

(3) The distance from the paper sensor to the print position is approx. 9 mm.

Figure 11-2 Auto Paper Loading Sequence

- Cut the paper end straight and at a right angle to the side edges.
- Manually feed the paper until its leading edge is inserted fully into the paper insertion slot, and make sure that the paper is further pulled into the slot by the platen.

Caution

Do not insert a fluffy or folded end of paper into the paper insertion port. Otherwise the platen may fail to rotate properly or may not rotate at all depending on the ambient temperature or driving voltage.

- If the paper is skewed, manually feed it until the skew is canceled or lift up the head and correct the skew.
- If the paper end does not come out of the paper exit, manually feed the paper or temporarily pull out the paper, cut the paper end at a right angle, then insert it again into the paper port.
- If the printer is left unused for long with the head in down position, the head may be stuck on the platen surface, inhibiting paper insertion. In such an event, temporarily lift the head in the up position before attempting paper insertion again.

3. Removal of paper

- When removing paper, pull the head-up lever to keep the head off the platen.
- Pull the paper straight to the paper discharging direction.