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EPSON

Thermal Line Printer

M-T173H

(2-detector Model)

Designer's Guide

STANDARD	
Rev. No.	A
Notes	

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SEIKO EPSON CORPORATION

MATSUMOTO MINAMI PLANT
2070 KOTOBUKI KOAKA, MATSUMOTO-SHI, NAGANO, 399-8702 JAPAN
PHONE+81-263-86-5353 FAX+81-263-86-9925

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Revisions		Design Section			Sheet Rev. No.					
Rev.	Document	WRT	CHK	APL	Sheet	Rev.	Sheet	Rev.	Sheet	Rev.
A	Enactment	Futatsugi	Yamada	Takami	I	A				
					II	A				
					1	A				
					2	A				
					3	A				
					4	A				
					5	A				
					6	A				
					7	A				
					8	A				
					9	A				
					10	A				
					11	A				
					12	A				
					13	A				
					14	A				
					15	A				
					16	A				

TITLE	Front Part							
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REVISION SHEET

REV.	SHEET	CHANGED CONTENTS
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TITLE

M-T173H (2-detector Model)
Designer's Guide
(STANDARD)

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1. CIRCUIT DESIGN REFERENCE

1.1 Example Motor Drive Circuit

1.1.1 Example circuit of the motor drive

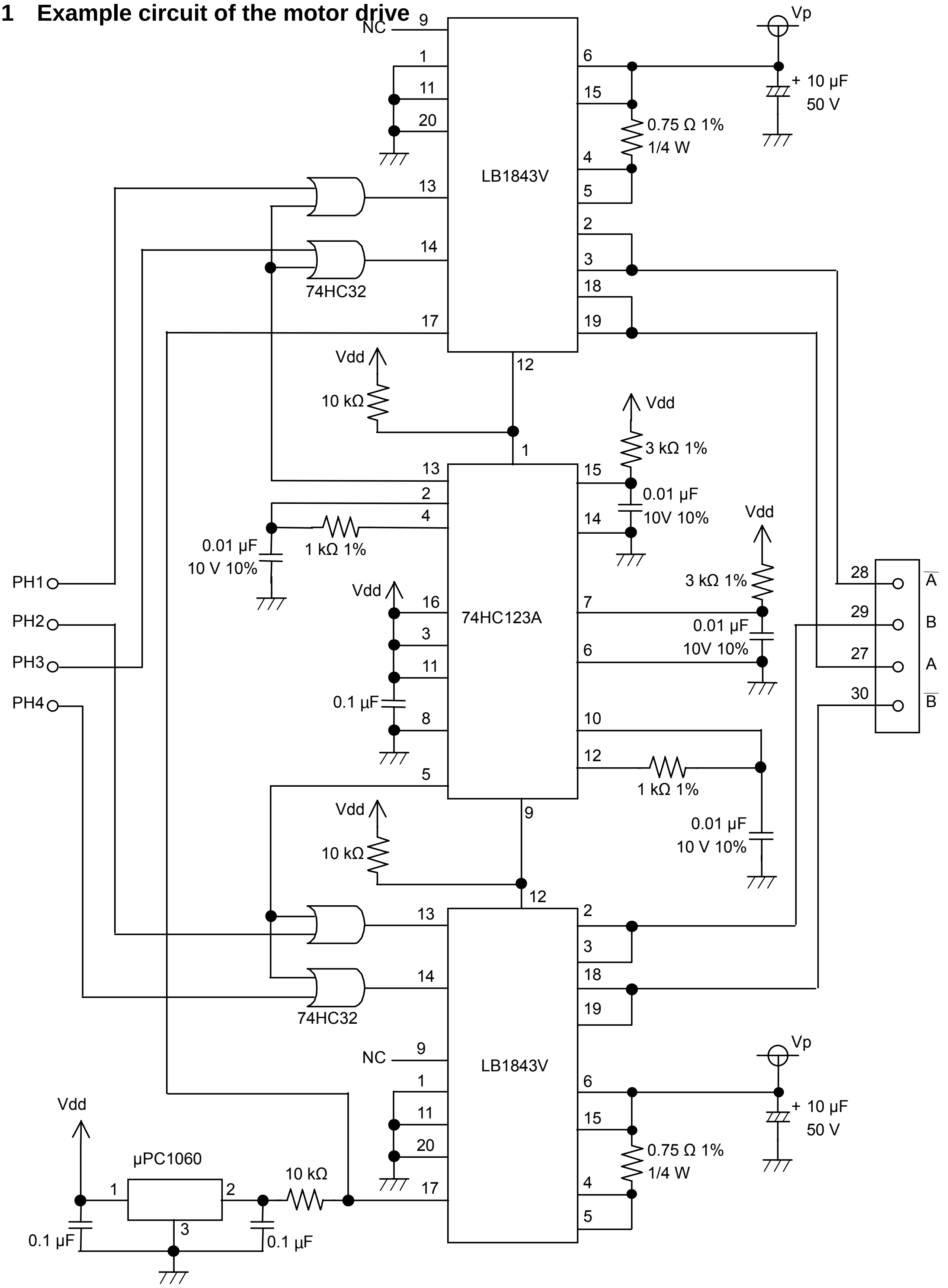

Figure 1.1.1 Example Motor Drive Circuit

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1.2 Motor drive sequence

1.2.1 Phase excitation during paper feed (rotation direction: counterclockwise (CCW) as viewed from the motor gear side)

A 4-phase bipolar stepping motor is used.
Two-phase signals are sequentially energized in order, as shown in Table 1.2.1 so that the motor rotates counterclockwise (CCW).

Table 1.2.1 Motor Rotation Direction and Phase Excitation

	Input Signal				Output Signal			
Step	PH1	PH2	PH3	PH4	$\overline{A}$	B	A	$\overline{B}$
1	L	H	H	L	L	H	H	L
2	L	L	H	H	L	L	H	H
3	H	L	L	H	H	L	L	H
4	H	H	L	L	H	H	L	L

NOTE: The motor must not be rotated clockwise (CW) as viewed from the motor gear side.

1.3 Example Power Supply Connection Circuit for the Thermal Print Head

1.3.1 Example circuit to prevent malfunction due to noise and IC crash due to surge voltage

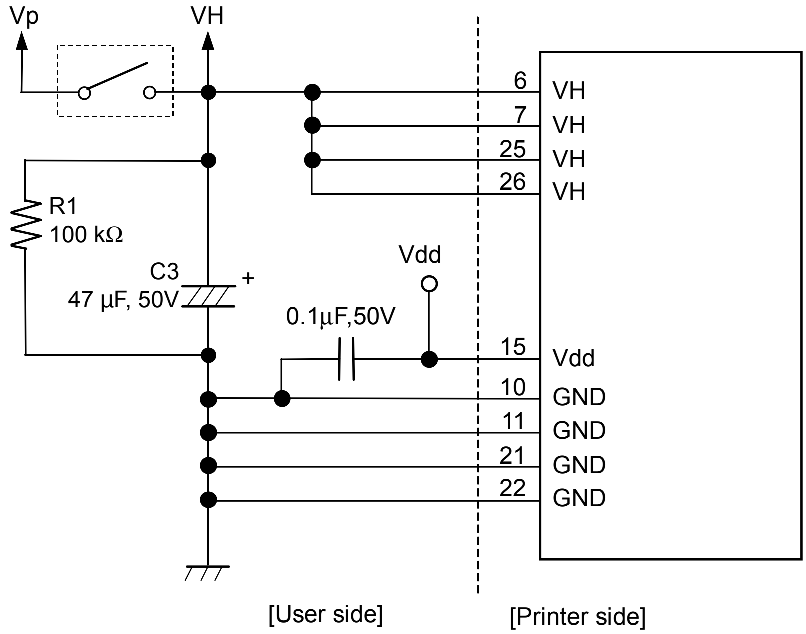
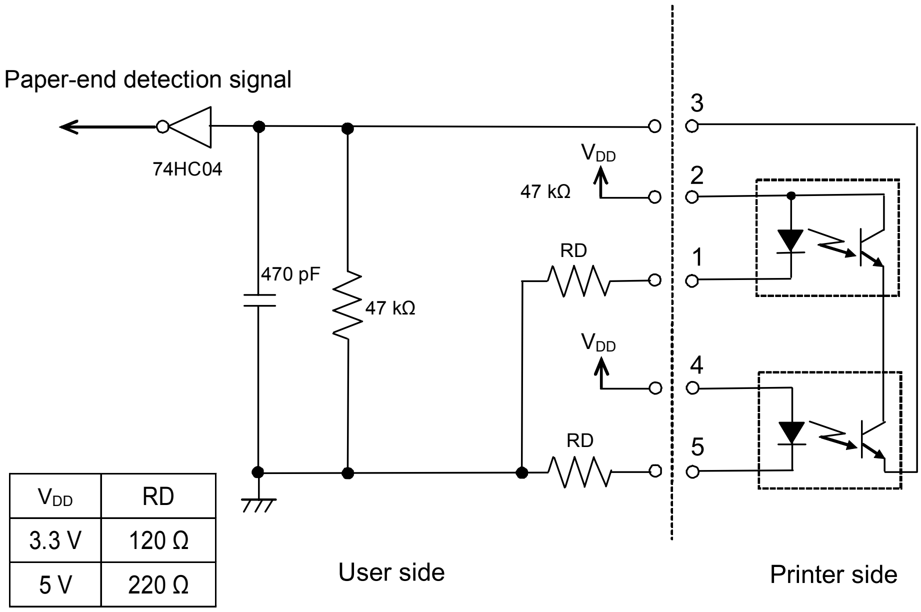


Figure 1.3.1 Example Power Supply Connection Circuit for the Thermal Print Head

1) To prevent electrolytic corrosion of the print head electrode, a device that turns the power supply for the head on/off must be installed. (See inside the dotted box line in Figure 1.3.1.)
   This device (such as FET) should have a low voltage loss.
2) Since there may be some cases that the print head is energized continuously by a CPU malfunction, be sure to turn the power off if there is a CPU malfunction.
   Otherwise, it may cause a fire or smoke.
3) To prevent electric corrosion by the capacitor C3, design the circuitry so that its charging voltage must go down to the ground level within 20 seconds after turning off the power to the print head.

1.4 Example Paper-end Signal Detection Circuit

1.4.1 Example paper-end signal detection circuit



V_{DD}	RD
3.3 V	120 Ω
5 V	220 Ω

Figure 1.4.1 Example Paper-end Signal Detection Circuit

1) To detect a paper end, sample signals for each dot line.
   If LOW is found two or more times consecutively, this is interpreted as a paper end.
2) If a paper end is detected, printing stops.
   However, if a paper end is detected while printing, it is possible to print 15 dot lines or less (30 steps for the motor) from the position when a paper end is interpreted.
3) To prevent deterioration with aging of the paper detector due to constant energization, the element (such as FET) that stops supplying the power to the detector must be implemented when the detector is not used.
   To detect paper, read the signal when 1 ms or more has passed after starting energization.
4) To prevent incorrect operation of the paper detector due to ambient light, the printer case must be designed so that the detector is not exposed to ambient light.

2. CONTROL DESIGN REFERENCE

2.1 Motor Drive Frequency

2.1.1 Slow-up table

1) When starting motor operation, gradually accelerate the motor according to Table 2.1.1 slow-up table until the maximum motor drive frequency is reached, and then drive the motor at the constant speed.

   Calculate the maximum frequency for driving the motor matched to its drive voltage according to the formula in 2.1.2.

Table 2.1.1 Motor Slow-up Table

Step	Drive frequency (PPS)	Drive cycle (µs)
Start rush-driving (a)	-	30000
1	332	3013
2	430	2327
3	512	1953
4	584	1712
5	649	1541
6	708	1412
7	763	1310
8	815	1227
9	864	1158
10	910	1099
11	954	1048
12	996	1004
13	1037	964
14	1076	929
15	1114	898
16	1150	869
17	1186	843
18	1220	819
19	1254	798
20	1287	777
21	1318	758
22	1350	741
23	1380	725
24	1410	709
25	1440	694

(Unit: µs, Precision: ±50 µs in the deceleration and acceleration range, however, ±50/-0 µs in the constant speed range)

NOTE: Uneven printing is sometimes caused by voltage fluctuation or some print patterns.

2.1.2 Motor drive

1) Maximum motor drive frequency

Calculate the maximum frequency for driving the motor matched to its drive voltage according to the following formula to drive the motor:

When Vp > 5.5 V

Vp x 160 + 80 (pps) (max.: 1440 pps)

When Vp ≤ 5.5 V

Vp x 210 - 195 (pps)

Table 2.1.2 Example of Maximum Motor Drive Frequencies

Motor drive voltage (V)	Maximum motor drive frequency during paper feed (pps)	Minimum motor drive cycle Tm (µS)	Paper feed speed (mm/s)
4.5	750	1333.3	46.9
5	855	1169.6	53.4
6	1040	961.5	65
7.2	1232	811.7	77
8	1360	735.3	85
8.5	1440	694.4	90

2) Motor start/stop methods

To start the motor from a stopped (non-excited) state, perform start rush-driving for 30 ms at the same phase as the stop step, and then start slow-up control.

To restart the motor during stop-rush driving, stop stop-rush driving, and start slow-up control.

To stop the motor, perform stop rush-driving for 30 ms at the same phase as the finish motor phase.

(Do not stop the motor at the same phase in which printing energizing is finished.)

Do not energize the motor while it has stopped.

NOTES: 1. During printing, drive the motor while varying the motor drive frequency according to the operating conditions (voltage, temperature, number of energizing dots, etc.)

2. Be sure to perform rush driving when starting and stopping the motor.

2.2 Print head Control

To calculate the pulse width, use a compensation coefficient in formula 2.2.1 according to the use conditions. Calculate each value shown in formula 2.2.2-1 to 2.2.4-2, and then apply the pulse width according to the PLS value calculated by assigning a value to formula 2.2.1.

Two energizations must form 1 dot.

2.2.1 Energizing pulse width PLS (μs)

$PLS = Pt \times Qv \times Qs \times Qc \times Qd$ {Allowable = 5 %} ….. Formula 2.2.1

- Pt is defined as follows, depending on the temperature detected by the thermistor:
  When $-20 \leq T \leq 34$: $Pt = -12 \times T + 945$ ….. Formula 2.2.2-1
  When $34 < T \leq 80$: $Pt = -7.45 \times T + 790$ ….. Formula 2.2.2-2
  T: temperature detected by the thermistor (°C)

- Q_V is defined as follows, depending on the print head terminal voltage:
  $Q_V = (0.1 \times VH \times VH - 3 \times VH + 66) / (VH \times VH)$ ….. Formula 2.2.3
  V_H: Print head voltage (V)

- Qs is defined as follows, depending on the motor drive cycle:
  When $697 \leq SLT < 3500$ (μs): $Qs = 1.35 \times LOG(SLT/1000) + 0.845$ ….. Formula 2.2.4-1
  When $3500 \leq SLT < 10000$ (μs): $Qs = 2.53 \times LOG(SLT/1000) + 0.2$ ….. Formula 2.2.4-2
  SLT: Cycle time of energizing the motor (μs)

  Use the motor drive cycle in the order shown in Table 2.1.1 Motor Slow-up Table from step 1. Calculate the minimum motor drive cycle from the maximum motor drive frequency calculated in 2.1.2 Motor drive and set the motor drive cycle to more than the minimum motor drive cycle.

- Qc is defined as follows, depending on the number of the heat elements in each strobe energized simultaneously:
  When $1 \leq n \leq 16$: Qc = 0.92
  When $17 \leq n \leq 32$: Qc = 0.96
  When $33 \leq n \leq 48$: Qc = 1.00
  When $49 \leq n \leq 64$: Qc = 1.05
  When $65 \leq n \leq 80$: Qc = 1.10
  When $81 \leq n \leq 96$: Qc = 1.15
  When $97 \leq n \leq 112$: Qc = 1.20
  When $113 \leq n \leq 384$: Qc = 1.26
  n: amount of the dots that are simultaneously energized with each strobe signal

- Qd is defined in the range of 1.0 to 1.2, depending on the thermal paper type and printing conditions.

NOTES:
1. If the SLT is completed before turning off the head energization, do not change the phase of the motor before turning off the head energizing.
2. Keep motor drive frequency in 2.3.6 Drive method in the specification in mind because the motor drive frequency depends on the head energization time.

2.3 Timing Chart

2.3.1 Initial setting

1) When the power is turned on, the motor is driven 20 steps with a constant speed at 3.013 ms to adjust each phase of the stepping motor.
2) When the motor restarts after holding, execute a phase excitation sequence, rush-driving the last phase of the drive sequence in use when the motor stopped.

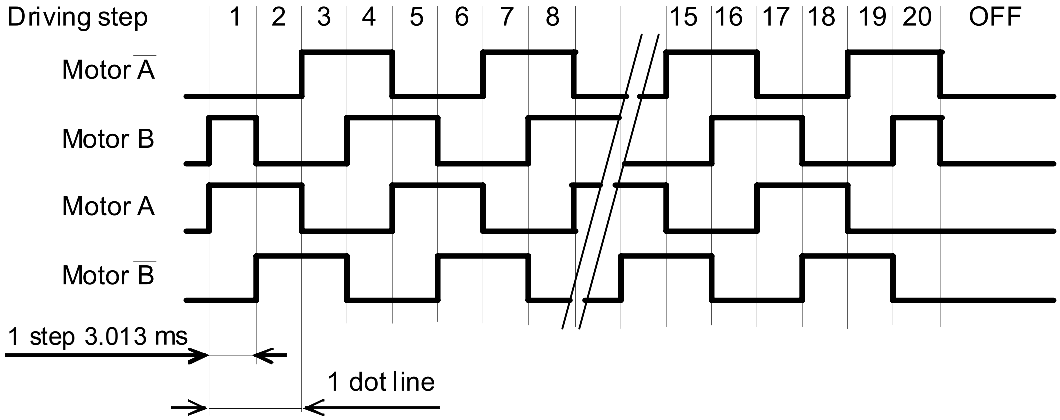


Figure 2.3.1

2.3.2 Paper feeding

1) To start feeding paper, rush-drive the last phase at the initial setting or the last phase in use when the motor stopped.
   The motors are driven at a constant-speed after a one-step slow-up.
2) Energizing the motors in each step is performed according to the slow-up table and constant drive time shown in table 2.1.1.
3) To stop the motor, energizing all phases is stopped after carrying out rush-drive to the last phase for 30 ms.

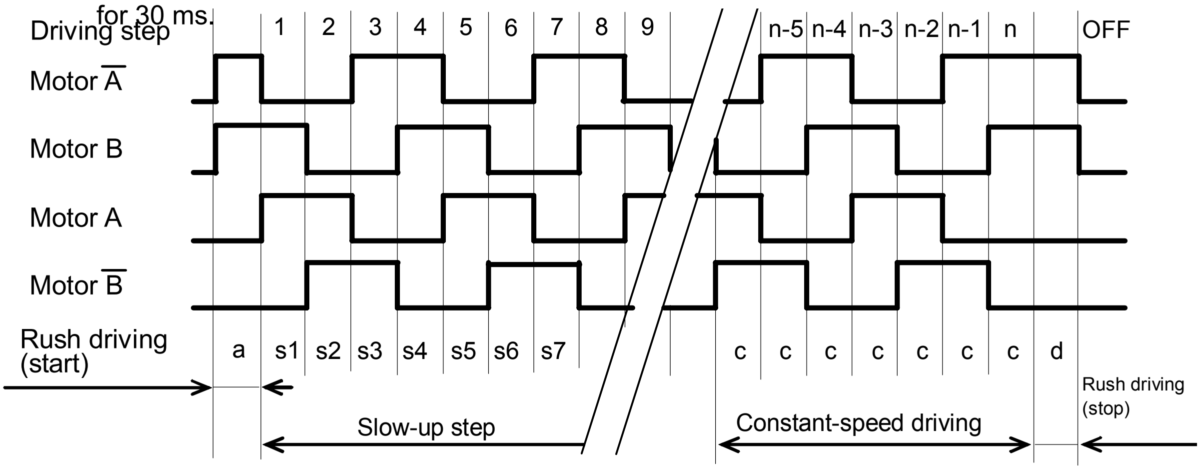


Figure 2.3.2 Motor Timing Chart in Paper Feeding

4) Drive frequency for each step

Rush driving (start)	a = 30 ms
Slow-up	s
Constant speed driving	c
Rush driving (stop)	d = 30 ms

2.3.3 Printing

Concrete values are applied to the following example conditions to provide examples of calculation and timing chart. See Figure 2.3.5 for a timing chart example.

Example: When starting printing at 7.5 V, 25°C, 384-dot printing (128-dot simultaneous energization, 3-partition printing), energizing twice per dot

1) To start printing, the sequence is the same as that for paper feeding.
Rush-drive for 30 ms in the last energizing phase at the initial setting or the last phase in use when the motor stopped.

2) Drive the motor by 1 step.

3) Maximum drive frequency = 7.5 × 210 – 195 = 1380 pps Tm (7.5 V) = 1 × 106/1380 = 725 μs
<First dot of the first drive pulse>

4) Calculate PLS and energize the print head.
(For being the first step of slow-up) Motor drive cycle: 3013 μs > Tm
Therefore, SLT = 3013 μs
Head temperature check: T = 25
Pt = -12 × 25 + 945 = 645
Qs = 1.35 × LOG (3013/1000) + 0.845 = 1.492
Qv = (0.1 × 7.5 × 7.5 -3 ×7.5 ×66)/(7.5 × 7.5)= 0.873
Qc = 1.26
Qd = 1
PLS = Pt × Qs × Qv × Qc × Qd = 1059 μs
Energize the print head in order of (STB1 + STB4), (STB2 + STB5), and (STB3 + STB6) at 1059 μs.

5) How to calculate the time for printing
Assume time of delay in energization as 30 μs
(PLS+30 μs) × 3-partition energization) = (1059 + 30) × 3 = 3266 μs

6) Switch the motor phase.
Slow-up rate: 3013 μs < printing time: 3266 μs
Therefore, switch the motor phase 3266 μs after completing printing.

7) Calculate PLS and energize the print head.
(For being the second step of slow-up) Motor drive cycle: 2327
Therefore, SLT = 2327 μs
Head temperature check: T = 25
Pt = -12 × 25 + 945 = 645
Qs = 1.35 × LOG (2327/1000) + 0.845 = 1.340
Qv, Qc, Qd remains the same as the first dot.
PLS = Pt × Qs × Qv × Qc × Qd = 951 μs
Energize the print head in order of (STB1 + STB4), (STB2 + STB5), and (STB3 + STB6) at 951 μs.

8) How to calculate the time for printing
Assume time of delay in energization as 30 μs
(PLS+30 μs) × 3-partition energization) = (951 + 30) × 3 = 2944 μs

9) Switch the motor phase.
Slow-up rate: 2327 μs < printing time: 2944 μs
Therefore, switch the motor phase 2944 μs after completing printing.

10) Repeat steps 4) through 9) to print.
Further, the 24th step being the 24th step of slow-up step, motor drive frequency: 725 μs = Tm
Therefore, SLT = 725 μs
So, slow-up ends here and SLT becomes 725 μs in the following steps.

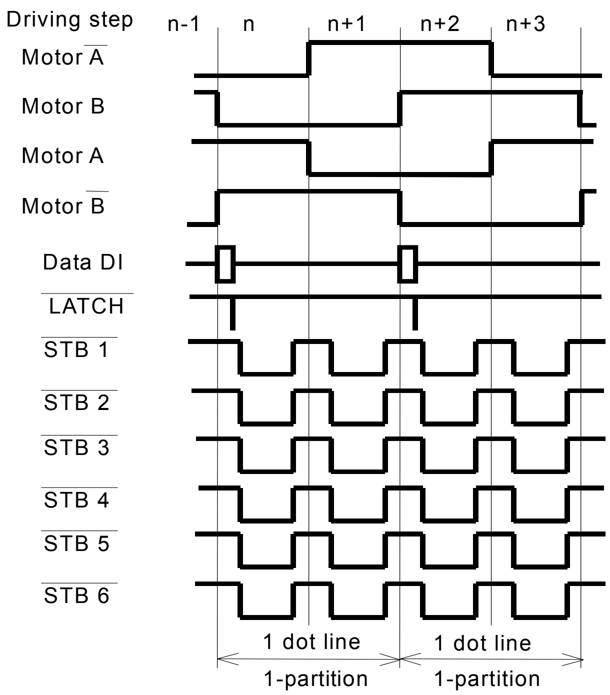


Figure 2.3.3 Example of 1-partition Energizing Timing

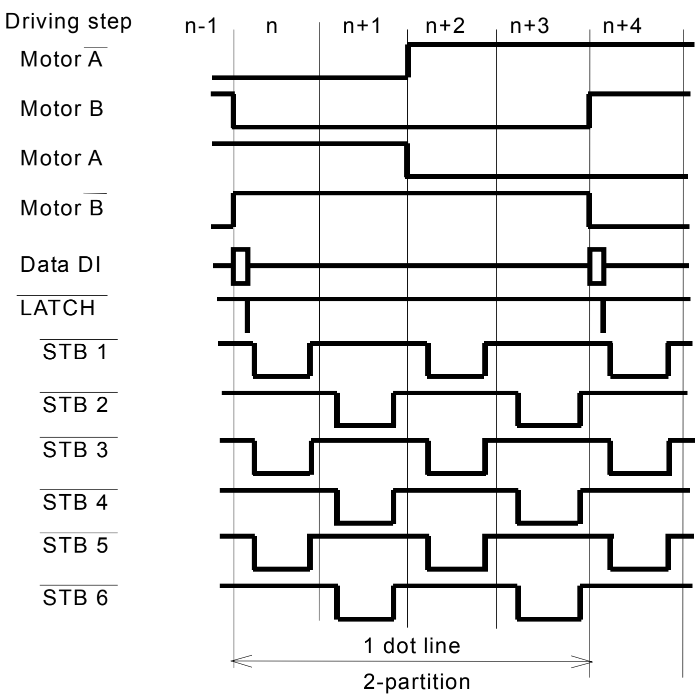


Figure 2.3.4 Example of 2-partition Energizing Timing

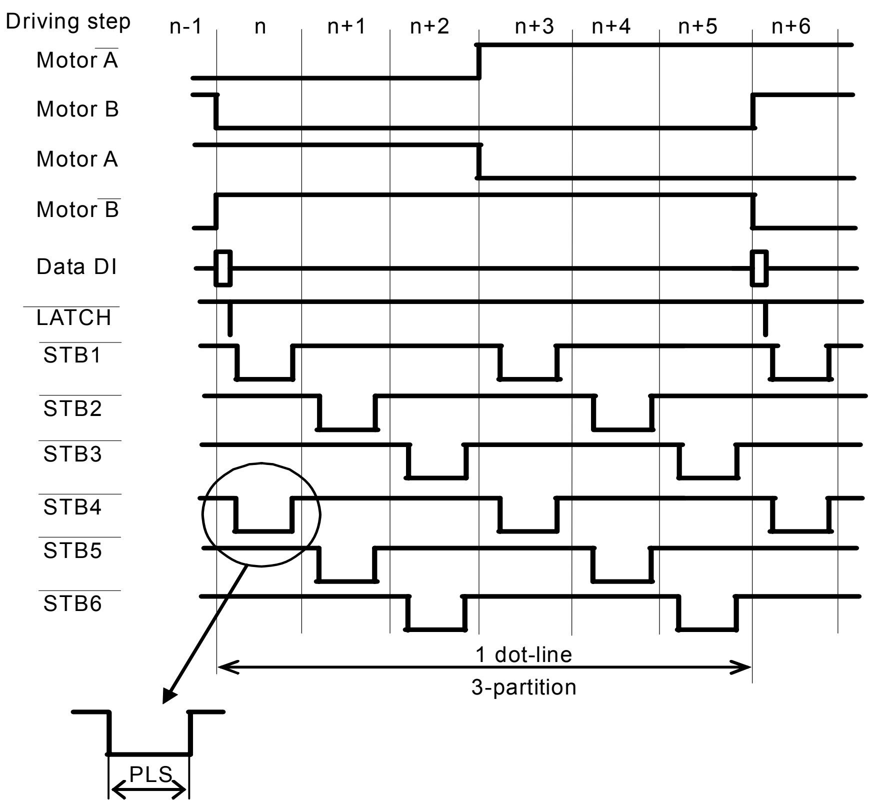


Figure 2.3.5 Example of 3-partition Energizing Timing

NOTE: The timing charts show only printing.

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3. CASE DESIGN REFERENCE

3.1 Designing and installation of the Case of the Printer Main Unit

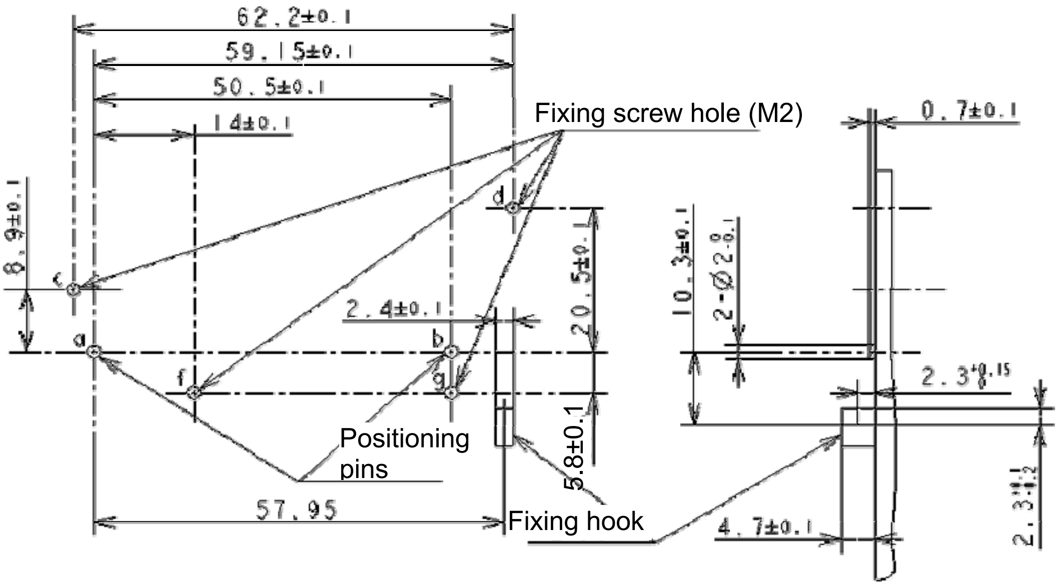
Fasten the printer main unit with the two positioning pins, either a fixing hook, or two screws.

Figures 3.1.1 shows the shape of the mounting portion on the case side.

3.1.1 Designing the printer main unit mounting location

1) See the overall dimensions for the positions of the fixing screw hole and positioning holes on the main unit.
2) When mounting the printer, select either of the methods below to fasten the printer, and use the positioning pins (a, and b) for positioning.
   - Method 1: 2 fixing screw holes (c, and d) and a fixing hook
   - Method 2: 2 fixing screw holes (c, and d) and one of the 2 fixing screw holes (f, or g)

   No part of the printer except the mounting-foot locations should touch the case.
3) Be sure that the height of positioning pins is 0.7±0.1 mm, and the diameter is Φ2+0/-0.1 mm.
4) Recommended screws: round head screws M2.0, round head screws nominal 2.0 for plastic.
5) Pay attention to the following points when mounting the printer main unit:
   - Do not apply unnecessary force on the printer main unit and prevent it from being deformed.
   - The installation base must have sufficient strength to prevent deformation, etc. when the platen open lever is operated for removal of the platen unit.
   - When removing and attaching the platen unit, the connector cable (FPC) moves 1 to 2 mm. Therefore, provide enough length to the connector, or print quality may be affected.



[Units: mm]

Figure 3.1.1

3.1.2 Designing the roll paper insertion and exit parts

1) Design the roll paper insertion part so that the paper insertion angle to the printer is within 22 to 60° down from the horizontal face.
2) The roll paper supply load must be 0.49N {50 gf} or less.
3) To prevent incorrect paper feeding and paper jams, the paper holder must be designed so that the center of the paper printer guide width matches the center of the roll paper. The holder must be able to guide 57.5±0.5 mm wide paper.
4) The case must be designed to prevent the paper from rewinding around the roll paper.
5) Design the paper exit area on the printer case so that paper can be fed smoothly.
6) Design the case for the roll paper supply unit for guiding 27.5±0.5 mm wide paper as shown in Figure 3.1.3. Polycarbonate, SUS (stainless steel), or other less-wearing materials are recommended for the division plate.

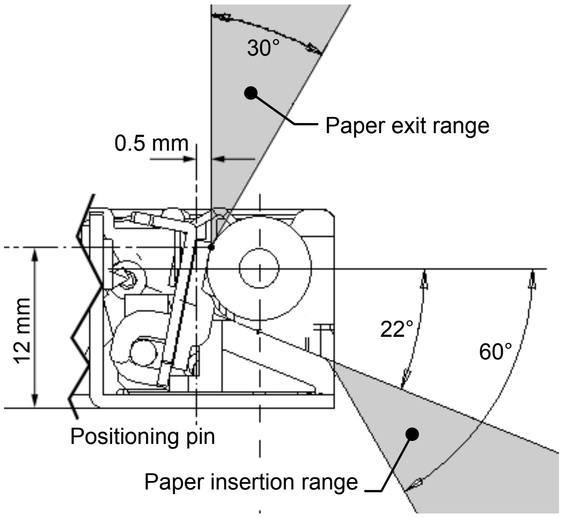
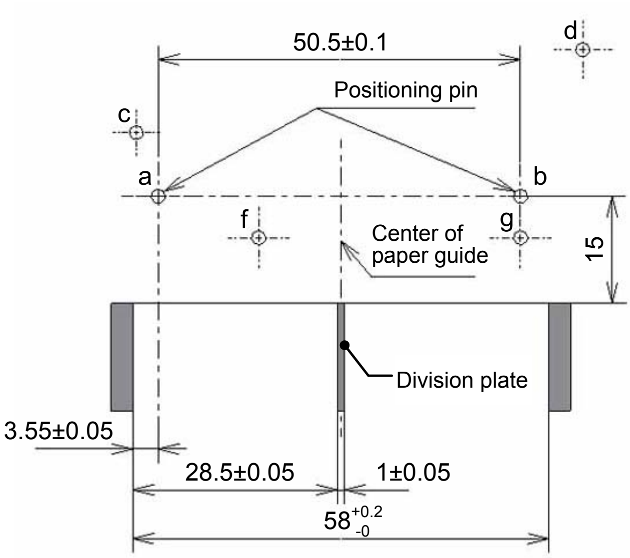


Figure 3.1.2



[Units: mm]

Figure 3.1.3

3.1.3 Measure to prevent malfunction of the paper end detector

To prevent malfunction of the paper end detector, design the case so that light from outside (natural light, light from illumination, etc.) does not directly strike the paper-end detector.

3.1.4 Designing the platen open operating portion on the case side

Design the platen open operating portion on the case side so as to apply the required amount of force for opening the platen.

When providing an operating portion to be pressed by finger, design it in an easily operable size.

3.1.5 Installing the ground cable

1) To install the ground cable, secure the printer at fixing screw hole C and secure it with a fixing screw. See the overall dimensions for the positions of the screw holes for installing the printer.
2) Round crimped terminals of outside diameter Φ5.5 mm or less are recommended for use on the printer side of the ground cable.

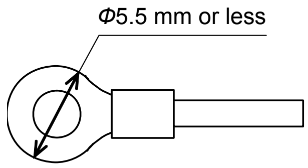


Figure 3.1.4

3.1.6 Cutter installation position

1) Arrange the cutter blade position so that its edge is positioned within the range of paper ejection shown in Figure 3.1.2.
2) Design the area from the paper exit to the case so as not to catch the paper edge.

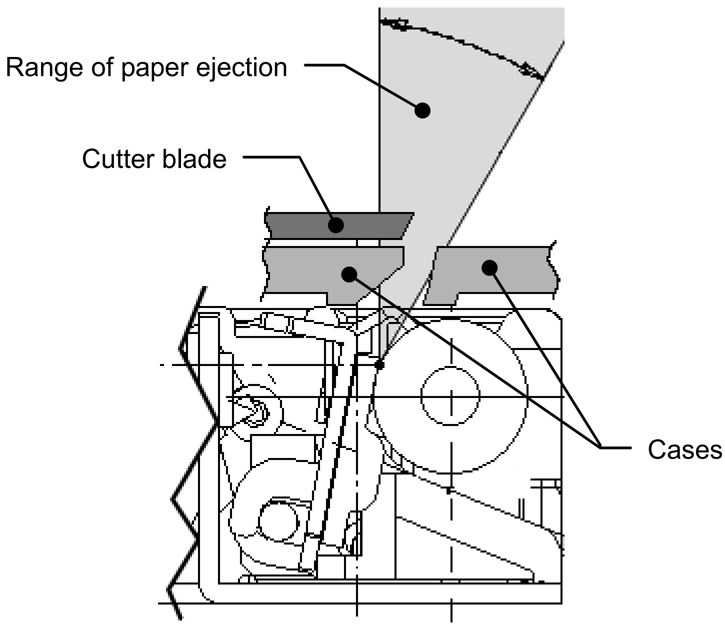


Figure 3.1.5

3.2 Designing the Case for the Platen Unit

3.2.1 Installing the platen unit

To install the platen unit, first prepare a snap fit support for fitting in the platen unit bearing on the case (e.g. plastic paper cover), and then fit the platen unit bearing in the snap fit support.

Figure 3.2.1 shows the shape of the snap fit unit.

Polycarbonate is the recommended plastic material for the platen unit bearing support. The platen unit bearing will not fit in the support if aluminum or other metal is used.

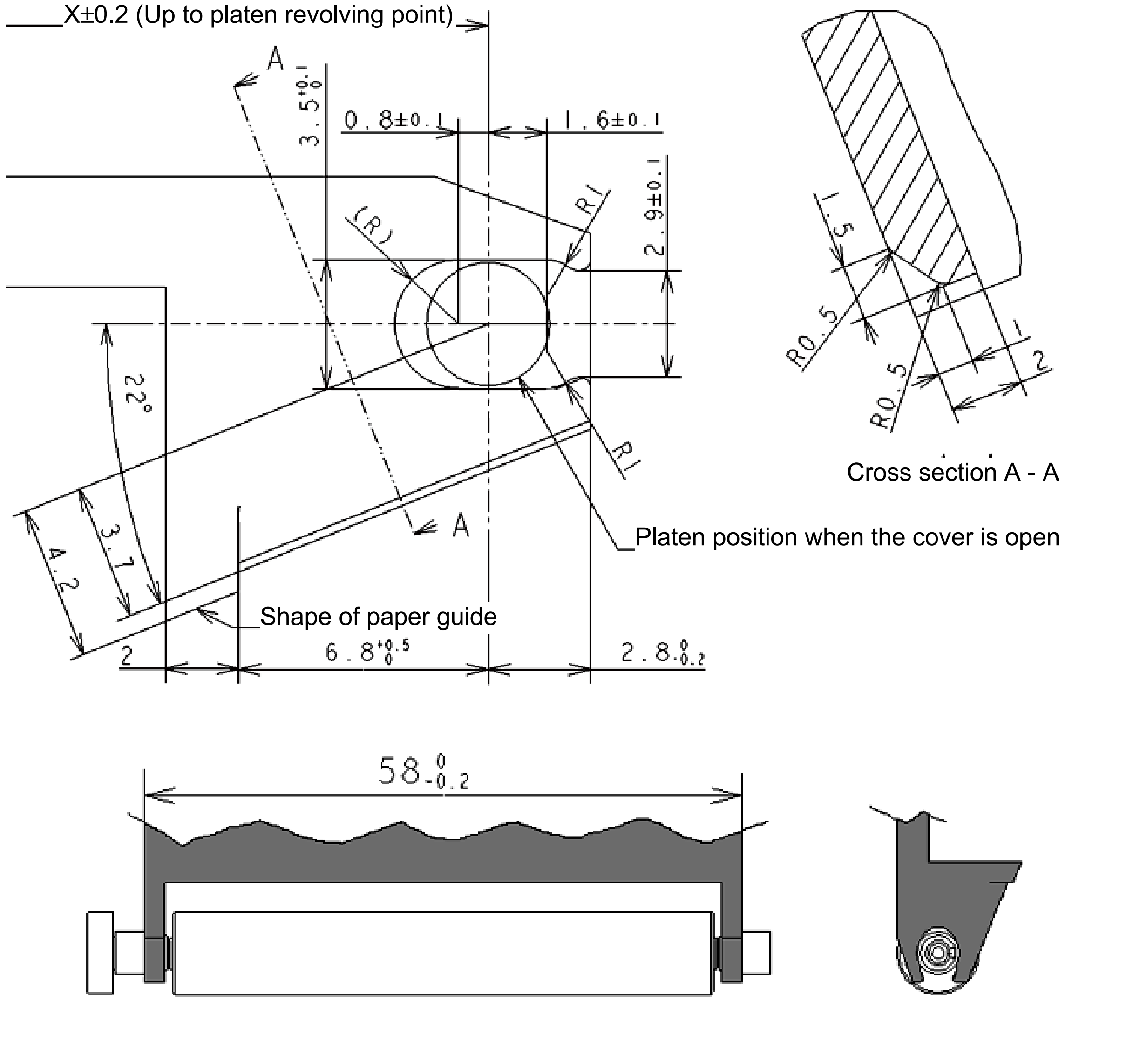


Figure 3.2.1

Cross section AA above shows the paper guide to be used when inserting the receipt cover is being inserted. To stabilize the paper position while paper feeding and to detect a paper-end accurately, the paper guide must be shaped as shown in Figure 3.2.1.

3.2.2 Positional relation between the platen unit and printer main unit

Figures 3.2.2 shows the relations between the installation positions of the platen unit and printer main unit.

1) Limit the shift to the left and right to within ±0.2 mm of printer main unit positioning hole a.

2) Pay attention to the following point when installing the platen unit:

- When designing the case, check the platen unit installation positions and bearing support positions. If these positions are inappropriate with respect to the printer main unit, the platen unit cannot be fixed at the specified position on the printer main unit, which will cause problems in print quality, operation, etc.

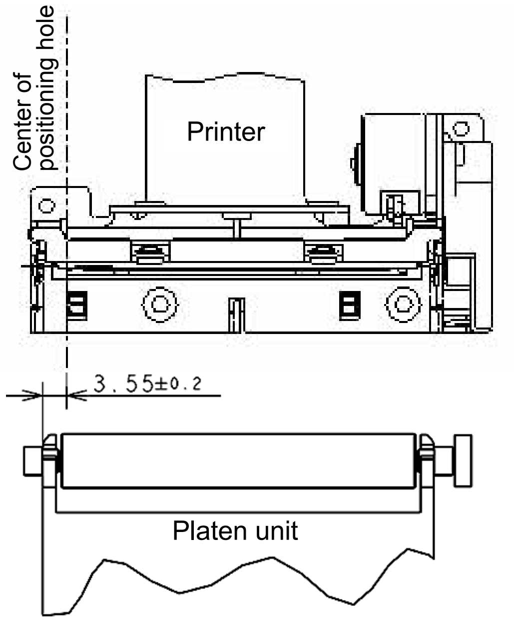


Figure 3.2.2

3.2.3 Cautions on designing the paper cover

The platen unit is held in place by the platen bearings on the left and right. If an attempt is made to close the paper cover with the left and right sides misaligned, the platen unit may be incompletely held (single holding).

Make sure of the following points to prevent problems due to printer operation with single side of the platen unit held:

1) The receipt cover has a shape that is high in torsional rigidity.
2) To close the receipt cover evenly on the left and right, devise the shape of the operating portion of the receipt cover (the part that is pressed by a finger); for example, place the receipt cover in the center.
3) The receipt cover should be so designed that the irregular position (e.g. tilt) of the platen bearings can be found easily.