SII

Seiko Instruments Inc.

LTPH245

LINE THERMAL PRINTER MECHANISM

TECHNICAL REFERENCE

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PREFACE

This reference manual describes the specifications and basic operating procedures for the LTPH245 Line Thermal Printer Mechanism (hereinafter referred to as “printer”).

Chapter 1 “Precautions” describes safety, design and operational precautions. Read it thoroughly before designing so that you are able to use the printer properly.

SII has not investigated the intellectual property rights of the sample circuits included in this manual. Fully investigate the intellectual property rights of these circuits before using.

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CHAPTER 1

PRECAUTIONS

Read through this manual to design and operate the printer properly.
Pay special attention to the precautions noted in each section.

1.1 SAFETY PRECAUTIONS

Follow these precautions when designing a product using the printer, and include any necessary precautions and warning labels to ensure the safe operation of your product by users.

- **Preventing the thermal head from overheating**
  When electricity is continuously supplied to the thermal head heat element by a CPU or other malfunction, the thermal head may overheat, causing smoke and fire.
  Follow the method described in **Section 3.6.10** to monitor the temperature of the thermal head to prevent overheating.
  Turn the printer off immediately if any abnormal conditions occur.

- **Preventing the user from touching the thermal head and motor**
  Warn the user not to touch the thermal head, its periphery or motor as they are hot during and immediately after printing. Failure to follow this instruction may lead to personal injury including burns.
  Also, allow cooling by designing clearance between the head, motor and the outer case.

- **Preventing the user from touching the rotary drive portion**
  Design the product so that the motor does not operate when the outer case and platen block are open. The user could be caught in the motor when the drive gear is exposed.

1.2 DESIGN AND HANDLING PRECAUTIONS

To maintain the initial level of performance of the printer and to prevent future problems from occurring, observe the following precautions.

1.2.1 Design Precautions

- If too much energy is applied to the thermal head, it may overheat and become damaged. Always use the printer with the specified amount of energy.
  Do not apply a pulse of 2V and 20 nsec or higher to each signal terminal of the thermal head.

- Use C-MOS IC chips (74HC240 or equivalent) for interfacing the CLK, LATCH, DAT and DST signals of the thermal head.

- When turning the power on or off, always DISABLE (put in “Low” state) the DST terminals.

- To prevent the thermal head from being damaged by static electricity:

  - Fix the printer to the Frame Ground (FG) with the FG connector as shown in **Figure 7-2**.
  - Connect the GND terminal (SG) to FG through 1 MΩ resistor so that the electric potential of the SG of the thermal head and the FG of the printer are equal.

- Keep the Vp power off when not printing to prevent the thermal head from becoming electrically corroded.

- Wire resistance should be 50 mΩ or less (however the less the better) between the power supply and the Vp, and the GND terminals on the thermal head controller. Maintain a considerable distance from signal lines to reduce electrical interference.

- The surge voltage between Vp and GND should not exceed 10 V.

- As a noise countermeasure, connect the capacitor noted below between the Vdd and GND terminals near the thermal head control connector.

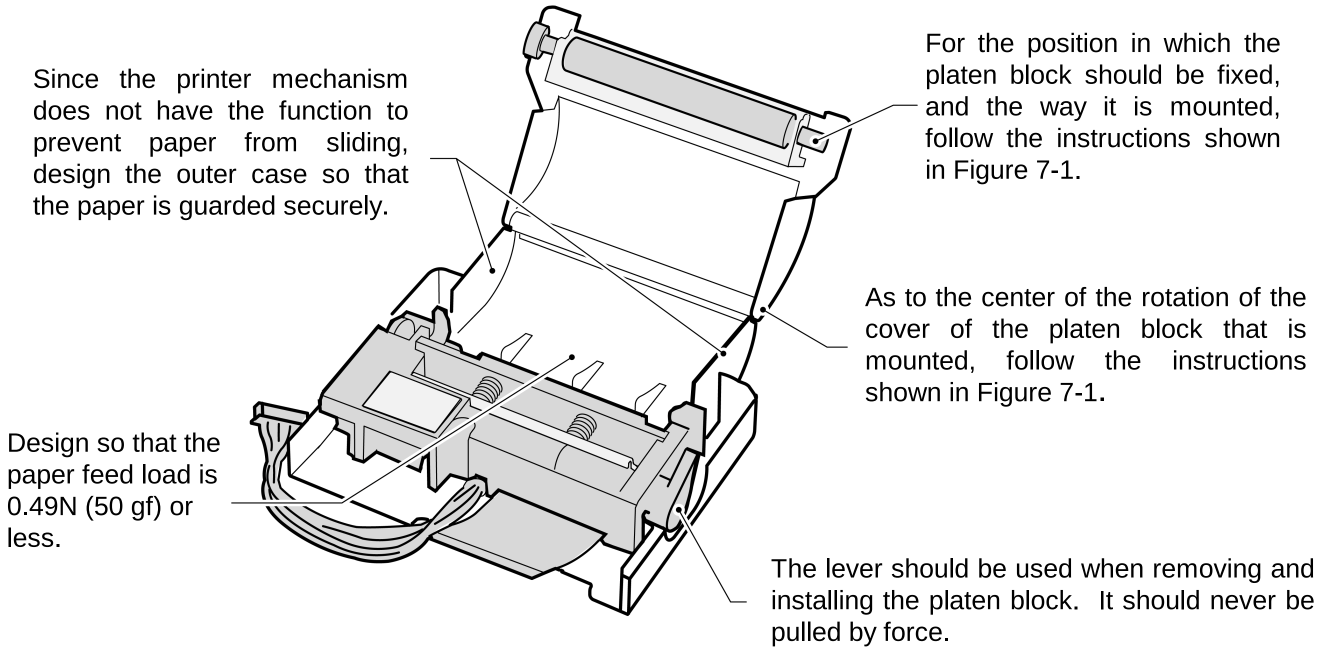
Vp ↔ GND:	approximately 10µF
Vdd ↔ GND:	approximately 1µF

- When turning the power on or off, perform the Vp and Vcc simultaneously or in the order of 1) and 2) as follows:

At power ON:	1) Vcc (5 V)	→	2) Vp
At power OFF:	1) Vp	→	2) Vcc (5 V)

- Always monitor the output of the platen position sensor and paper detector. Incorrect activation of the thermal head may damage and reduce the longevity of the thermal head and the platen.
  Design the outer case so that the paper detector is not affected by light from outside. Since a reflection type photo interrupter is used in the paper detector, the detector may be affected by light from outside.

- Allow for movement of the FFC when designing the outer case because the FFC will shift 1 to 2 mm from the thermal head moving. Also, design the outer case so that it prevents the paper feed out from being caught in the platen.



1.2.2 Handling Precautions

To maintain the initial level of performance of the printer and to prevent future problems from occurring, observe the following precautions.
Also, include any necessary precautions to ensure the safe operation of your product by users.

- To protect the heat elements, ICs, etc. from static electricity, discharge all static electricity before handling the printer.
  Pay special attention to the thermal head control terminals when handling.

- Do not apply stress to the thermal head control terminals: Doing so may damage the connectors and FFC (Flexible Flat Cable).

- Using anything other than the specified paper may cause the following:
  - Poor printing quality
  - Abrasion of the thermal head
  - The thermal surface of the paper and the thermal head may stick together
  - Excessive noise
  - Fading print
  - Corroded thermal head

- Always print or feed with the specified paper inserted to protect the platen, thermal head, and reduction gear.

- Do not hit or scratch the surface of the thermal head with sharp or hard objects as it may damage the heat element.

- If the thermal head remains in contact with the platen, the platen may become deformed and deteriorate print quality.
  If the platen is deformed, the uneven surface of the platen can be recovered by feeding paper for a while.

- Never connect or disconnect cables with the power on. Always power off the printer first.

- When printing a black or checkered pattern at a high print rate in a low temperature or high humidity environment, the vapor from the paper during printing may cause condensation to form on the printer or may soil the paper.
  If water condenses on the printer, keep the thermal head away from water drops as it may corrode the thermal head, and turn printer power off until it dries.

- Prevent contact with water and do not operate with wet hands as it may damage the printer or cause a short circuit or fire.

- Never use the printer in a dusty place, as it may damage the thermal head and paper feeder.

CHAPTER 2

FEATURES

The LTPH245 Line Thermal Printer Mechanism is a compact, high-speed thermal line dot printing mechanism. It can be used with a measuring instrument and analyzer, a POS, a communication device, or a data terminal device. Since the printer can be battery driven, it can easily be mounted onto a portable device such as a hand-held terminal.

The LTPH245 has the following features:

- **Battery drive**
  Since the range of operating voltage of 4.2V to 8.5V is wide, four to six Ni-Cd batteries or Ni-MH batteries or two Lithium-ion batteries can also be used.

- **Compact and light weight** [1]
  The mechanism is compact and light: 76.8 mm in width, 38 mm in depth, 16 mm in height, and approximately 46 g in weight.

- **Improved operability**
  The platen roller can be released easily by lever operation allowing easy paper installation and head cleaning.

- **High resolution printing**
  A high-density print head of 8 dots/mm produces clear and precise printing.

- **Longevity**
  The mechanism is maintenance-free with a long life of 50 km print length and/or 100 million pulses.

- **High speed printing** [2]
  A maximum print speed of 200 dot lines per second (25 mm per second) at 5 V, 450 dot lines per second (56.25 mm per second) at 7.2 V, and 500 dot lines per second (62.5 mm per second) at 8.0 V are attainable.

- **Low current consumption**
  The printer can be driven on low discharge current lithium-ion batteries due to low current consumption. Continuous printing can be also performed.

- **Low noise**
  Thermal line dot printing is used to guarantee low-noise printing.

- **Realizing easy design of outer case**
  The printer mechanism is designed to fit easily into the outer case, allowing for reduced number of outer case parts.

[1] The external dimensions exclude those of the lever and platen frame. 46 g in weight includes all parts.

[2] Print speed differs depending on working and environmental conditions.

CHAPTER 3

SPECIFICATIONS

3.1 GENERAL SPECIFICATIONS

Table 3-1 General Specifications

Item	Specification
Print method	Thermal dot line printing
Dots per line	384 dots
Resolution	8 dots/mm
Print width	48 mm
Maximum printing speed	200 dot lines/s (25.0 mm/s) (at 5 V) [1] 450 dot lines/s (56.25 mm/s) (at 7.2 V) [1] 500 dot lines/s (62.5 mm/s) (at 8.0 V) [1]
Paper feed pitch	0.125 mm
Head temperature detection	Via thermistor
Platen position detection	Via mechanical switch
Out-of-paper detection	Via photo interrupter
Operating voltage range V_P line (for head and motor drive) V_{dd} line (for head logic)	 4.2 V to 8.5 V [7] (equivalent to four through six Ni-Cd or Ni-MH batteries, or two lithium-ion batteries) 4.5 V to 5.5 V
Current consumption For driving the head (V_P) For driving the motor (V_P) For head logic (V_{dd})	 Average: 1.8 A (at 5 V), 2.6 A (at 7.2 V), 2.8 A (at 8.0 V) [2] Maximum: 2.1 A (at 5 V), 3.0 A (at 7.2 V), 3.3 A (at 8.0 V) [2] Maximum 0.46 A Maximum 0.01 A

[1] Maximum printing speed is attained with the following conditions:

- When the driving voltage is 5 V, the character size is a 24-dot font, the line spacing is 16 dots, the temperature of the head is 60°C or more, and the number of simultaneously activated dots is 64 dots or less
- When the driving voltage is 7.2 V, the temperature of the head is 40°C or more, and the number of simultaneously activated dots is 64 dots or less
- When the driving voltage is 8.0 V, the temperature of the head is 30°C or more, and the number of simultaneously activated dots is 64 dots or less.

[2] When the number of simultaneously activated dots is specified as 64.

Table 3-1 General Specifications (Continued)

Item	Specification
Operating temperature range	-5°C to 50°C [3] No condensation
Storage temperature range	-25°C to 70°C [3] No condensation
Life span (at 25°C and rated energy) Activation pulse resistance Abrasion resistance	 100 million pulses or more (print ratio=12.5%) 50 km or more
Paper width	58^{+0}_{-1} mm
Paper feeding force	0.49N (50 gf) or more
Paper holding force	0.78N (80 gf) or more
Dimensions (width×depth×height)	76.8 × 38.0 × 16.0 mm (excluding lever)
Weight	Approximately 46 g
Recommended thermal paper	TF50KS-E2C (65 µm paper) TP50KJ-R (65 µm paper) AP50KS-E (65 µm paper) from Nippon Paper Industries HP220-AB1 (65 µm paper) from Mitsubishi Paper Industries PD160R-N (75 µm paper) [4] from Oji Paper Industries

[3] Outside this range, prining may blot or be light.
[4] When the print ratio is high, this thermal paper may generate a noise during printing.
[5] The paper roll should be placed facing the thermal surface outward (See **Figure 6-3**). Also, do not use paper with edges that are pasted or have turnups at the start of the roll. If they need to be used unavoidably, replace with new paper roll as soon as possible before the entire roll is used up.

3.2 HEAT ELEMENT DIMENSIONS

The printer contains a thermal head with 384 heat elements (dot-size).

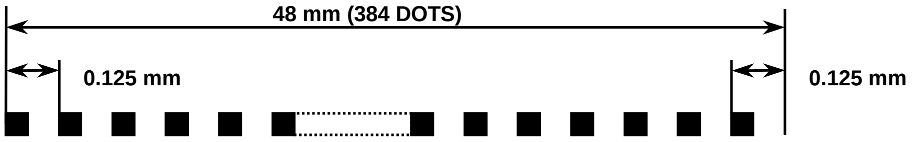


Figure 3-1 Heat Element Dimensions

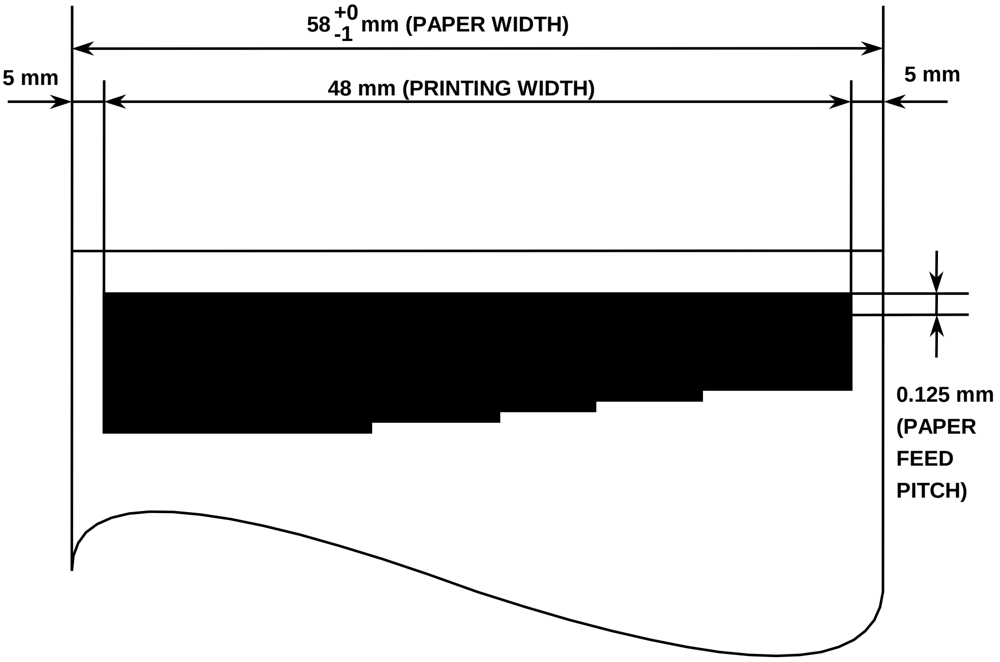


Figure 3-2 Print Area

3.3 PAPER FEED CHARACTERISTICS

- Paper is fed in a forward direction when the motor shaft is rotating in the normal direction (clockwise) when seen from the motor gear side.

- The motor is driven by a 2-2 phase excitation, constant current chopper method and feeds paper 0.125 mm (equivalent to a single dot pitch) every two steps of the motor drive signal.

- To prevent deterioration in printing quality due to backlash of the paper feed system, the motor should be driven 40 steps in a reverse direction and then 40 steps in the normal direction during initialization or after backward feeding.

- During paper feeding, the motor should be driven lower than the value obtained by equation (1).

  Equation (1):

  $$Vp \times 165 - 220 \text{ (pps)} \quad \text{(max.1000 (pps))}$$

- During printing, the motor drive frequency should be adjusted according to working conditions such as voltage, temperature, number of activated dots, etc. (For details, see **CHAPTER 5 DRIVE METHOD**.)

- Do not print while the motor is rotating in the reverse direction.

Table 3-2 Sample Motor Drive Frequency

Operating Voltage	Drive Frequency (Paper feed)
4.2 V	473 pps
5 V	605 pps
6 V	770 pps
7.2 V	968 pps
8 V	1000 pps
8.5 V	1000 pps

3.4 STEP MOTOR CHARACTERISTICS

Table 3-3 General Specifications of the Motor

Item	Specification
Type	PM
Number of phases	4-phase
Drive method	Bipolar chopper
Excitation	2-2 phase
Winding resistance per phase	14 Ω ±10%
Rated voltage	4.2 - 8.5 V
Rated current	0.23 A/phase, 0.15A/phase [1]
Maximum current consumption	0.46 A
Drive frequency	50 - 1000 pps (according to drive voltage)

[1] See 3.4.3 Precautions for Driving the Motor.

3.4.1 Motor Drive Circuit

(1) Sample Drive Circuit

Sample drive circuits for the motor are shown in **Figure 3-3**.

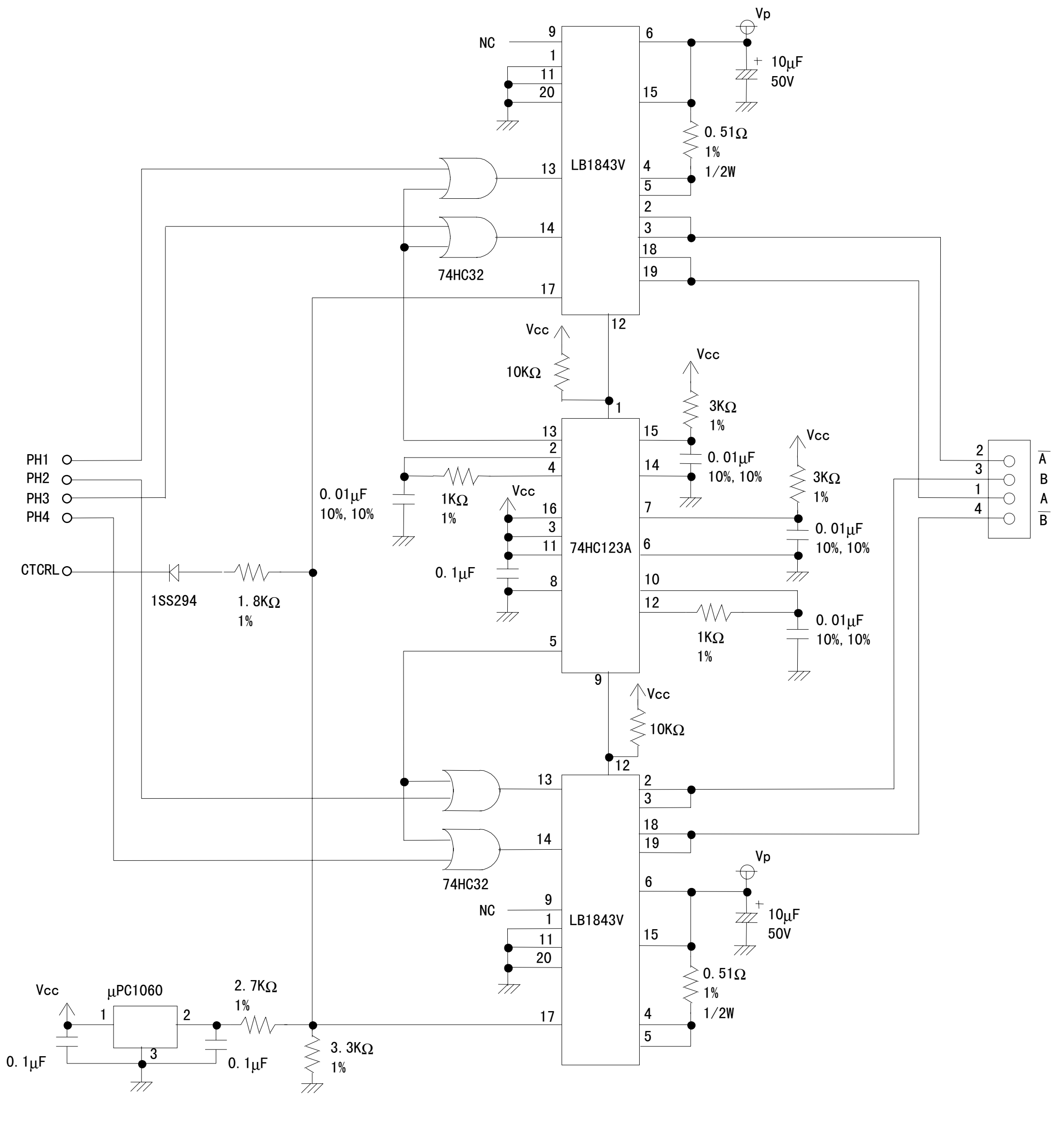


Figure 3-3 Sample Drive Circuit

(2) Excitation Sequence

As shown in **Table 3-4**, the printer feeds paper in the normal direction when the motor is excited in the order of step 1, step 2, step 3, step 4, step 1, step 2, ... On the other hand, to rotate the motor in a reverse direction, drive the motor in the reverse order of: step 4, step 3, step 2, step 1, step 4, step 3, ...

Table 3-4 Excitation Sequence

Signal Name	Sequence			
	Step 1	Step 2	Step 3	Step 4
$\overline{A}$	Low	High	High	Low
B	High	High	Low	Low
A	High	Low	Low	High
$\overline{B}$	Low	Low	High	High

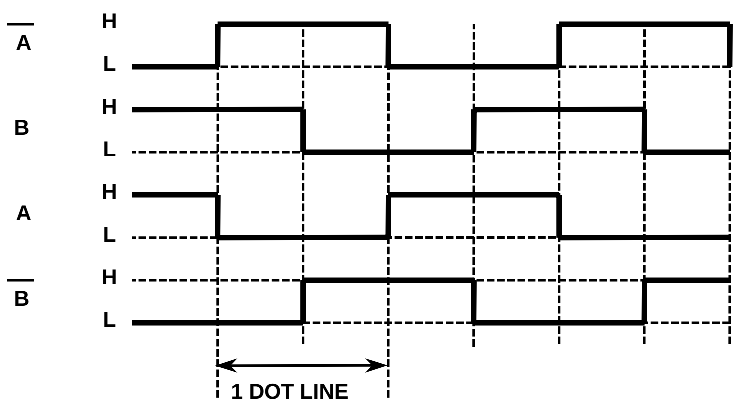


Figure 3-4 Input Voltage Signals for the Sample Drive Circuit

3.4.2 Motor Timing

Refer to the timing chart in **Figure 3-5** when designing the control circuit and/or software for starting and stopping the motor. Also take note of the following precautions:

Precautions for Designing the Motor Control Circuit and Software

(1) Stop step

- To stop the motor, excite for a single step period with a phase that is the same as the final one in the printing step.

(2) Pause state

- In the pause state, do not excite the step motor to prevent the motor from overheating. Even when the step motor is not excited, it maintains a holding force to prevent paper from sliding.

(3) Start step

- To restart the motor from the stop step, shift the motor into the printing sequence.
- To restart the motor from the pause (no excitation) state, shift the motor into the printing sequence after outputting a single step of a phase that is the same as that of the stop step.

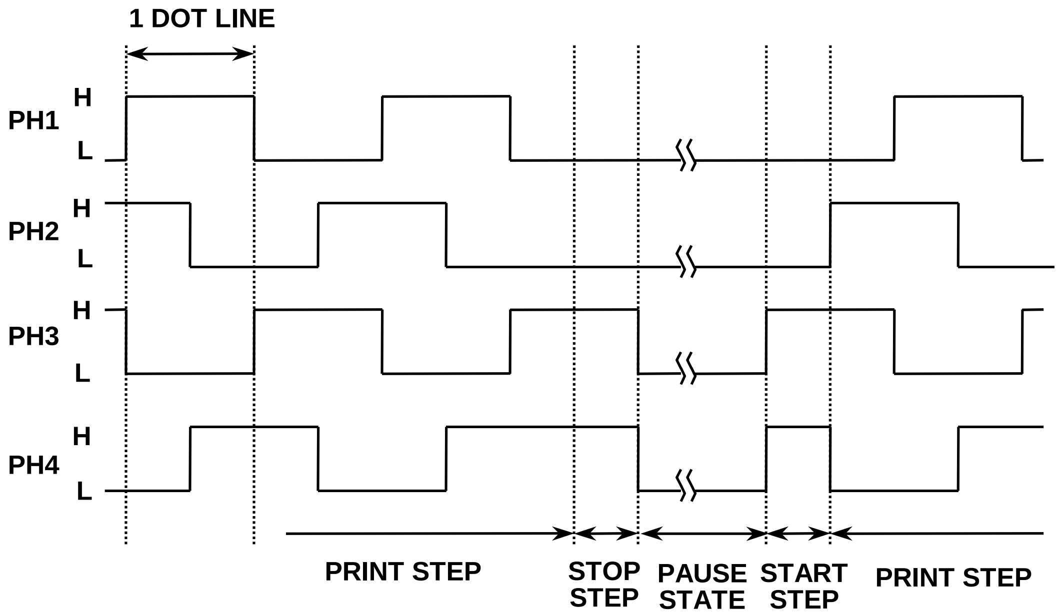


Figure 3-5 Motor Start/Stop Timing

(4) Others

- Do not print paper in intermittent feed mode. Doing so may deteriorate the printing quality due to irregular paper feeding pitch.

- To print characters and bit images, always follow the start step and stop step.

3.4.3 Precautions for Driving the Motor

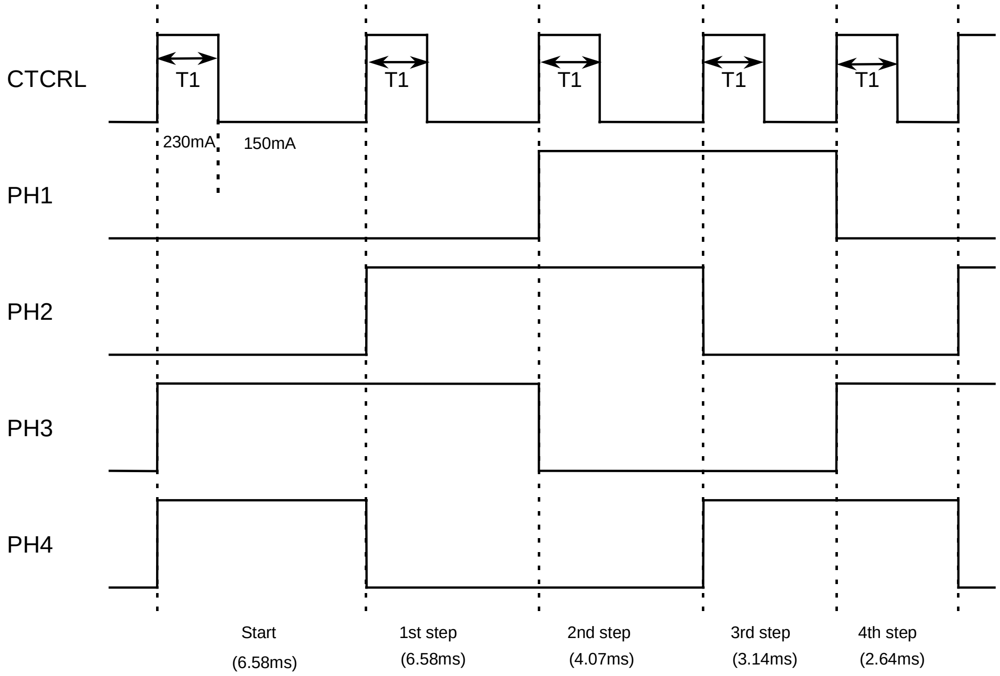
(1) Motor Current Control

When the motor speed decreases during printing because of the division drive method, the contents of print data, or input data transfer speed, noise and overheating of the motor may occur due to over-torque of the motor.
To prevent these symptoms from occurring, control the motor current as follows:

First, activate the motor with the 1st setting current in each motor drive step.
Change the activation current to the 2nd setting current after activating the motor with the 1st setting current for T1.
T1 is defined from each period of the motor drive step and Vp voltage as follows:

<u>How to define T1 (unit: μs)</u>

When Vp is under 7.2 V :
T1: Compare the following two values and adopt the smaller one.
(Each period of the motor drive step - 500) and 925.9
When Vp is 7.2 V or more :
T1: Compare the following two values and adopt the smaller one.
(Each period of the motor drive step - 500) and (1000000 / (3600 - Vp × 350))



Set the 1st setting current at CTCRL="High": 0.23 (A)
Set the 2nd setting current at CTCRL="Low": 0.15 (A)

Figure 3-6 Motor Drive Timing Chart

(2) Acceleration Control

When driving the motor, acceleration control is needed to start paper feeding. When the motor is to be driven at the maximum motor drive frequency that is calculated using equation (1), the motor may come out of step under heavy load.
Drive the motor to the maximum driving speed that is calculated using equation (1), according to the acceleration steps in **Table 3-5**.

The method for accelerating the motor is as follows;

1. Output start step (6580 (μs)) for the time calculated using equation (1)
2. Output first step for the first acceleration step time
3. Output second step for the second acceleration step time
4. Output nth step for the nth step acceleration time
5. After outputting the time calculated using equation (1), the motor is driven at a constant speed.

The printer can print during acceleration.

Table 3-5 Acceleration Steps

Number of Steps	Speed (pps)	Step Time (μs)
start	—	6580
1	152	6580
2	246	4066
3	318	3140
4	379	2636
5	433	2311
6	493	2028
7	547	1828
8	597	1675
9	644	1553
10	687	1456
11	728	1374
12	768	1302
13	805	1242
14	840	1191
15	874	1144
16	907	1103
17	939	1065
18	970	1031
19	1000	1000

3.5 THERMAL HEAD

3.5.1 Structure of the Thermal Head

As shown in **Figure 3-7**, the thermal head of the printer consists of 384 heat elements, and head drivers to drive the heat elements.

Serial printing data input from the DAT terminal is transferred to the shift register synchronously with the CLK signal, then stored in the latch register with the timing of the LATCH signal.

Inputting the head activation signal (DST 1 to 6) activates heat elements in accordance with the printing data stored in the latch register.

A maximum of six division printing is available for the printer.
Table 3-7 shows the relationship between DST signals and heat elements.

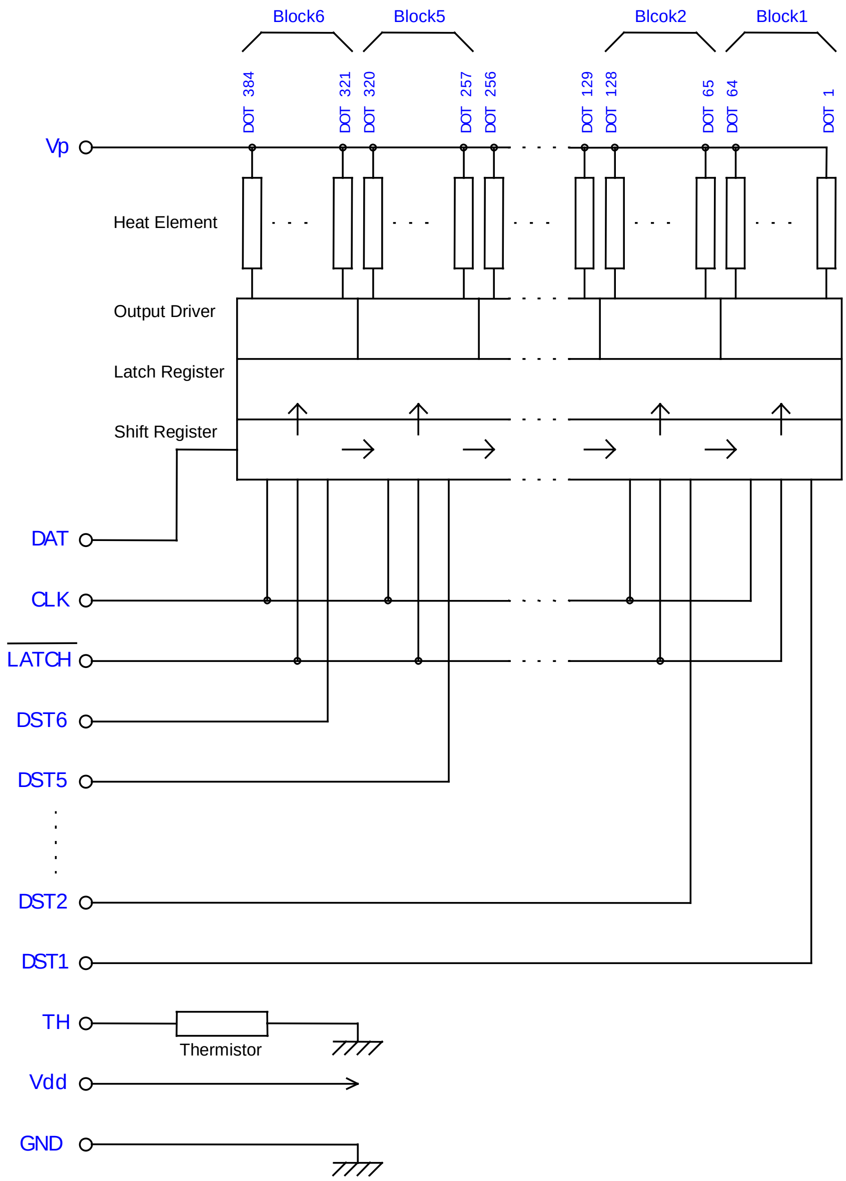


Figure 3-7 Thermal Head Block Diagram

Table 3-6 Blocks and Activated Heat Elements

Block Number	Heat Element Number	Dots / DST
1	1 - 64	64
2	65 - 128	64
3	129 - 192	64
4	193 - 256	64
5	257 - 320	64
6	321 - 384	64

3.5.2 Printed Position of the Data

Data dots from 1 to 384 which are transferred through DAT are printed as shown in **Figure 3-8**.

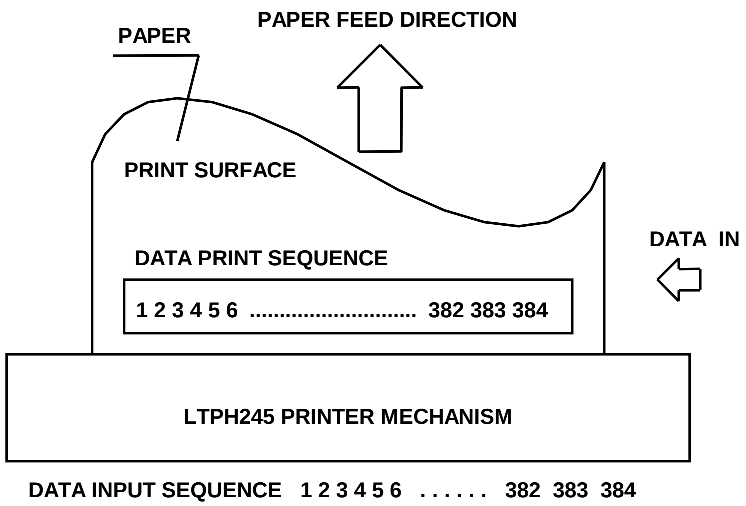


Figure 3-8 Printed Position of the Data

3.5.3 Head Resistance

The head resistance of the printer is classified into three ranks as shown in **Table 3-7**.

Table 3-7 Head Resistance Ranks

Rank	Head Resistance
A	178.6 to 195.5 Ω
B	161.6 to 178.5 Ω
C	144.5 to 161.5 Ω

* The head resistance ranks are indicated on the label located on the top of the printer.

<u>Sample Label showing the Head Resistance Rank</u>

In this example, the head resistance rank is B.

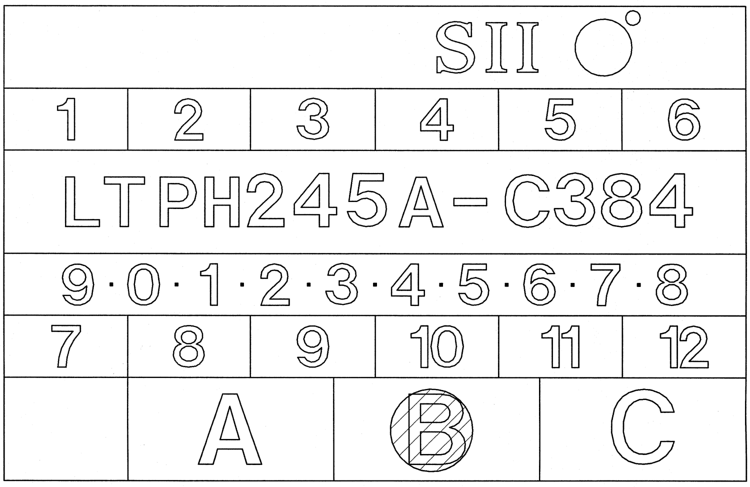


Figure 3-9 Head Resistance Rank Sample

3.5.4 Head Voltage

The printer has a built-in head driver IC. **Table 3-8** shows the head voltage.

Table 3-8 Head Voltage

Item		Voltage Range
Head drive voltage	Vp	4.2 to 8.5 V
Head logic voltage	Vdd	4.5 to 5.5 V

3.5.5 Peak Current

Since the peak current (maximum current) may reach the values calculated using equation (2) when the thermal head is driven, make sure that the allowable current for the cable material and the voltage drop on the cables are well within the specified range.

Equation (2):

$$Ip = \frac{N \times Vp}{RH}$$

Ip: Peak current (A)
N: Number of dots that are driven simultaneously
Vp: Head drive voltage (V)
RH: Head resistance (Ω)

3.5.6 Thermal Head Electrical Characteristics

Table 3-9 Thermal Head Electrical Characteristics

(Vdd=4.5 to 5.5V, Ta=0 to 50°C)

Item		Simbol	Conditions		Rated Values MIN	TYP	MAX	Unit
Head resistance		RH			144.5	170	195.5	Ω
Head drive voltage		Vp			4.2	7.2	8.5	V
Head drive current		Ip	max. common activated dot 64		1.3	2.6	3.5	A
Logic block voltage		Vdd			4.5	5.0	5.5	V
Logic block current		Idd	Ta=25°C	Waiting for activation	-	-	0.5	mA
				fclk=4MHz,DAT=fixed	-	-	6	mA
				fclk=4MHz,DAT=1/2fclk	-	-	10	mA
"High" input voltage		Vih	CLK,DAT,LATCH,DST		0.8×Vdd	-	Vdd	V
"Low" input voltage		Vil	CLK,DAT,LATCH,DST		0	-	0.2×Vdd	V
"High" input current	CLK	Iih	Ta=25°C Vdd=5.0(V) Vih=5.0(V)		-	-	3	μA
	DAT				-	-	0.5	μA
	LATCH				-	-	3	μA
	DST				-	-	55	μA
"Low" input current	CLK	Iil	Ta=25°C Vdd=5.0(V) Vil=0(V)		-	-	-3	μA
	DAT				-	-	-0.5	μA
	LATCH				-	-	-3	μA
	DST				-	-	-0.5	μA
Driver leak current		I leak	Vp=7(V), for 1 bit		-	-	1.0	μA
CLK frequency		fclk			-	-	4	MHz
CLK pulse width		t1	See the Timing Chart		80	-	-	ns
DAT setup-time		t2	See the Timing Chart		50	-	-	ns
DAT hold time		t3	See the Timing Chart		50	-	-	ns
LATCH setup time		t4	See the Timing Chart		120	-	-	ns
LATCH pulse width		t5	See the Timing Chart		120	-	-	ns
LATCH hold time		t6	See the Timing Chart		120	-	-	ns
DST setup time		t7	See the Timing Chart		120	-	-	ns

3.5.7 Timing Chart

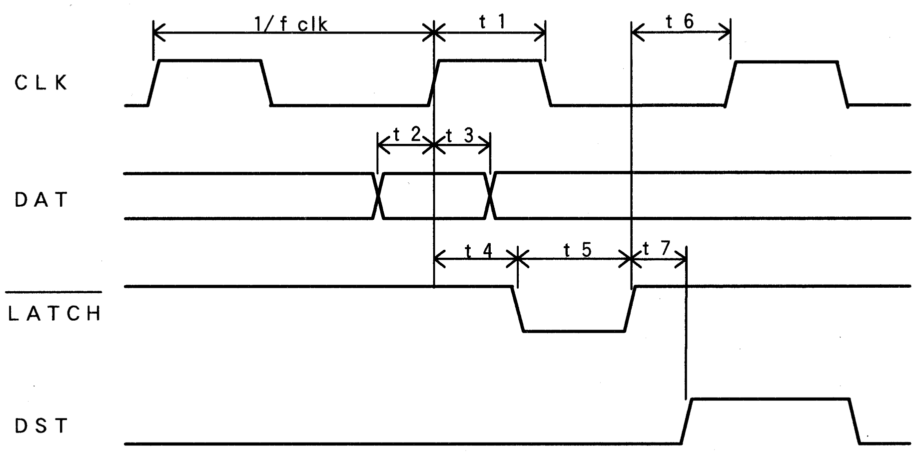


Figure 3-10 Timing Chart

3.6 CONTROLLING THE HEAD ACTIVATION (DST) PULSE WIDTH

3.6.1 Calculation of Head Activation Pulse Width

Head activation pulse width is calculated using the following equation (3).
To execute high quality printing using the printer, the value that is calculated using the following equation (3) must be adjusted according to the environment the printer is used in. Calculate each value used according to the steps in **Sections 3.6.2** to **3.6.7** and control them so that the pulse width with the t value obtained by substituting each value into the equation (3) is applied.
Printing using too high of a voltage or too long of a pulse width may shorten the life of the thermal head.

Equation (3):

$$t = \frac{E \times R}{V^2} \times C \times D$$

t :	Head pulse width (ms)	
E :	Standard applied energy (mj)	See **Section 3.6.2**.
V :	Applied voltage (V)	See **Section 3.6.3**.
R :	Head resistance (Ω)	See **Section 3.6.4**.
C :	Head pulse term coefficient	See **Section 3.6.6**.
D :	Heat storage coefficient	See **Section 3.6.7**.

3.6.2 Calculation of Applied Energy

Applied energy should be in accordance with the temperature of the thermal head and the environment the printer is used in.
The thermal head has a built-in thermistor. Measure the temperature using thermistor resistance. Standard applied energy is based on a temperature of 25°C. Calculate the printing energy using equation (4) and the temperature coefficient.

Equation (4):

$$E= (0.260 - T_C \times (T_X - 25))$$

T_X: Detected temperature using the thermistor (°C) [1]
T_C : Temperature coefficient 0.003373

1 The thermistor resistance value at T_X (°C). See **Section 3.6.8**.

3.6.3 Calculation of Head Activation Voltage

Calculate the applied voltage using equation (5).

Equation (5):

$$V = Vp \times 0.98 - 1.26$$

Vp: Head activation voltage (V)

3.6.4 Calculation of Head Resistance

A drop in voltage occurs depending on the wiring resistance. Calculate the head resistance using equation (6).

Equation (6):

$$R = \frac{(RH + 25 + (R_C + r_C) \times N)^2}{RH}$$

RH: Head resistance depending on resistance ranks
rank A (178.6 - 195.5Ω): 195.5 (Ω)
rank B (161.6 - 178.5Ω): 178.5 (Ω)
rank C (144.5 - 161.5Ω): 161.5 (Ω)
25: Wiring resistance in the thermal head (Ω)
R_C: Common terminal wiring resistance in the thermal head: 0.2 (Ω)
r_C: Wiring resistance between V_P and GND (Ω) [1]
N: Number of dots driven simultaneously

[1] It indicates a series resistance of wire and relay switching circuits used between the FFC terminals and power supply.

3.6.5 Determination of Activation Pause Time and Activation Pulse Period

Dot lines may be activated in succession to the same thermal dot in order to protect thermal head elements. Determine the activation period (the time from the preceding activation start to the current activation start) which conforms to equation (7) to reserve the pause time.

Equation (7):

$$W > t + 0.5(ms)$$

W : Activation period of 1-dot line (ms)

3.6.6 Head Activation Pulse Term Coefficient

Make adjustments using the head activation pulse term coefficient (equal motor drive frequency) as the printing density changes by the printing speed.
According to equations (8), calculate compensation coefficient C of the heat pulse.

Equation (8):

$$C = 1 - 2.6/(5.0 + w)$$

w = 2000 / motor drive frequency

3.6.7 Heat Storage Coefficient

In high speed printing, a difference in temperature arises between the rise in temperature of the thermal head due to head activation and the temperature detected by the thermistor. Therefore, the activation pulse must be corrected by simulating a rise in the temperature of the thermal head.
No correction is needed when the print ratio is low. When correction is not needed, set “1” as the heat storage coefficient.

The heat storage coefficient is calculated as follows:

1) Prepare the heat storage software counters to simulate heat storage.

   (a) Heat storage due to head activation
   The heat storage counter counts up in each print period as follows.

   $$T' = T + \frac{N}{6}$$

   T : Heat storage counter value
   N : Number of the activated dots

   (b) Radiation
   The heat storage counter value is multiplied by the radiation coefficient in each 2 msec.

   $$T' = T \times K$$

   K : Radiation coefficient 0.996

2) Calculate the heat storage coefficient with the following equation (9).

Equation (9)

$$D = 1 - \frac{T}{31936}$$

3.6.8 Calculation Sample for the Head Activation Pulse Width

Table 3-10 lists the calculation sample of the head activation pulse width that was calculated using equation (3) and the values obtained using equations (4) to (8).

Table 3-10 Activation Pulse Width

Head Drive Voltage (V)	Thermistor Temperature ℃	Motor Drive Frequency (PPS)									
		100	200	300	400	500	600	700	800	900	1000
4.2	0	9.91									
	10	8.94									
	20	7.97									
	30	7.00									
	40	6.03									
	50	5.06	4.67								
	60	4.09	3.77								
	70	3.12	2.87	2.70							
	80	2.14	1.98	1.86	1.77						
5.0	0	6.10									
	10	5.51									
	20	4.91	4.53								
	30	4.31	3.98								
	40	3.71	3.42	3.22							
	50	3.11	2.87	2.70							
	60	2.52	2.32	2.18	2.08	2.00					
	70	1.92	1.77	1.66	1.58	1.52	1.47				
	80	1.32	1.22	1.15	1.09	1.05	1.01				
6.0	0	3.79	3.50	3.29							
	10	3.42	3.15	2.96							
	20	3.05	2.81	2.64							
	30	2.68	2.47	2.32	2.21						
	40	2.30	2.13	2.00	1.90	1.83					
	50	1.93	1.78	1.68	1.60	1.53	1.48				
	60	1.56	1.44	1.35	1.29	1.24	1.20	1.17			
	70	1.19	1.10	1.03	0.98	0.94	0.91	0.89			
	80	0.82	0.76	0.71	0.68	0.65	0.63	0.61			
7.2	0	2.41	2.22	2.09	1.99	1.91					
	10	2.17	2.00	1.88	1.79	1.72	1.67				
	20	1.94	1.79	1.68	1.60	1.54	1.49				
	30	1.70	1.57	1.47	1.40	1.35	1.31	1.27	1.24		
	40	1.46	1.35	1.27	1.21	1.16	1.12	1.09	1.07	1.05	
	50	1.23	1.13	1.07	1.01	0.97	0.94	0.92	0.90	0.88	
	60	0.99	0.92	0.86	0.82	0.79	0.76	0.74	0.72	0.71	
	70	0.76	0.70	0.66	0.62	0.60	0.58	0.56	0.55	0.54	
	80	0.52	0.48	0.45	0.43	0.41	0.40	0.39	0.38	0.37	
8.0	0	1.87	1.72	1.62	1.54	1.48	1.43	1.39			
	10	1.68	1.55	1.46	1.39	1.34	1.29	1.26	1.23	1.20	
	20	1.50	1.39	1.30	1.24	1.19	1.15	1.12	1.10	1.07	
	30	1.32	1.22	1.14	1.09	1.05	1.01	0.98	0.96	0.94	0.93
	40	1.14	1.05	0.99	0.94	0.90	0.87	0.85	0.83	0.81	0.80
	50	0.95	0.88	0.83	0.79	0.76	0.73	0.71	0.69	0.68	0.67
	60	0.77	0.71	0.67	0.64	0.61	0.59	0.57	0.56	0.55	0.54
	70	0.59	0.54	0.51	0.48	0.47	0.45	0.44	0.43	0.42	0.41
	80	0.40	0.37	0.35	0.33	0.32	0.31	0.30	0.29	0.29	0.28
8.5	0	1.62	1.49	1.40	1.34	1.28	1.24	1.21	1.18		
	10	1.46	1.35	1.27	1.21	1.16	1.12	1.09	1.06	1.04	
	20	1.30	1.20	1.13	1.07	1.03	1.00	0.97	0.95	0.93	0.91
	30	1.14	1.05	0.99	0.94	0.91	0.88	0.85	0.83	0.82	0.80
	40	0.98	0.91	0.85	0.81	0.78	0.76	0.73	0.72	0.70	0.69
	50	0.83	0.76	0.72	0.68	0.66	0.63	0.62	0.60	0.59	0.58
	60	0.67	0.62	0.58	0.55	0.53	0.51	0.50	0.49	0.48	0.47
	70	0.51	0.47	0.44	0.42	0.40	0.39	0.38	0.37	0.36	0.36
	80	0.35	0.32	0.30	0.29	0.28	0.27	0.26	0.26	0.25	0.25

Do not use this area because paper feed errors may occur because of the motor torque.

Note)

The above table shows values for recommended 65 μ thermal paper, resistance rank B, Rc+rc=0.20, and N=64.

In the shaded area, the drive pulse width exceeds the allowable activation pulse width or the activation pulse width exceeds the motor drive frequency. Therefore, use the motor drive frequency shown in the unshaded areas.

3.6.9 Thermistor Resistance

The resistance of the thermistor at the operating temperature T_X (°C) is determined using the following equation (10).

Equation (10):

$$R_X = R_{25} \times EXP \left\{ B \times \left(\frac{1}{273 + T_X} - \frac{1}{298} \right) \right\}$$

R_X: Resistance at operating temperature Tx (°C)
R_{25}: 15 kΩ ± 10% (25°C)
B: 3440 k ± 3%
T_X: Operating temperature (°C)
EXP (A): The Ath power of natural logarithm e (2.71828)

[Rating]

Operating temperature range: -40°C to +125°C

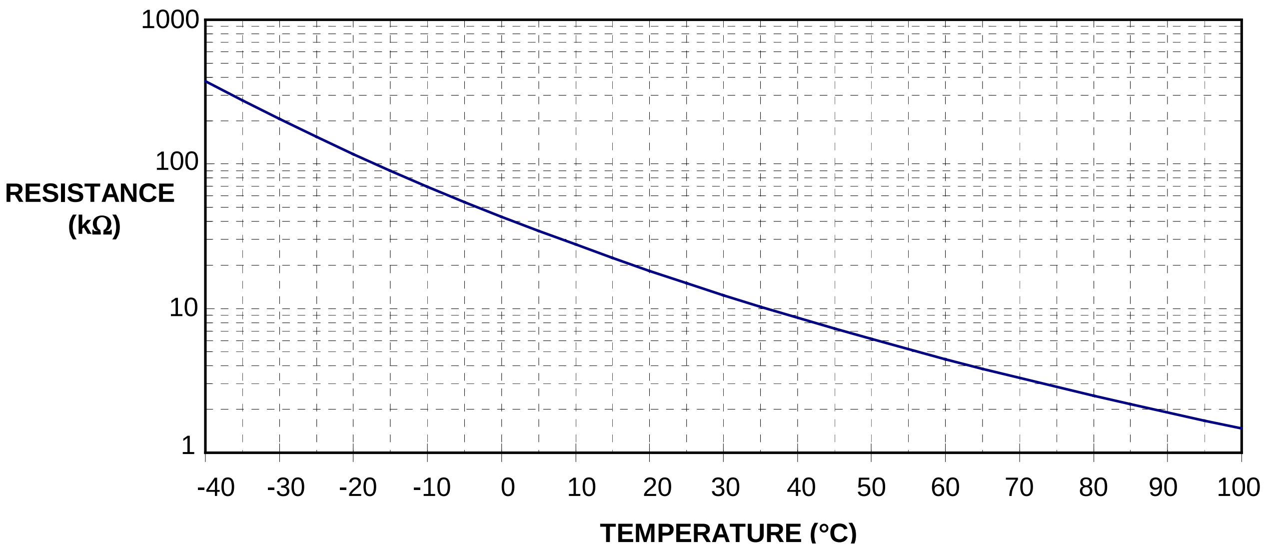


Figure 3-11 Thermistor Resistance vs. Temperature

Table 3-11 Temperature and Thermistor Resistance

Temperature (°C)	Thermistor Resistance (kΩ)	Temperature (°C)	Thermistor Resistance (kΩ)
-40	375.54	40	8.63
-35	275.40	45	7.26
-30	204.55	50	6.14
-25	153.76	55	5.22
-20	116.89	60	4.46
-15	89.82	65	3.83
-10	69.71	70	3.30
-5	54.61	75	2.86
0	43.17	80	2.48
5	34.42	85	2.17
10	27.66	90	1.90
15	22.40	95	1.67
20	18.27	100	1.47
25	15.00		
30	12.40		
35	10.31		

3.6.10 Detecting Abnormal Temperatures of the Thermal Head

To protect the thermal head and to ensure personal safety, abnormal thermal head temperatures must be detected by both hardware and software as follows:

- **Detecting abnormal temperatures by software**

  Design software that will deactivate the heat elements if the thermal head thermistor (TH) detects a temperature 80 °C or higher (thermistor resistance $RTH \leq 2.48$ kΩ), and reactivate the heat elements when a temperature of 60 °C or lower ($RTH \geq 4.46$ kΩ) is detected. If the thermal head continues to be activated at a temperature higher than 80 °C, the life of the thermal head may be shortened significantly.

- **Detecting abnormal temperatures by hardware**

  If the control unit (CPU) malfunctions, the software for detecting abnormal temperatures may not function properly, resulting in overheating of the thermal head. Overheating of the thermal head may cause damage to the thermal head or injury.
  Always use hardware in conjunction with software for detecting abnormal temperatures to ensure personal safety. (If the control unit malfunctions, it may be impossible to prevent damage to the thermal head even if a detection of abnormal temperature is detected by hardware.)

  Using a window comparator circuit or similar detector, design hardware that detects the following abnormal conditions:

  (a) Overheating of the thermal head (approximately 100 °C or higher ($RTH \leq 1.47$ kΩ)).

  (b) Faulty thermistor connection (the thermistor may be open or short-circuited).

  If (a) and (b) are detected, immediately deactivate the heat elements. Reactivate the heat elements after the temperature of the thermal head has returned to normal.

3.7 PAPER DETECTOR

The printer has a built-in paper detector (reflection type photo interruptor) to detect whether paper is present or not.

An external circuit should be designed so that it detects output from the paper detector and does not activate the thermal head and motor when there is no paper. Doing not so may cause damage to the thermal head or platen roller or shorten the life of the head significantly. If the motor is drived when it is out-of paper, a load is put on the reduction gear and the life of the gear may be shortened.

3.7.1 General Specifications

Table 3-12 Absolute Maximum Ratings of Detectors

(at 25°C)

Item		Symbol	Rating
LED (input)	Forward current	I_F	50 mA
	Reverse voltage	V_R	5 V
	Allowable current	P	70 mW
Phototransistor (output)	Collector-to-emitter voltage	V_{CEO}	20 V
	Emitter-to-collector voltage	V_{ECO}	5 V
	Collector current	I_C	20 mA
	Collector loss	P_C	70 mW
Operating temperature		T_{opr}	-20°C to + 80°C
Storage temperature		T_{stg}	-30°C to + 100°C

Table 3-13 Detectors Input/Output Conditions

Item		Symbol	Conditions	Standard	Max.
LED (input)	Forward voltage	V_F	I_F=10mA	1.2V	1.6V
	Reverse current	I_R	V_R=5V	–	10µA
Photo-transistor (output)	Dark current	I_{CEO}	If=0mA, V_{CE}=10V	–	200nA
Transfer characteristics	Photo electric current	I_C	I_F=10mA, V_{CE}=5V	–	350µA
	Leak current	I_{LEAK}	I_F=10mA, V_{CE}=5V	–	1µA
	Collector saturation voltage	V_{CE}(sat)	I_F=10mA, I_C=50µA	–	0.5V
	Response time (at rise)	t_r	I_C=1mA, V_{CC}=5V	5µs	-
	Response time (at fall)	t_f	R_L=100Ω	5µs	–

3.7.2 Sample External Circuit

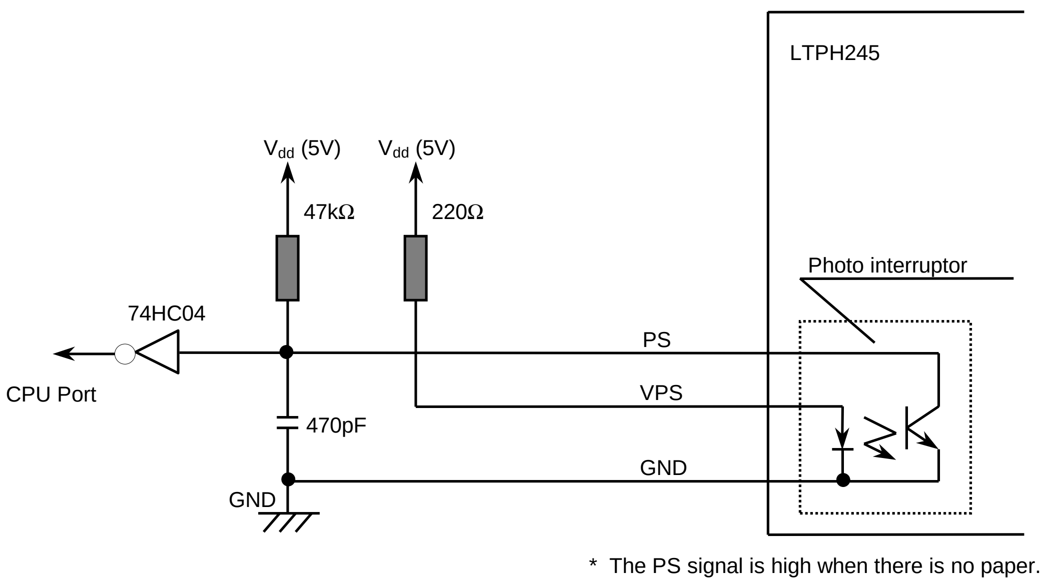


Figure 3-12 Sample External Circuit of the Paper Detector

3.8 PLATEN POSITION SENSOR

The printer has a platen position sensor to detect whether or not the platen block is set.
The platen position sensor is a switch type sensor shown in Figure 3-13. The platen position sensor switch is closed when the platen block is set and is open when the platen block is released.

Design the control circuit so that the motor is not driven and the thermal head is not activated when the platen block is open by detecting output of the platen position sensor.

3.8.1 General Specification

Maximum rating: DC30V, 0.5A
Connection resistance: 200 mΩ or less

3.8.2 Sample External Circuit

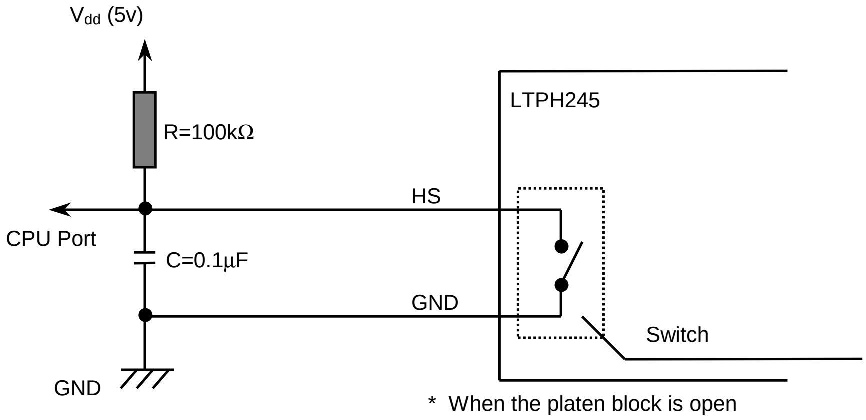


Figure 3-13 Sample External Circuit of the Platen Position Sensor

- Note that there is a time lag between operation of the platen position sensor and completion of pressurization to thermal head.
- To prevent a malfunction due to chattering of the switch, be sure to use the capacitor shown in Figure 3-13.

CHAPTER 4

CONNECTING EXTERNAL CIRCUITS

The printer has a FFC (Flexible Flat Cable) type connector and normal type connector (model No.51021-0900) made by Molex Co., Ltd. to connect to the external circuits.

Use the recommended connectors listed in **Table 4-1** to connect the printer firmly to the external circuits.

Table 4-1 Recommended Connectors

No.	External Circuit Functions	Number of Pins	Recommended Connectors (in the external circuit side)
1	Thermal head control	20	Molex Co., Ltd. 52044-2010 (horizontal type) 52045-2010 (vertical type) 5597-20APB (horizontal type) 5597-20CPB (vertical type)
2	Motor control, Paper detector Platen position detection	9	Molex Co., Ltd. 53047-0910 (vertical type) 53048-0910 (horizontal type) 51047-0910 (transmission type)

4.1 THERMAL HEAD CONTROL TERMINALS

Figure 4-1 shows the terminals configuration of the FFC thermal head control terminals.

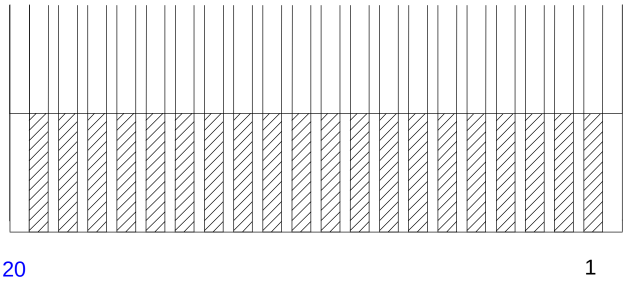


Figure 4-1 Thermal Head Control Terminals

Table 4-2 Thermal Head Control Terminal Assignments

Terminal Number	Signal Name	Input/ Output	Function
1	Vp	Input	Thermal head drive voltage
2	Vp	Input	Thermal head drive voltage
3	GND	-	GND
4	GND	-	GND
5	GND	-	GND
6	DAT	Input	Print data input (serial input)
7	CLK	Input	Synchronizing signal for print data transfer
8	$\overline{\text{LATCH}}$	Input	Print data latch (memory storage)
9	DST6	Input	Thermal head print activation instruction signal
10	DST5	Input	Thermal head print activation instruction signal
11	DST4	Input	Thermal head print activation instruction signal
12	DST3	Input	Thermal head print activation instruction signal
13	DST2	Input	Thermal head print activation instruction signal
14	DST1	Input	Thermal head print activation instruction signal
15	TH	-	Thermistor
16	Vdd	Input	Logic power supply (5V)
17	GND	-	GND
18	GND	-	GND
19	Vp	Input	Thermal head drive voltage
20	Vp	Input	Thermal head drive voltage

4.2 MOTOR AND DETECTOR TERMINALS

Figure 4-2 shows the terminals of the motor control, paper detector and platen position sensor.

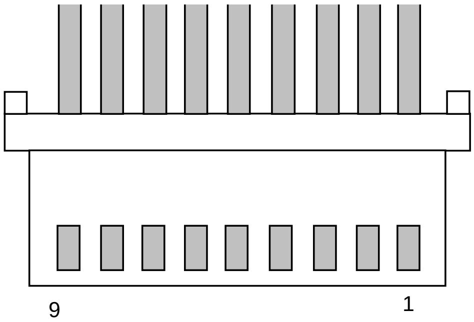


Figure 4-2 Motor and Detector Terminals

Table 4-3 Motor and Detector Terminals Assignments

Terminal Number	Signal Name	Function
1	A	Motor drive signal
2	$\overline{A}$	Motor drive signal
3	B	Motor drive signal
4	$\overline{B}$	Motor drive signal
5	V_{PS}	LED anode (Power supply side of the paper detector)
6	PS	Photo-transistor (Collector output of a photo-transistor)
7	GND	GND
8	GND	Platen position sensor (GND)
9	HS	Platen position sensor output

4.3 CAUTION IN CONNECTION

Pay attention to the following during installation of the printer.

- Always remove or install the thermal head controls vertically while holding the reinforcement portion of the FFC.
- Do not bend the FFC. If the FFC must be bent unavoidably, try to do so without removing the reinforcement sheet from the reinforcement portion of the FFC.
- Always remove or install the motor and sensor connector vertically while holding the connector housing.

If the connectors are not connected properly, it may damage the printer, cables or connectors.

CHAPTER 5

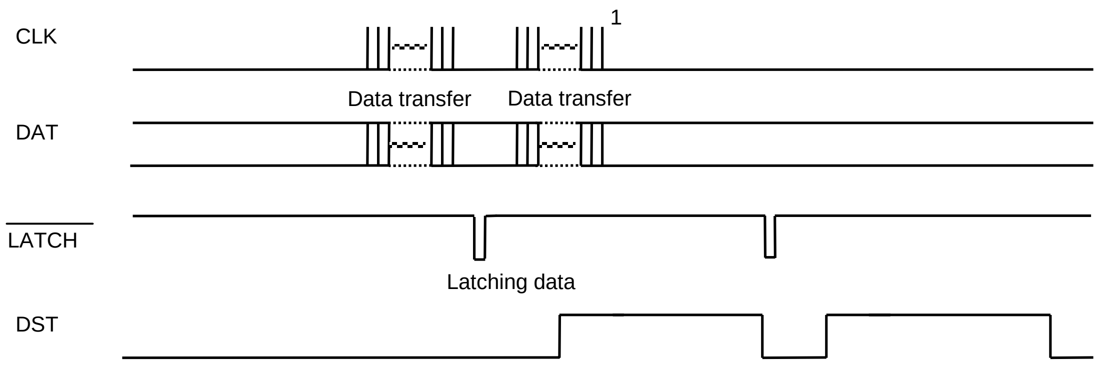
DRIVE METHOD

5.1 THERMAL HEAD DRIVE TIMING

- **Input of print data**
  Input of DAT and CLK transfer the print data to the shift register in the serial input. “High” means printing and “Low” means no-printing in DAT. DAT data is read in at the rising edge of the CLK inputs. The transferred line of data is stored in the latch register by turning LATCH to “Low”.

- **Input of the head activation pulse**
  Setting the DST on "High" drives the heat elements of the thermal head. Select the block to be activated and drive for the time calculated using the formula shown in **"3.6 CONTROLLING THE HEAD ACTIVATION (DST) PULSE WIDTH"**, then set the DST to "Low".

Figure 5-1 shows the example of timing chart of the thermal head driving.



1: The print data for next dot line can be transferred immediately after storing the print data into the latch register.

Figure 5-1 Example of Timing Chart of the Thermal Head Driving

5.2 MOTOR DRIVE TIMING

To print, the phase of motors need to be synchronized with that of the thermal head.
As example, the print method which divides one dot line to two groups; the block 1,3, and 5 and the block 2,4, and 6, and prints each group data for each step of the motor is described below.

The basic pulse width of the motor drive pulse, Tm, is a value (unit: msec) of the reciprocal number of the driving frequency calculated using equation (1) of **"3.3 PAPER FEED CHARACTERISTICS"**.

- **Pause State**
  Transfer the print data to the thermal head according to **"5.1 THERMAL HEAD DRIVE TIMING"**.

- **Start up phase**
  Excite the phase which is output just before the motor stops for the time of the start up step shown in Table 3-5.

- **1st line, 1st step**
  Drive the motor by one step (1st step). The step time should be the acceleration 1st step time or Tm, whichever is longer.
  Set DST for the block 1, 3, and 5 to “High” in synchronization with the motor drive.
  After setting DST to “High”, set DST to “Low” when the driving time calculated in **“3.6 CONTROLLING THE HEAD ACTIVATION (DST) PULSE WIDTH”** has passed.
  Move to the 2nd step after completion of the 1st step time of the motor and the activation of blocks 1, 3, 5.

- **1st line, 2nd step**
  Drive the motor by one step (2nd step). As to how much step time is output, compare Tm with the time that was taken in the previous step.

  (1) <u>In case Tm < the time that was taken in the previous step,</u>

  the next closest acceleration step time to the previous step time or Tm, which is longer, is output.

  (2) <u>in case Tm > the time that was taken in the previous step,</u>
  the closest acceleration step time to Tm and the acceleration step time that is larger than Tm, are output.

  Set DST for blocks 2, 4, and 6 to “High” in synchronization with the motor drive. After setting DST to “High”, set DST to “Low” after completion of the head activation time. Transfer the print data of the next dot line to the thermal head after completion of printing for blocks 2, 4, and 6.
  Move to the 2nd dot line after completion of the 2nd step time of the motor and the transfer of print data for the next dot line.

- **2nd line, 1st step**

  Drive the motor by one step (3rd step). As to how much step time is output, compare Tm with the time that was taken in the previous step.

  (1) in case Tm < the time that was taken in the previous step
  the next closest acceleration step time to the previous step time or Tm, which is longer, is output.

  (2) in case Tm > the time that was taken in the previous step
  the closest acceleration step time to Tm and the acceleration step time that is larger than Tm, are output.

  Activate blocks 1, 3, and 5 in the same manner as the 1st line.

- **2nd line, 2nd step**

  Drive the motor by one step (4th step). As to how much step time is output, compare Tm with the time that was taken in the previous step.

  (1) in case Tm < the time that was taken in the previous step
  the next closest acceleration step time to the previous step time or Tm, which is longer, is output.

  (2) in case Tm > the time that was taken in the previous step
  the closest acceleration step time to Tm and the acceleration step time that is larger than Tm, are output.

  Activate blocks 2, 4, and 6 in the same manner as the 1st dot line, then transfer the next dot line data.

Print each line in the same manner continuously.

Figure 5-2 shows an example of the motor drive timing chart.

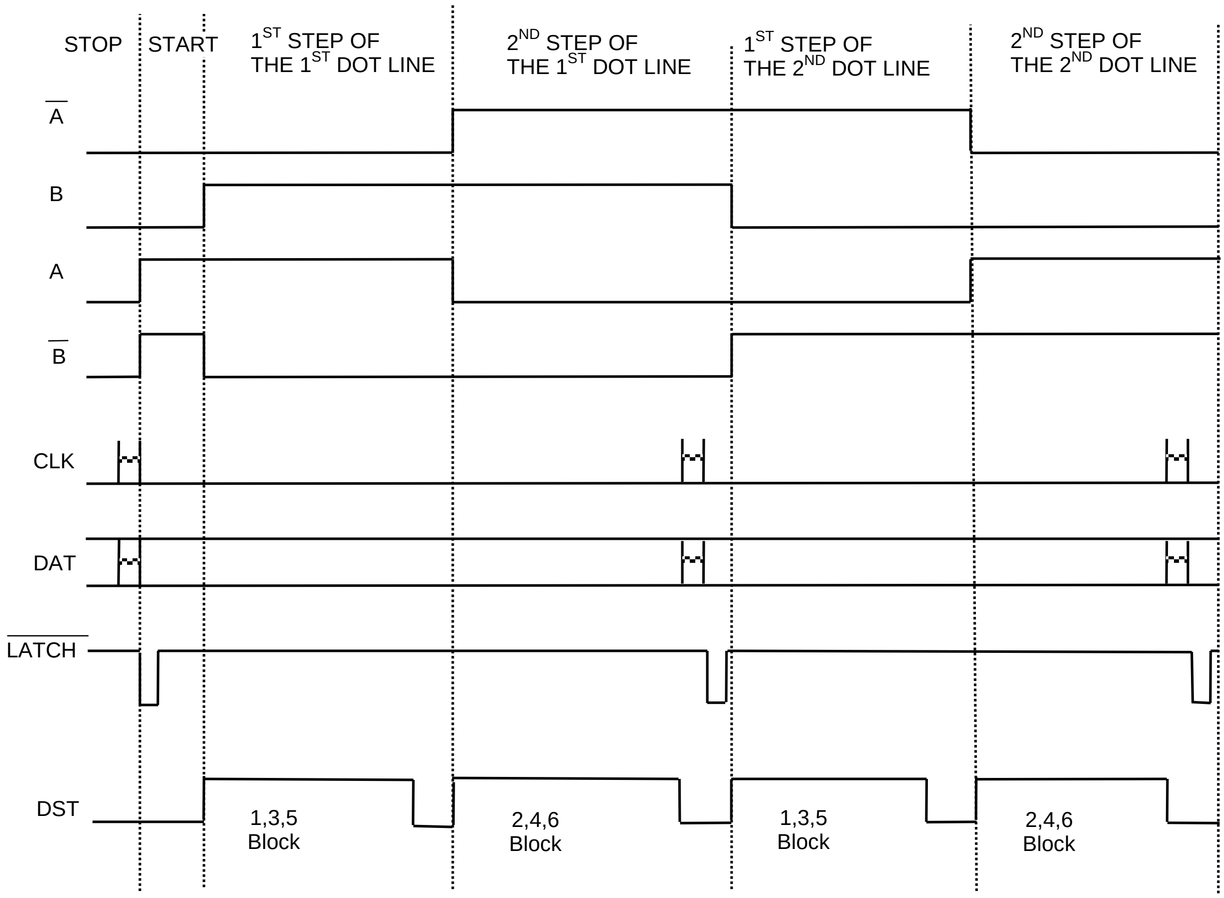


Figure 5-2 Example of Motor Drive Timing Chart

CHAPTER 6

HOUSING DESIGN GUIDE

6.1 SECURING THE PRINTER

The main body of the printer and platen must be secured to the outer case separately with screws.

6.1.1 Printer Mounting Method

Secure the printer in the 3 locations shown below (a,b,c). Holes A and B are used for positioning the main body of the printer.
See **"CHAPTER 7 APPEARANCE AND DIMENSIONS"** for locations and dimensions.

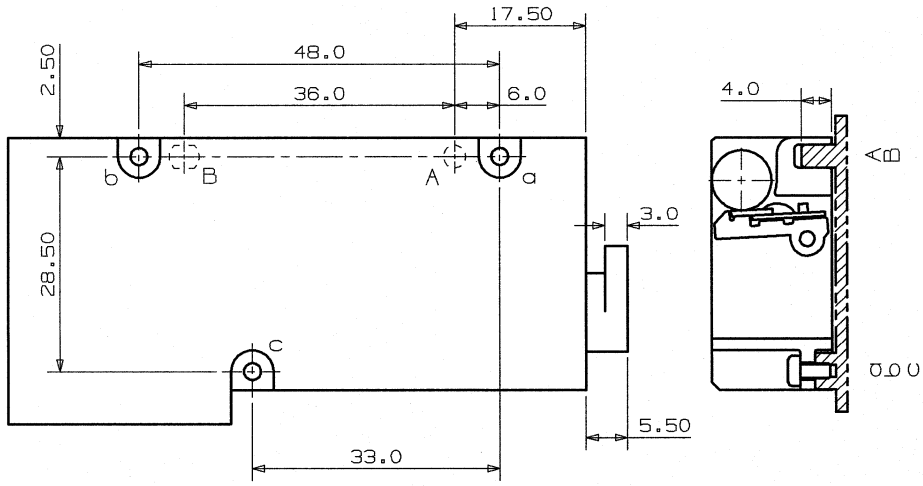


Figure 6-1 How to Secure the Printer

Recommended Screws

The recommended mounting screws are as follows:

1) Screw: M2.0 cross-recessed pan head machine screw

2) Screw: Pan head tapping screw 2.0 to secure resinated material

6.1.2 Mounting Platen Block

Secure the platen block in the 2 locations shown below (a,b). Holes A and B are used for positioning the printer main body.
See **"CHAPTER 7 APPEARANCE AND DIMENSIONS"** for locations and dimensions.

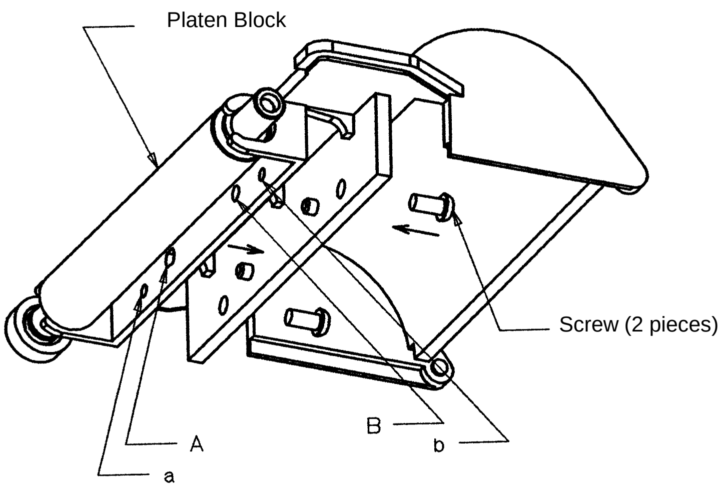


Figure 6-2 How to Secure the Platen Block

<u>Recommended Screws</u>

The recommended mounting screws are as follows:

Screw: M2.0 cross-recessed pan head machine screw

The nominal size of the screw should be the wall thickness of the outer case plus 2 mm. To secure the platen block to the wall of a thickness of 2 mm, screws of the nominal size of 4 mm should be used.

6.1.3 Precautions for Securing the Printer

Pay attention to the following when designing the case and securing the printer. Failure to follow these instructions may cause deterioration of print quality, paper skew, paper jam, noise or damage.

- Prevent excessive force or torsion when securing the printer.
- Remove the platen block before securing the printer.
- The bracket for the platen block is made of aluminum. Secure it with an appropriate torque.
- Design the case so that the thermal head control terminals can move 1 to 2 mm to compensate for the head moving.
- If the FFC for the thermal head control touches the bottom of the outer case, the FFC will disconnect and/or short-circuit. Leave a space of approximately 0.3 mm between the bottom of the outer case where the FFC passes through and the bottom of the printer mechanism.
- Secure the platen block to the printer correctly as shown in Figure 7-1. The platen block should not be used in any other way than as described in Figure 7-1.

6.2 LAYOUT OF PRINTER AND PAPER

- The printer can be laid out as shown in **Figure 6-3** according to the loading direction of the paper.
- Design the paper outlet with an angle of 60 to 90°.
- Design the paper inlet with an angle of 90° or more.

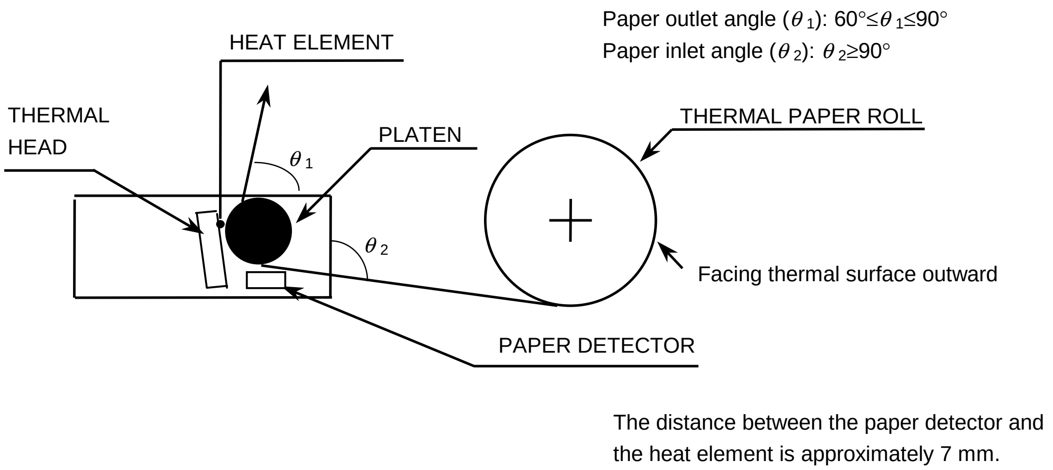


Figure 6-3 Paper Path

6.3 WHERE TO MOUNT THE PAPER HOLDER

When determining the layout of the paper holder, note the following:

- Hold the paper so that the paper is straight to the paper inlet without any horizontal shifting, and the center axis of the paper roll is parallel with the printer.
- Keep the paper feed force to 0.49N (50 gf) or less.
- Mount the platen block to the paper holder cover.
  For the rotation support point, see **CHAPTER 7 APPEARANCE AND DIMENSIONS**.

6.4 SETTING THE PAPER

Follow these precautions when setting the paper.

- Be sure to use the recommended paper described in this technical reference.
- Place the paper roll into the holder facing the thermal surface outward. Also, do not use paper with edges that are pasted or have turnups at the start of the roll. If they need to be used unavoidably, replace with new paper roll as soon as possible before the entire roll is used up.
- Keep the paper feed force to 0.49N (50 gf) or less.

6.5 POSITIONING THE PAPER CUTTER

Design the position of the paper cutter so that the paper cutter is within the recommended range as shown below.
If the distance between the edge of the paper cutter and position reference hole A of the printer is less than 6.9 mm, the paper cutter may interfere with the platen block when it is opened or closed. If the distance between them is more than 7.5 mm, the paper is not pressed against the cutter edge and it is difficult to cut. Therefore, position the paper cutter so the distance between the edge of the paper cutter and the position reference hole A of the printer is from 6.9 to 7.5 mm.
Figure 6-4 shows the recommended position

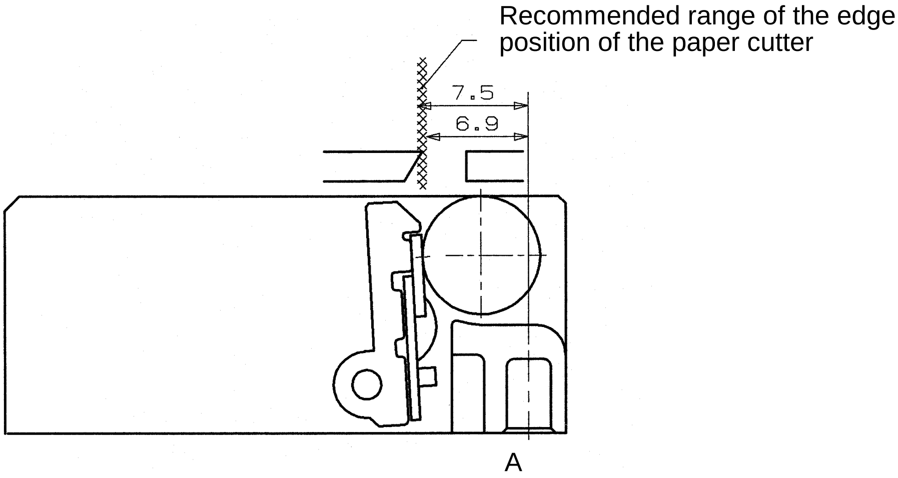


Figure 6-4 Paper Cutter Mounting Position

- Use a cutter with a sharp edge so that paper can be cut easily without excessive force.

Figure 6-5 shows the shape of the blade of the paper cutter that should be used.

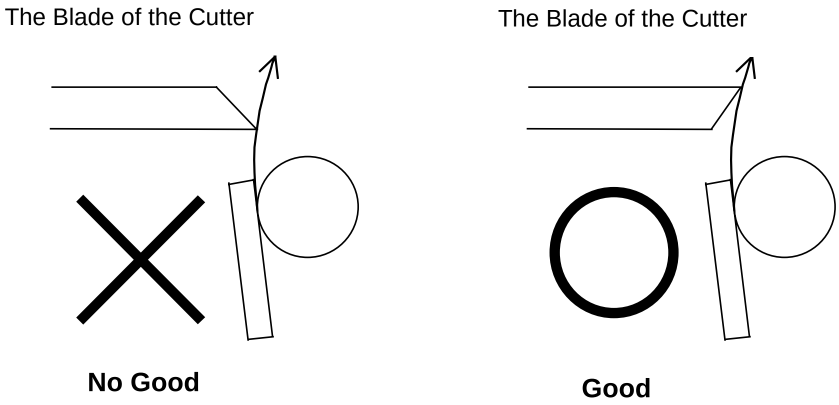
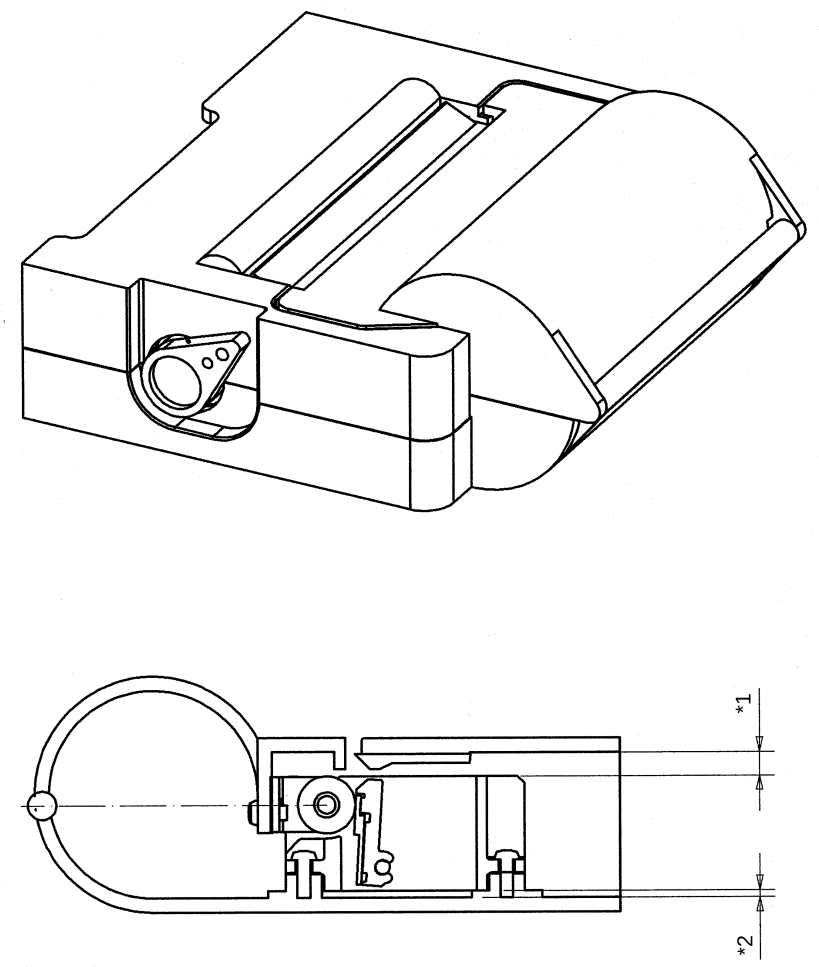


Figure 6-5 The Blade of the Paper Cutter

In the left cutter of **Figure 6-5**, the cut paper may be caught by the blade of the cutter and rolled inside. Therefore, use a cutter with the shape of a blade that will not catch the cut paper as in **Figure 6-5** to the right.

6.6 OUTER CASE STRUCTURE

Figure 6-6 shows a sample of an outer case.



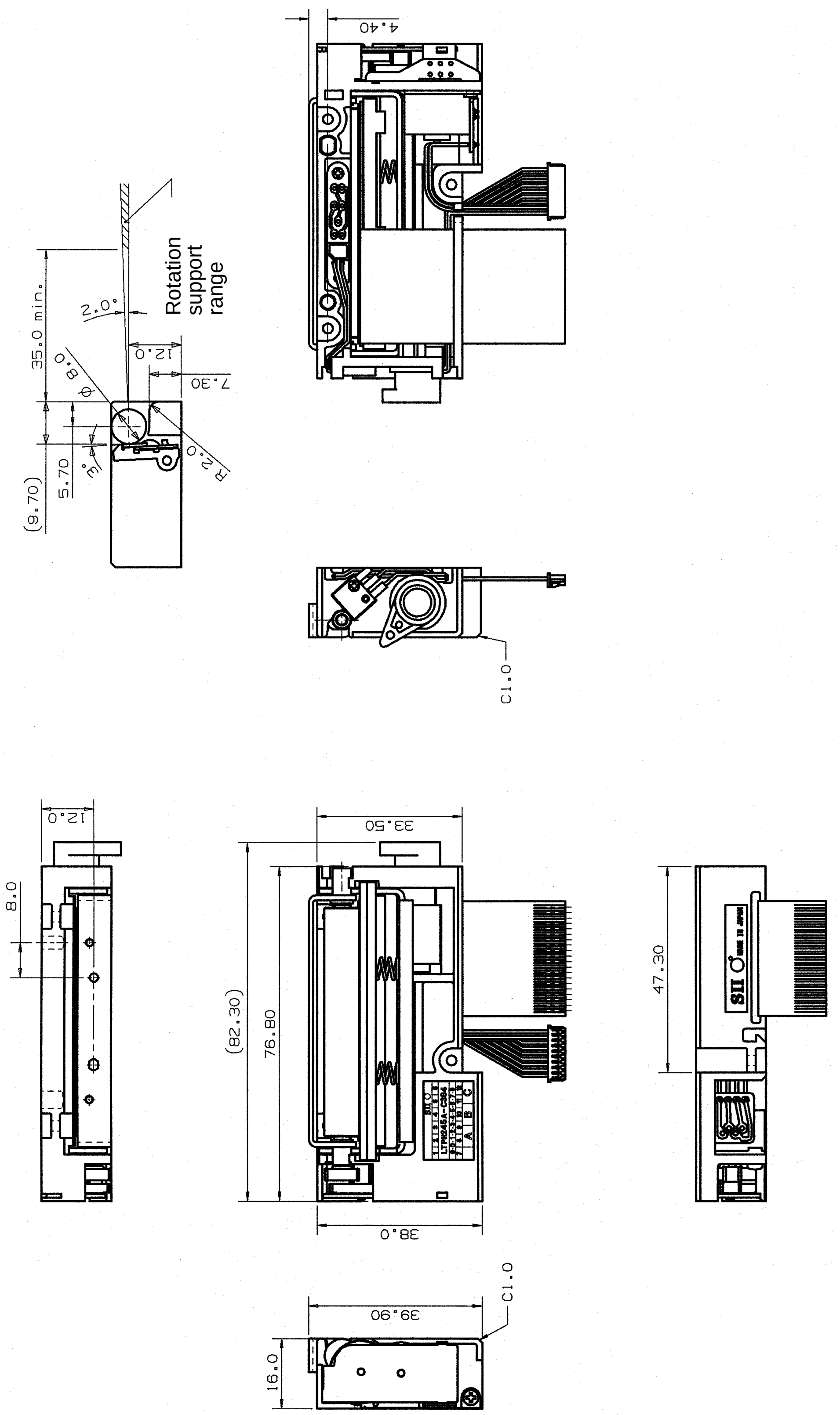
*1 Provide a gap of a few mm between the printer and the outer case to allow for cooling of the thermal head.
*2 When the FFC contacts bottom of the outer case strongly, disconnection and short circuit may occur. Provide a gap between the printer main body and the outer case.

Figure 6-6 Sample Outer Case Structure

CHAPTER 7

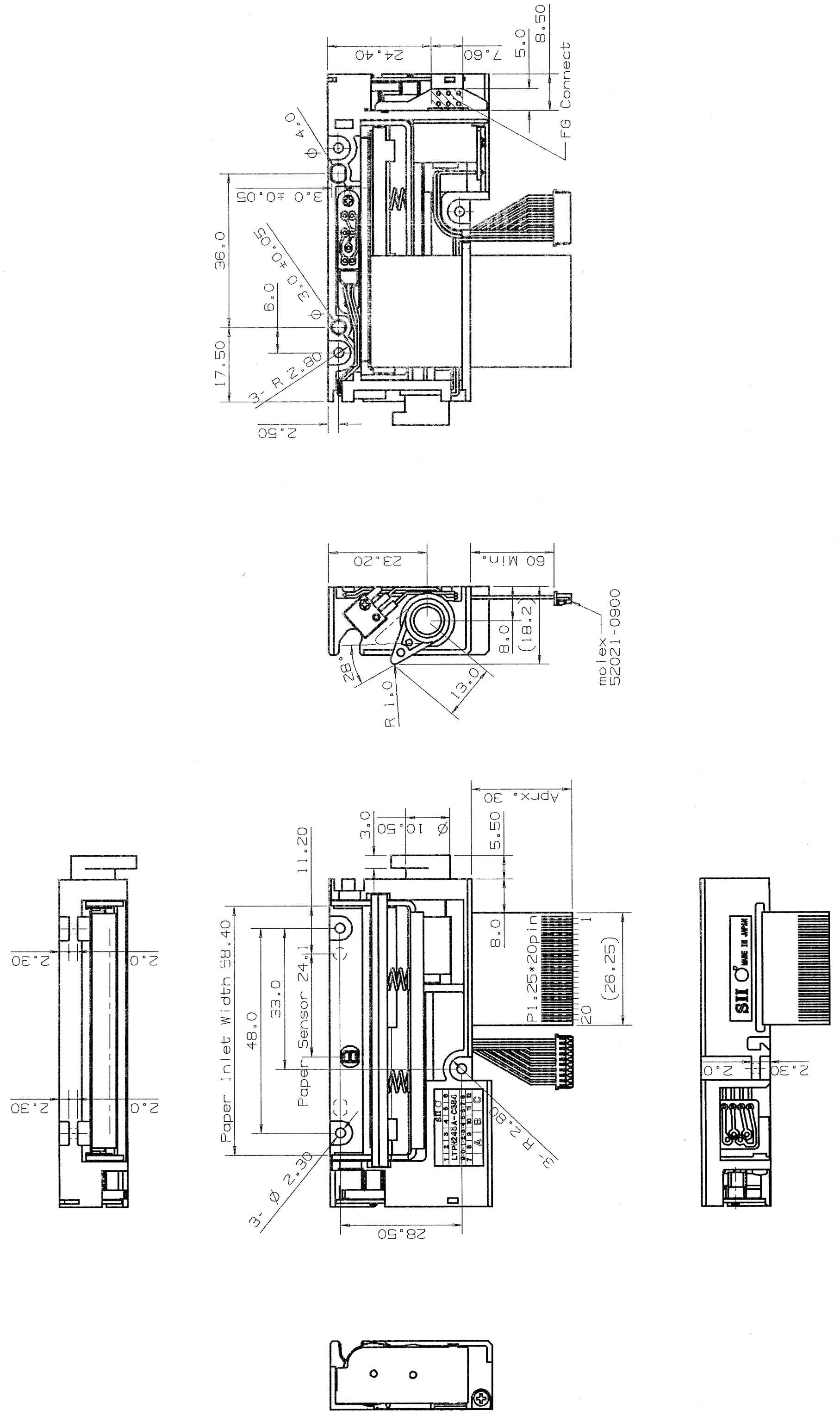
APPEARANCE AND DIMENSIONS

Figure 7-1, 7-2 and **7-3** show the appearance and external dimensions of the LTPH245.



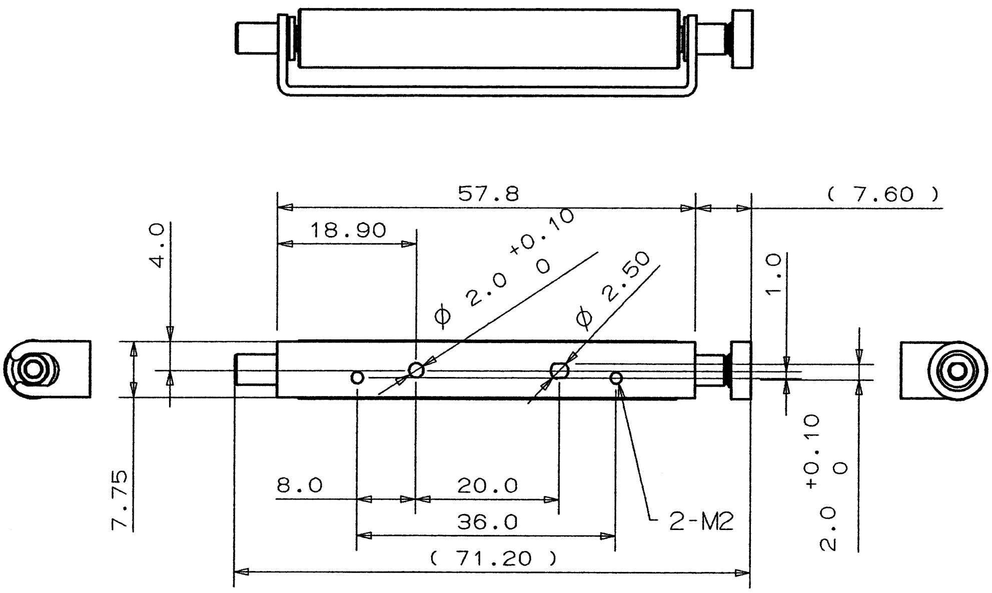
Unit : mm

Figure 7-1 Appearance and Dimensions



Unit : mm

Figure 7-2 Printer Main Body Appearance and Dimensions



Unit : mm

Figure 7-3 Platen Block Appearance and Dimensions

CHAPTER 8

LOADING/UNLOADING PAPER AND HEAD CLEANING

8.1 LOADING/UNLOADING PAPER PRECAUTIONS

1) Loading paper

- Turn the release lever in the direction of the arrow shown in **Figure 8-1**.

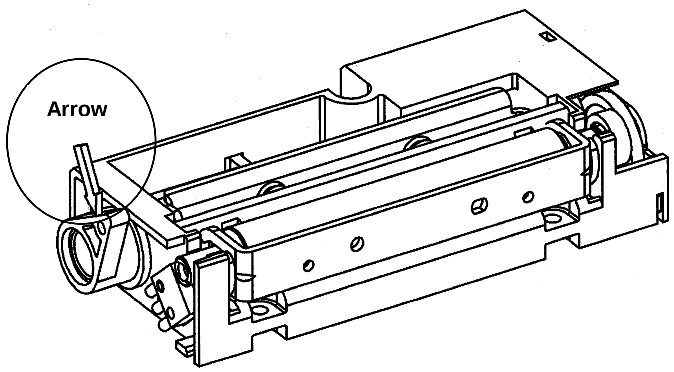


Figure 8-1 Loading Paper (1)

- After confirming that the platen block has separated from the printer mechanism, lift the platen block up.

- Insert the paper vertically into the printer. (See **Figure 8-2**).
  Pull the paper through the paper outlet and replace the platen block into the printer mechanism. Make sure that the platen block locks with a click.

- Opening the platen block exposes the reduction gear which can be damaged if touched. Therefore, take care not to damage the gear when inserting the paper. Moreover, make sure there is no foreign matter on the gear.

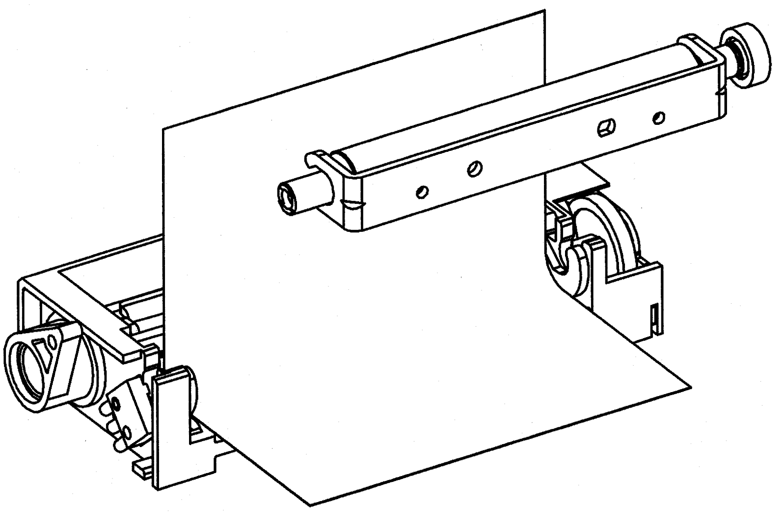


Figure 8-2 Loading Paper (2)

- The paper detector may not operate properly if covered with foreign matter. Therefore, if you find foreign matter on the sensor, remove it and clean the sensor.

- If the paper skews, feed the paper so that it returns to normal, first, then take it out and set it again.

2) Unloading paper

- Open the platen block and remove the paper.

3) Removing jammed paper

- Open the platen block and remove any jammed paper.

- Do not pull the paper by force.

8.2 HEAD CLEANING PROCEDURE AND PRECAUTIONS

8.2.1 PRECAUTIONS

1) Do not clean the thermal head immediately after printing because thermal head and its periphery are hot during and after printing.

2) Do not use sandpaper, cutter knives etc. when cleaning. They will damage the heat elements.

8.2.2 PROCEDURE

1) Turn the release lever in the direction of the arrow shown in **Figure 8-1**. After confirming that the platen block has separated from the printer mechanism, lift the platen block up.

2) Clean the heat elements using alcohol and a cotton swab.

3) Wait until the alcohol dries and close the platen block.

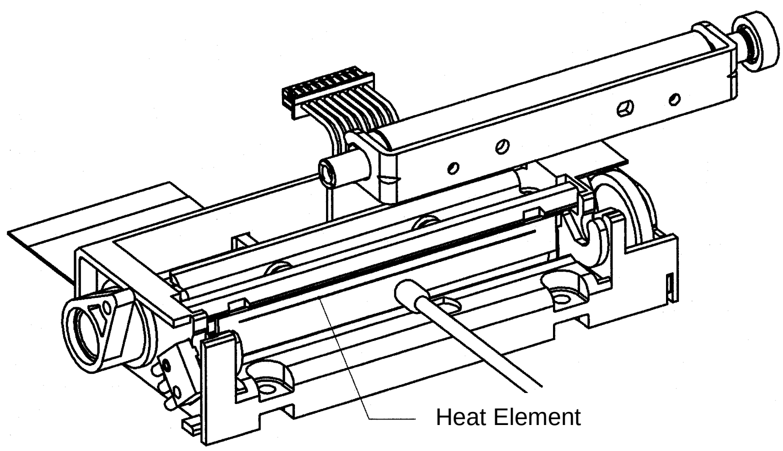


Figure 8-3 Head Cleaning Procedure