THERMAL PRINTER TECHNICAL MANUAL Ver. 1.0

Fujitsu Component Ltd.

Introduction

This technical manual describes precautions and usage when a thermal printer, made by Fujitsu Component Ltd., is used. Thoroughly read this manual and comprehend the contents prior to use. Refer to the respective product specification for a detailed description of the product.

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Appendix 2 Energy conditions of FTP-608 series

1. What is a thermal printer?

1.1 Comparison of printing methods and features of a thermal printer

Printer types are classified into impact type and non-impact type. An impact type transfers characters or dots onto plain paper via an ink ribbon, for example, and is represented by a typewriter and wire dot printer. A non-impact type is printing which does not use the impact principle, and is represented by a laser printer and ink jet printer. A thermal printer is a non-impact type, and there are two types: a serial type which moves a thermal head horizontally with respect to a paper feeding direction, and a line type which has heating elements lined up throughout the printing width.

The market for thermal printers is increasingly expanding since the mechanism is simple, compact, maintenance is easy, and use is stable even in a poor environment, and also because of the commercialization of thermo-sensitive paper, which can be stored for a long time and storage life is guaranteed for 10 years. Table 1 shows the advantages and disadvantages of each printer type.

Table 1 Comparison of printer types

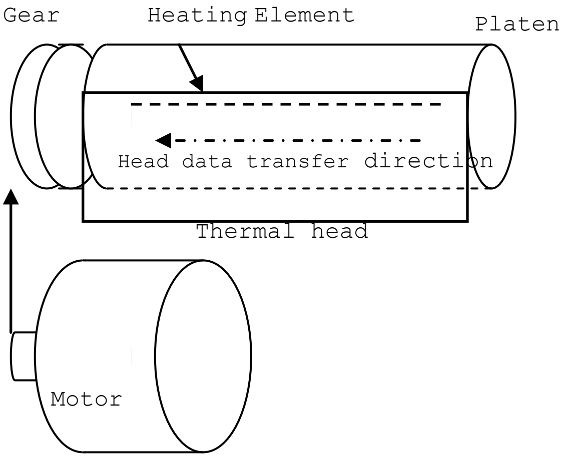
Type	Intended use	Advantage	Disadvantage
Thermal printer	General business use (POS, label printer, ticket machine, receipt printer, etc.)	• Usable in most environments, high-speed printing possible • Simple mechanism, downsizing possible • Good maintainability	• Special paper required • Storage of thermal paper easily influenced by environment
Laser printer	Office equipment	• High resolution printing • Printed matter storage period is long • Plain paper can be used	• Fusion processing required • Vulnerable to environment • Device size is large • Poor maintainability

Ink jet printer	Home use Office use	• Relatively compact, full color supported • Plain paper can be used	• Vulnerable to environment, ink clogging may occur • Consumes large volume of ink • Slow printing speed

1.2 Principle of thermal printer

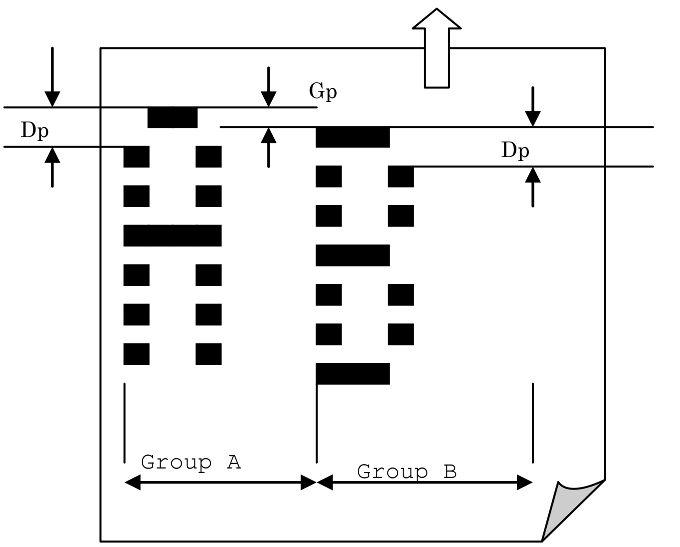
Fig. 1 shows a block diagram of a thermal printer. A thermal printer is comprised mainly of a thermal head for printing data, a platen where paper is inserted and fed, a gear installed on one side of the platen, and a motor for transferring the feeding force and angle (normally a stepping motor is used).

Fig. 1 Configuration of thermal printer



Data is sent to the head when data is printed. Once print data is complete, the data is latched by an IC mounted on the head. And once data is latched, the next print data can be sent to the head even if previous data is being printed.

Fig. 2 Printing timing



Dp: Pitch of one dot line
Gp: Shift between groups
Group A: Group A which energized simultaneously
Group B: Group B which energized simultaneously

For printing, 1 dot line is normally separated into groups to be energized, in order to suppress a peak current. Fig. 2 is an example when 1 dot line is separated into two groups.

When previous printing ends and the next printing starts, the motor is positioned at the next printing position. At the timing of printing, the current phase of the motor is output, and Group A is energized. Energization for a predetermined time is required for color printing. After Group A is energized, the motor is moved for a half of 1 dot (Dp) (Gp = Dp/2 in the example at the right). Group B is energized synchronizing with the activation of the motor. After printing Group B, the motor phase is moved to the next phase, and a gap Gp is also generated at this time. As a result, the timing to print the next dot line shifts by 2x Gp = Dp from the previous Group A. The step difference Gp between Group A and Group B is too small to be recognized. When Group B is energized, the next line data is transmitted to the head, and the head stands by. When the energization of Group B is over, the already transmitted data is latched. By repeating this sequence, a target image is recorded on thermo-sensitive paper.

2. Before using thermal printer

A thermal printer uses thermo-sensitive paper. The following precautions are required to use thermo-sensitive paper.

2.1 Operating environment

If the operating environment conditions are quite different from the following, or if there are questions, contact one of Fujitsu Components Ltd. sales offices prior to use. Thermo-sensitive paper is vulnerable to high temperature, high humidity and solvents, and the temperature range is -35°C ~ 75°C at most. See Fig. 3 for the temperature and humidity ranges.

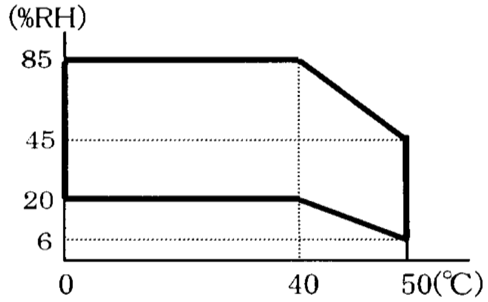


Fig. 3 Operating environment conditions

If the thermal head is applied constant voltage for a long time in a humid environment, the connected portions of the thermal head deteriorate due to electric corrosion caused by ions (K^+, Na^+, Cl^- and S^-) included in the thermo-sensitive paper and air. Do not use the printer when temperature and humidity are high or when condensation occurs, or in an environment which contains a high volume of the above mentioned ions. If condensation occurs, immediately shut the head power OFF and completely dry off the printer prior to using it again.

The front surface of the thermo-sensitive paper is made of water soluble material. Therefore if paper is inserted between the head and the platen in a damp status, the thermo-sensitive paper surface may adhere to the head surface. If printing is continued in this status, paper may jam or print data may not be completely printed because of the thermo-sensitive agents adhering to the head surface. At the worst, radiation of the head heating element is affected, and the head becomes damaged. In this case, immediately remove foreign substances from the head surface using IPA (isopropyl alcohol), for example, and completely dry off the head surface prior to using it again.

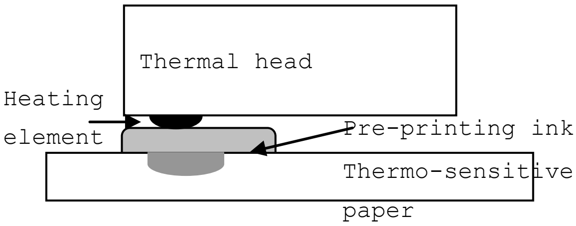
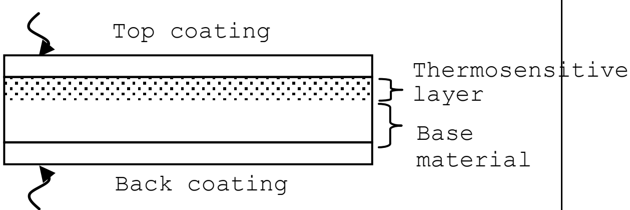
2.2 Printing paper

Thermo-sensitive paper is used for the thermal printer. Confirm the following conditions prior to use. The base material of the paper is different depending on the thermo-sensitive paper manufacturer, even if the sensitivity is the same. Some material characteristics may abnormally wear out and damage the head. If the paper is pre-printed, paper sticking may occur or electric corrosion may occur, depending on the ink material.

The head may be damaged depending on the direction of the cut or the perforation of the paper and the labels. Prior to using the paper, be certain to evaluate the storage life and print characteristics using actual paper. Do not use paper that is not specified by Fujitsu Component Ltd. Contact Fujitsu Components Ltd. sales offices if specified paper cannot be obtained.

Table 2 Precautions before using paper

Matters requiring attention	Precaution	Supplementary Information
Brand of paper	User specified brand of paper	Use of unspecified paper causes abnormal abrasion and damage to head
Thickness of paper	Rigidity of paper differs depending on thickness and density of paper. Strong paper rigidity causes poor contact between surfaces of head heating element and paper, which may make printing light or cause data printing to miss. Conform that paper is printable by an actual printer prior to use.	Check specifications and confirm the paper thickness. Some paper is more rigid even if thickness is the same.
Width of paper	Slack at the left or right causes skew feed. To prevent skew feed, paper sides must be guided. Applying back tension is also effective in suppressing skew feed. If paper width is narrower than the width of the head heating element, printing load is decreased if data is divided at the center. Error detection occurs if the paper detection sensor extends beyond the edge of paper. Set paper so that the paper edge does not extend 1mm outside the paper sensor position. Error detection may also be caused by the influence of external light or curling of a paper edge during paper feed. Be certain that the paper surface does not rise 1 mm or higher from the sensor surface by pressing the back surface, for example. Also a skew feed prevention side face guide is required. Paper edges cause abrasion of the head surface during	Set back tension, including paper feed force, to about 0.49N. A low setting causes skew feed, while a high setting causes paper jam.

	feeding. Do not print 2 mm from the paper edge. A blur or missed data in printing may occur	
Surface Pre-printing	Total density of predetermined ions, included in printing ink, should be 1000 ppm or less as a guide line. Manage the ink quantity to be an appropriate thickness so that blur and missed data in printing and paper sticking do not occur. Fig.4 Influence of pre-printing  If the printed ink amount is high, the heat propagates to the surface of the thermo-sensitive paper, and printing may become light. Top coating may be performed in order to improve storage life. If such paper is used, confirm that sticking does not occur. Fig. 5 Surface coating  Storage life is improved by coating, which prevents the entry of alcohol, water, cream, etc.	Sticking or electric corrosion occurs depending on the printing ink.
Mark of Paper	See the mark specification for printing a mark.	
Label paper	A separated label may be peeled by R of the platen section. When a label is used, a straight path must be used as a paper path. The use of a curl path makes it easy for a label to be peeled. Either use a 125 μm or less thin label paper to decrease peel strength, or	Certain label paper may not be used depending on the mechanism. Confirm the compatibility of the label and printer.

<table>
<tr>
<td></td>
<td>use strong glue to increase peel strength. Both edges of a perforated line are connected so that peeling is not generated.

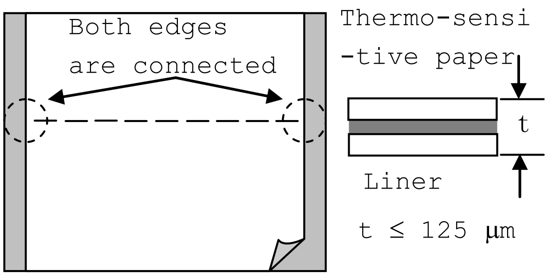
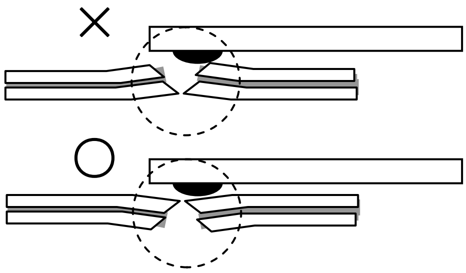
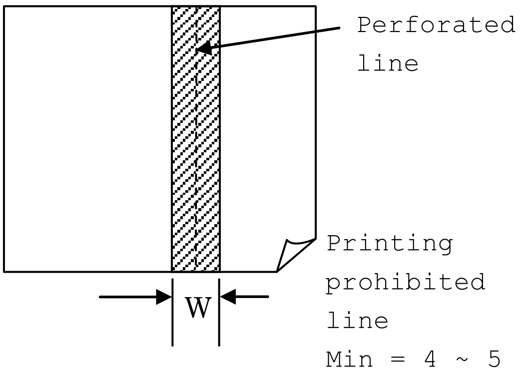
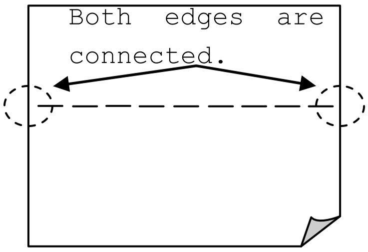
Fig. 6 Processing both edges of perforated line

</td>
<td></td>
</tr>
<tr>
<td>Perforated line</td>
<td>The perforated direction must be from the front surface to the back face of the thermo-sensitive paper.

Fig. 7 Perforation processing


Do not use vertical perforation since it wears the head surface out. If this must be used, do not print near the perforation because printing may become blurred.

Fig. 8 Perforation prohibited area

</td>
<td>Edges of perforation rub against the head surface and wear the head out or cause head failure. If the paper edge has a cut, the edge swells outward at a bent area, such as at the platen, and contacts the head surface. This may cause a skew and/or jam.</td>
</tr>
</table>

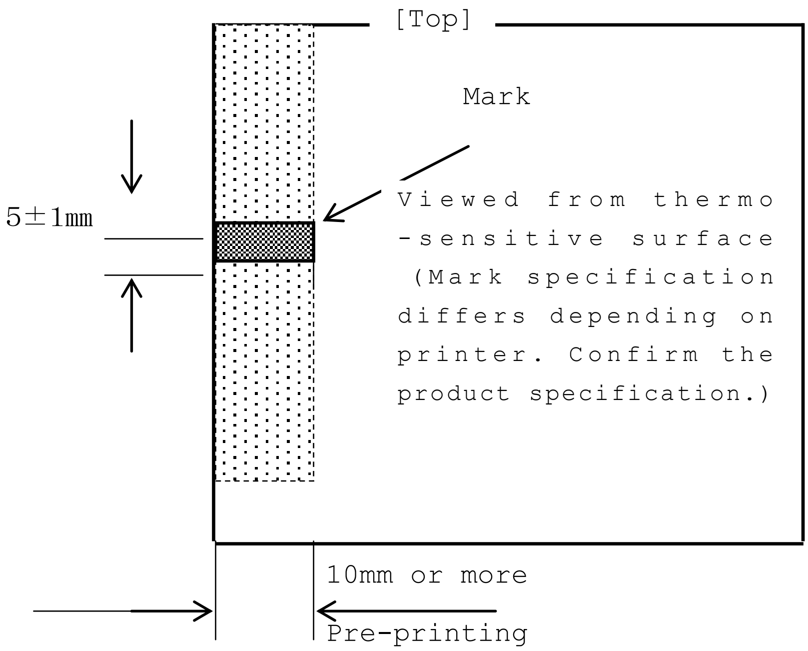
	If a large cut exists on both edges, the corners roll up and a paper jam occurs. Both edges must be connected. Fig. 9 Edge processing  	

2.3 Pre-printing

2.3.1 Detection mark position

Print the detection marks on the thermo-sensitive surface (in the case of a curled path mechanism) at 5±1mm x 10mm (5 mm to left and right from the sensor center). In the case of a straight path, the detection mark is printed on the back face.

Fig. 10 Mark specification



2.3.2 Pre-printing of positioning mark

The mark is black, and the density has a 7% or less reflectance and a 0.9 or more PCS. Use oil ink and make the density uniform. Overprint the mark to increase the PCS value. Use the following measuring device to measure density. Reflectance is a value when measured in a 900 nm range. Density does not always match the visually observed density.

PCS measuring device: Macbeth reflection type densitometer PCM-II

(filter: D range 900 nm)

2.3.3 Pre-printing prohibition

Pre-printing is prohibited in the mark detection area (10 mm from right edge), but if pre-printing must be performed for any reason, select an ink whereby the reflectance becomes 80% or more in the range of the wavelength band used by a photo-interrupter (700 ~ 1000 nm).

2.3.4 Precautions for pre-printing

The characteristics of thermo-sensitive paper differs compared with general printing paper and non-carbon paper. Pay attention to the following when pre-printing is performed.

(A) Printing method

Thermo-sensitive paper has poor ink drying properties, so use a UV printing method.

(B) Ink

(1) Use an ink which has no negative influence on a thermal printer, such as the adhesion of foreign substances, abrasion of the head and sticking.

(2) Use an ink of which the Na and K^+ ion quantities are 50 ppm or less respectively. The ion quantity of Cl^- must be 100 ppm or less.

Recommended ink: RNC type made by F&K TOKA

(3) The surface strength of the thermo-sensitive layer is generally weaker than that of general printing paper, so be careful with the ink tack. The ink tack should be about 6.0 for general thermo-sensitive paper, and one equivalent to non-carbon paper for a high storage type thermo-sensitive paper. If the

tack is decreased by a reducer, the quantity added must be 5% or less, otherwise operability becomes poor.

(4) Do not supply an excessive volume of ink. If the ink quantity is excessive, color printing problems and thermal printer sticking may occur.

(5) The ink material should be heat resistant and should not have a heat reducing function. Also use a similar ink for a non-thermo-sensitive surface.

(6) Confirm that ink adhered to paper after printing. UV ink is normally sensitive to water, so pay close attention to the management of damping water.

(7) Be certain that the transfer and blockage of inks does not occur.

(8) Protect pre-printing from rubbing off due to water and alcohol.

(C) Damping water

(1) Thermo-sensitive paper tends to repel water, so pay attention to the management of damping water.

(2) An excessive IPA in damping water may cause color fogging. Set it to 5% or less for general thermo-sensitive paper, and to 10% or less for high preservation type thermo-sensitive paper.

(D) Other

(1) If a UV lamp is frequently used, be certain that heat does not cause paper shrinkage (feed direction, width direction) and color fogging.

(2) The paper surface is smooth, so set the retainer roller pressure of the drive roll relatively high.

(3) Perform overprinting to increase the PCS value of the positioning marker.

(4) Sticking may occur by pre-printing. Be certain to pre-print with an actual device and confirm the result.

3. Precautions to select thermal printer

Select a thermal printer as follows.

3.1 Selection based on paper

Paper is selected based on the following conditions.

[1] Paper width (58 mm, 80 mm, 114 mm)

[2] Paper thickness (55-100 μm, 100-125 μm, 100-150 μm)

[3] Form (standard paper, thick paper, label paper, copy paper)

3.2 Paper width

There are three types of standard paper widths: 58, 80 and 114 mm. If other paper must be used, consult first with our sales personnel. The paper width of a Fujitsu paper product can be easily known by checking the product type classification.

FTP-6 0 * M C L * * *

2: supports 58 mm paper width
3: supports 80 mm paper width
4: supports 114 mm paper width

3.3 Paper thickness

The paper thickness that can be used differs depending on the product. For details see the respective product specification. If paper is too thin then the rigidity of the paper is low, which causes paper jams and other problems. If paper is too thick then the rigidity of the paper is high. A thermal printer is designed to contact the heating elements to the paper surface by the pressure between the thermal head and the platen, but if the rigidity of the paper is too high, it is difficult to maintain appropriate contact with the pressure spring. At the worst, not only does printing become blurred, but also printing becomes impossible or paper cannot be fed. If a cutter is in use, the life of the cutter may be shortened. Always use appropriate paper.

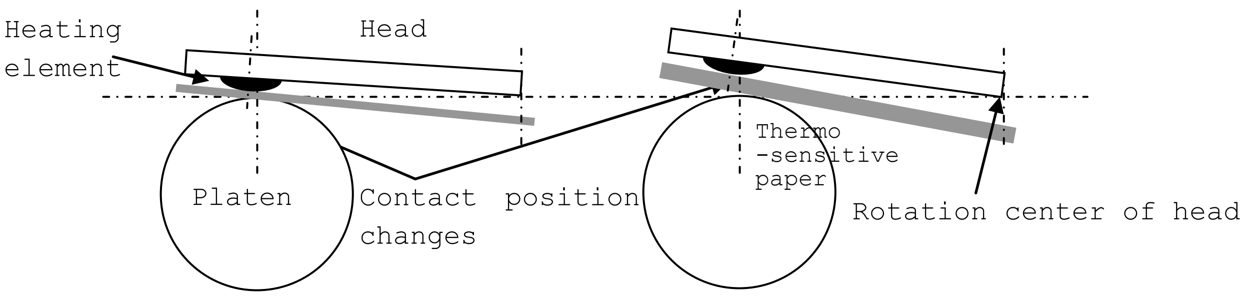


Fig. 11 Influence of paper thickness

A special mechanism is necessary to use thick paper. If a curl path is used for paper, the force to raise the head is increased by the rigidity of the paper, and blurred printing increases. Use a straight path. The FTP-609 MCL series has a mechanism that corresponds to a straight path. Note that the FTP-607 MCL and FTP-608 MCL series do not support thick paper.

FTP - 6 0 9 M C L * * 0

1, 3: curl path

2, 4: straight path

If the product number begins with "5" in the lower three digits, confirm details with our sales personnel.

3.4 Paper roll diameter

The feeding load changes depending on the diameter of the roll paper. The diameter of the paper roll that can be fed stably is determined by the type of motor to be used. Select a mechanism to be used according to the paper diameter required for use. The following are just the reference values, load changes depending on the installation conditions of the roll paper.

Table 3 Maximum external dimensions of roll paper to be used

Series Name	Drive Voltage (V)	Drop-in Type (mm)	With Rotation Axis (mm)	Remarks
ＦＴＰ－６０８	～８．５	φ６０	φ８０	Load differs depending on paper route
ＦＴＰ－６０７	２４	φ８０	φ１００	
ＦＴＰ－６０９	２４	φ１００	φ２５０	A brake mechanism is required for a large diameter roll paper

3.4.1 Support of large diameter roll paper

If a large diameter roll paper is rotated at high-speed, the roll paper may continue rotating due to inertia even when printing and feeding have stopped, and paper may spin out. If printing is performed in this status, a large load is applied at the moment when slack disappears and printing is interrupted. Set the paper tension spring to suppress this shock and to prevent a printing interruption. The angle of the paper route greatly differs between when the diameter is largest and when the end of the paper roll is near. Use a coil spring type in order to apply stable tension even with this angle difference.

[Beginning of roll]

To implement a force to absorb the shock and a stroke in the beginning of the roll, the position of the center of the rotation axis overlaps with the roll paper. This makes installation difficult.

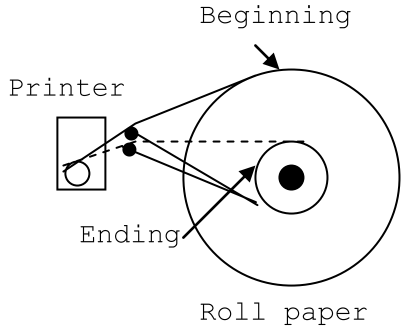


Fig. 12 Influence of path of outer surface printing roll paper

Change the route of the paper if sufficient tension cannot be applied. The above is an example when the thermo -sensitive face of the paper is on the outside, but if an inner face printing roll is used, design becomes simpler. The required spring tension and deflection amount are as follows.

Beginning of roll (large diameter)

> > ending of roll (small diameter)

Shock increases as the diameter of the roll increases, so a force and deflection amount of the spring that can to absorb this shock are required.

[Beginning of roll]

The path of the paper is upward, so sufficient stroke can be taken downward at the beginning.

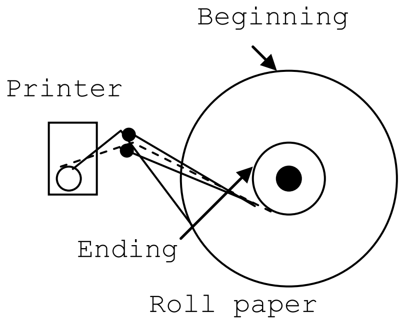
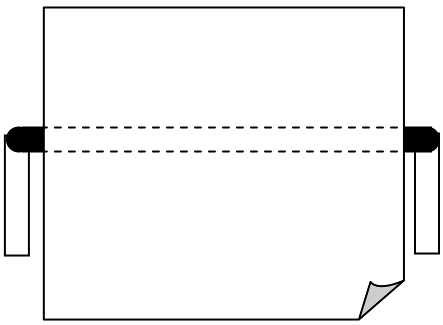


Fig. 13 Influence of path of inner surface printing roll paper

As a rule we recommend an outer surface printing roll. Friction on the head surface is high if an inner surface printing roll is used. Also in the case of automatic paper feed, the edge of the paper may contact the head, which makes insertion impossible. In the case of the outer surface printing roll, the edge of the paper is curled in a direction away from the head, so insertion is easy. Apply tension by a bar type so that tension is applied evenly throughout the width. If pressure is localized to a specific area, paper is not only scratched but is ripped as well, which causes a paper jam. Design such that the bar contacts the back surface. Paper is scratched if the bar contacts the front surface.

Fig. 14 Paper tension bar

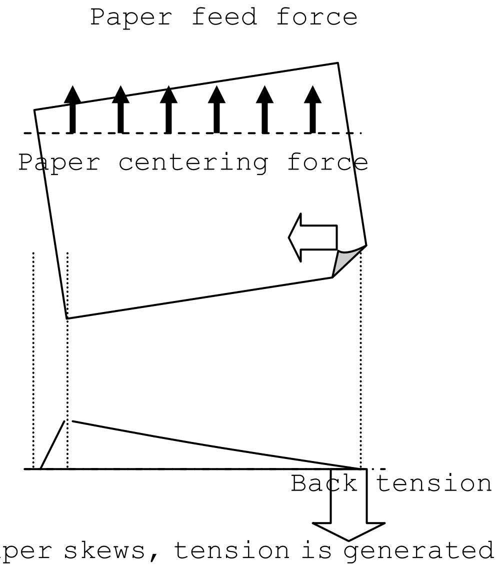


If a print jam occurs due to paper load, the printing operation is performed in paper stopping status. In this case, the paper surface adheres to the head, and paper feed may become impossible. The head is damaged if printing is continued in this status. Since the motor is no longer in sync and paper feed stops, immediately stop the printer and clean the head.

3.4.2 Precautions when role paper is dropped in

Design the paper pullout force to be 0.49N or less. If it is 0.49N or less, the back tension force increases as the paper pullout force increases, and skew feed can be suppressed. If the paper pullout force is close to "0", back tension force is no longer available, so only the paper guide can retain paper, and skew feed, paper meandering (edge of paper is bent and split) and jamming may occur.

If the pull out force is 0.49 or more, install a roller under the roll paper.



Paper skews, tension is generated at longest path side

Fig. 15 Effect of back tension

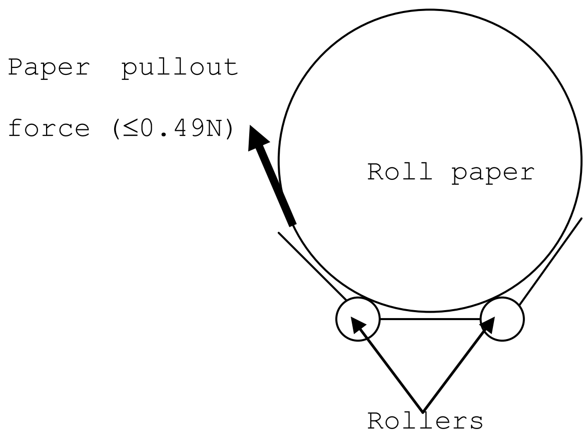


Fig. 16 Load decreased by roller

A method of decreasing the load is to create ribs at the paper housing section. This decreases the contact face with paper, and friction is decreased. If the contact face is too narrow, black lines are generated on the paper surface by friction. For the drop in type, the maximum roll paper diameter is ϕ100 mm. If a roll larger than this is used, set the paper axis, for example, to decrease the load.

4. Selecting printing speed and voltage

Thermal printers are classified as follows depending on the voltage range.

4.1 Voltage and printing speed depending on series

Paper can be selected based on the following conditions. Select an appropriate series according to the intended use.

Table 4 Printing speed and drive voltage depending on series

<table>
<tr><th>Series Name</th><th>Series</th><th>Drive Voltage (V)</th><th>Maximum Printing Speed (mm/sec)</th><th>Remarks</th></tr>
<tr><td rowspan="3">ＦＴＰ－６０８</td><td>Standard</td><td>４．２～８．５</td><td>８０</td><td>Standard</td></tr>
<tr><td>＃２１</td><td>２．７～７．２</td><td>８０</td><td>Low voltage series</td></tr>
<tr><td>６４８</td><td>４．２～８．５</td><td>５０</td><td>4 inch</td></tr>
<tr><td rowspan="2">ＦＴＰ－６０７</td><td>４００</td><td rowspan="4">２４</td><td>１００</td><td>150 mm/sec possible under predetermined conditions</td></tr>
<tr><td>６００</td><td>１５０</td><td>Standard high-speed series</td></tr>
<tr><td rowspan="2">ＦＴＰ－６０９</td><td>Standard</td><td>２００</td><td>Standard</td></tr>
<tr><td>３inch</td><td>２５０</td><td>Mechanism dedicated to 640 dots</td></tr>
</table>

4.2 Precautions to use interface board

Pay attention to the following to use the Fujitsu interface board.

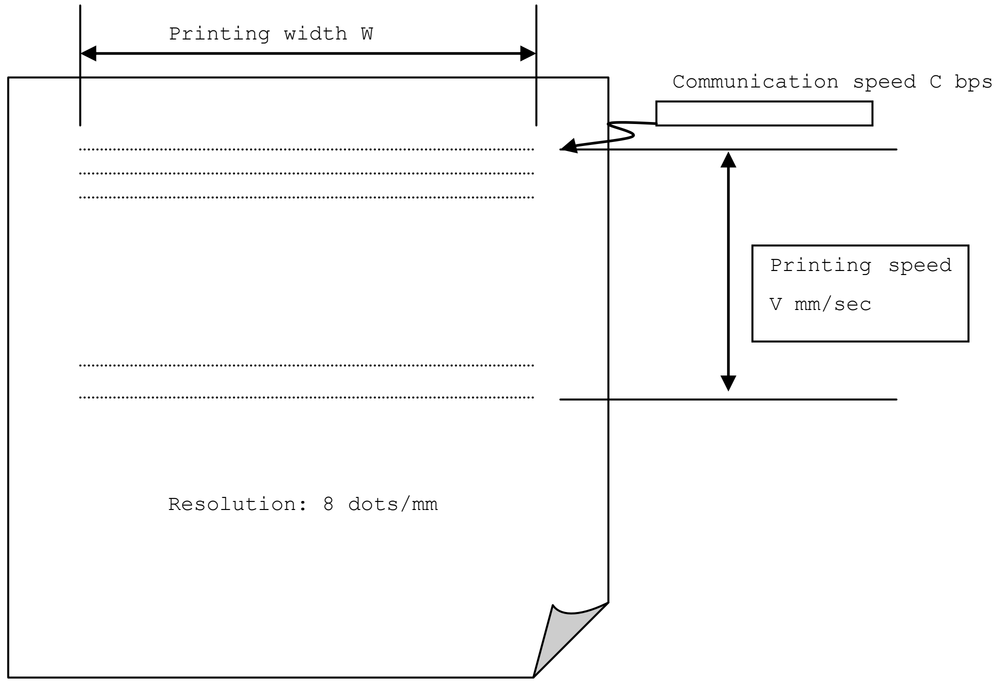
4.2.1 Printing speed

The specified printing speed is the maximum speed under predetermined conditions. The actual printing speed differs depending on the interface in use, communication speed, paper in use, installed memory and printing mode.

(A) Relationship with communication speed

A thermal printer processes the data sent from the main unit and prints it. Therefore if data is not received from the main unit at a required speed, the thermal printer stands by until the next data is received. The printing speed drops if data is sent at a slow speed. The relationship between the communication speed and the printing speed is as follows. In this example, the printing mode is bit image mode (all print data is sent as image data by driver software).

Fig. 17 Relationship of data transfer speed and printing speed



【Print Condition】

Target printing speed:	V (mm/sec)
Communication speed:	C (bps) in the case of RS-232C
Printing width:	W (mm)
Head resolution:	8 (lines/mm)

When the printing width is W, the total number of heating dots N per 1 dot line is determined as follows since the resolution is 8 dots / mm.

Number of printed dots N (dots/line) = 8 W

If the target printing speed is V (mm/sec), the number of printed lines per second is as follows.

Number of printed dot lines (lines/sec) = 8 V

Therefore the total number of dots D to be printed per second is given by the following expression.

Total number of dots D = (8W) x (8V) = 64 WV

In other words, if 64 WV bits or more of data is not sent per second from the main unit, data becomes insufficient, and the printer stands by to receive data. If the data transmission speed is slow, the data must be stored in a memory first, then printed.

[Example 1] In the case of FTP-628MCL103:

In order to implement the specified 80 mm/sec printing speed, 384 x (80x8) = 245,760 bits of data transfer is necessary per second. This means that a 246 Kbps or higher transfer speed is required.

(a) RS-232C serial interface

The standard rates of RS-232C, 115.2 kbps or 19.2 kbps, are too slow.

(b) Centronics parallel interface

The standard communication speed of a parallel interface is about 28 kbyte/sec. Since 1 byte = 8 bits, this speed c orresponds to 28 k x 8 = 224 kbps. Therefore a faster interface is required to implement 80 mm/sec.

(B) Relationship with printing mode

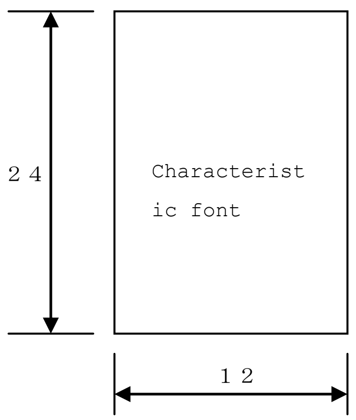


Fig. 18 Font configuration

Above is the case of performing all processing printing as image data. The situation is different in text mode where internal fonts are used. To simplify explanation, print processing efficiency is ignored here. Let us consider the case of printing 12 x 24 characters, as shown in Fig. 18, for 32 columns (= 384/12). The number of data required for 1 line is 32 bytes. If 1 line is about 1/6 inch, then 80 mm/sec. is 640 dot lines, which is equivalent to

$19 \approx 640/((25.4/6) \times 8)$ line.

Therefore the number of codes required for 1 second is 608 bytes (= 19 x 32). Even if data is transferred in serial, about 6.7 kbps (= 11 x 608) is required. Therefore sufficient speed can be implemented even with 115.2 kbps or 19.2 kbps.

Prior to use, be certain to confirm whether the required printing mode is text mode or bit image mode.

5. Precautions for installing thermal printer

5.1 Installation directions of printer mechanism

In theory the installation direction does not matter for a thermal printer, however in practical terms it is important to avoid damage to the head caused by paper debris and paper cut chafings that drop on top of the head, and to prevent applying unnecessary force to paper.

5.1.1 Concept of installation

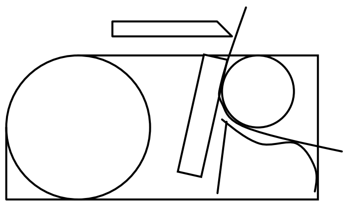
The installation directions follow.

(A) Installation condition 1-1

Paper debris drops down when paper is cut. This debris can lodge between the paper and the head. However the paper feed direction is upward, so the paper moves debris to the outside. It is for this reason that installation condition 1-1 is one of the most preferable installations.

Fig. 19 Installation condition 1-1

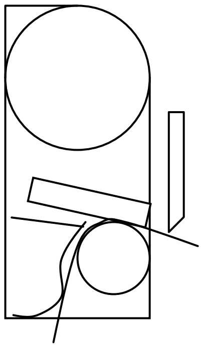
(Appropriate O)



(B) Installation condition 1-2

Fig. 20 Installation condition 1-2

(Appropriate O)

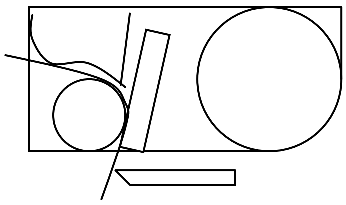


In installation condition 1-2, paper debris, when paper is cut, drops outside the printer. The top of the platen is covered by the head, which prevents the entry of debris. It is for this reason that this is one of the recommended installations.

(C) Installation condition 1-3

Fig. 21 Installation condition 1-3

(Conditionally appropriate Δ)

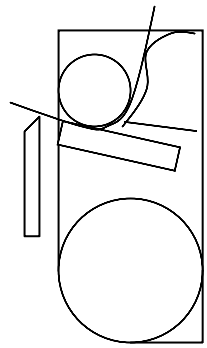


In installation condition 1-3, paper debris, when paper is cut, drops down from the printer but causes no problems. However if debris drops onto the rear face of the printer or on paper, debris is carried to the head by the paper, which causes abrasion or damage to the head. Also in this installation, the self-weight of the roll paper is applied to the roll paper cover, so support is necessary to prevent force from being applied to the platen shaft. This installation can be used as long as dust proofing and self-weight support conditions are possible, however normally this installation is not recommended.

(D) Installation condition 1-4

Fig. 22 Installation condition 1-4

(Prohibited x)



In installation condition 1-4, the roll paper is positioned immediately above the head. So paper chafings drop and enter between the paper and platen, which wears out the head surface during paper feed, causing damage to the head. This installation is prohibitted.

5.1.2 Concept of installation of cutter type printer

The installation conditions of a cutter type printer follow.

(A) Installation conditions 2-1 to 2-4

Even for a printer with a cutter, the installation conditions of the printer mechanism are the same as section 5.1.1

Fig. 23 Installation condition 2-1 (Appropriate O)

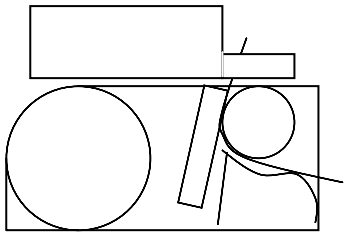


Fig. 24 Installation condition 2-2 (Appropriate O)

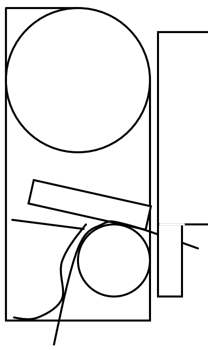


Fig. 25 Installation condition 2-3 (Conditionally appropriate

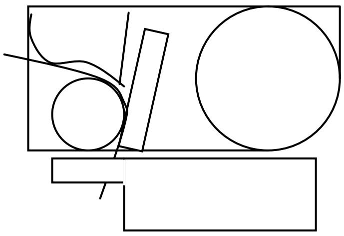
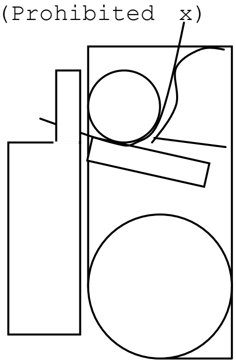
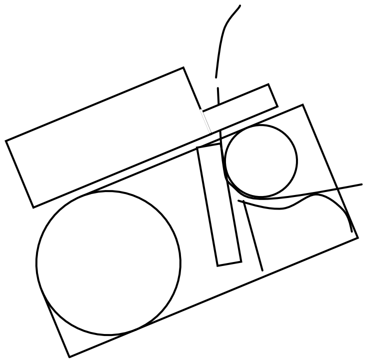


Fig. 26 Installation condition 2-4 (Prohibited x)



(B) Problem unique to printer with cutter

Fig. 27 Cutter problem



In the case of a printer with a cutter, cut paper may drop by its own weight and double cutting may occur. If double cutting occurs, thin and long paper debris may enter inside the cutter and cause cutter problems. The angle of the printer and measures to prevent cut paper dropping by its own weight must be considered.

5.1.3 Roll paper and printer installation conditions

The installation directions follow.

(A) Easy loading conditions

For easy loading, roll paper can be loaded whether the roll direction is inward or outward, since the platen is opened and closed when paper is set. The rolling direction, however, is critical.

If the paper roll direction is outward, paper rotates in a direction away from the printer when paper is fed, so there is no problem.

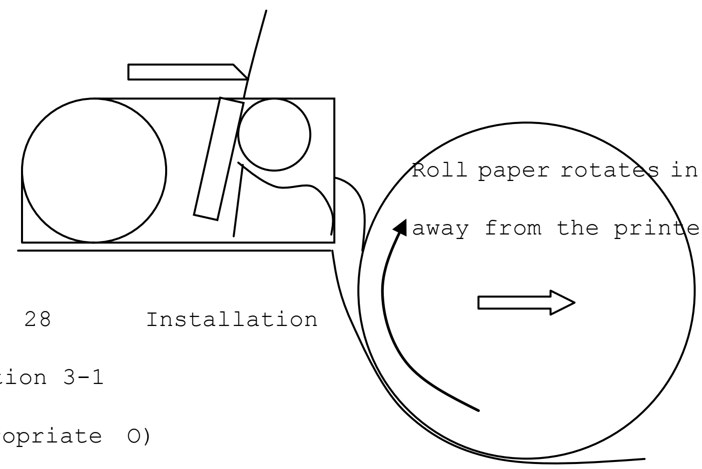


Fig. 28 Installation condition 3-1 (Appropriate O)

If the paper roll direction is inward, however, a curl in the opposite direction from the platen is generated in the paper, so the paper feed load may increase. Also the rotation direction of the roll is in a direction of the paper entering the printer, so paper may be caught or a printing jam may be generated depending on the design of the roll paper holder.

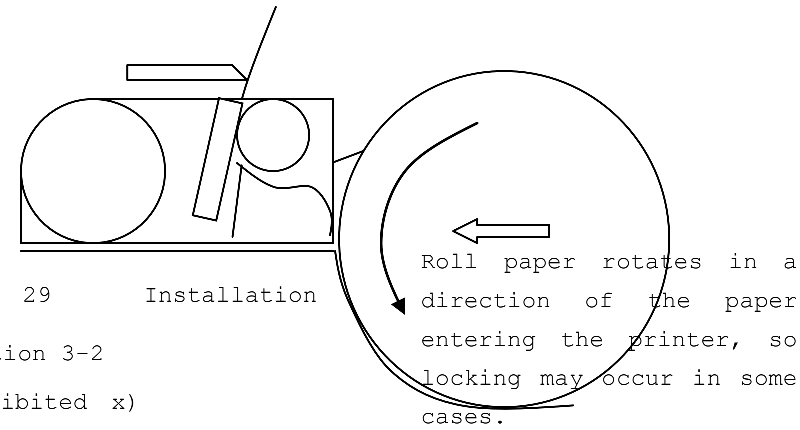
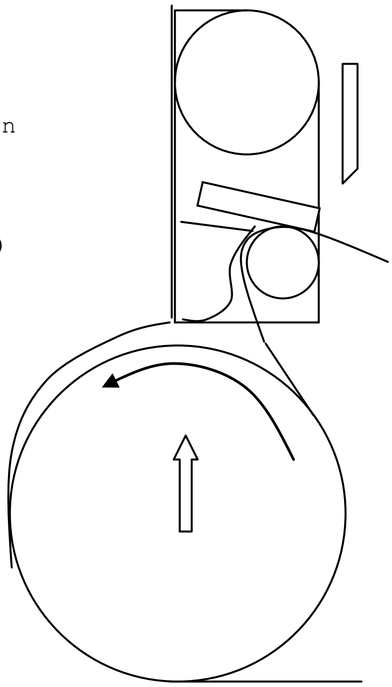


Fig. 29 Installation condition 3-2 (Prohibited x)

Even if the roll direction is inward, a lock is not generated if the roll is installed vertically. This is because paper is always away from the printer by its own weight. This means that in the case of inward rolling paper, the positional relationship of the roll paper and the printer must be considered.

Fig. 30 Installation condition 3-3

(Conditionally appropriate Δ)



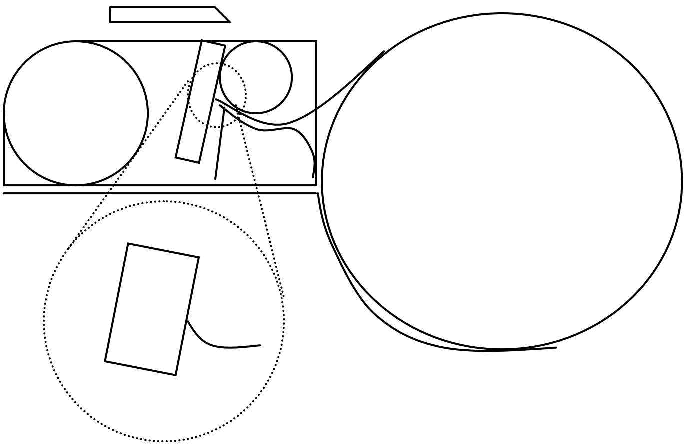
(B) Automatic paper feed condition

In the case of automatic paper feed, an inward rolling paper may not be able to be inserted under curl path conditions, since the tip of the paper contacts the head at a right angle.

Either insert the paper after rounding the edge, or use an outward rolling paper.

Fig. 31 Installation condition 3-4

(Prohibited x)



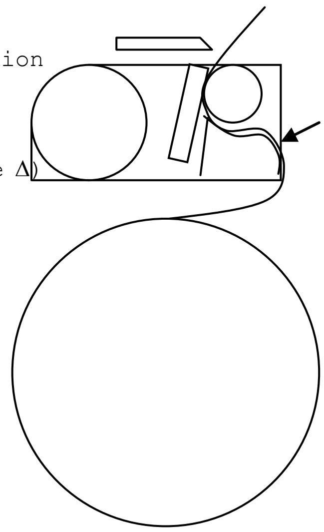
5.1.4 Relationship of printer installation and paper load

Problems may occur depending on the position of the paper.

(A) Problem of paper load

The load of paper depends on the contact angle of the paper surface and the guide. In the example below, the contact angle is close to 270 - 360 degrees in the beginning of the roll paper, which generates a large load. In some cases, a printing jam occurs. Therefore this installation is prohibited.

Fig. 32 Installation condition 4-1 (Conditionally appropriate Δ)



A large load is generated in this section. To use the printer, load must be decreased at the roller.

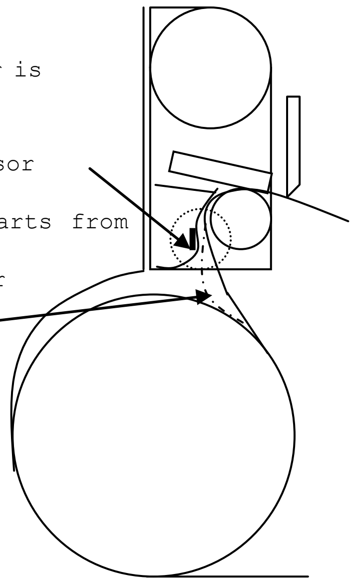
(B) Problem of paper route

In the following example, if tension is applied to the paper, paper departs from the guide, and a paper detection error occurs. To prevent the generation of a detection error, the paper must be pressed from the rear face so that the paper is not separated from the sensor surface by 1 mm or more.

Fig. 33 Installation condition 4-2

(Measure to prevent separation of paper is required)

(Conditionally appropriate Δ)



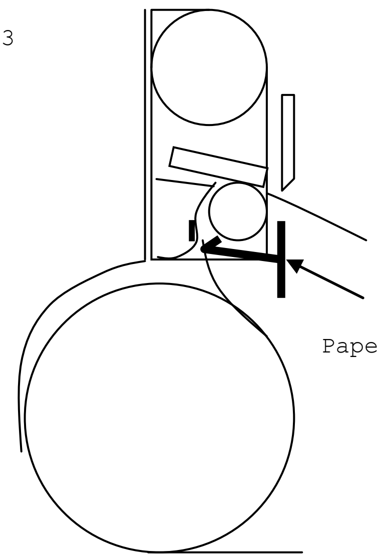
The paper presser presses the paper inlet as shown below. Even if tension is applied to the paper, the paper must be kept within 1 mm from the sensor.

(C) Paper route countermeasure

In order to keep the distance of the paper from the sensor to within 1 mm, a paper presser is installed, as shown below. By this, the distance from the surface of the sensor can be stabilized.

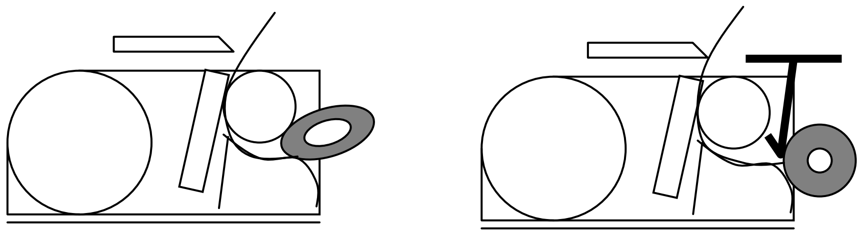
Fig. 34 Installation condition 4-3

(Appropriate O)



5.1.5 Paper end handling

When paper end comes, the roll diameter becomes small and roll weight become light, and the paper enters the paper inlet in a rolled status. If there is no guide, the paper is caught between the platen and the paper guide, and becomes locked.



Installation condition 5-1a (Prohibited x)

Installation condition 5-1b (Appropriate O)

Fig. 35 Paper end handling

5.2 Platen holding

Applying force to the platen in a status when the platen holding cover is closed causes printing strains and a printing jam. Printer metal fittings must have some play in the X axis direction. Design such that the platen shaft can be smoothly set using this play. Although the platen is caught by the die cast at the mechanism side and the top of the platen holding arm, be certain to create some play in the design. If the platen shaft is set in a status where unnecessary force remains, printing problems occur.

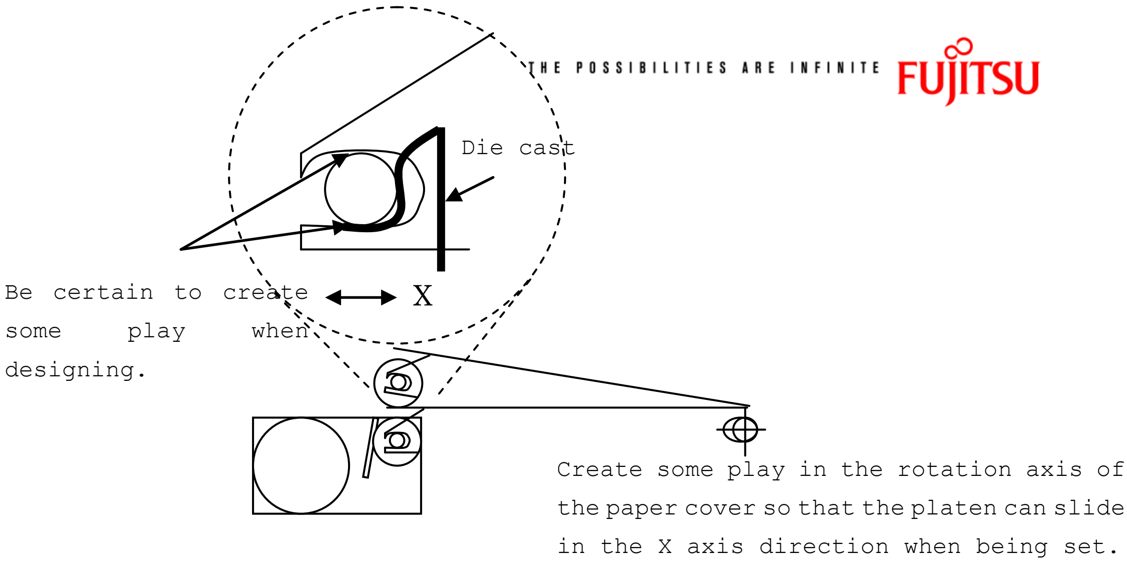


Fig. 36 Precaution for platen holding section

5.3 Platen holding cover support axis

Create some play for the rotation support axis of the platen holding cover. When the platen is engaged, the cover slides in the X direction, and the platen is set at an appropriate position.

5.4 Paper cover lock

Some printer mechanisms have a lock mechanism (FTP-607/608 MCL 400 series, FTP-609 MCL 300 series), but other printer mechanisms do not have a lock mechanism (FTP-607/608 MCL 100 series). Mechanisms having a lock mechanism can use the lock mechanism, but printer

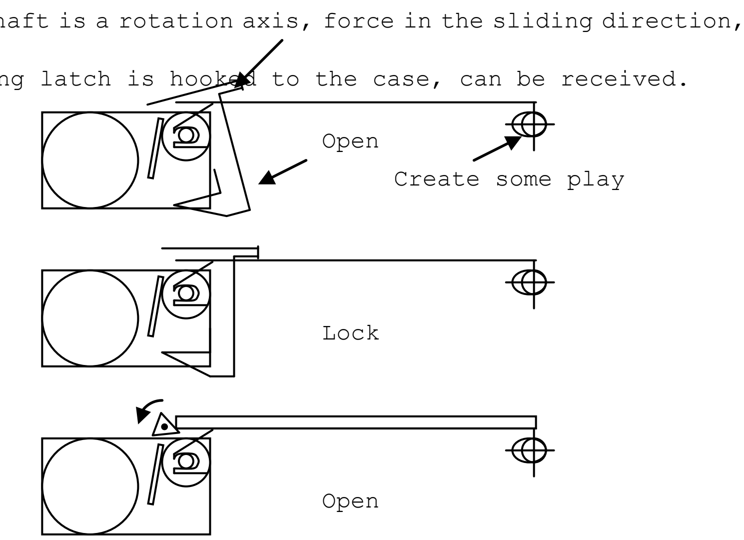


Fig. 37 Paper cover

mechanisms that have no lock mechanism perform locking using the case cover. In the case of a mechanism that has no lock mechanism, designing a case for this function is more flexible. A lock or open mechanism can be built into the device by utilizing a part of the case, using latches or a lever principle.

6. Precautions for designing thermal printer drive circuit

6.1 Thermal head drive circuit

The major drive signals of the thermal head are as follows.

Table 5 Head drive signals

Signal Name	Signal Content	Description
DATA IN(DI)	Head input data	Data input signal to head
CLOCK (CLK)	Data transfer clock	Synchronization clock for transmitting head data
DATA OUT (DO)	Head output data	Data output of end of data. Some product do not have this signal.
/LATCH	Data latch signal	Pulse signal for latching data to head
STROBE (STB)	Strobe terminal	Power ON gate signal having both positive and negative logic
TH	Thermister	Output at both ends or only at one end
VDD/GND (VDD)	Head logic power supply	
VH/GND (VH)	Head power supply	

Note) In the case of battery driving, all lines connected to the head, including the power supply, must be set to "Low" in order to decrease power consumption during standby. Be certain that wrap around from the circuit side logic power supply is not generated.

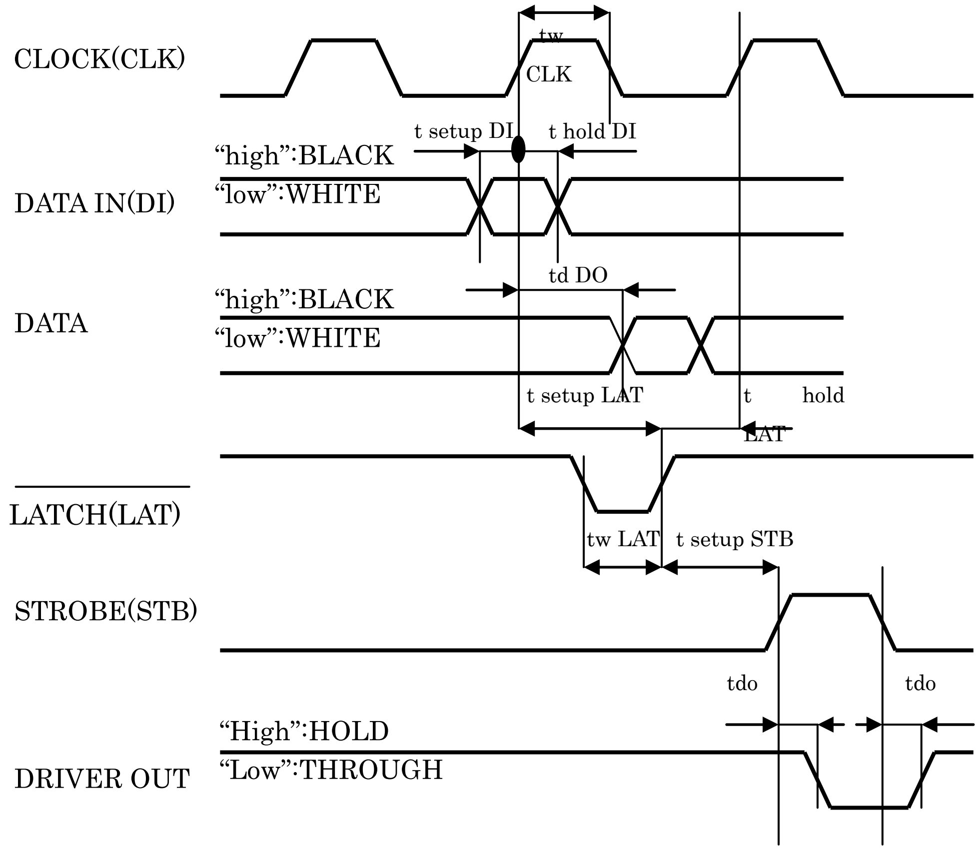


Fig. 38 Head drive timing

6.1.1 DI, CLK (data and clock when data is set to head)

(A) Signal description and processing method

To transfer data to the head, the SCI (Serial Communication Interface) of the CPU or an external IC for parallel-serial conversion is normally used. This is for easily connecting the IC in series with less signals for various heads from narrow to wide widths, where a clock synchronizing serial connection is used. For this, the image data developed in memory is read in word units by the internal processing of the CPU, is converted into clock synchronizing serial data, and is transferred. The clock frequency depends on the IC in use, and 6 MHz or 8 MHz is used, and recently

ICs which can implement 16 MHz high-speed transfers have been commercialized.

If noise enters the CLK terminal, incorrect data is sent to the head. Therefore a measure that blocks noise from entering the CLK signal terminal must be taken, and an element for noise removal, such as a capacitor, is added. The capacity of the capacitor for noise removal must be determined by an ESD test, for example, but the range is normally 100 - 1000 pF. For the DI signal as well, adding a capacitor for noise removal is recommended.

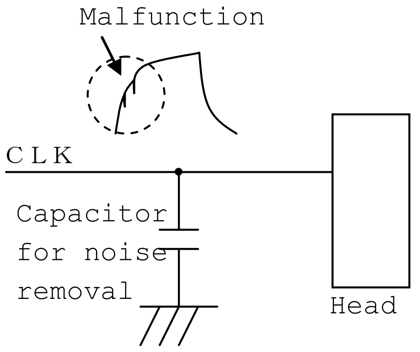


Fig. 39 Terminal noise countermeasure

As a rule clock duty is 50%, and the frequency depends on the printer mechanism, so refer to the respective product specification for this information.

The data (DI) is loaded at the rise of the clock (CLK), and the data must be held stably before and after the rise of the clock, and during periods of tsetup and thold. If data changes during these periods, a printing error may occur. Pay attention to the clock timing.

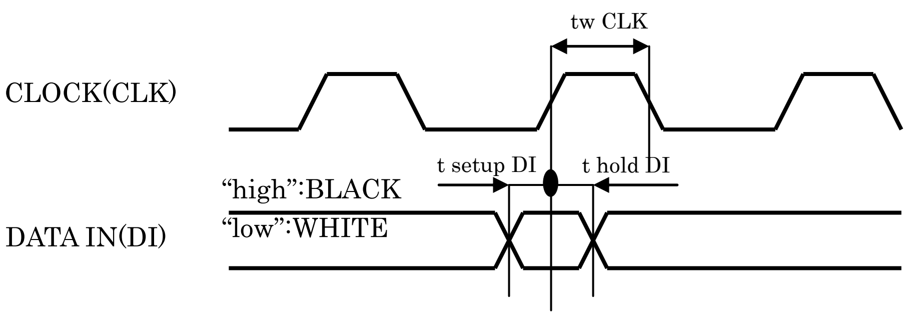
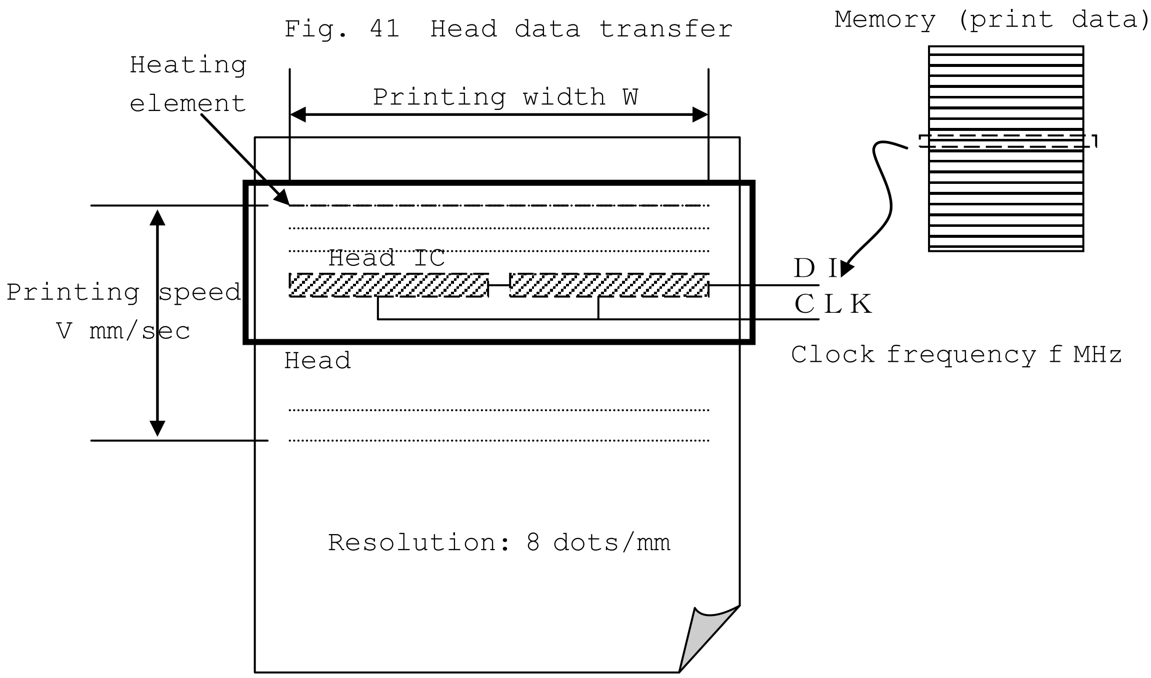


Fig. 40 Clock timing

(B) Concept of transfer rate

The data transfer rate to the head must be determined according to the target printing speed, or by such purposes as the processing for improving the printing quality and processing based on the printing ratio. This is described using the above mentioned model.

Fig. 41 Head data transfer



[Printing conditions]

Target printing speed:	V (mm/sec)
Clock frequency:	f (MHz)
Printing width:	W (mm)
Head resolution:	8 (lines/mm)
Data transfer count:	N (times)

If the target printing speed is Vmm/sec, the number of dot lines is 8V dot lines. Therefore the cycle of 1 dot line is 1000/(8V) = 125/Vmsec. The number of dots included in 1 dot line is 8W. If 8W number of data is sent during 1 dot line period, the time required for 1 bit is (125/V)/(8W) = 125/(8WV)msec. This is an ideal case, but actually data may be divided and sent several times (N times) in order to improve printing quality or to decrease power consumption. In this case, the time required for 1 bit is 125/8(NWV).

If the clock frequency of the head is fMHz, then 1 cycle is 1/fμsec.

As a result,

$$125 / (8NWV) \times 1000 = 1/f$$

$$f = NWV / 15625 \text{ (MHz)}$$

is required.

[Example]

The case of implementing 100 mm/sec using a 384 dot (48 mm printing width) head (8 dots/mm) is considered. Driving 384 dots synchronizing with 2 or 4 motor steps makes dividing difficult since the number of divisions of the head is 6 blocks (6 x 64 = 384), but dividing into 4 (4 x 96) by firmware makes synchronization easier, which involves 4 motor steps and 4 blocks of the head. In order to divide data by firmware, it is assumed that data is separated and sent to the head 4 times, simplifying the firmware structure.

$N = 4$

$W = 48$ mm

$V = 100$ mm/sec

$f = 4 \times 48 \times 100/15625 = 1.22$ MHz

Therefore 1.22 MHz or more is required. If the maximum frequency of the head is 8 MHz, for example, enough margin is secured for the transfer speed. Actually if the SCI of the CPU is used, for example, the transfer rate is determined by the frequency of the basic clock of the CPU, so in order to satisfy the above specification,

$$1.22 \leq f \leq \text{maximum clock frequency of head}$$

must be set.

Increasing frequency means increasing the margin of transfer, but noise coming from the outside tends to enter the clock, so we recommend not to increase frequency unnecessarily.

6.1.2 DO (data output terminal of head)

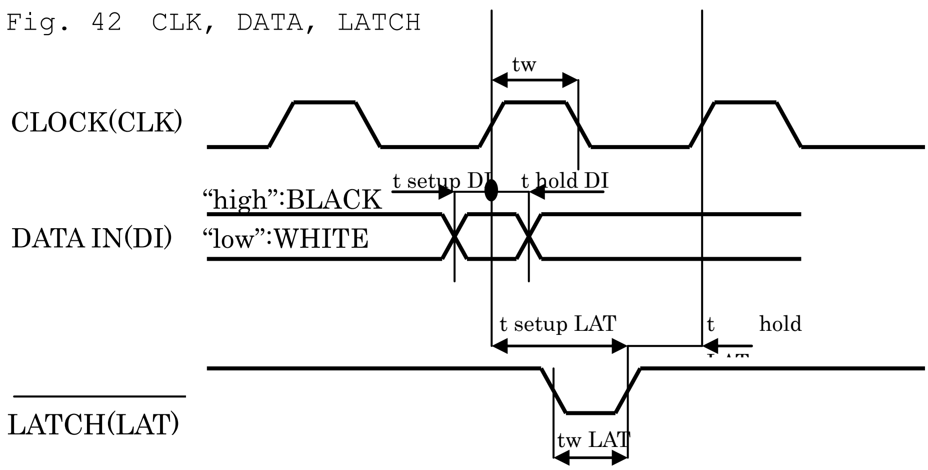
(A) Signal description and processing method

Some printers do not have a DO terminal. Confirm this by referring to the respective product specification. This signal is an output signal from the printer head, and does not have to be connected (N. C.). However when printer mechanisms of various widths are used, the printer size can be judged automatically by loading this signal to the CPU. In automatic judgment, predetermined data is sent to the head, and the width of the head is known by measuring the number of transmitted clocks of the data which is output from DO. Transmit a pattern in which "1" and "0" alternate. The data which is set in the internal IC of the head immediately after power ON is not guaranteed, so at the worst an identical pattern may be detected. This signal is an output signal from the head, so input this signal to the CPU or gate, either directly or inserting a serial resistor to protect from a short circuit.

6.1.3 /LATCH (signal for latching data sent to head)

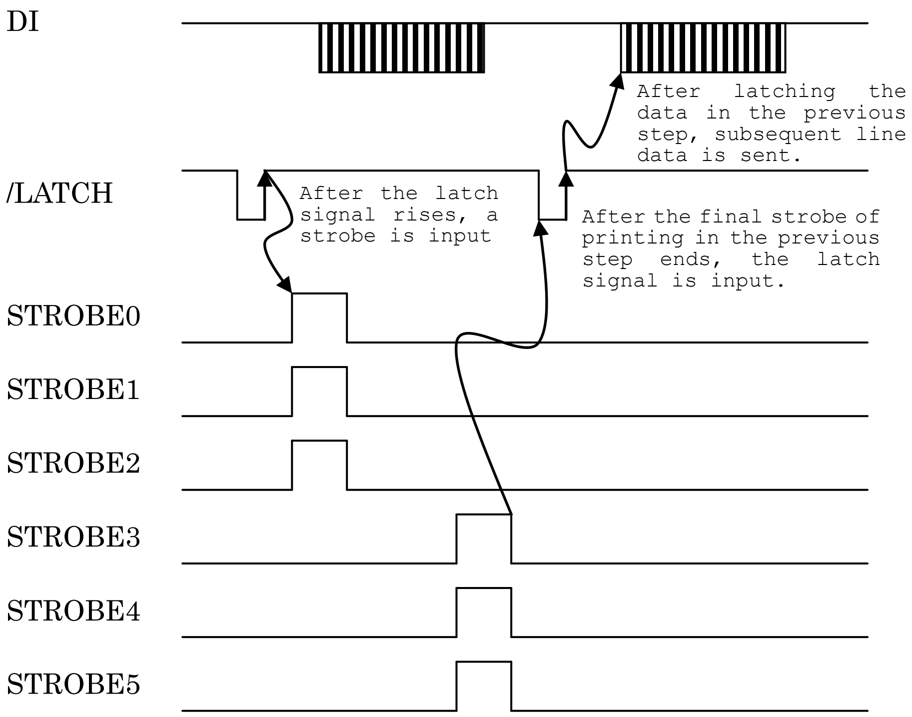
(A) Signal description and processing method

Fig. 42 CLK, DATA, LATCH



The latch signal is used for latching the print data, which was sent to the head, to the driver inside the IC. When the latch signal is "Low", data is output "through". Data is latched at the rise edge of /LATCH. So hold this signal at "High" while printing the previous data, and input the latch pulse after the final data is printed.

Fig. 43 LATCH, STROBE

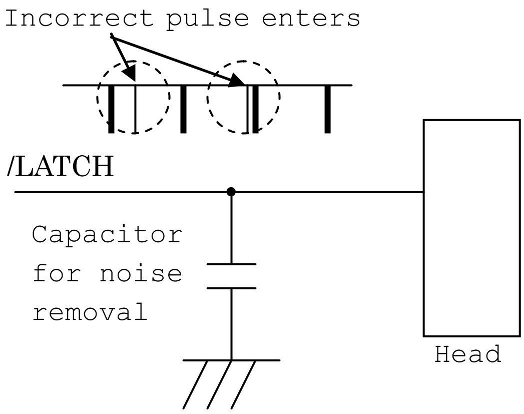


When noise enters the /LATCH terminal, incorrect data is latched to the head. To avoid entering this noise to the /LATCH terminal, add an element for noise removal, such as a capacitor. If such noise as ESD is superimposed onto the /LATCH signal, data during transfer for the next printing is output, and printing is disturbed. The capacity for the capacitor for noise removal must be determined based on the result of an ESD test, for example, but is normally in a 100 - 1000 pF range. The latch pulse is normally output by rewriting "Low" to "High" to the firmware port. For this, several steps are required.

Be certain to secure at least the minimum period tw LAT of the pulse width written in the product specification.

This pulse is very narrow, so if the capacity of the capacitor is too large, the pulse may not rise, and the latch may be missed. Carefully check the waveform, and confirm that an abnormal distortion was not generated.

Fig. 44 LATCH signal

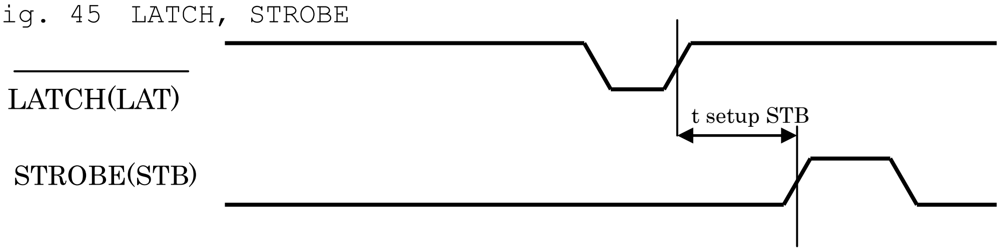


An effective countermeasure when latch errors occur frequency by EST is taking tw LAT wide, and increasing the capacity of the capacitor.

6.1.4 STROBE (strobe signal for emerging head)

(A) Signal description and processing method

Fig. 45 LATCH, STROBE

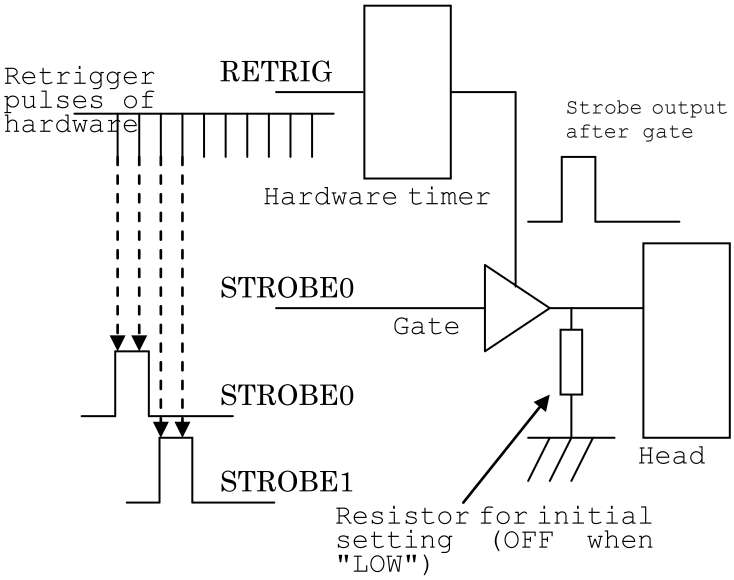


Note that for a strobe signal, the logic may be reversed depending on the print head. Carefully check the printer specification.

To output the strobe signal, tsetup STB time must be taken from the rise edge of the latch signal. The STROBE signal must be fixed to the OFF side during the reset period or during power rise transition. This is because when power is turned ON, the internal data of the IC installed in the head is unstable, and if the STROBE signal is turned ON during this unstable period, erred data may be printed.

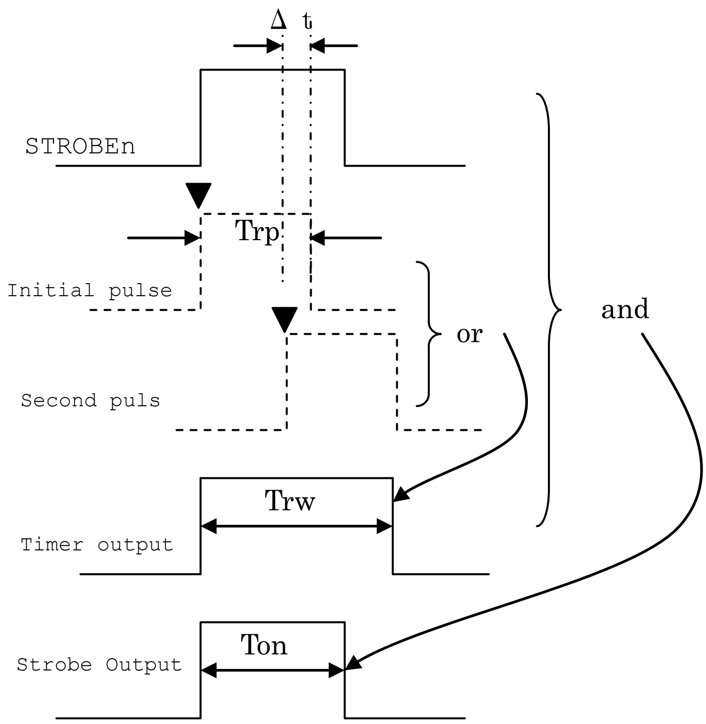
In the case when the port is latched and fixed to the ON side due to noise, if an enable signal is output, a STROBE signal, higher than the absolute maximum rating, is input, and the heating element of the head may be damaged or thermo-sensitive paper may be burned. To prevent this, be certain to input the STROBE signal via the gate based on the hardware timer. Fig. 46 is an example of a positive logic strobe.

Fig. 46 Hardware timer



When power is turned ON or at reset, be certain that the enable signal is not output by error. We recommend that 1 strobe is comprised of a plurality of retrigger pulses. This is because even if noise enters by mistake, the influence of the noise on output becomes minor enough to be ignored if 1 timer time is short. Fig. 47 shows the operation principle during normal time. OR of the 2 outputs of the retrigger pulses becomes the hardware timer output. The timer

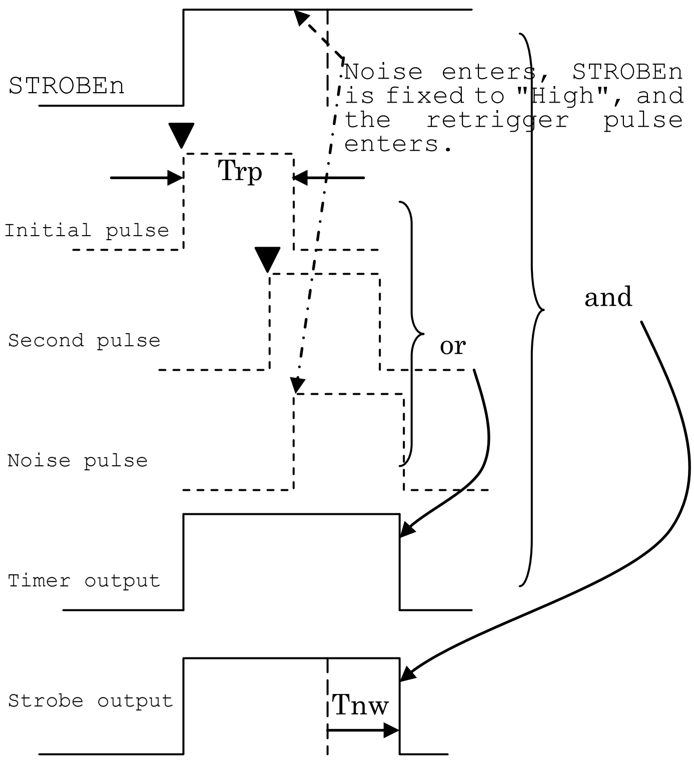
Fig. 47 Strobe division



output is used as a gate through which STROBE n signal is output. Based on the time control by firmware, The STROBEn signal turned OFF at a predetermined time. Retrigger pulses are input at a timing overlapping Δt respectively. By this, the retrigger pulses become one pulse linked with Trw.

Set to Trw < 2 x Trp and Ton < Trw. Ton changes considerably depending on the environmental conditions. Therefore Trw must be greater than the maximum pulse width Ton (Max) in low temperatures. Or the number of times of retriggering may be increased in low temperatures. Fig. 48 shows a case when noise enters and STROBEn is latched up. Because of this noise, the pulse width becomes wider than the originally expected pulse width Ton by Tnw, even if the timer is retriggered. However Tnw is so small that this protects the head from burning. The smaller the Trp the smaller Tnw becomes, but the more the number of times retrigger by firmware increases, so control becomes complicated.

Fig. 48 Influence of noise

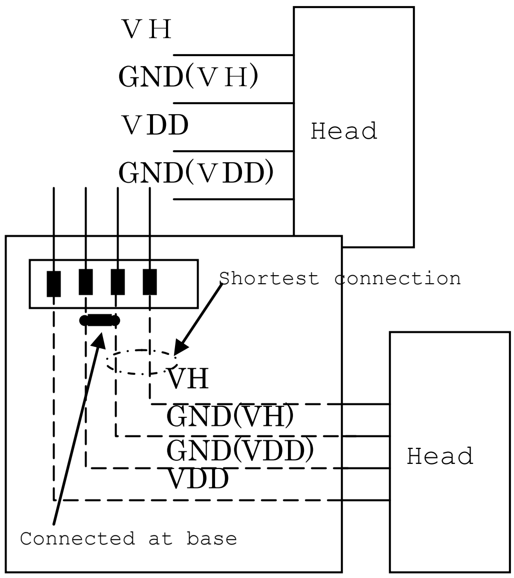


In terms of safety, be certain to implement protection by the hardware timer.

6.1.5 VH/VDD (Power supply of thermal head)

(A) Signal description and processing method

Fig. 49 Signal Wiring



The power supply lines of the head are VH, for applying voltage to the heating element, and VDD, for supplying power to the logic of the IC installed in the head. A large amount of current flows through GND (VH), which is a pair line of VH, during printing, therefore the VH-GND (VH) pattern must take sufficient distance from other signal lines so that voltage is not dropped by the current. Connect a 100 μF or higher capacitor. We also recommend to add a 47 μF or higher capacitor to the logic power supply. In some of the latest heads, a logic GND (VDD) and GND (VH) are connected to the ceramic of the head. As a rule, however, connect them at the bottom of the power supply input connector terminal inside the substrate. Be certain to wire the logic power supply VDD-GND (VDD) sufficiently away from heavy current patterns, so that noise does not enter from the outside.

(B) Electric corrosion countermeasures

Countermeasures against electric corrosion is required to supply power to the head. Electric corrosion is a phenomena where ions on the head surface (particularly K^+, Na^+, Cl^-, S^- require attention) enter through the film of the head in the status when voltage is being applied to the head, and electrode patterns are corroded, and if this occurs resistance of the electrode section drops abnormally, and printing defects occur. Therefore if a thermal head is used, the voltage being applied to the head must be cut during standby. For the switching element, a relay and MOS-FET transistors, which do not cause much leak current, must be used. For selection, confirm the maximum energizing load current and minimize the drop in voltage.

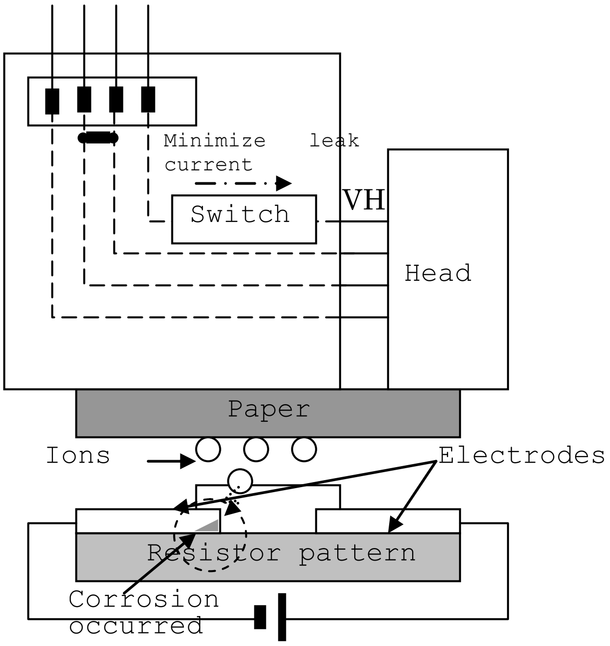
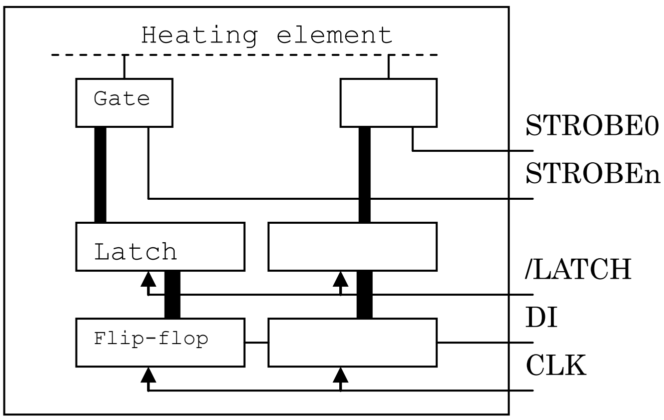


Fig. 50 Electric corrosion countermeasures

(C) Power ON sequence

Since the initial status of the internal register of the head is not constant when power is turned ON, abnormal printing may also be generated at transition timing in VH applied status, if the rise of VDD is slow or cut. At the worst, the head may be burned and damaged. In the initial processing immediately after power ON, be certain to transfer NULL data "0" to the head, and perform latch processing.

Fig. 51 Functional block diagram of head



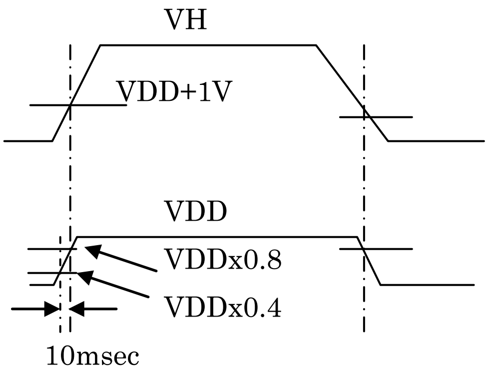
Functional block diagram viewed from rear face of head

Note) Flip-flop is undefined when power is turned ON

Always adhere to the power ON sequence specification. As a rule, design a sequence such that VH becomes within VDD + 1V at the maximum when VDD rises or falls 80% of the logic applied voltage or more.

It is desirable that the rise time of the power supply is short, and design such that the logic voltage rises from 40% to 80% of applied voltage within 10 msec. If this time is longer, the CPU will normally not start up, and at the worse, the head is burned and damaged.

Fig. 52 Power supply sequence



(D) Relationship of circuit logic voltage VCC and head logic voltage VDD

When the logic voltage VCC of the control circuit is applied, some head control terminals, such as the /LATCH terminal, are set to "High". If the power supply VDD to the head is turned OFF in this status, latch up may occur in the input section of an IC installed in the head. If a latch up occurs, the input is fixed to "High", and the head remains in an energized status, and at the worst, the head is burned and damaged. To prevent this, it must be

Fig. 53 Latch up countermeasure

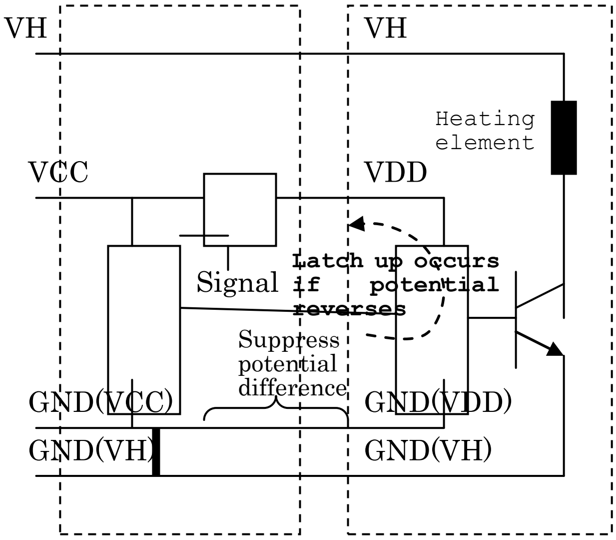
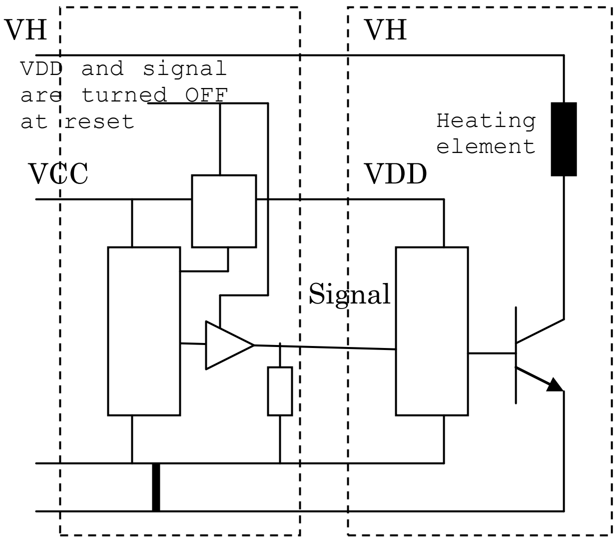


Fig. 54 Signal reset processing

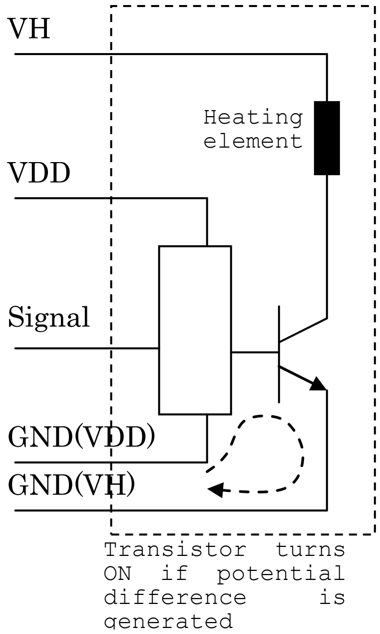


noted that reverse voltage is not generated between VDD and the input terminal. This status must be maintained even during the reset period. In a 24V system, normally it is unnecessary to cut VDD during standby, so design hardware such that the head control signal is maintained in the initial setting status.

In the case of battery driving, power consumption during standby must be minimized. Therefore VDD/VH is also turned OFF during a hardware reset period. Design circuits such that all control signals are also forcibly set to "Low" during a reset period.

(E) Precautions for GND (VH)/GND (VDD) /GND (VCC)

Fig. 55 GND processing



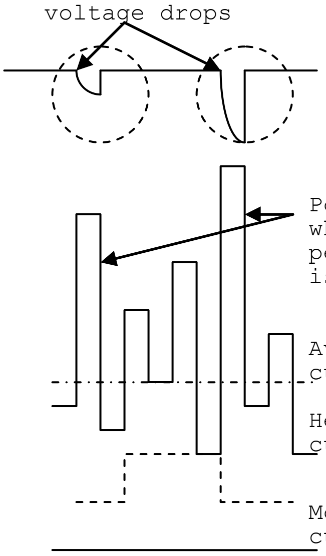
It was previously mentioned that GND (VH) and GND (VDD) are shared inside some of the latest heads available, but in other heads they are separate, and attention should be given to the potential difference of GND (VCC) and GND (VDD). When the potential difference thereof is Vin-Low of the head logic or more, the head IC may judge that "High" is input even if the signal is OFF. This is the same for GND (VDD) and GND (VH), and similar phenomena may occur if GND (VDD) and GND (VH) are separate inside the head. Therefore use thick patterns so that the potential difference between GND terminals becomes within 0.3V. During printing, a very heavy current flows through GND (VH) depending on the number of energized dots. Therefore if this current flows into GND (VDD), the logic potential may change and a malfunction may occur. Install the power supply connector near the head, and connect the

GND (VH) and the other GND patterns at the bottom of the connector.

(F) Precautions for VH

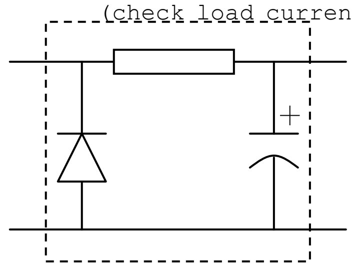
A pulse type heavy current flows through VH as the head is energized. Some power supplies do not support such high-speed peak current. Even if the current capacity has a several times margin, voltage may instantaneously drop and cause printing blurs if the peak response is low. Also if high load printing continues, voltage at the power supply side may drop.

Fig. 56 Influence of peak load



In this case, a density difference is generated between the left and right. This occurs largely because the peak current cannot be supported or the load is so large that voltage drops, even if the average power of the power supply has a margin. Either the printing ratio is decreased (since the number of energized dots each time must be decreased to decrease the printing ratio, the number of printing divisions in 1 dot line must be increased and the printing speed must be decreased), or the power supply response is increased (one method is to install an LC filter in the power supply input terminal

Fig. 57 Peak load countermeasure



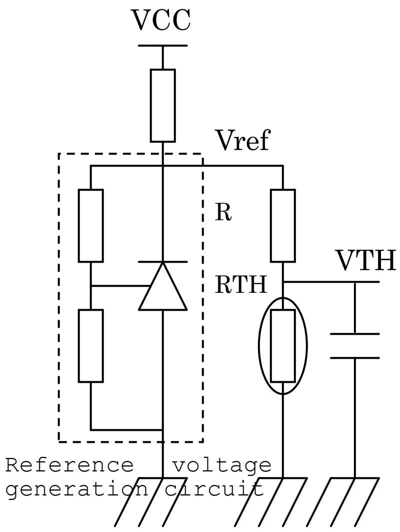
section, but an allowable DC load of the coil must be checked).

6.1.6 TH (Thermister control terminal)

(A) Signal description and processing method

In a thermister control terminal, either both ends are output or one side is connected to GND or to VDD, depending on the printer. Carefully confirm this in the product specification. The resistance value of the thermister changes depending on the temperature. Temperature is detected by detecting the change of the resistance value. Normally a thermister is input to the AD converter terminal of the CPU, for example. The resistance values of the thermister disperse, so temperature cannot be accurately detected unless the accuracy of the detection side is improved. The influence of dispersion is minor in low temperature, since the temperature gradient is large, but in high temperature, temperature detection disperses considerably since the temperature gradient curve is gentle.

Fig. 58 Thermister processing



*) RTH is a thermister resister

Generate a highly accurate reference voltage using a shunt regulator, for example, and detect the resistance value by dividing this reference voltage. For an external resistor, use a product with a precision temperature compensation that is less than 2%. For the output stage, it is recommended to attach an appropriate temperature compensation capacitor based on the confirmation of ESD. Since detected temperatures disperse considerably, take an average of the values detected a plurality of times, and use this average for judgment. Refer to the following to select the reference voltage and an individual constant.

Generally thermister resistance values are determined by the following expressions.

- Thermister constants

  B: B constant 3950k ± 2%

  R25: resistance value at 25°C 30kΩ ± 5%

  Calculation formula: Rx = R25 x EXP {B x (1/273 + X) - 1/298}

- Parameters

  Reference voltage: Vref

  High temperature conditions:

  RH (High temperature measurement/Lowest resistance)

  VH (High temperature measurement/Lowest voltage)

  Low temperature conditions:

  RL (Low temperature measurement/Highest resistance)

  VL (Low temperature measurement/Highest voltage)

  External resistor: R

Note) There is a method of connecting the thermister to the GND side and a method of connecting the thermister to the Vref side. Here the case of connecting the thermister to the GND side will be described. This means that the actual resistance value and the voltage are smaller at the high temperature side.

RL and RH are determined using calculation formula Rx, substituting the target temperature condition for X. For example, resistance is about 175Ω if X = -10°C. In the case of 75°C the resistance is 4.47Ω.

$$VH = Vref \times RH/(R + RH)$$

$$VL = Vref \times RL/(R + RL)$$

$$\alpha = VH/Vref, \quad \beta = VL/Vref$$

$$RL/RH = (\beta/\alpha)\{(1-\alpha)/(1-\beta)\} = A$$

RL/RH = A is determined based on the temperature range to be measured.

Using the above calculation formula α is assumed with an appropriate step. β is determined by the following formula using α and A..

$$\beta = \alpha A/(1 - \alpha + \alpha A)$$

Once α and β are determined, VH, VL and R are determined as follows.

$$VH = \alpha \times Vref, \qquad VL = \beta \times Vref$$

$$R = RH \times (1 - \alpha) / \alpha$$

A condition when VH is not too small and the widths of VH and VL are wide is selected from this.

Table 6 External resistor simulation

【Example】 Selection of external resistor
Detection tempera-10℃～75℃
VH ≧ 0. 5V
Width ≧ 2.0V target

A:	39.19059107	
RH:	4.467096019	@75℃
RL:	175.0681333	@-10℃
Vref Condition(V)	2.5	3

	α	β	VH @2. 5V	@3. 0V	VL @2. 5V	@3. 0V	R	Width @2. 5V	@3. 0V
1	0.01	0.283598114	0.025	0.03	0.708995286	0.850794343	442.2425059	0.683995286	0.820794343
2	0.05	0.673486733	0.125	0.15	1.683716832	2.020460199	84.87482436	1.558716832	1.870460199
3	0.09	0.794913549	0.225	0.27	1.987283873	2.384740648	45.16730419	1.762283873	2.114740648
4	0.1	0.813241552	0.25	0.3	2.03310388	2.439724656	40.20386417	1.78310388	2.139724656
5	0.2	0.907387236	0.5	0.6	2.268468091	2.722161709	17.86838407	1.768468091	2.122161709
6	0.3	0.943807495	0.75	0.9	2.359518737	2.831422485	10.42322404	1.609518737	1.931422485
7	0.4	0.963136441	1	1.2	2.407841103	2.889409323	6.700644028	1.407841103	1.689409323
8	0.5	0.975118555	1.25	1.5	2.437796386	2.925355664	4.467096019	1.187796386	1.425355664
9	0.6	0.983273644	1.5	1.8	2.458184111	2.949820933	2.978064012	0.958184111	1.149820933
10	0.7	0.989182724	1.75	2.1	2.472956809	2.967548171	1.914469722	0.722956809	0.867548171
11	0.8	0.993661353	2	2.4	2.484153382	2.980984058	1.116774005	0.484153382	0.580984058
12	0.9	0.997172868	2.25	2.7	2.492932169	2.991518603	0.496344002	0.242932169	0.291518603
13	0.91	0.99748276	2.275	2.73	2.493706899	2.992448279	0.441800705	0.218706899	0.262448279
14	0.92	0.997786101	2.3	2.76	2.494465253	2.993358303	0.388443132	0.194465253	0.233358303
15	0.93	0.998083098	2.325	2.79	2.495207744	2.994249293	0.336233034	0.170207744	0.204249293
16	0.94	0.998373947	2.35	2.82	2.495934866	2.99512184	0.285133788	0.145934866	0.17512184
17	0.95	0.998658836	2.375	2.85	2.496647091	2.995976509	0.235110317	0.121647091	0.145976509
18	0.96	0.998937949	2.4	2.88	2.497344872	2.996813846	0.186129001	0.097344872	0.116813846
19	0.97	0.999211457	2.425	2.91	2.498028644	2.997634372	0.138157609	0.073028644	0.087634372
20	0.98	0.99947953	2.45	2.94	2.498698824	2.998438589	0.091165225	0.048698824	0.058438589

In the above example, Vref = 3.0V, and the external resistance is 18kΩ. However a temperature range which is closely detected differs depending on the application. Perform settings according to the conditions.

6.2 Motor drive circuit

There is a stepping motor for feeding paper, and a DC motor and stepping motor for driving a cutter.

Table 7 Motor types

Motor type	Function	Remarks
Stepping Motor	Feeds paper	
	Drives cutter	FTP-608MCL400 series FTP-607MCL400 series
DC motor	Drives cutter	FTP-607MCL38x series FTP-628MCL35x series FTP-609MCL3xx series

6.2.1 Major signals

The motor drive signals are as follows.

Table 8 Motor control signals

Motor type	Signal name	Remarks
Stepping motor	MT-A	Bipolar Phase A
	MT-/A	Bipolar phase /A
	MT-B	Bipolar phase B
	MT-/B	Bipolar phase /B
DC motor	MT+	Motor terminal (+)
	MT-	Motor terminal (-)

6.2.2 Drive principle

(A) Stepping motor drive system

There are two types of stepping motor drive systems: unipolar and bipolar. The FTP-607/608/609 series uses bipolar systems. There are two types of bipolar systems in terms of controlling phase. A stepping motor is used for driving the paper feed motor and the cutter motor of the FTP-607/608/609MCL400 series.

Table 9 Motor excitation phases

1-2-phase excitation

Step	MT-A	MT-B	MT-/A	MT-/B
0	0	0	0	1
1	0	0	1	1
2	0	0	1	0
3	0	1	1	0
4	0	1	0	0
5	1	1	0	0
6	1	0	0	0
7	1	0	0	1

2-phase excitation drive

Step	MT-A	MT-B	MT-/A	MT-/B
0	0	0	1	1
1	0	1	1	0
2	1	1	0	0
3	1	0	0	1

- 2-phase excitation drive system

  In the case of a 2-phase excitation drive, the step angle for one step becomes large, and power is required. However, moving for a large angle is possible since 2 phases are excited in one step. In 2-phase excitation, 1 dot line is moved in 2 steps (FTP-607, 680 MCL series), and the step difference in each step is large (1/2 dot line). This tends to make the motor loud and noisy.

- 1-2-phase excitation drive system

  In the case of a 1-2-phase excitation drive, the feed amount is half that of 2-phase excitation, and the steps are small, so the step difference is less, and noise is also less.

  If there is an attempt to implement high torque in 1-phase excitation, power will be too high when 2-phase excitation is performed, so caution is advised. In 2-phase excitation, maintain the drive current at about 2/3 that of 1-phase excitation. Adjust the current value according to the load to be driven and the speed.

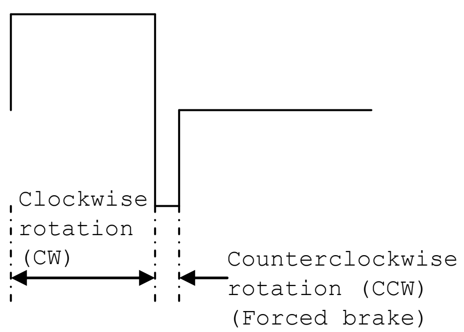
(B) DC motor drive system

A DC motor is used for driving a cutter. The DC motor normally stops rotation by ON/OFF control, but the motor has inertia and it cannot be guaranteed that the motor will stop at the appropriate position if the stopping method is short circuiting the terminals, for example. Therefore it is necessary that the motor stops stably at the appropriate position (home position), and to provide such a means as a quick brake (applying a negative phase for a short time) for emergencies. A DC motor is normally set to the "Low" side during a stop. These control timings vary depending on the cutter type and the drive circuit. Be certain to confirm the product specification of the cutter before designing.

Table 10 DC motor excitation

	MT +	MT −
CW	High	Low
CCW	Low	High
STOP	Low	Low
	High	High

Fig. 59 DC motor drive signal



6.2.3 Drive circuit

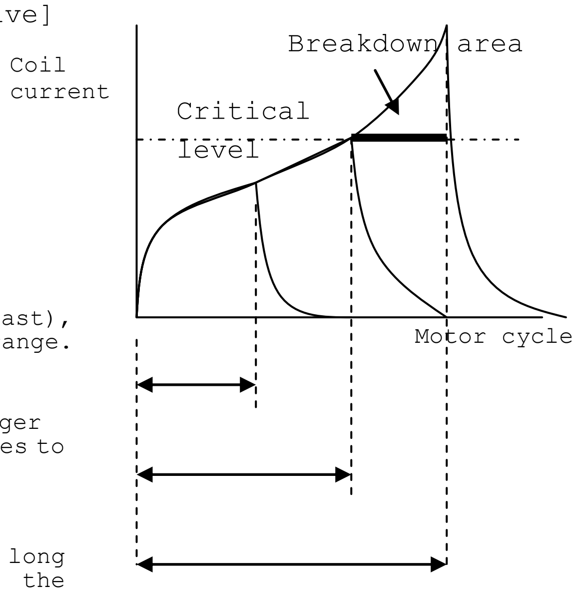
(A) Stepping motor drive system

When a stepping motor is driven, be certain to perform constant current control if a condition under which excitation current for phase exceeds 500 mA occurs. For example, in the case of the FTP-608 MCL series, a 10Ω motor is used. If the saturation voltage of the switching IC is 0.6V, then V = 0.5 x 10 + 0.6 = 5.6V. Therefore a constant current control is required if the applied voltage for driving the motor is 5.6V or more.

If constant voltage control is performed without performing constant current control, then at the worst about 0.74A of current flows to the motor coil when the applied voltage is 8V. The motor has an inductance component, and current does not increase immediately, even if a transistor is turned ON. If motor feed is performed at high-speed, the motor current does not increase, so major heating does not occur. If speed becomes slower, however, the motor current rises continually, and reaches the maximum current. Therefore if speed is slow, the coil current flows until it reaches maximum current, duty increases and heating increases.

Fig. 60 Motor excitation current

[At constant voltage drive]



If the cycle is short (fast), current flows in a safe range.

If the cycle becomes longer (slower), current increases to the critical range.

If the cycle becomes very long (slow), current enters the breakdown area.

At the worst, heat breaks down the insulating coating of the coil, and the coil is shorted. If the coil is instantaneously shorted to 0Ω, it is possible that the drive IC will break down or power may shutdown, but in reality a short occurs with some resistance value remaining. Loss when a 10Ω resistance drops to 5Ω is as follows.

At 10Ω $(8-0.6)^2/10 = 5.476$ (watts)

At 5Ω $(8-0.6)^2/5 = 10.952$ (watts)

In this way, loss increases and abnormal heating occurs, and in some cases the surrounding molding may melt and become deformed, or smoke may be emitted. To prevent this the current must be maintained at a constant level. See Table 11 for the maximum current of the coil.

Table 11 Maximum excitation current of motor

Motor diameter	Maximum current (mA)	
ϕ15	450	FTP-607MCL, FTP-608MCL
ϕ15 (double motor)	500	Special mechanism, such as FTP-637MCL 600 series
ϕ20 ~ ϕ25	550	FTP-609MCL

If heavy current flows to the motor, the generated torque becomes high. If the torque is unnecessarily high, jamming occurs, and when the platen or gear stops, forcibly turning the stopped gear at a high torque causes such problems as a gear breakdown. The current which flows through the motor should only be at a level where loss of synchronization does not occur, or where a gear is not destroyed even if the motor loses synchronization in gear locked status. Use one of the many ICs available that have a constant current circuit for 24V motor driving ICs. The following is the case when a dedicated IC is used.

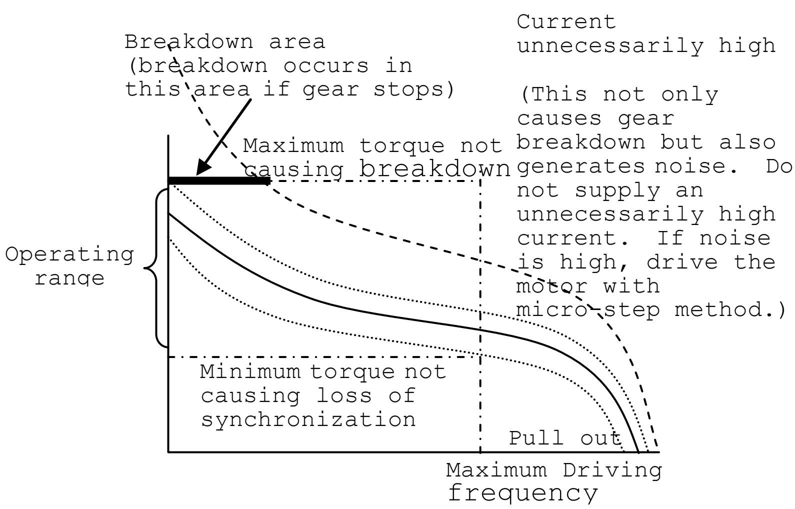


Fig. 61 Motor torque curve

[Important]

Use an external large capacity fast recovery diode or a Schottky barrier diode for the motor excitation signal. If a parasitic diode inside an IC is used, the counter current cannot be absorbed at high-speed, and this causes the IC to heat and the motor excitation current to become unstable.

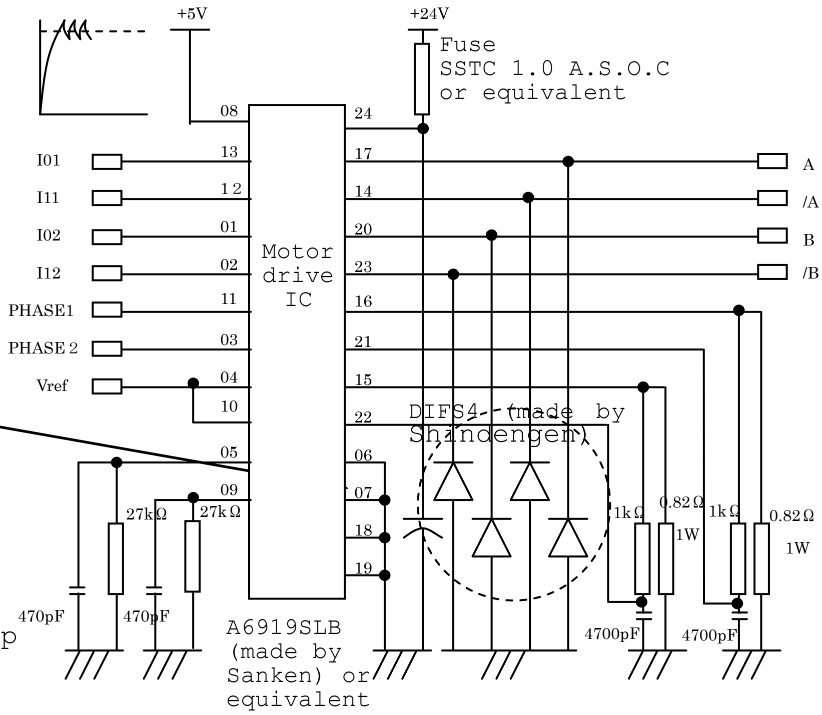
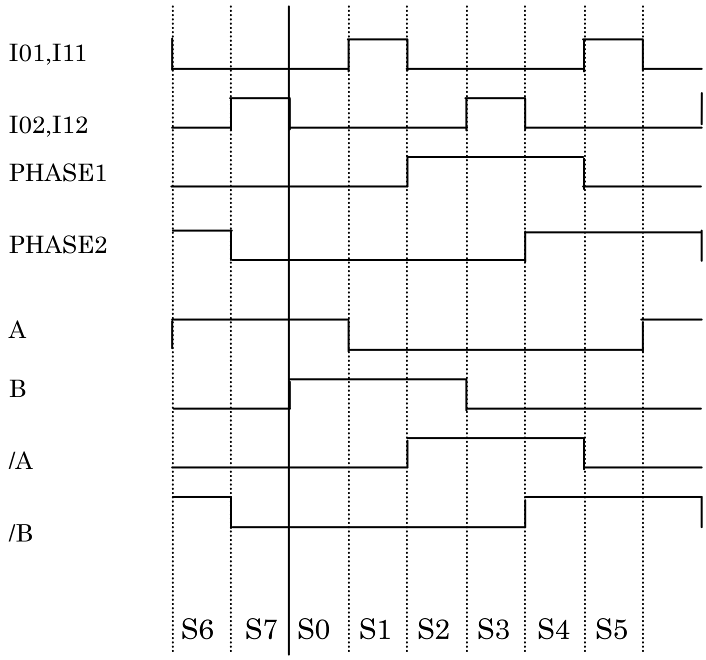


Fig. 62 Example of step motor drive circuit

Fig. 63 Example of motor excitation signal

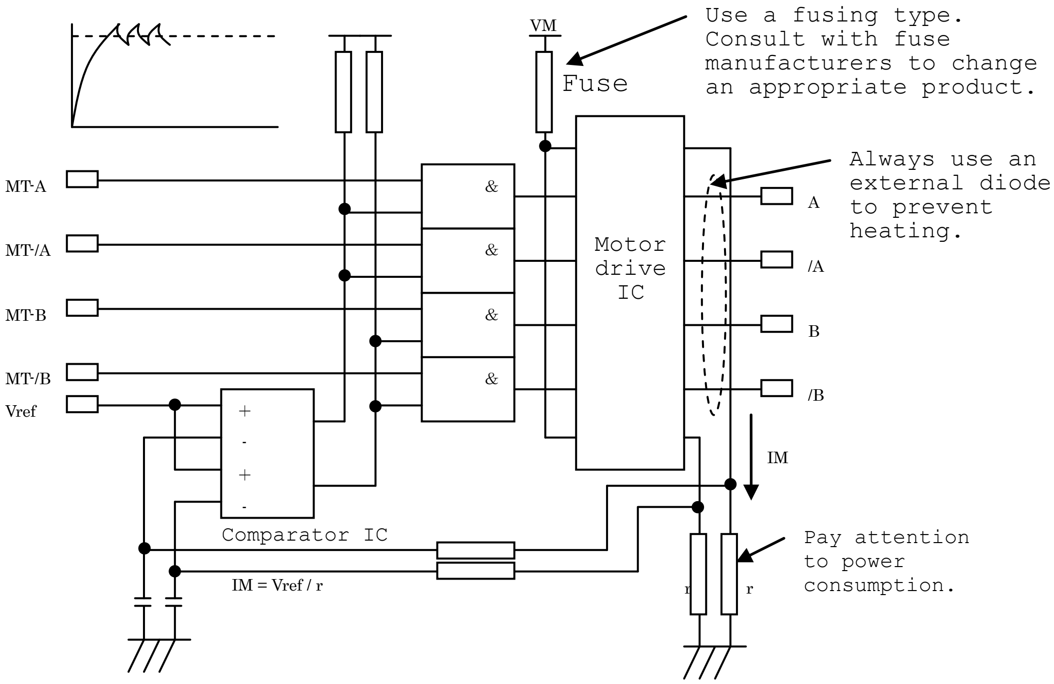
Input signal
* This is the signal when A6919SLB is used.
The signal shown in 5.2.2 is generated.

Output signal
* This is the signal when A6919SLB is used.
The motor is operated even if the logic is inverted.



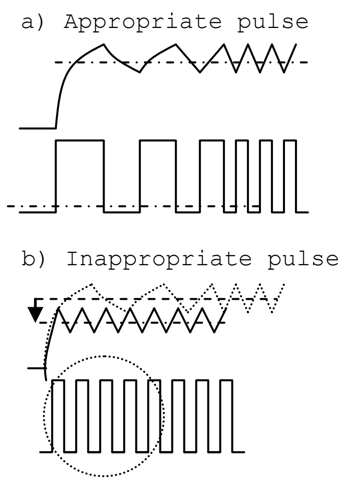
Drive ICs for low voltage rarely have these functions. Therefore a feedback circuit must be created to create a constant current circuit. It must be noted that the A-/A phase feedback circuit and the B-/B phase feedback circuit must be separated. The ground side must be separated inside the motor IC.

Fig. 64 Example of low voltage drive circuit for motor



Some MPUs have a built-in PWM function, and external circuits can be decreased by using this function. This is a way of limiting the motor current to be constant by switching each phase output signal. Since this circuit is not a feedback type, the accuracy of constant current control drops. However the circuit configuration can be simplified.

Fig. 65 Chopping drive



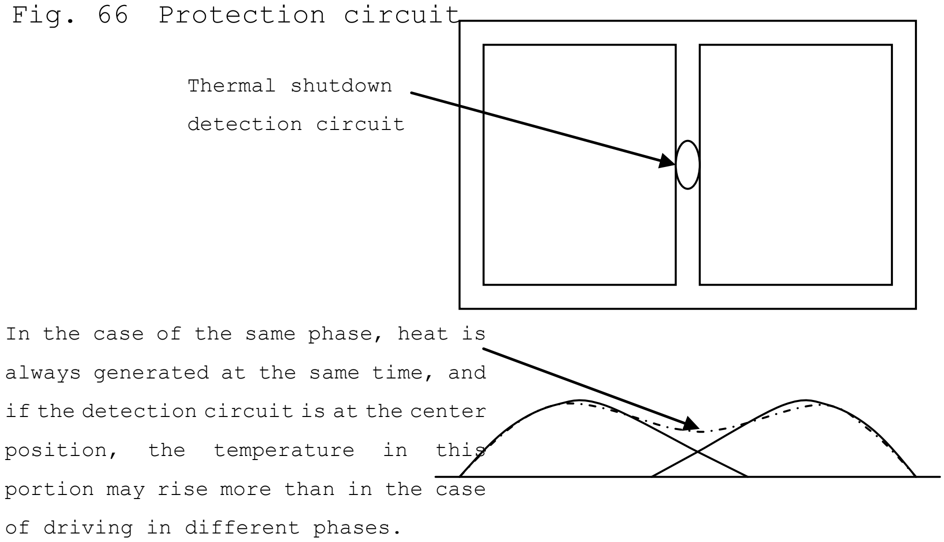
Note) Current does not rise if rapid switching is performed during rise time.

Use PWM for the pulse, and do not perform switching until current reaches a predetermined current. If switching is performed before current rises, the rise of current becomes slow, and the desired torque cannot be acquired. If the cycle of switching is lengthy, the width of the OFF period increases and the current OFF period increases. This increases the ripple width of the excitation current, and makes operation unstable. Also be certain to attach a fuse as a safety measure to the motor circuit to prevent smoking and combustion by a motor short circuit.

[Other precautions]

Because of the limitation of allowable loss of elements in use, ICs may have to be driven in parallel. Some ICs have a built-in thermal shutdown function. In this case, if the same ICs in the same phase are driven, a thermal shutdown may occur more quickly than in the case of using only one IC depending on temperature distribution.

Fig. 66 Protection circuit



In this case, it may be effective to separate the ICs. Confirm this before designing. If the timing difference between two ICs is major, a short circuit current may be generated, so mount the ICs close together with a short interconnect, and minimize the difference of signals between ICs.

(A) DC motor drive system

If the DC motor is driven by a transistor, as shown in Fig. 67, the motor cannot immediately stop even if the transistor is turned OFF. At worst, the cutter overruns the home position, causing problems. Be certain to use an IC dedicated to DC motors, and if an overrun occurs, apply reverse bias for a predetermined period, and brake when necessary. If reverse bias is applied unnecessarily long, reverse rotation occurs, which causes problems. Adhere to the period of time stated in the respective specification. Fig. 68 shows an example when a dedicated IC is used. The pull up and pull down resistance of the input terminal are for turning OFF the current to the cutter while the CPU is being reset, and stopping abnormal operation. If the cutter is locked, heavy current flows in the DC motor to forcibly rotate the motor. If the motor is stopped due to an abnormality, at the worst this current flowing in the motor may generate an internal short circuit. As a safety measure, be certain to insert a fuse in the power supply line to prevent smoking and combustion. See the respective product specification for information on timing.

Fig. 67 DC motor drive circuit

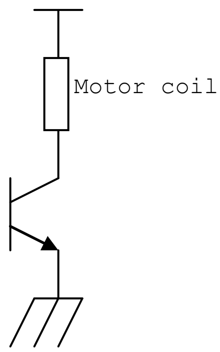


Fig. 68 Example of DC motor drive circuit for cutter

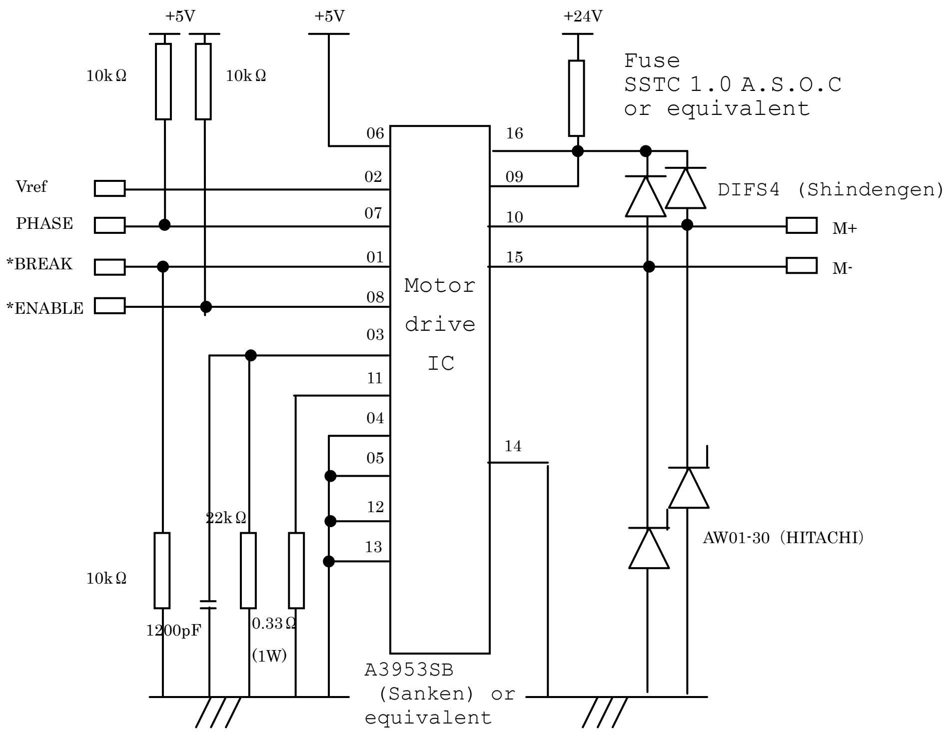
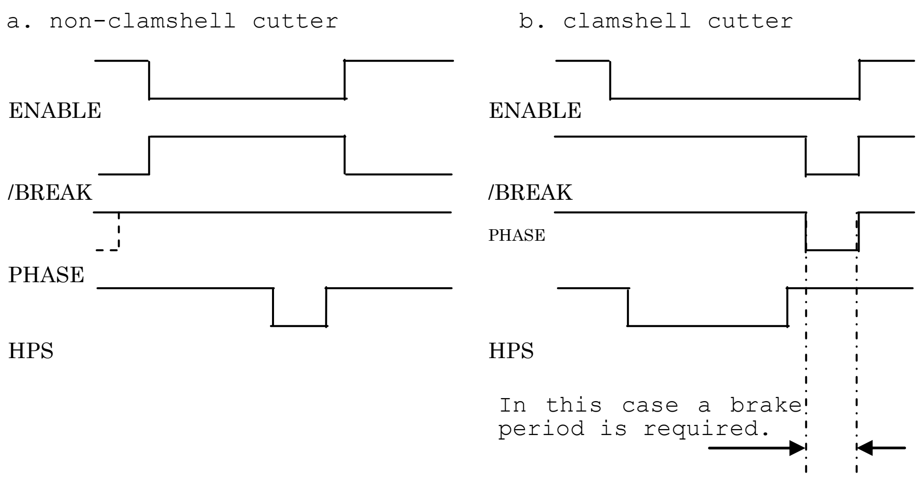


Fig. 69 Example of control vibration timing



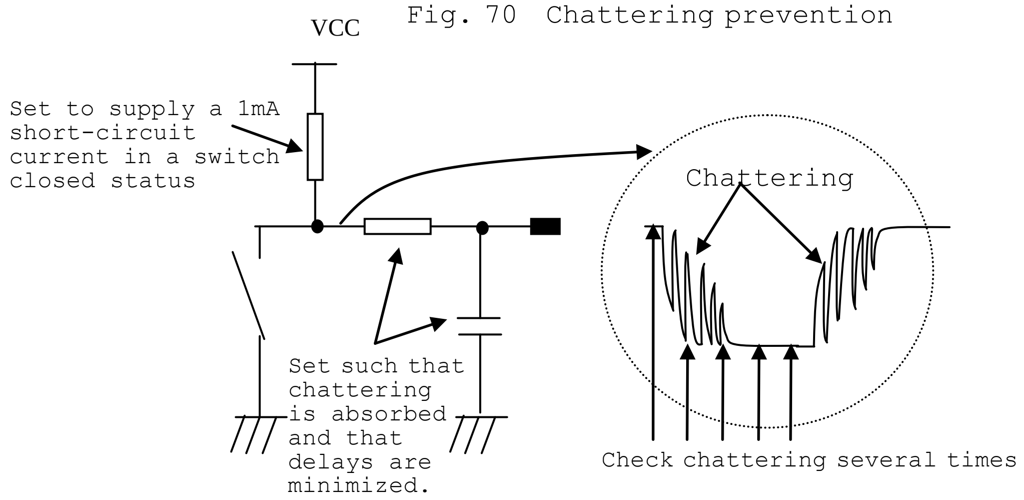
(C) Home position processing

A cutter requires a home position. A home position sensor is controlled either by a micro switch (for cutters excluding FTP-607/608 MCL 400 series) or by a photo sensor (for FTP-607/608 MCL 400 series).

[Micro switch type]

In the case of a micro switch, chattering is generated when a contact opens/closes. Set the current that flows to the contact to about 1mA (for details, see the respective specification), and to prevent chattering use an RC filter circuit or firmware, and check chattering several times.

Fig. 70 Chattering prevention



[Photo sensor type]

For details on the photo sensor type, see the section on the paper detection sensor in the next section.

6.3 Sensor circuit

The major sensor functions are as follows. Refer to the respective section for a function already described.

Table 12 Detection circuits

Detection function	Detection device	Refer to	Remarks
No paper detection	Photo interrupter	Fig. 71	
Platen up detection	Micro switch	Fig. 70	
Cutter home position detection			
	Photo sensor	Fig. 71	Low height cutter
Temperature detection	Thermister	Fig. 58	

6.3.1 Photo interrupter drive circuit

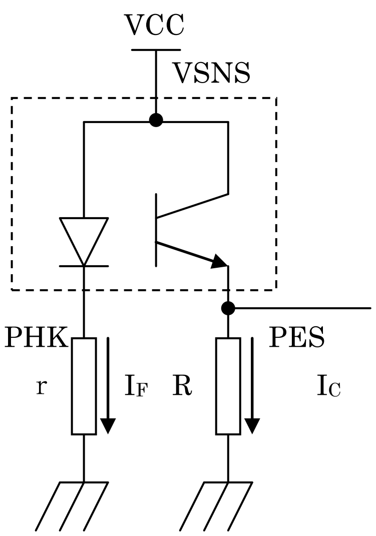
Details on the terminals of a photo sensor follow. A photo transistor is an emitter follower circuit. If current increases due to heating, for example, the voltage between VCEs is dropped by an external resistor, and current is decreased (negative feedback) to stabilize the circuit. Stable detection is possible even if the environment temperature fluctuates.

Table 13 Photo interrupter

Signal name	Function	Description
PHK	Photo diode cathode	Sets I_F by resistance r
PES	Photo transistor emitter	Generates voltage of Ic x R by resistance R
VSNS	Photo interrupter power supply	Switching by power supply recommended

Switch the power supply to the photo sensor, and turn it OFF during standby. Reading output V (PES) from the photo interrupter by an AD converter is recommended. The IC changes considerably depending on the paper route, the distance from the sensor surface and the angle.

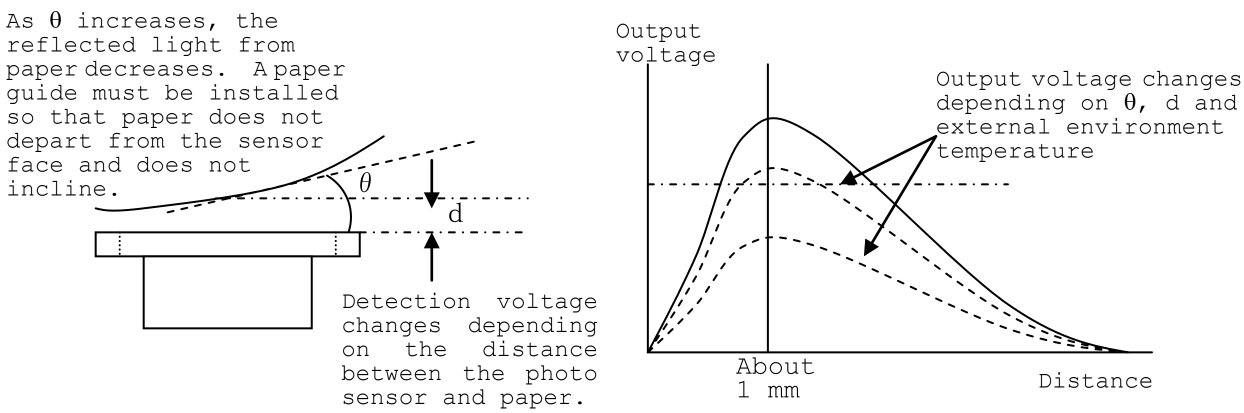
Fig. 71 Sensor drive circuit



Also when a sensor is used for mark detection, the IC changes depending on the reflectance, and V (SNS) also changes. We therefore recommend making the threshold programmable.

Normally the IF is set to IF = about 20 mA. If the bias resistance R of the output is increased, potential rises even with a dark current, and voltage does not sufficiently drop. If the bias resistance R is small, on the other hand, voltage does not rise sufficiently even if paper exists. Therefore adhere to the circuit conditions stated in the respective product specification.

Fig. 72 Relationship between detection face distance from sensor surface and sensor output



7. Thermal printer drive system

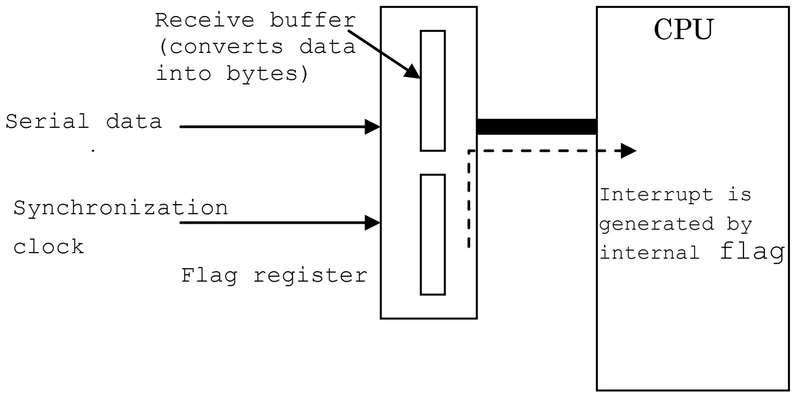
7.1 Thermal printer drive flow

7.1.1 Data receive processing

For a thermal printer where print quality is critical, the timing of the motor related to printing is very important. For this, the highest priority is normally assigned to the timing of energizing the motor. In the case of serial communication, where an RS-232C interface is used, for example, an error occurs if the receive timing is missed. So in this case, higher priority must be assigned to serial communication. If serial receive processing takes time, then the timing of the phase shift of the motor is missed, and printing is disturbed.

Normally UART is used in serial communication, where 1 byte of serial data is received, and after receiving the serial data, an interrupt is generated and byte data is saved in the receive buffer as internal interrupt processing. At this time, the receive buffer in the first stage loads the received codes once, regardless whether it is data or commands, so that data is not lost. Determine the buffer size in several tens of bytes to several kbytes according to the receive speed. If the buffer becomes full, the printer notifies busy status to the host, and the host stops data transmission until an open area is generated.

Fig. 73 Serial receive block



If the transfer speed is 115.2 kbps, for example, and if the data length is 11 bits, including the start bit, stop bit and parity bit, then 1 byte data requires

115200 / 11 = 10473 bytes/sec.

95.5 μsec/byte

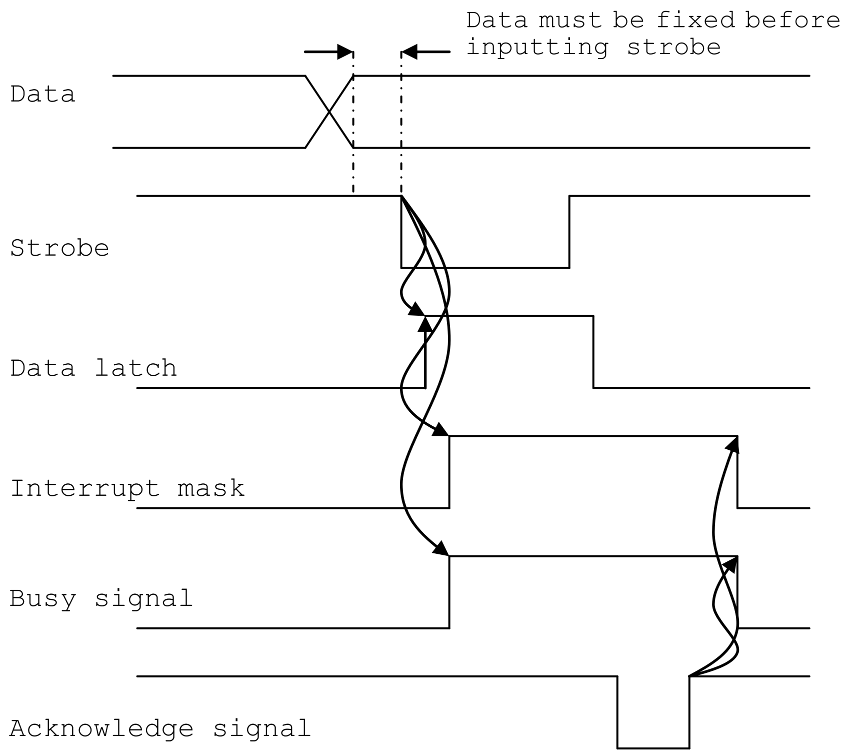
So it is necessary to receive one interrupt every 95 μsec. For interrupt processing, several steps or more processing are required, including stack saving, return, UART internal memory read and write to buffer. Therefore if receive processing is lengthy, data may be lost during receiving. To simplify processing, a code buffer dedicated to receiving is created, and save processing is performed especially for write processing to the code buffer.

In the case of parallel interface, a hardware handshake is installed, so data can be held in byte or word units. Therefore a measure to avoid losing data, required for serial communication, is unnecessary. However if an interrupt is generated by a write pulse, and data is read and loaded into an internal buffer without using the data latch function, data may be changed before receiving an interrupt and loading the data, and in this case data may be lost. Because of this always provide the latch function.

Latching holds data at a rise edge. Therefore define the data before inputting a strobe, use an inversion signal of the strobe as a latch pulse, and latch the data when the strobe drops to "Low". At the same time, an interrupt is generated to the CPU when the strobe is at "Low". When interrupt processing starts, an interrupt mask is set. If the strobe remains "Low" when processing is over and the mask is cleared, an interrupt may occur again for the same data. Therefore the interrupt mask must be cleared after confirming that the strobe signal is "High".

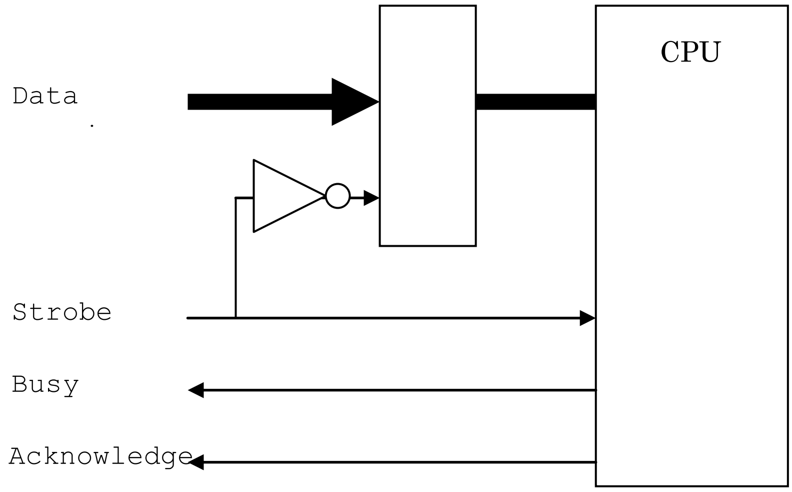
At the same time with the input of a strobe, the printer returns a busy signal to the host. When the busy signal returns to "Low" and it is confirmed that data has been processed, the host sends the next data. Generally the printer notifies the host that data is received by an acknowledge, clears the mask at the same time when busy is cleared, and then enables receiving the next data. The printer performs a busy/acknowledge handshake.

Fig. 74 Data receive timing



The functional blocks are shown below.

Fig. 75 Parallel receive block



7.1.2 Receive buffer management

Data is transmitted/received by a serial or parallel interface, and a receive buffer is installed in order to prevent data loss. Since data is loaded and written to an internal receive buffer, software pointers are used. The buffer normally constitutes a ring buffer. An index buffer must be installed to form a ring buffer to judge whether the buffer is full or if there is an area to write data to.

In initial status:

"write pointer" = "read pointer"

write pointer: = '0'

read pointer: = '0'

buffer full flag = '0'

buffer empty flag = '1'

Use an offset from the first address or a direct address for the pointer, depending on the respective configuration. A receive interrupt is generated when data is sent. Under buffer full conditions, interrupt disabled is set since there is no area to write data to even if data is received. Under conditions where a receive interrupt is generated, at least 1 byte of write area exists. After writing 1 byte of data, the pointer for writing is incremented. After incrementing the pointer, the incremented pointer is compared with the buffer end address, and if it exceeds the buffer end address, the buffer first address is set for the write pointer. The method and location for comparison depends on the firmware configuration, so perform judgment based on the respective firmware configuration. Then the write pointer is compared with the read pointer. If the write pointer matches the read pointer, the buffer is full. If data is received and saved when data does not exist in the buffer, the buffer empty flag is cleared.

Fig. 76 Data receive interrupt flow

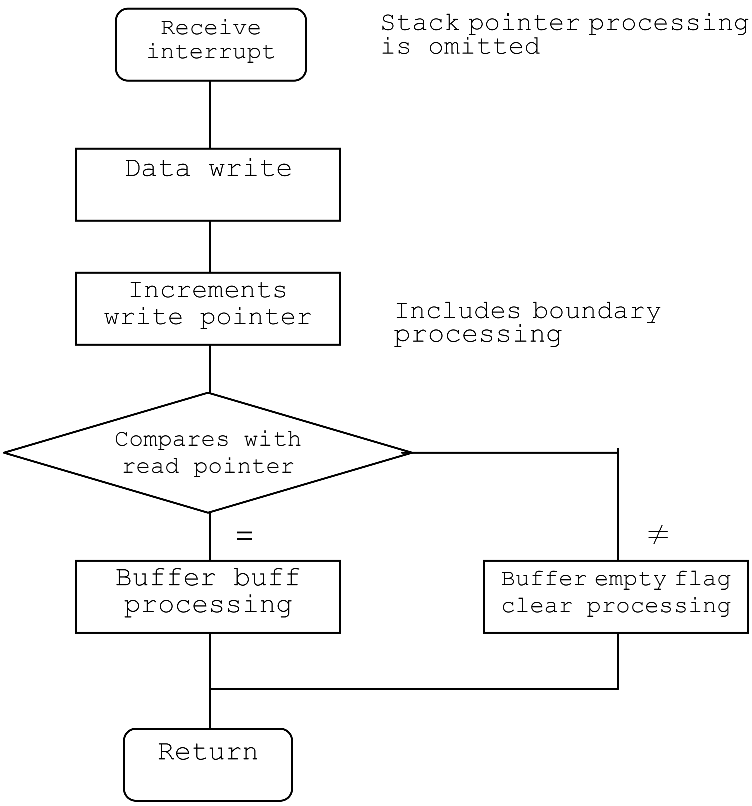
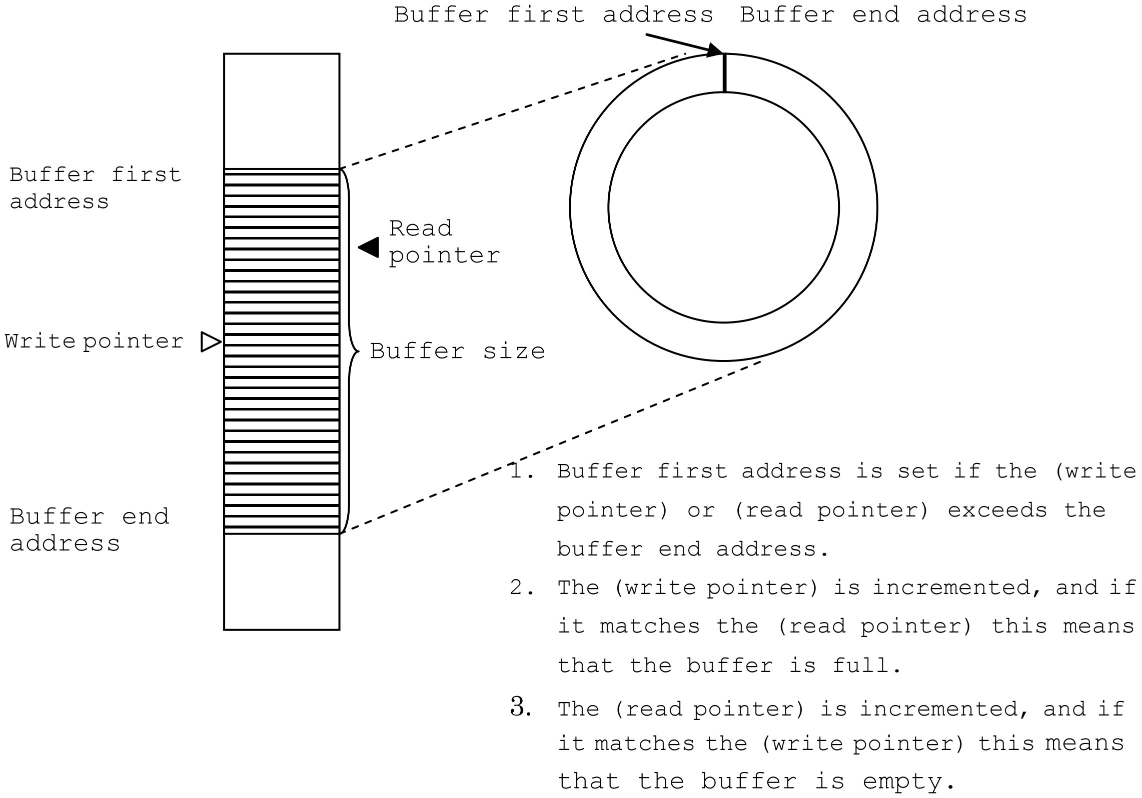


Fig. 77 Ring buffer structure



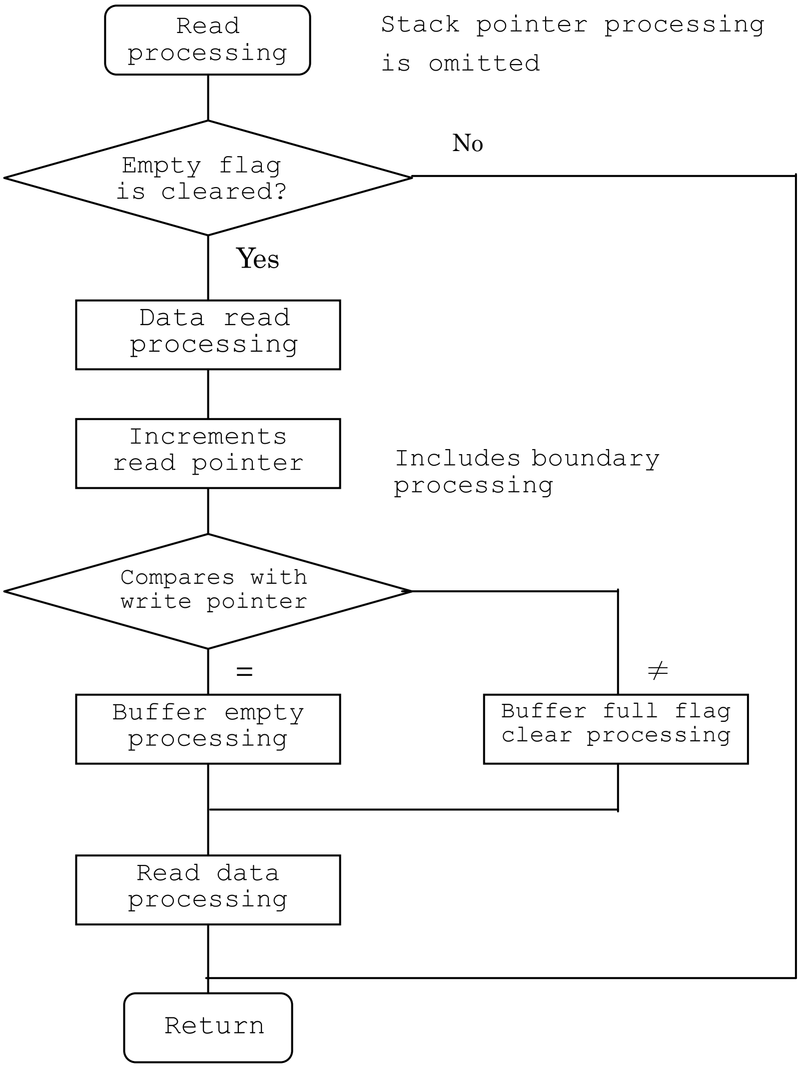
7.1.3 Receive buffer read processing

To process the received data as data or a command, the processing is performed at a level where priority is lower than a receive interrupt, normally as a subroutine within a main routine.

The existence of read data is judged by whether the buffer empty flag is cleared. 1 byte of data is read from the address indicated by the read pointer (code buffer) and the read pointer is incremented. At this time, the incremented read pointer is compared with the write pointer, and if there is a match, this means that the buffer is empty, and if there is no match and if the buffer flag is ON, [the flag] is cleared.

This processing is called up whether data is present or not, since interrupt processing is not used. Therefore the existence of data is judged at the beginning of processing, and processing is exited if data does not exist. Even if there is no data to be read from the code buffer, but data may be in the buffer for printing when data is developed, be certain that a loop is not generated in read processing.

Fig. 78 Receive buffer read flow

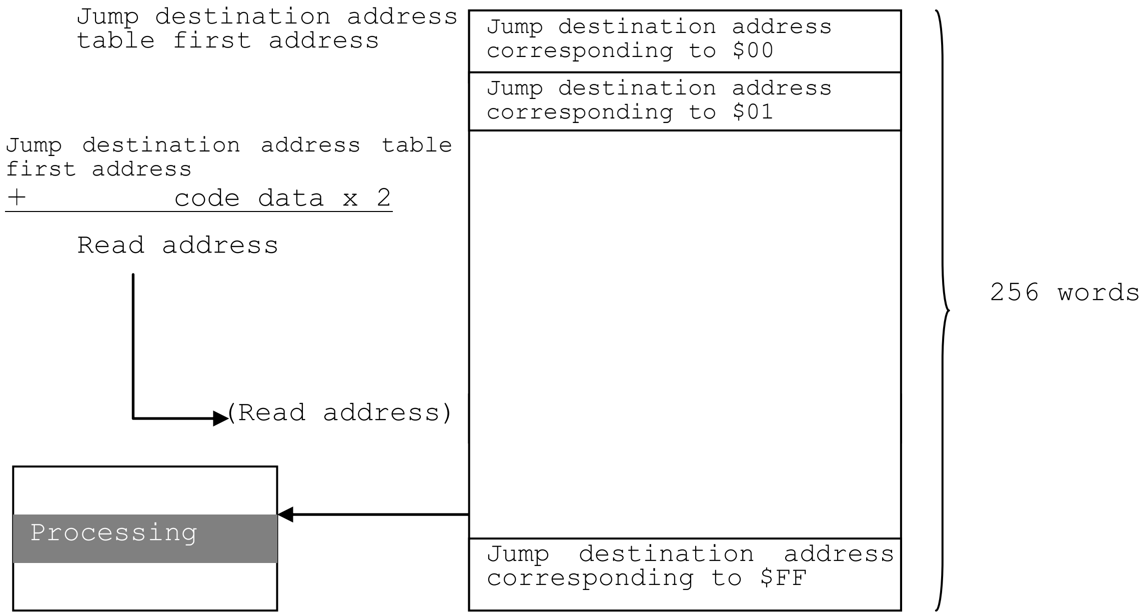


7.1.4 Receive buffer data development processing

Data read from the code buffer must be analyzed to determine whether it is for command processing or for print data.

In the beginning of data evaluation, the judgment assigned to ASCII codes is performed. In other words, a table corresponding to the codes $00 to $FF is prepared, and processing is executed after jumping to the address provided by the table.

Fig. 79 Receive buffer data development

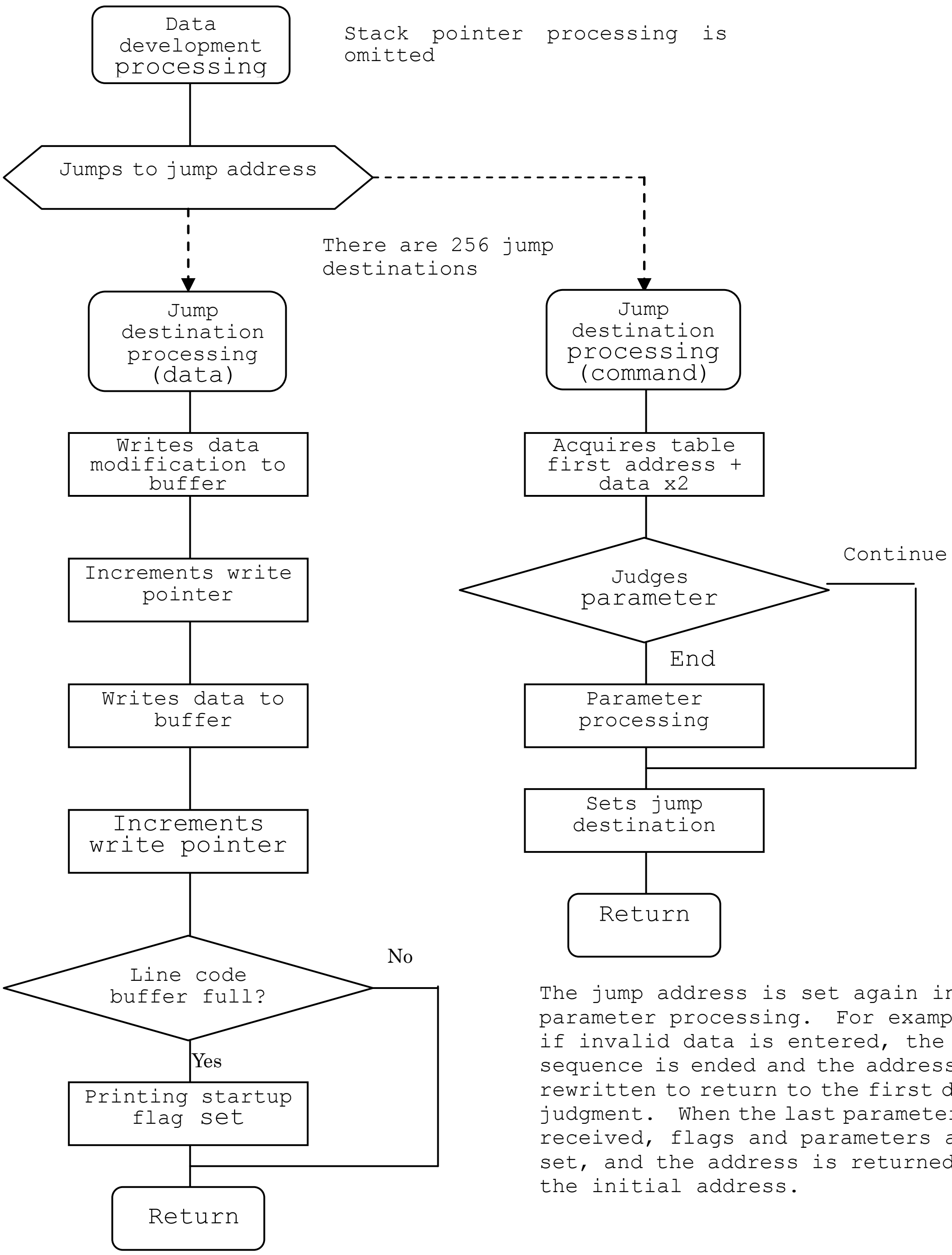


An address is normally comprised of 2 bytes, so the code read from the code buffer is doubled, and that result is added to the jump destination first address. The jump destination address provided for the address value calculated in this way is read, and the current address jumps to this address. In the beginning of the routine, a processing to jump to the jump address is inserted. For example, in the case of having parameters, as in the case of the ESC sequence, the first read data is $1B. In this stage, it is judged whether the read data is data or a command, and the first address of ESC processing is set to the jump address. In the beginning of the second read data, processing can jump to ESC processing. The following table is provided for ESC processing, and the next jump destination address can be set to a jump address based on the read code.

Flags and parameters are set in order to end the command sequence in this stage, and the address is returned to that of the initial code judgment processing.

Processing is performed at sequentially deeper levels depending on the number of parameters, but the address is reset each time, so even if the number of parameters increase, the processing time is averaged each time, and becomes fast.

Fig. 80 Buffer development processing



The jump address is set again in parameter processing. For example, if invalid data is entered, the sequence is ended and the address is rewritten to return to the first data judgment. When the last parameter is received, flags and parameters are set, and the address is returned to the initial address.

In the above example, a line buffer is set. The command parameter and the print data are separated, and a flag for modification is added to each character. Whether printing can be started or not depends on the mode for each character. For example, if 80 digits at double width are set, 40 digits of data can be printed. Every time data is written, it is judged whether data is full. The above example is in line mode, but in the case of page mode, the print start command is used to set the print start flag.

7.1.5 Image buffer development processing

In the above processing, when it is judged that the line buffer is full, the data must be converted into actual print data. In the case of graphic printing, line data = print image data, but in the case of text data, code is read, font data corresponding to code is read from the CG (character generator), and this font data is converted into data that can be transferred to the head.

For example, the CG data is comprised of the data shown in Fig. 81. CG data can be row data or

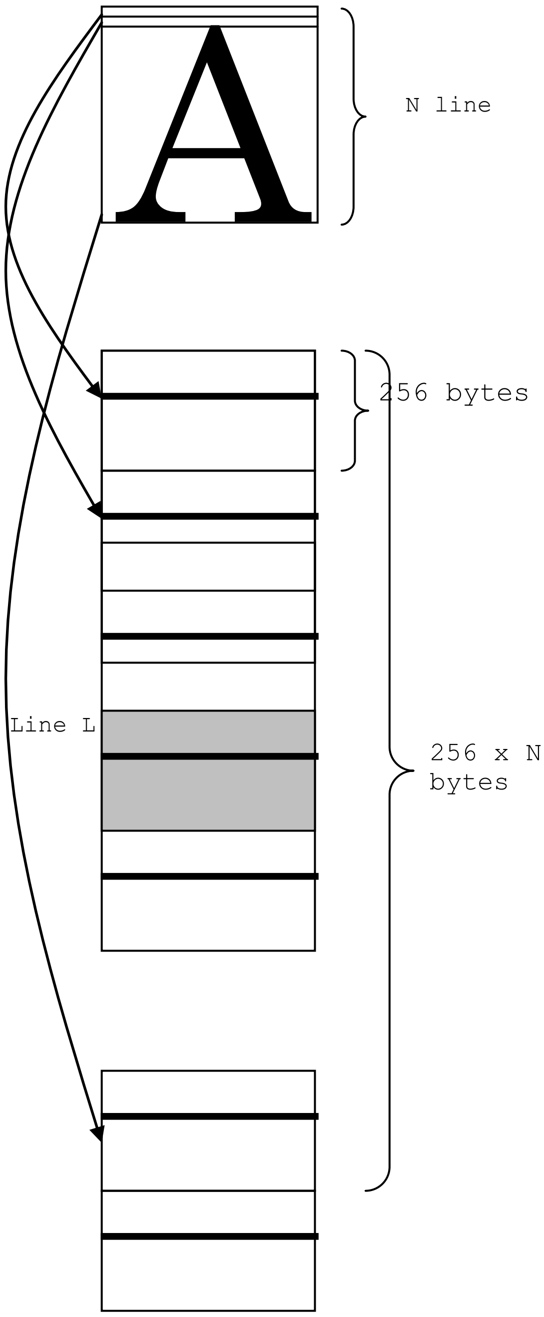


Fig. 81 Font data table

column data depending on the way data is arranged. Adhere to the specification of the respective CG to be used.

In the case of row data, it is unnecessary to prepare the image buffer for the height of the character to develop data in the image buffer. In the case of column data, all data must be developed in the image buffer.

In the case of row data, if the row data of the same character is stored in a table, data can be sent to the head without developing the data in the image buffer using the data of the code buffer and the line counter as offsets.
When data is read from the line buffer, if the currently printing line is L, then the data of characters corresponding to all the codes in the line L is stored in 256 bytes. This means that data on the Lth line, from the code of the read character, which is sent to the head, is in the following address:

Font table first address + L x 256 + code

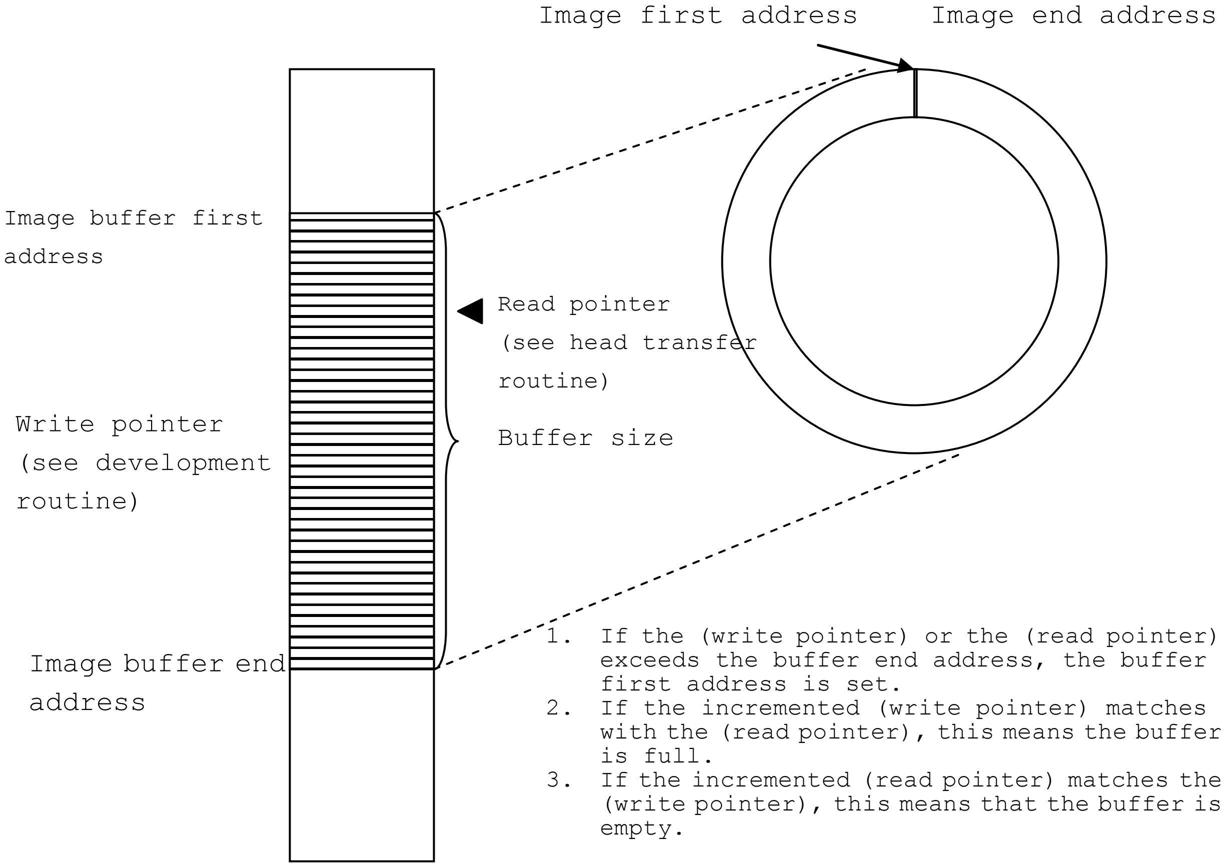
Therefore data is read from this address and sent to the head.

7.1.6 Head data transmission processing

When data development in the image buffer is over, the print data is sent to the head. At this time, the ring buffer configuration is used so that memory is optimized by the write pointer for image development and the read pointer for transferring data to the head.

The data in the line code buffer is developed in the image buffer referring to the CG. If 1 dot line of print data is prepared, the developed data can be sent to the head, and printing can be started.

Fig. 82 Image buffer development

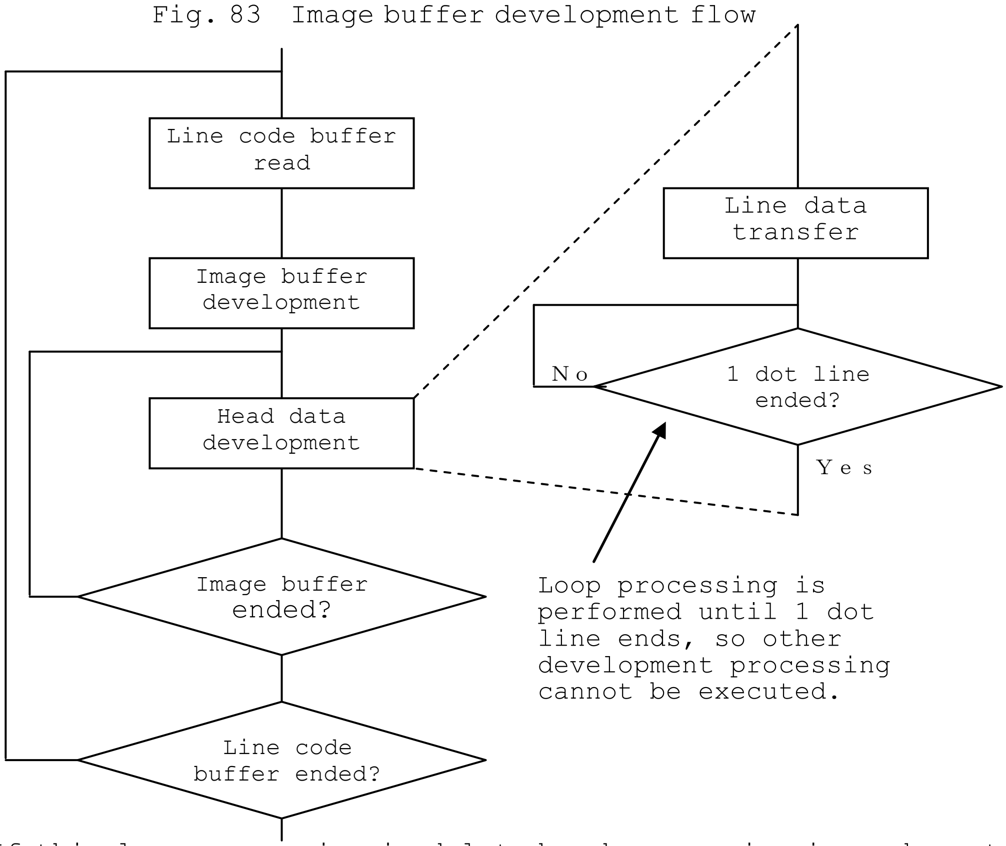


1. If the (write pointer) or the (read pointer) exceeds the buffer end address, the buffer first address is set.
2. If the incremented (write pointer) matches with the (read pointer), this means the buffer is full.
3. If the incremented (read pointer) matches the (write pointer), this means that the buffer is empty.

If the image buffer development time + the head development time < printing line cycle is established for each line, including the time consumed for interrupts, all of the processing time can be continuously processed in parallel (time sharing). However if this is not possible, printing must be started after sufficient data is image-developed first, otherwise printing stops in 1 dot line units, which disrupts printing and causes noise. Select a buffer size appropriate for the respective situation.

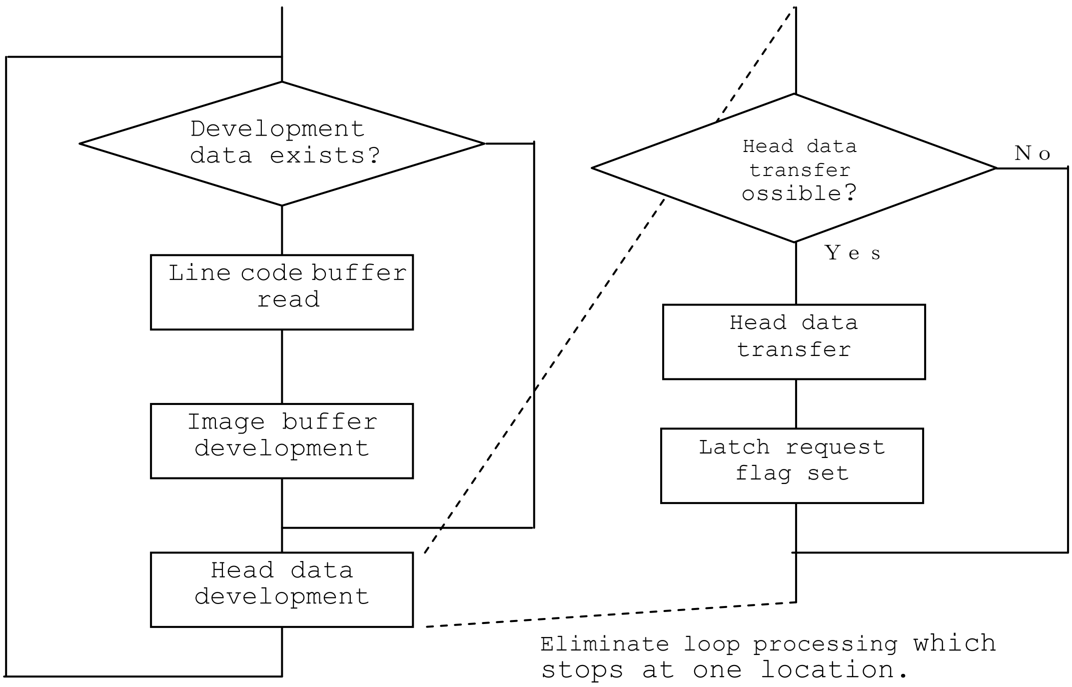
If the following configuration is used, the next data may not be able to be developed before the printing of 1 dot line is over, and this drops efficiency (printing speed becomes slow).

Fig. 83 Image buffer development flow



If this loop processing is deleted and processing in each routine is judged by flags, processing speed increases. However processing speed drops if judgment processing is performed in all the steps. Handle this issue as the respective case dictates, such as by performing processing in block units.

Fig. 84 Head data development flow



This processing method is very effective when the input data is directly printed as is, just like the case of graphic data. The above development processing is executed in a main routine, and speed can be increased by avoiding programs that consume steps, such as conditional branching.

For the data sent to the head, data latch and energizing processing are performed using interrupt processing. The above example is a case when the head data is sent 1 time/1 dot line, and if data is divided by software, a corresponding change is required.

7.1.7 Head energizing processing

Timer interrupts are used for the timing of latch processing of the head and strobe driving.

In a timer interrupt, data latch processing, strobe ON/OFF processing and motor phase processing, for example, are executed. If there is a limitation in the number of timer interrupts of the CPU, sensor detection may be performed in the time processing. To activate the timer, the timer is set when data is ready in the main routine, and an interrupt is activated. Some combinations are possible in interrupt processing. For this, an index counter is installed according to the processing, and the status is shifted when a process is interrupted.

In this way, the processing time for each time can be decreased, and a complicated processing system can be reduced to a simple model.

Fig. 85 Head energizing processing

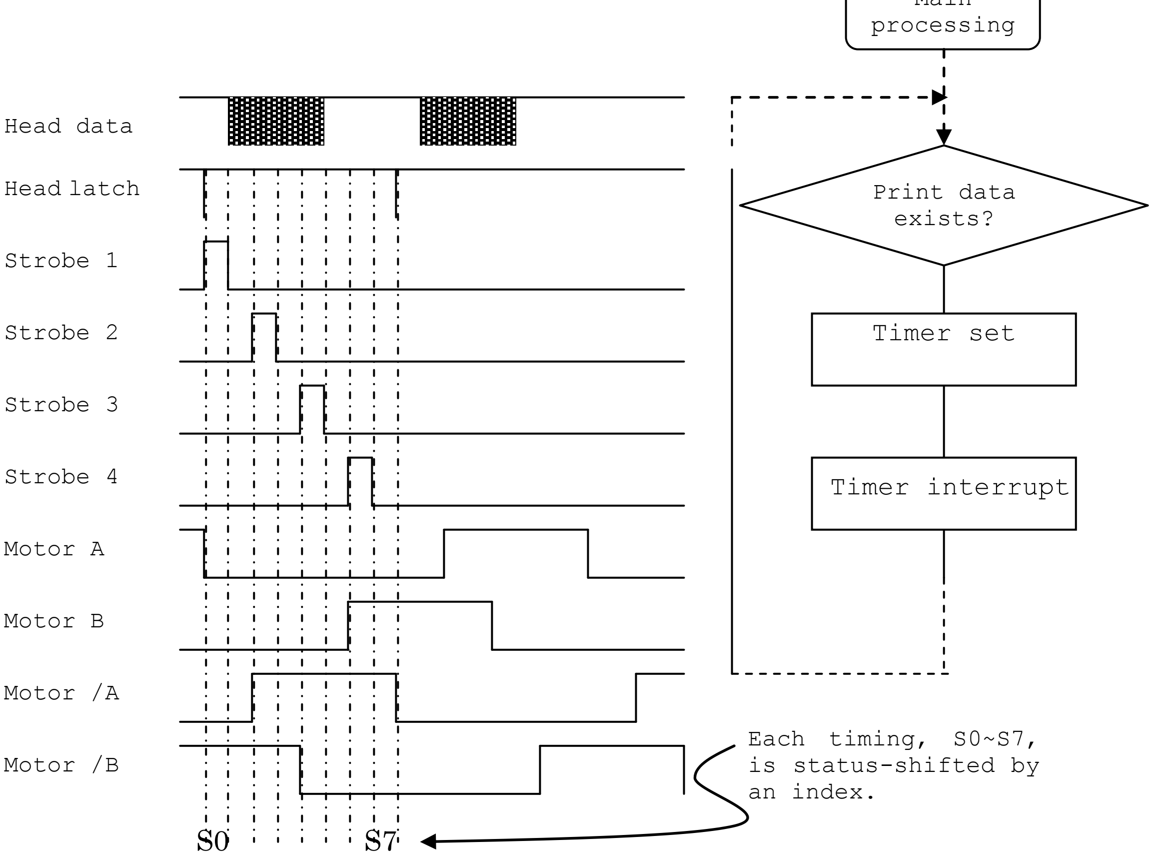
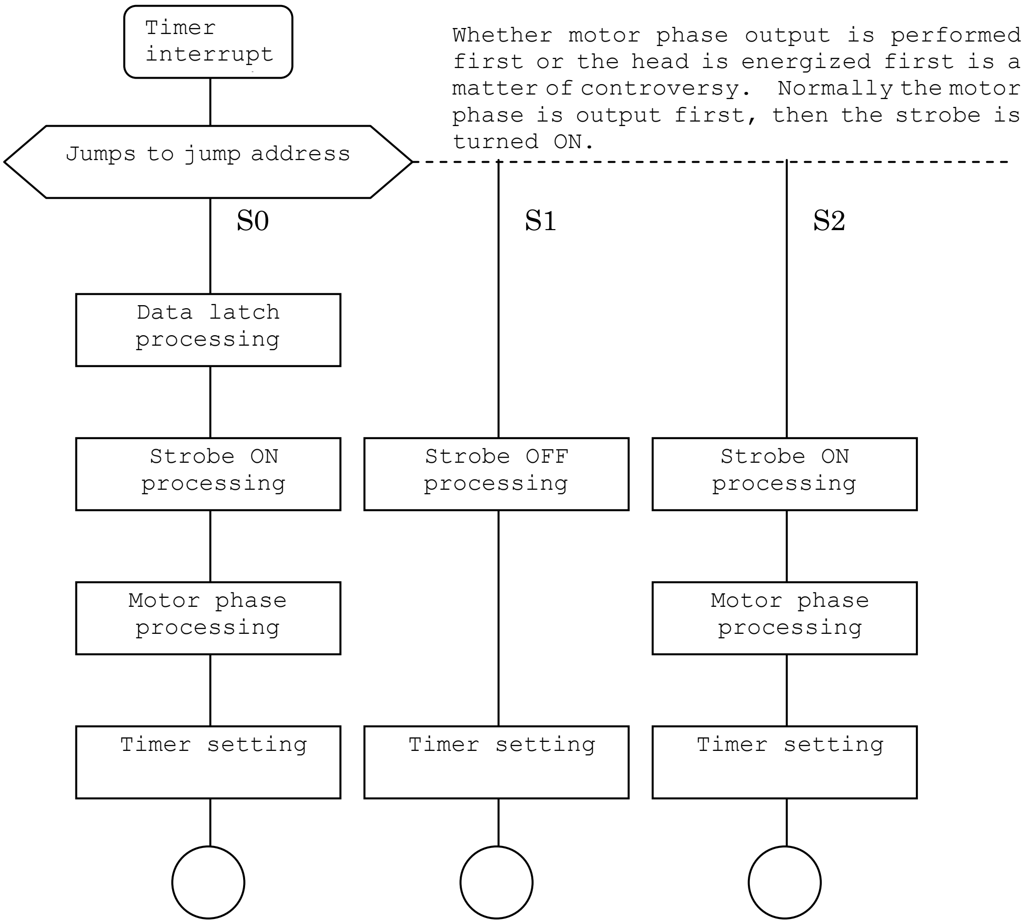


Fig. 86 Timer interrupt



7.1.8 Motor phase processing

An index counter is installed for motor phase processing, and this counter is incremented or decremented to output a corresponding phase. The output timing synchronizes with the timer of the head. In the following table, two sets of statuses (strobe ON and strobe OFF) correspond to one motor phase.

Table 14 1-2 phase excitation

Corresponding status	MT-A	MT-B	MT-/A	MT-/B
S0, S1	0	0	0	1
S2, S3	0	0	1	1
S4, S5	0	0	1	0
S6, S7	0	1	1	0
S0, S1	0	1	0	0
S2, S3	1	1	0	0
S4, S5	1	0	0	0
S6, S7	1	0	0	1

An example of simply outputting the excitation phase for the motor excitation phase is shown, and individual output differs depending on the motor driver IC to be used. The output data for a motor phase is read by the motor phase

table first address + index counter.

If it is defined that normal rotation is for incremation, and reverse rotation is for decremation in advance, then the output data can be easily acquired by masking the significant 5 bits of 1 byte with "0".

7.1.9 Head strobe output processing

In the above description, it is assumed that

S_{2n}: strobe ON

S_{2n+1}: strobe OFF

The strobe ON period depends on the paper to be used and the environmental temperature. The strobe OFF period is shorter than the strobe ON period. The cycle is also different depending on the printing speed, so

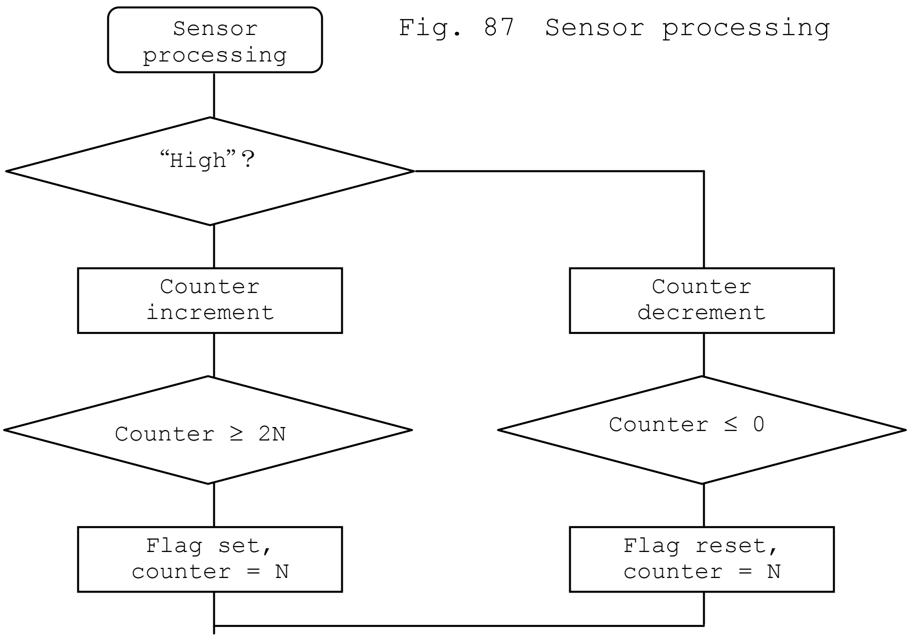
strobe OFF period = 1 strobe cycle - strobe ON period

In some cases the strobe OFF period is "0". If this relationship cannot be satisfied, it is necessary to lengthen the cycle or increase the voltage by dropping the printing speed, or decreasing the ON period using high sensitivity paper.

7.1.10 Sensor detection processing

Sensor detection is also normally executed during a timer interrupt. Since chattering is generated in a sensor during transition, judgment must be made after data is read several times.

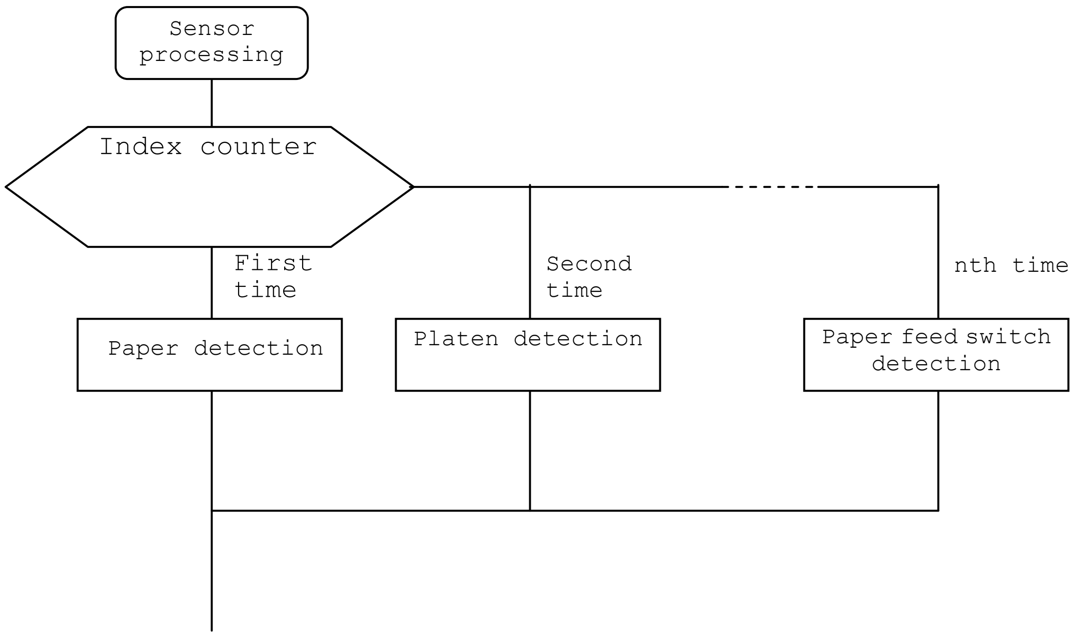
Fig. 87 Sensor processing



During sensor processing, other processings, such as the processing of an operation switch, are also performed. To read a sensor, either ports are read all at once and then judged, or data is sequentially read in 1 bit units.

In the case of sequential reading, one processing can be short. Timer interrupts that are too frequent are meaningless due to the influence of chattering. Here sequential reading is effective.

Fig. 88 Sensor processing time sharing



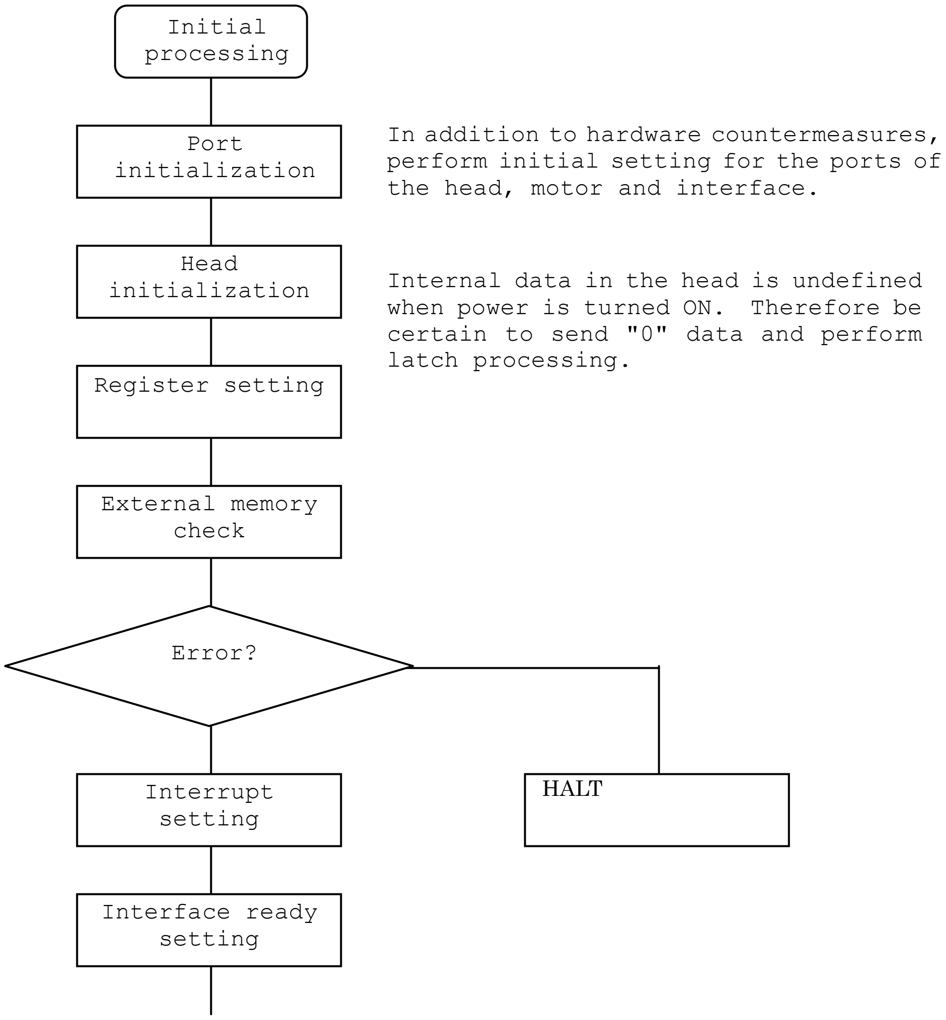
7.1.11 Initialization processing

Set hardware so that the head is OFF, the motor is OFF and the interface is busy during the reset period. If these settings are neglected, the printer operates abnormally when reset is performed or when power is turned ON, and at the worst the head is burned and damaged or the motor emits smoke.

When the hardware reset is cleared, the CPU starts up. When the CPU is started, initialization must be performed as the first processing. First set the ports. In port setting, port output to the head and the motor is set to OFF, and the ports of the interface are set to busy.

Then "0" data is sent to the head, latch processing is performed, and initial setting is performed. Then the internal registers are set. If there is an external memory, check that memory as well. When an error occurs and if the error is unrecoverable, the error information is notified and HALT is performed. When the system recovers, the watch dog timer is activated, the interface is set to ready, and main processing begins.

Fig. 89 Initial processing



7.1.2 Main processing

In the main processing flow, the configuration can be simpler if data is loaded to the buffer in data receive interrupt processing, and command processing is executed here so that data can be buffered. The data stored in the buffer is developed in the main routine, and data is sent to the head while monitoring the latch timing. The transmitted data is latched in a timer interrupt, and strobe control, motor phase output and sensor detection are performed. Actual processing based on the sensor status could be performed in the main routine.

The data receive interrupt has priority in a serial interface, and code development must be processed in the main routine.

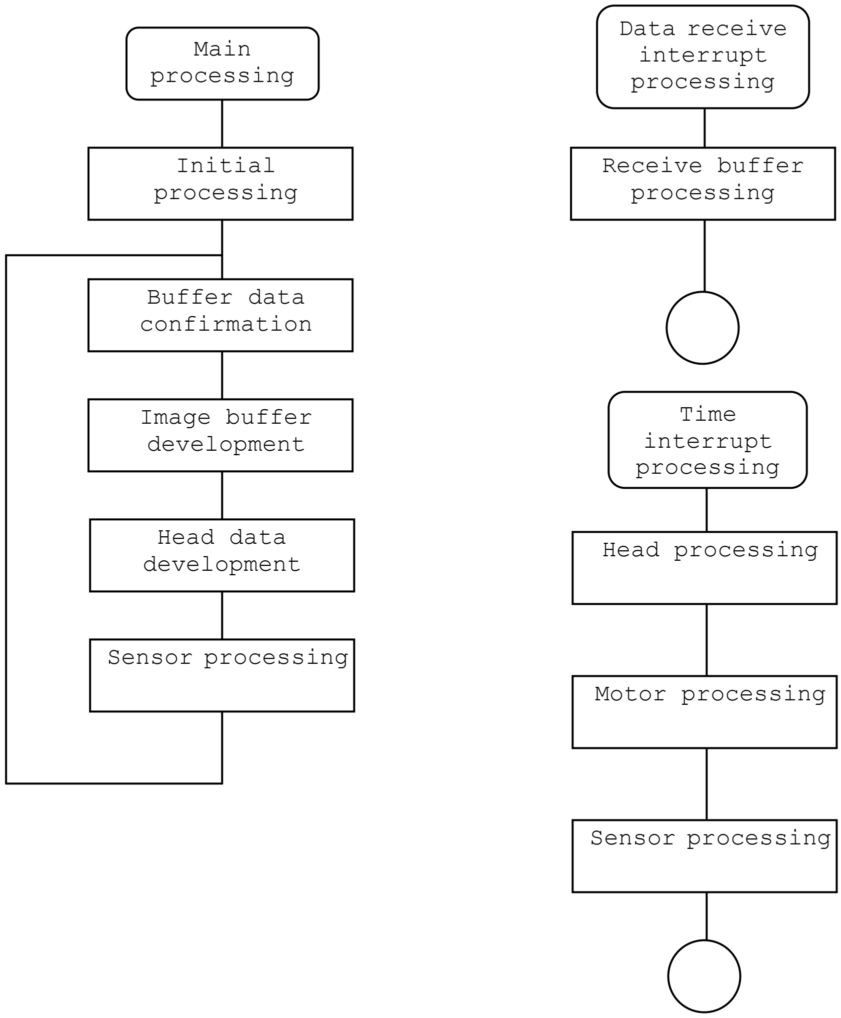


Fig. 90 Main processing

7.2 Step motor driving

7.2.1 Motor characteristics

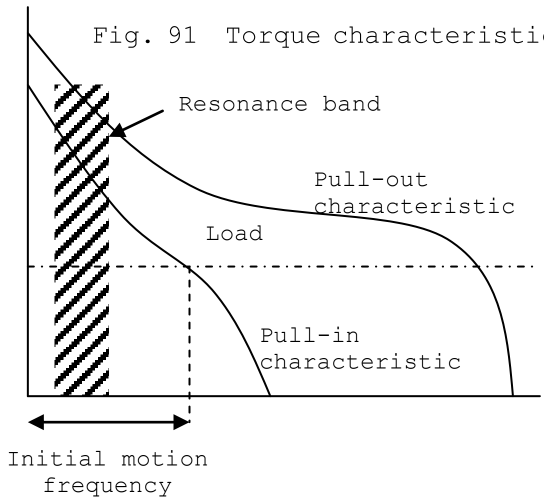
The motor has a pull-in characteristic (characteristic when the motor rotates by initial motion) and a pull-out characteristic (characteristic after motor moves). In pull-in the response is normally poor, so the initial motion starts slowly and the motor accelerates and reaches maximum speed. The low speed area includes the resonance area (frequency with which output torque drops in a specified frequency range) band, and this band must be avoided. This band is normally 200 - 500 PPS; check information on the respective motor for details. Unless otherwise specified, start with about 800 PPS.

The maximum frequency depends on the product.

Table 15 Maximum frequency

Series	Maximum frequency	Conditions
608MCL	3000	8.0V～8.5V
607MCL	4000	24V
609MCL	4000	24V

Fig. 91 Torque characteristic



7.2.2 Motor acceleration control

For acceleration/deceleration control, normally a trapezoidal control method is used. For example, it is assumed that speed is increased from 800 PPB to a maximum of 3000 PPS. In many cases, the excitation of the motor is OFF before the motor is started. For restart, a phase, which is currently stopped, is excited. In step "0", the current phase is output. The next phase is output 1.25 ms later, then the phase is switched a second time 0.74 ms later.

In the same way, a phase is output with a 0.33 ms interval in the fourth step or later.

Do not change phase 70% or more in 1 step. If a change of more than 70% is required, increase the number of steps.

Table 16 Acceleration table

Step	Frequency	Time (ms)
0	800	1.25
1	1350	0.74
2	1900	0.53
3	2450	0.41
4	3000	0.33

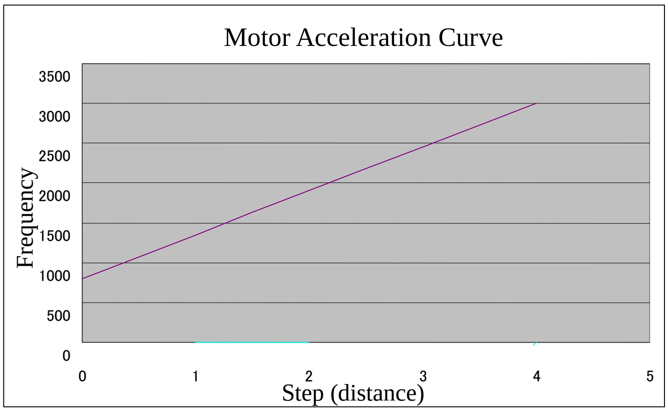


Fig. 92 Acceleration curve

In the above example, the motor is accelerated to maximum speed in 4 steps. In the FTP-608 MCL series, maximum frequency is about 3000 PPS (8.0V or more). If the motor is started up in 4 steps, about 70% increases, from the initial 800 PPS to the next 1350 PPS. 4 steps is equivalent to the step amount of 1 dot line, and normally the motor can be accelerated to the maximum speed during 1 dot line. In the FTP-608 MCL series, the drive voltage may fluctuate in a 4.2 ~ 8.5V range. Since the maximum drive frequency also changes depending on the voltage to be applied, attention to this matter is advised.

In the case of the FTP-607 MCL series, the maximum frequency is about 4000 PPS. If acceleration is performed in 4 steps, the initial change rate exceeds 70%, so the number of steps is increased. Normally a multiple of the number of dot lines or an even step over 4 is desirable. This example shows the case of 8 steps.

Table 17 Acceleration table

Step	Frequency	Time
0	800	1.25
1	1200	0.83
2	1600	0.63
3	2000	0.50
4	2400	0.42
5	2800	0.36
6	3200	0.31
7	3600	0.28
8	4000	0.25

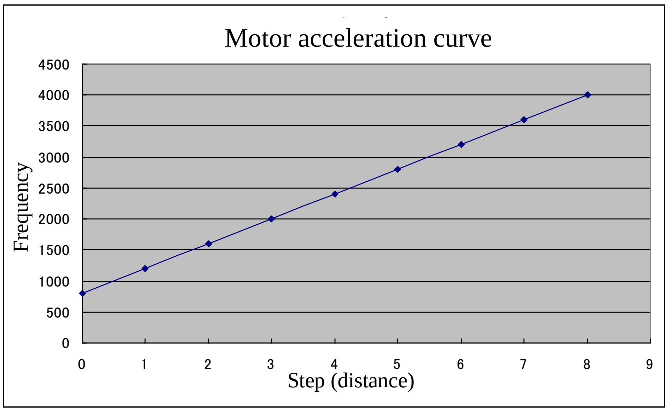


Fig. 93 Acceleration curve

In the case of the FTP-609 MCL series, the maximum frequency is about 4000 PPS. However since this series has 2 steps/dot line and the load of 1 step is high, acceleration in 12 or more steps is recommended. If the motor is not accelerated to a maximum speed of 4000 PPS, the number of steps can be decreased.

Table 18 Acceleration table

Step	Frequency	Time
0	800	1.25
1	1067	0.94
2	1333	0.75
3	1600	0.63
4	1867	0.54
5	2133	0.47
6	2400	0.42
7	2667	0.38
8	2933	0.34
9	3200	0.31
10	3467	0.29
11	3733	0.27
12	4000	0.25

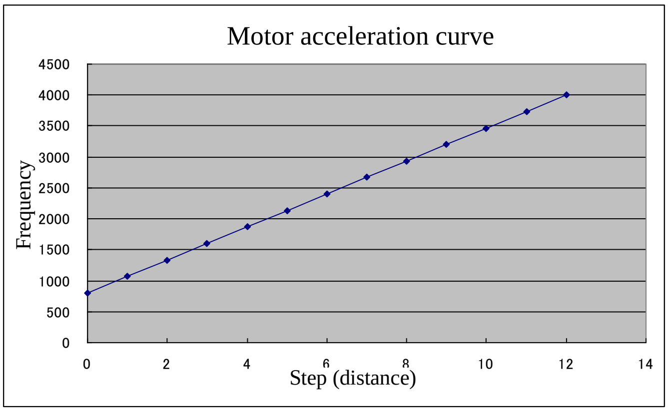


Fig. 94 Acceleration curve

The cycle of this motor must be managed by timer interrupts, so a comparison of S0 ~ S7 shown in 7.1.2 is as follows.

[In the case of FTP-607/608 MCL series]

S0 + S1 = motor step 1

S2 + S3 = motor step 2

S4 + S5 = motor step 3

S6 + S7 = motor step 4

[In the case of FTP-609 MCL series]

S0 + S1 + S2 + S3 = motor step 1

S4 + S5 + S6 + S7 = motor step 2

7.3 Thermal head driving

7.3.1 Head driving parameters

The internal parameters for driving the print head are as follows.

[Internal parameters]

heating element resistance value, head common resistance value, drive ICON resistance, head heating element area

The external parameters thereof are as follows.

[External parameters]

drive voltage, environmental temperature, paper to be used, printing speed, printing ratio density

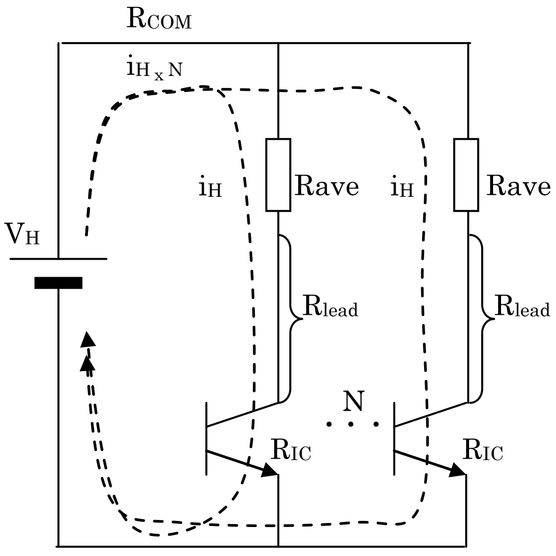
The internal parameters are parameters that are unique to the mechanism, and cannot be changed. The external parameters, however, can be changed depending on the system, under conditions unique to the client. For example, in order to increase the printing speed, the applied voltage is increased, and if the system driving voltage can be changed, the driving force for the print head can be changed. The printing density can be increased or decreased by controlling the heating value of the thermal head. The heating value is determined by the energy to be supplied to the heating element. Current is supplied to the head heating element resistor according to the applied voltage VH, which is an external parameter. The head requires a pattern that connects from the connector to both ends of the heating element. In the case of a low voltage driving head, the resistance value generated by this pattern cannot be ignored. The current, which flows through the common pattern, changes depending on the number of energized dots, and this current causes a drop in voltage. In the equivalent circuit shown in Fig. 95, it is assumed that iH flows through one closed loop. In this case, iH flows through Rave, Rlead and RIC, but current N x iH flows through Rcom if the number of energized dots is N. According to Kirchhoff's Law,

$$VH = R_{com} \times N \times iH + R_{ave} \times iH + (R_{lead} + R_{IC}) \times iH$$

Therefore the current that flows through the head is

$$iH = VH/(R_{ave} + R_{com} \times N + R_{lead} + R_{IC}).$$

Fig. 95 Head equivalent circuit



Head internal equivalent resistance = common resistance (Rcom) + heating element resistance (Rave) + lead resistance (Rlead) + drive IC internal resistance (RIC)

Here it is difficult to separate Rlead and RIC in measurement, so they are regarded as one resistance. If this current flows through the heating element, power $iH^2 \times R_{ave}$ is consumed, which turns into thermal energy.

$$P = VH^2 \times R_{ave}/(R_{ave} + R_{com} \times N + R_{lead} + R_{IC})^2$$

Therefore if pulse Ton is applied to the head, then energy P x Ton is consumed.

$$E = P \times T_{on}$$

However, the energy to be supplied to each unit area contributes to the coloring of the thermo-sensitive paper. If the area is large, energy in dot units is consumed in the entire area, and the temperature of the heating element does not increase. The coloring density of the thermo-sensitive paper depends on how the heating element increases temperature and on the sensitivity of the paper. Even if the same amount of energy is applied, sufficient coloring density cannot be acquired with a paper that has low sensitivity.

If ε_0 is the energy per unit area required for coloring the thermo-sensitive paper for a required amount, the following relationship is established.

$$\varepsilon_0 = E/S$$

Therefore the required T_{on} is

$$Ton = S \times \varepsilon_0 \times (R_{ave} + R_{com} \times N + R_{lead} + R_{IC})^2 / (VH^2 \times R_{ave})$$

and if $\varepsilon = S \times \varepsilon_0$, then

$$Ton = \varepsilon \times (R_{ave} + R_{com} \times N + R_{lead} + R_{IC})^2 / (VH^2 \times R_{ave})$$

The above is the case of static characteristics. For dynamic characteristics, however, correction is required. This is because the heat of previous printing remains, and in the case of high-speed printing, this heat becomes offset, and the ultimate temperature becomes higher even if a same energy is applied.

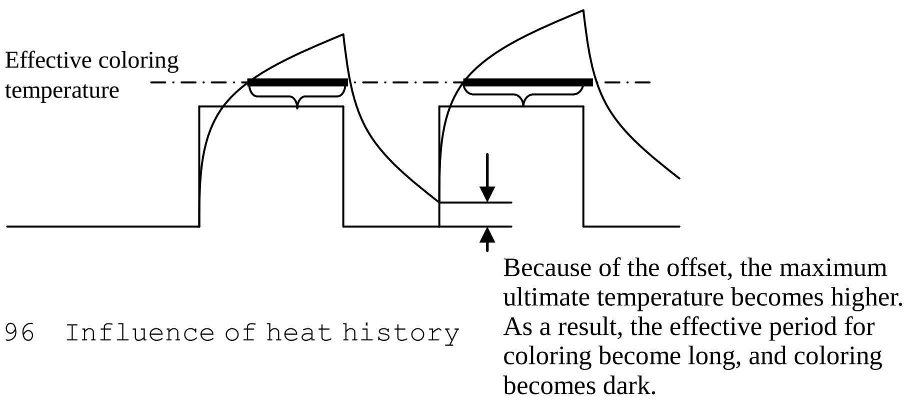


Fig. 96 Influence of heat history

In this case, parameter η (t) of the printing speed must be added to the above expression.

$$Ton' = \eta(t) \times \varepsilon \times (R_{ave} + R_{com} \times N + R_{lead} + R_{IC})^2 / (VH^2 \times R_{ave})$$

In the above expression, the included parameters are applied voltage VH, printing ratio parameter N and printing speed parameter η. The parameter of environment temperature, which is required later, is expressed by the coloring characteristic ε(T) of the thermo-sensitive paper, and the following expression is acquired.

$$Ton' = \eta(t) \times \varepsilon(T) \times (R_{ave} + R_{com} \times N + R_{lead} + R_{IC})^2 / (VH^2 \times R_{ave})$$

ε(T) differs depending on the head to be used and the speed. Refer to the following appropriate expressions.

7.3.2 Head driving parameter approximate expressions

Each parameter approximate expression changes depending on the printer mechanism to be used. Refer to the following information.

7.3.2.1 FTP-608 series

A) FTP-608MCLxxx, FTP-608MCLxxx#11 series

Table 19 Paper energy approximate expressions

FTP-608MCLxxx (normal pitch mode)

Paper	ε(T) T: Celsius temperature (°C)
TF50KS-E4 equivalent	109.044/(T+155.000)-0.381
RD150R equivalent	111.640/(T+155.000)-0.390
HA220AA equivalent	95.877/(T+163.438)-0.263
AFP-235 equivalent	48.105/(T+81.210)-0.175

Table 20 Printing speed correction parameter η(t) approximate expression

Mechanism	η(t) t: printing dot line cycle (msec)	Approximate range
FTP-608MCL series	{-45085.5/(t+78.22)+625.5} /64	1.0≦t≦10 msec

(B) FTP-608MCLxxx#21 series

Table 21 Paper energy approximate expression

FTP-608MCLxxx#21 (normal pitch mode)

Paper	ε(T) T: Celsius temperature (°C)
TF50KS-E4 equivalent	
RD150R equivalent	
HA220AA equivalent	
AFP-235 equivalent	

Table 22 Printing speed correction parameter η(t) approximate expression

Mechanism	η(t) t: printing dot line cycle (msec)	Approximate range
FTP-608MCL series	{-45085.5/(t+78.22)+625.5} /64	1.0≦ t ≦10 msec

See Appendix 2 for information on the calculation of actual energizing pulse widths.

7.3.2.2 FTP-607 series

A) FTP-607MCLxxx series (100 mm/sec product)

Table 23 Paper energy approximate expression

FTP-607MCLxxx (normal pitch mode)

Paper	ε(T) T: Celsius temperature (°C)
TF50KS-E4 equivalent	
RD150R equivalent	
HA220AA equivalent	
AFP-235 equivalent	

Table 24 Printing speed correction parameter η(t) approximate expression

Mechanism	η(t) t: printing dot line cycle (msec)	Approximate range
FTP-607MCL series		1.0≦ t ≦10 msec

7.3.2.3 FTP-609 series

A) FTP-609MCLxxx series

Table 25 Paper energy approximate expression

FTP-609MCLxxx (normal pitch mode)

Paper	ε(T) T: Celsius temperature (°C)
TF50KS-E4 equivalent	65.925/(T+156.957)-0.128
RD150R equivalent	72.792/(T+156.957)-0.141
TP60KS-F1 equivalent	54.881/(T+117.297)-0.117
TP60KS-F equivalent	50.890/(T+117.297)-0.109
HA220AA equivalent	64.860/(T+117.297)-0.138
AFP-235 equivalent	67.321/(T+130.455)-0.101

Table 26 Printing speed correction parameter η(t) approximate expression

Mechanism	η(t) t: printing dot line cycle (msec)	Approximate range
FTP-609MCL series	$-0.0003t^4+0.0076t^3-0.0858t^2+0.5128t+0.3683$	$1.0 \leqq t \leqq 10$ msec

7.4 Head and motor synchronization

7.4.1 Number of head divisions

T_{on} required for print coloring is determined as shown in section 7.3. The cycle t of the printing dot line must be greater than T_{on}. The number of dots that can be energized at once depends on the power supply capacity. I_{PEAK} is

$$I_{PEAK} = N \times iH = N \times VH/(R_{ave} + R_{COM} \times N + R_{lead} + R_{IC})$$

If the allowable peak current of the power supply is $I_{PEAK\ Max}$, then $I_{PEAK\ Max}$ must be

$$I_{PEAK\ Max} \geq I_{PEAK} \quad \text{and}$$

when the maximum number of dots simultaneously energized ≥ N, then N must be

$$N \leq I_{PEAK\ Max}/iH$$

If the total number of dots of one dot line is M, then 1 dot line must be divided as follows.

Number of divisions K ≥ [M/N] +1

7.4.2 Example of synchronization

(A) K ≤ number of motor steps

If the number of divisions K of the head is smaller than the maximum number of steps of the motor, N dots can be energized in each motor step. Examples are shown below.

a) In the case of N = 4

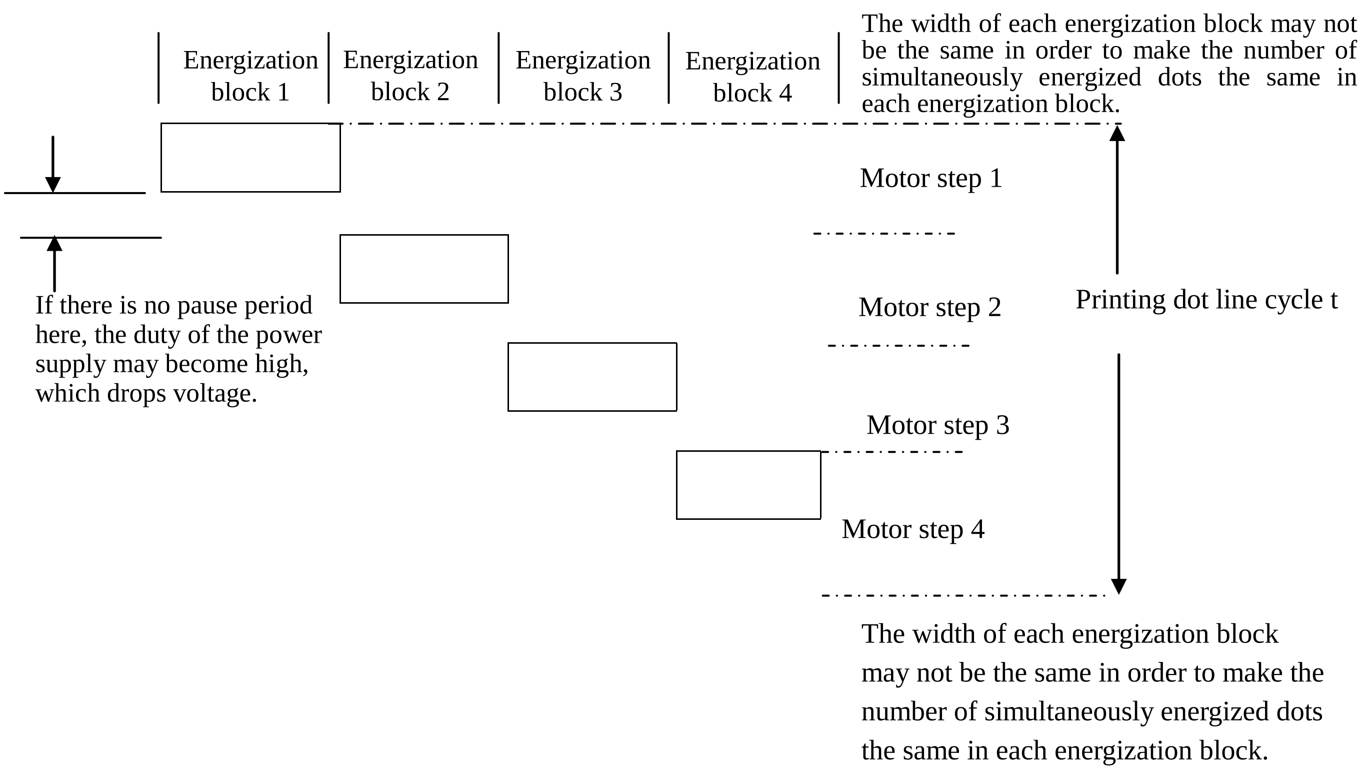


Fig. 97 Case when number of motor steps and number of divisions of head are the same

b) In the case of N = 3 (Example 1: in the case of synchronizing with motor excitation timing)

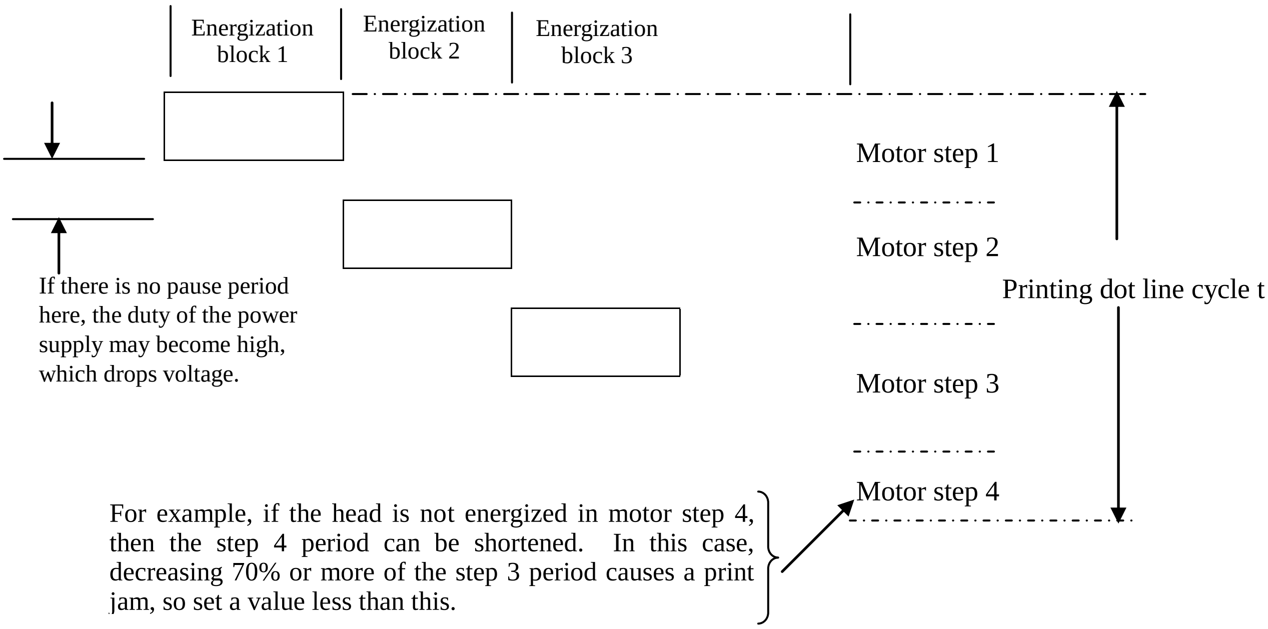


Fig. 98 Case when then number of divisions of head is smaller than number of motor steps

c) In the case of N = 3 (Example 2: In the case of not synchronizing with the motor excitation timing)

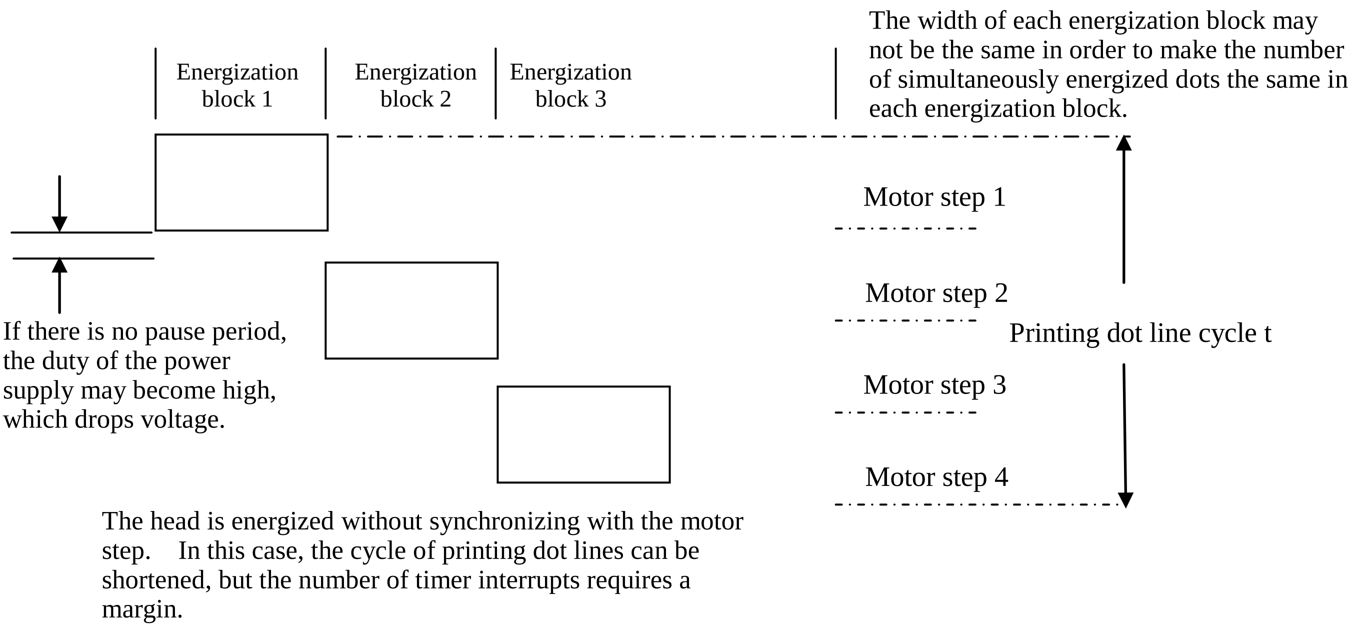
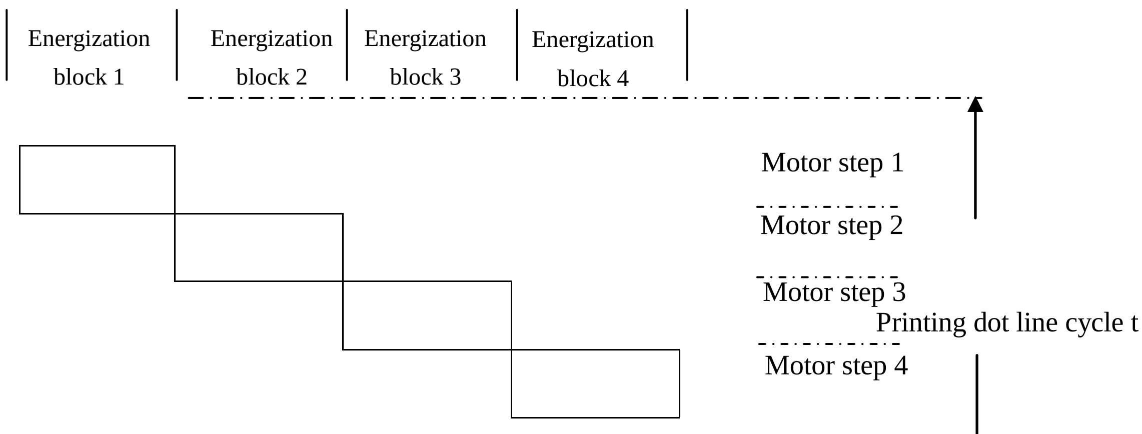


Fig. 99 Case when head division synchronizes with cycle of motor steps

d) Prohibited case



If the head is energized first and then motor steps are executed all at once, the melted portion of thermo-sensitive paper adheres to the head, blocking printing and causing failure. To stop the motor, feed paper until the energized portion is distant from the head, then stop the motor.

Fig. 100 Example of prohibition

(B) K > number of motor steps

If the head is driven synchronizing with the motor steps, a plurality of energizations must be performed during one motor step. If asynchronous driving is possible, the total energization time of the head can be divided into 4 steps, as shown in section (A)-c.

a) Standard division

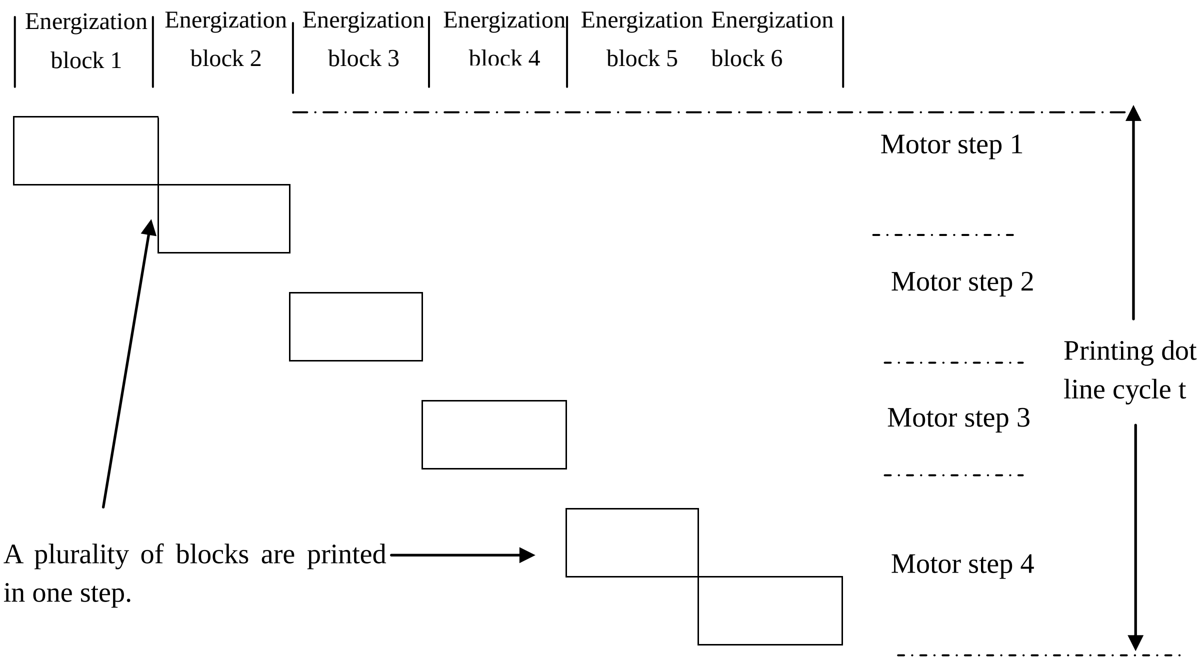


Fig. 101 Case when head division is allocated to motor steps

b) Example 2

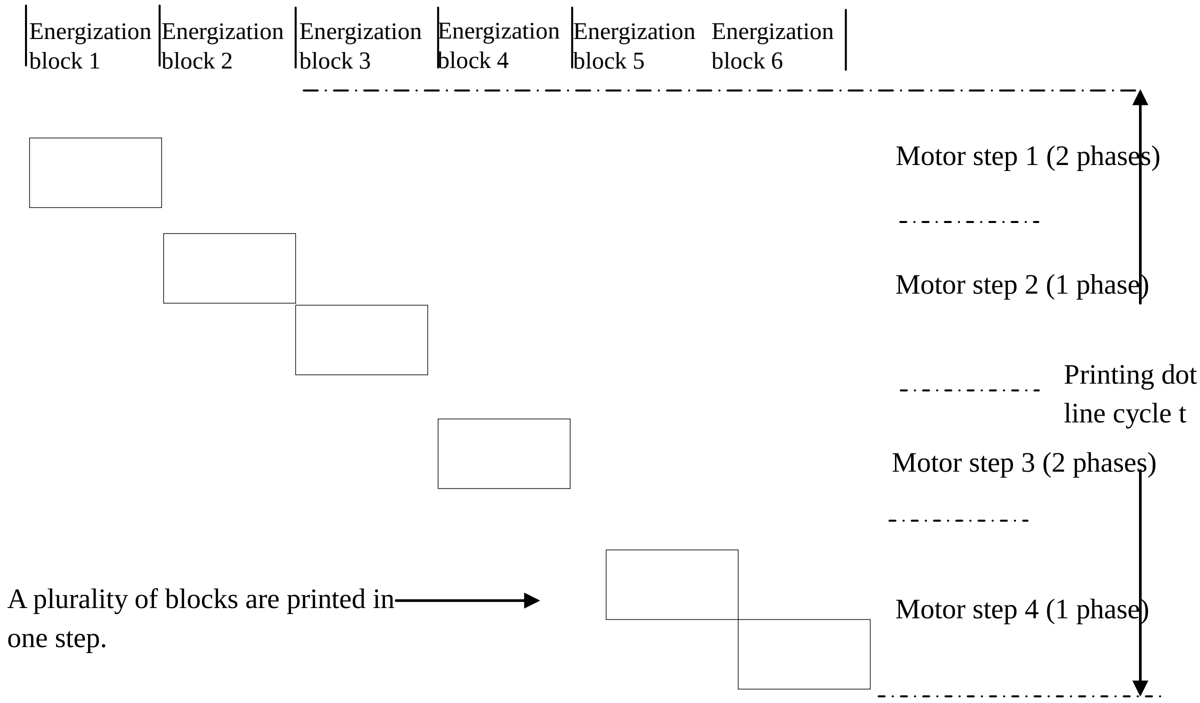


Fig. 102 Case when head division synchronizes with motor phase

If the power supply capacity has no margin, decrease the number of energization blocks of the head for 2-phase motor excitation, and increase the number of blocks for 1-phase motor excitation, as shown in Example 2, for example. If this driving is performed, the motor energizing time is long at 1-phase driving (slow → output torque of motor is high), and the motor energizing time is short at 2-phase driving (fast → output torque is low). In the case of 2-phase excitation, the output torque is exerted in 2-phase excitation, and the total output torque is higher than 1-phase excitation, so the drop in the output torque caused by increasing the speed can be compensated.

7.4.3 Other precautions

One synchronization method is to energize the blocks of the entire head with a pulse shorter than an ordinary pulse for each motor step, and printing is executed by repeating 4 steps/4 times. In this case, if printing is performed by dividing the head into 4 blocks, each group is energized with ¼ or less duty. In other words, ¾ becomes the pause period, and the heating element can cool down. In such an energization, an energy exceeding the power applied to paper E is required. Since data is printed in an unsaturated status each time, the image itself cannot be saturated, and dispersion in each mechanism increases. Therefore do not use this divided printing method.

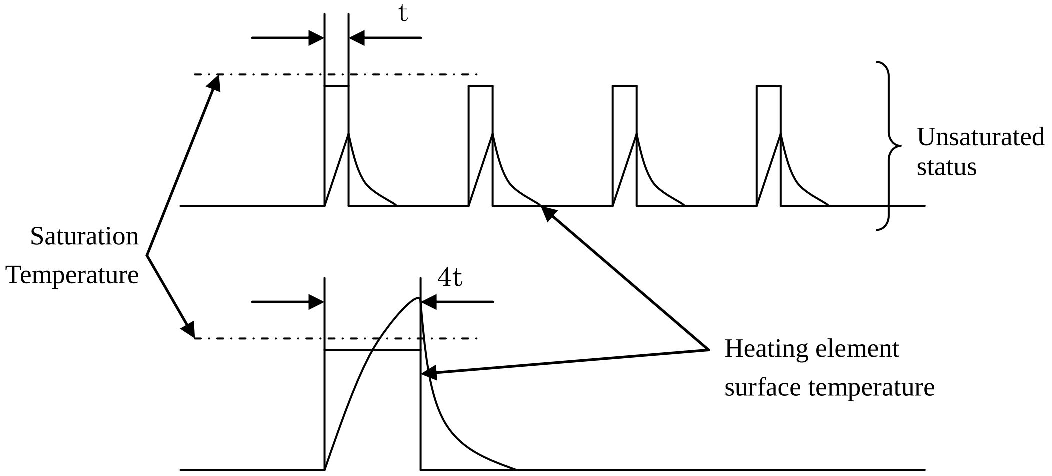


Fig. 103 Influence of head pulse division

7.5 Current consumption

7.5.1 Head current consumption

As section 7.3.1 shows, the current that flows through the head heating element is

$$i_H = V_H/(R_{ave} + R_{COM} \times N + R_{lead} + R_{IC})$$

If the number of energized dots is N, the peak current I_{PEAK} that flows through the head is

$$I_{PEAK} = N \times i_H = N \times V_H/(R_{ave} + R_{COM} \times N + R_{lead} + R_{IC})$$

Since the printing duty is T_{on}/t where T_{on} is the energizing time and t is the printing dot line cycle, the average current is

$$I_{AV} = I_{PEAK} \times T_{on}/t$$

7.5.2 Motor current consumption

As section 5.2.3 shows, the current that flows through the motor per phase is I_M, so in 1-2 phase excitation driving, the current is

$$I_{M\ PEAK} = 2 \times I_M$$

$$I_{M\ AV} = 1.5 \times I_M$$

7.5.3 Current consumption

Current consumption is the total current which flows through the head and the motor. The logic system, however, is not included. The peak current $I_{TOTAL\ PEAK}$ and the average current $I_{TOTAL\ AV}$ at this time are acquired by the following expressions.

$$I_{TOTAL\ PEAK} = I_{PEAK} + I_{M\ PEAK}$$

$$I_{TOTAL\ AV} = I_{AV} + I_{M\ AV}$$

The energizing timing is acquired based on section 6.4. Combine the currents according to this timing. If PEAK does not match in the above expression, current consumption is lower than the total.

8. How to use thermal printer interface board

8.1 Interface

The main unit can primarily use the following interfaces to drive a printer.

[1] Centronics based parallel interface

[2] RS-232C interface

[3] USB interface

8.1.1 Centronics based parallel interface

Primarily the following signals are exchanged with the main unit.

(A) Interface signals

Table 27 Centronics control lines

Signal name	Signal direction	
Data (8 bits)	Main unit → printer	
Strobe signal	Main unit → printer	Main unit inputs strobe signal to printer as synchronization signal to notify data to printer.
Busy signal	Printer → main unit	Notifies main unit of busy status when strobe signal is received, so as to disable strobe input.
Acknowledge signal	Printer → main unit	Returns acknowledge signal to notify the main unit that printer received data sent from main unit.
Error notification signal	Printer → main unit	To notify an error signal, either only an error signal is returned or a plurality of error statuses are notified by the RINF signal. See the respective product specification.

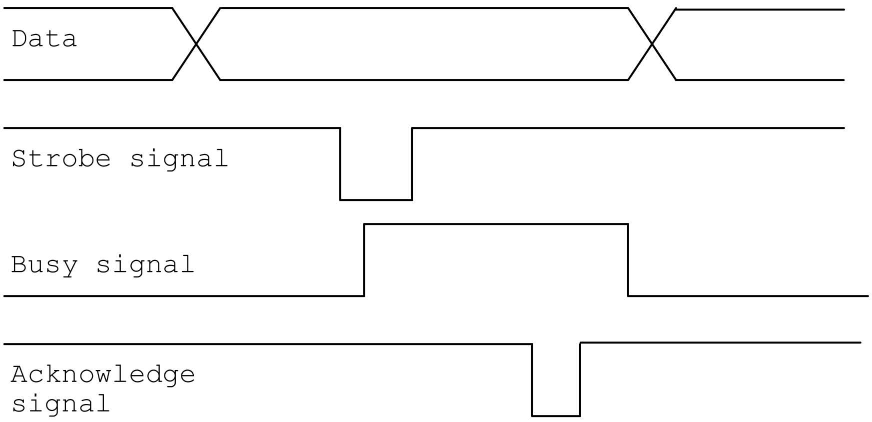


Fig. 104 Handshake sequence

(B) Data receiving speed and printing speed

This interface does not have bidirectional communication. The maximum communication speed of the data is about 28 kbytes/sec. If bit image data is printed with the 639 series, which supports 72 bytes/dot line, then 28000/72 = 388 dot lines of data can be received in 1 second. Since resolution is 8 lines/mm, 388 lines corresponds to 48.5 mm. If data is sent completely as a bit image, about 50 mm/sec is the maximum speed. In the case of the 629 series, which supports 54 bytes/line, the receive speed is a maximum of 518 dot lines/sec, which is equivalent to about 65 mm/sec.
Therefore even if the printer capability is 200 mm/sec, the data receiving speed becomes the bottleneck, and the printer cannot exhibit its best performance features.

Therefore batch image print mode is provided, and by printing after data is loaded, a speed of 200 mm/sec can be implemented.

(C) Acquisition of printer error information

An error notification signal (RINF) is provided in the Centronics interface. By acquiring this signal information, the status of the printer can be read. For details, see the respective product specification.

8.1.2 RS-232C based serial interface

Primarily the following signals are exchanged with the main unit.

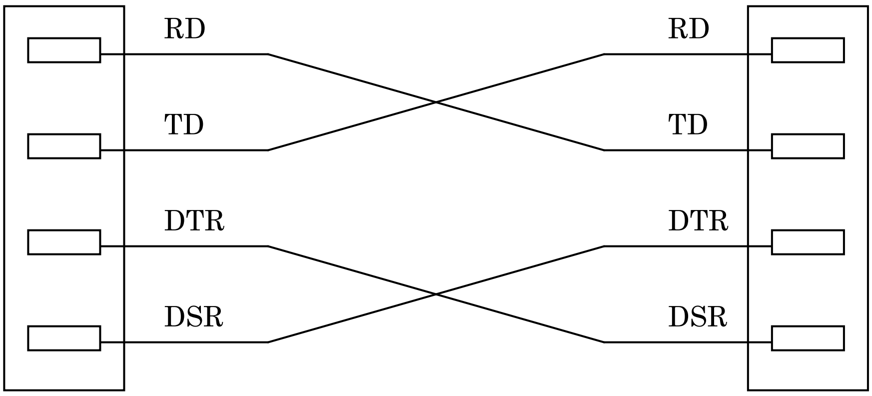
(A) Interface signals

Table 28 Serial control lines

Signal name	Signal direction	
TD	Printer → main unit	Output signal from printer to main unit Logic "1": Mark (-3 ~ -12V) Logic "0": Space (+3 ~ +12V)
RD	Main unit → printer	Input signal from main unit to printer Logic "1": Mark (-3 ~ -12V) Logic "0": Space (+3 ~ +12V)
DTR	Printer → Main unit	Ready signal indicating whether printer can receive data from main unit Receive disabled: Mark (-3 ~ -12V) Receive enabled: Space (+3 ~ +12V)
DSR	Main unit → printer	Signal indicating whether main unit can receive data from printer Transmission disabled: Mark (-3 ~ -12V) Transmission enabled: Space (+3 ~ +12V)

Use a cross cable to connect with the main unit. A straight cable cannot be used for communication.

Printer Fig. 105 Signal wiring Main unit



Note) If the main unit uses a CTS signal, then some procedure must be taken, such as connecting DSR and CTS of the main unit.

The transmission signal (TD) of the main unit and the receive signal

(RD) of the printer are connected by a cross cable, or the transmission signal (TD) of the printer and the receive signal (RD) of the main unit are connected by a cross cable. Therefore the receiving side can read the transmitted data. With a straight cable, output and output or input and input collide, and communication cannot be performed.

The main unit and the printer transmit/receive data by a DTR/DSR or XON/XOFF handshake.

A receive buffer is installed in the interface board of the printer. If this receive buffer becomes full, busy is notified, and if an opening is generated, ready is notified. For details, see the respective specification. Note that the data of which printing is not completed or code may be saved in the receive buffer. Therefore depending on the reset timing, the data stored in the receive buffer may be deleted, which makes printing abnormal. If the main unit outputs a reset signal, resend the data from the beginning of the data, for example.

(B) Data receiving speed and printing speed

In the RS-232C interface, normally 1 byte of data is extended to about 11 bits of data, that is

start bit (1) + data (8) + parity bit (1) + stop bit (1),

and is transmitted and received in serial. If the transfer speed is 115.2 kbps, the number of data bytes that can be received in 1 second is about 10472 bytes. In the case of the 639 series, which supports 72 bytes/line, this corresponds to 145 dot lines. With an 8 line/mm resolution, only an 18 mm/sec speed can be exhibited.

Therefore print the data using codes, for example.

With a 460.3 kbps board as well, a maximum speed of 72 mm/sec can be exhibited in bit image printing. Therefore use batch printing mode, for example.

For the transfer speeds of RS-232C, see the respective product specification.

(C) Printer error information acquisition

To use a serial interface, there are the following error information acquisition methods. For details, see the respective specification.

① Setting automatic status transmission (command example: GS a+n)

② Setting reply parameter (command example: FS r+n)

If automatic status transmission is enabled by the automatic status transmission setting command, a 4 byte status is transmitted to the main unit regardless the receive enable/disable status of the main unit.

Table 29 Status

Byte	Data	Function
First byte	Printer information	Buffer full status, online/offline status
Second byte	Error information	Power supply voltage abnormality, receive data abnormality, platen open, cutter abnormality, hardware abnormality, head temperature abnormality
Third byte	Paper detection information	Paper existence, mark detection, near end
Fourth byte	Parameter	Parameter set by FSr command

The status of the printer can be read by receiving this data.

However, in the case of a serial interface, the received data is buffered once, so unless it can be judged how far printing has been executed, the retransmission start point cannot be judged.

In order to judge where an error occurred, the reply parameter setting command is provided. This command sets the parameter at the fourth byte in automatic status transmission.

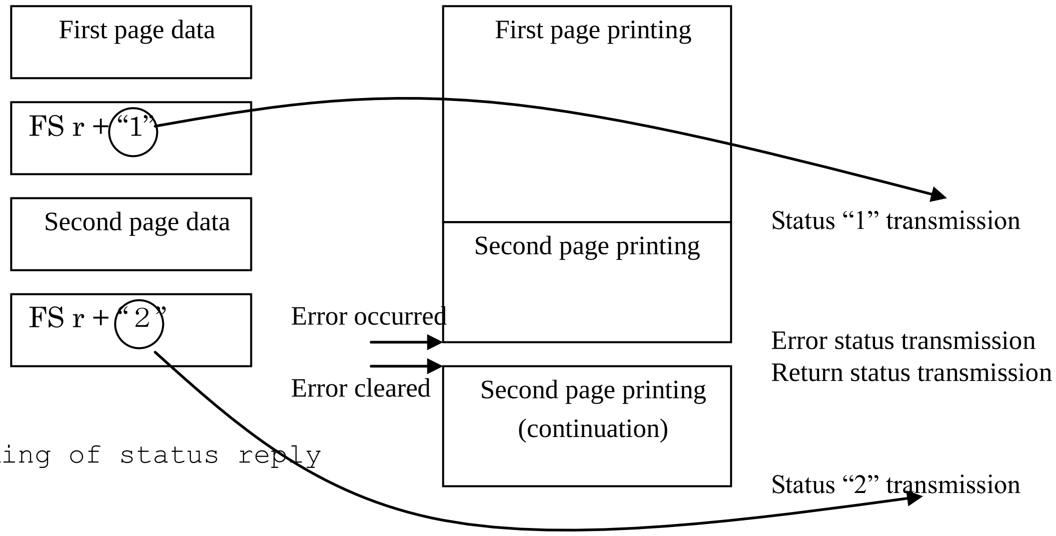


Fig. 106 Timing of status reply

8.1.3 USB interface

For details on this see the respective specification. See section 7.1.2 for details on error information acquisition.

9. How to use interface command

9.1 Data and commands

Codes to be sent from the main unit to the printer include text data, bit image data, commands and invalid codes.

Codes to be received first are classified in a code table. Normally $00 - $1F are classified as commands. In some cases $80 - $9F are also handled as commands.

The first data is \$00 - \$1F, and portions not having corresponding functions in a code table are ignored and considered invalid codes. However this is not common for all interface boards, so send \$00 if invalid data is sent.

Commands are classified into 1 byte commands and expanded commands. A 1 byte command can execute the function of the code itself, such as

1 byte execution command e.g. LF (line feed), FF (form feed)

1 byte status setting command e.g. SO (double width setting command)

The 1 byte execution command is a command which executes printing and paper feed by itself. The 1 byte status setting command does not activate printing or perform paper feed even if a code is received. This command sets a mode of data which is received herein below. For example, the received text data is printed using double width characters.

\$20 - \$7F, \$A0 - \$FF, and in some cases \$80 - \$9F are handled as text data. Therefore if this code is received, the corresponding characters are printed. For actual printing, printing is activated when 1 line of the buffer becomes full or when a printing activation command is received.

Other commands are:

Expanded commands	ESC = \$1B (ESC sequence)
	FS = \$1C (FS sequence)
	GS = \$1D (GS sequence)

For these commands, subsequent data is read as respective parameters. The received parameters are checked in a command analysis routine, and if undefined data is received, the printer returns an error, exits the sequence, and restarts reading for the first data. If all the required data is received without error, the code is recognized as a command, and is executed.

When data is sent from the main unit, it must be recognized whether the data is hexadecimal (Hex) notation or decimal (Dec) notation, since data notation differs depending on the application software in use.

9.2 Examples

(Functions may be different depending on the model. For details, see the respective specification.)

(A) Bit image printing

Printing is executed using the bit image command ESC*+m+n1+n2+d1~dN.

[Command]

Command data sequence	ESC*
Mode setting parameter	m
Number of printing lines setting parameter	n1+n2
Bit image data	d1 ~ dN

The first 2 bytes are data for classifying the command, where 2 bytes {$1b, $2A} are required.

The third byte is a parameter for setting the mode. When m is {$97}, it sets a double density image. The double density image is a mode where 1 bit of data corresponds to 1 dot in printing. This mode is used for normal driver software.

n1 and n2 specify the length of the printing data. Critical here is that a parameter in the width direction is not included since the number of bytes required for 1 dot line is uniquely determined depending on the mechanism to be used.

[Parameter] Paper width - - - not included in command

FTP-629MCL103	54 bytes/line
FTP-639MCL103	72 bytes/line

The number of lines is specified by n1 and n2. Here the total number of dot lines is n2 x 256 + n1.

Note the sequence of n1 and n2. As a result, the number of data N to be sent becomes

FTP-629MCL103 N = 54 x (n2 x 256 + n1)

FTP-639MCL103 N = 72 x (n2 x 256 + n1)

If the total number of data is insufficient, data subsequent to the command is loaded as a part of the bit image data, so specified printing is not executed. If data is not sent, the printer waits until the required number of data is received. If excessive data exists, the printer completes the ESC sequence in the middle of the data, so the data, up to this portion, is printed as an image. The rest of the data is analyzed as the first code.

In the image data portion, many data corresponding to such commands as $00 - $1F are included, so abnormal operation is performed, such as a line feed or width changes to double width. If lots of data remain, printing continues endlessly. If this status is generated, the power supply must be reset, for example.

The data stream is

$$\{\$1B、\$2A、\$97、\$08、\$00、\underbrace{\$FF、\cdot\cdot\cdot\cdot\$FF}_{N}\}$$

and in the case of 629MCL103, 8 lines of a black solid band can be printed by continuously sending data of N = 54 bytes x 8 lines = 432 bites (e.g. $FF).

(B) Text printing

The codes of the characters to be printed are determined. Let us assume the "Fujitsu" is printed at double width.

Codes corresponding to "Fujitsu" are acquired from the code table.

{Fujitsu} = {$46、$75、$6A、$69、$74、$73、$75}

Pay careful attention to upper case and low case input.

The print mode specification command (ESC!+n) is used to set double width printing. As the description of the command shows,

ESC! = {1B, $21}

Parameter n is

n = %00100001 (Note: % is binary notation)

so as to expand the bit width to 1, and a 12 x 24 font is specified as ANK.

Now %00100001 is $21, so the double width setting by 12 x 24 font ANK is

{$1B、$21、$21}

After setting the mode, data to be printed is set. However printing cannot be activated only by

{$1B、$21、$21、$46、$75、$6A、$69、$74、$73、$75}

This is because buffer full and printing activation commands do not exist. To start printing, the line feed command (LF), for example, is sent. Since

LF command = {$0A}

the transmission data stream becomes

{$1B、$21、$21、$46、$75、$6A、$69、$74、$73、$75、$0A}

10. How to use driver software

The installation method for the driver software differs depending on the OS. It also differs depending on the printer model to be used. Refer to the "Readme" file.

11. Other

Should there by any other questions, please contact the respective Fujitsu personnel.

Appendix 1 Troubleshooting

Classification	Trouble mode	Check point	Confirming matters
Circuit + mechanism	Does not operate even if board and mechanism are connected	Power supply measured and input at circuit side terminal portion?	If power is not ON, turn it ON and check again
		Are GNDs of logic supply and head power supply connected in common?	If not, connect GNDs in common and check again
		Error occurred?	Insertion slot of paper is correct?
			Paper is on detection sensor?
			Head cable is appropriately connected?
			Platen or head is set?
		Motor moves when power is turned ON?	Connect power supply and check if error exists
	Color not printed even if printer operates	Front and back of paper inverted?	Check direction of paper, and check operation again
		Is paper sensitivity sufficient?	Color is not printed if paper sensitivity is low. Use paper with appropriate sensitivity
		Is paper thickness appropriate?	If paper is thick, head is raised by paper, color is not generated appropriately. Change paper thickness to appropriate one, and check again.
	Part of data is not printed	Dust adheres to head surface?	Clean with IPA and print again. Be certain to dry head completely after cleaning, then print again
	Printing spots exist	Power supply capacity sufficient?	If power capacity is low, voltage drops, printing become light. Increase capacity and check again.
		Is power supply cable sufficiently thick and short?	Power may drop, making printing light, or reset may be activated.

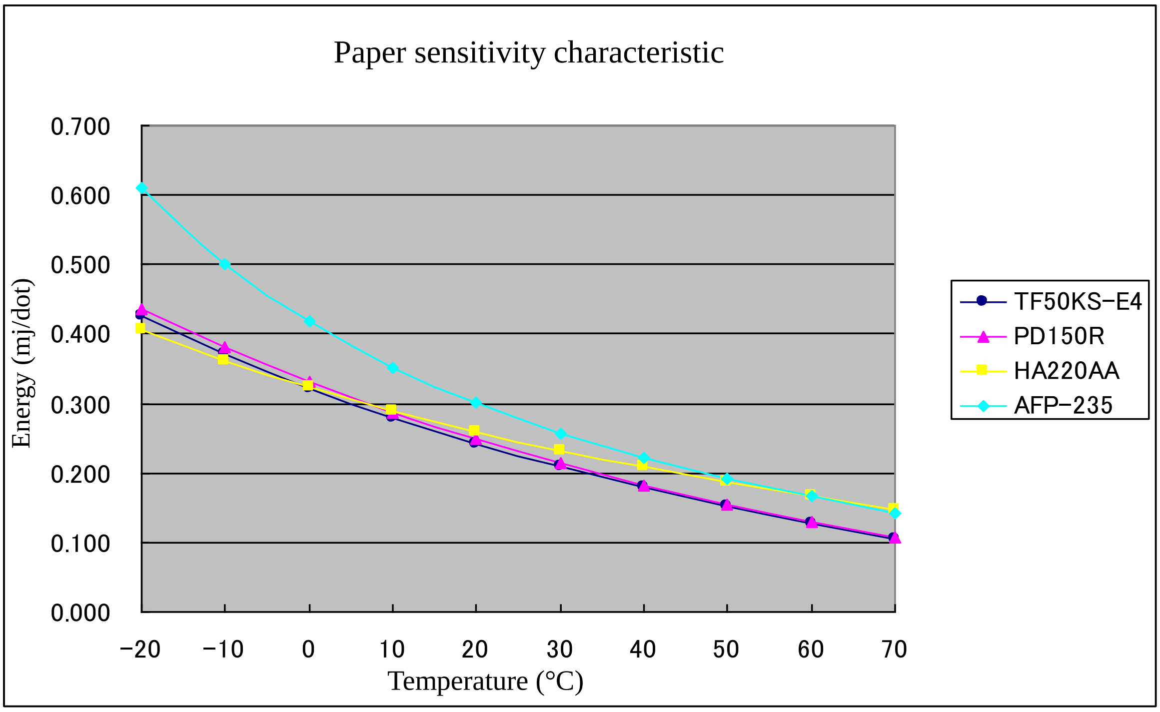
Circuit + mechanism	Printing is slow	Is communication speed sufficient?	For image data, printing speed does not increase, even at max speed.
		Is applied voltage correct?	Printing speed changes depending on voltage. Speed matches voltage?
	Printing result different from expected	Is communication setting appropriate?	Check if data is being sent appropriately.
		In case of bit image, check if number of data is correct	Number of transmission data differs depending on setting of mechanism. Check settings.
	Cannot communicate with serial interface	Communication speed setting matches with host?	Set it again, and check again.
		Cross cable?	Data cannot be transmitted/received with a straight cable. Use a cross cable.
		RS level? not TTL level?	Voltage levels match? Correct signal level, and check again.
		Hardware handshake? XON/XOFF setting match?	Correct handshake mode, and check again.
	Does not operate with PC	Is driver software installed?	Check if correct driver software is registered
		Is settings, such as paper size, appropriate?	Make appropriate settings.
	Test printing disabled	Is power ON?	Also check if GNDs of logic and head are commonly connected.
		Confirm there is no error	Paper detection position is appropriate? Platen and head are set?
		Flexible code and cable not cut? Not disconnected?	Connect correctly, and check again.

Mechanism	Printing jam occurs	Is large load applied to roll paper?	If load is high, motor losses sync, and print may occur.
		Is paper surface sticky?	Depending on preprinted paper or on type of paper, paper may more easily adhere to head, causing printing jam.
		Is printing speed abnormally slow?	If printing speed becomes extremely slow, colored portions adhere to head, causing printing jam. Print data as fast as possible.
		Is diameter of roll paper too large?	If a large diameter roll paper is dropped in and used, load becomes high and printing jam may occur. Use roller or paper shaft if necessary.
		Is sync lost when slacked paper is stretched?	When slacked paper is stretched, a large load is generated and printing jam occurs.
		Is roll paper rubbing holder side face?	If paper rubs, paper load increases and sync is lost. Margin is required.
		Paper skew?	If paper skews and paper edge is rolled up, printing jam may occur due to paper load.
		Motor acceleration slowly increase from pull in?	Sync may be lost if motor is not accelerated, or acceleration is too quick.
		Is motor current sufficient?	If current is not sufficient, torque becomes low and motor may loose sync.
		Is there unnecessary force on platen bearing?	If unnecessary force is applied to platen bearing, motor load increases and printing jam may occur.

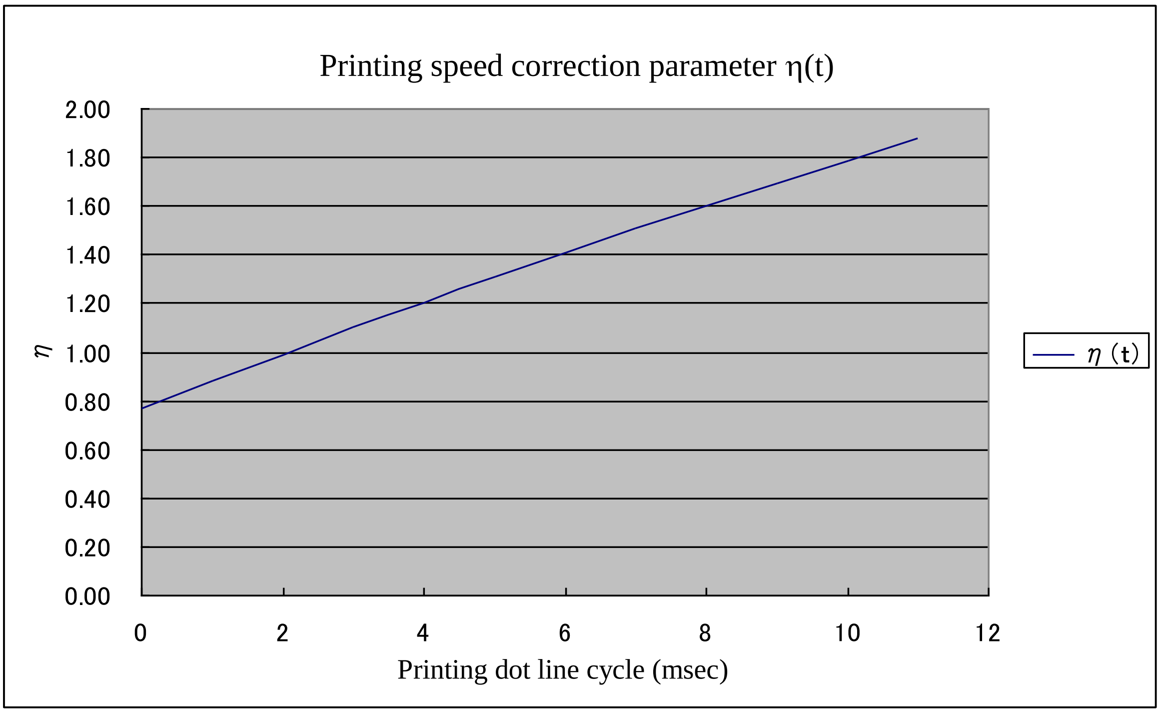
Mechanism		Is paper route appropriate?	Friction load may be applied to paper depending on paper route, and printing jam may occur.
	Printing spots are large	Is paper thickness appropriate?	If paper is too thick, heating element position of head changes, and printing becomes light.
	Printing is light	Is sensitivity of thermo-sensitive paper appropriate?	Choose appropriate sensitivity of thermo-sensitive paper and check again
		Force is not applied to head cable or flexible cable	If cable is in pulled status, head is lifted and printing becomes light
Cutter	Cannot cut	Is paper thickness appropriate?	If paper is thick, paper may not be cut.
		Is blade angle appropriate (low height type)?	If blade angle is inclined + or -, cutting capability drops.
	Paper jam occurs	Is cutter back to home position?	If blade is not completely closed, paper may stack up at blade, and paper jam occurs.
	Paper jam occurs with round blade cutter	Does paper debris remain in cutter?	Paper is caught by paper debris, and paper jam occurs.

Appendix 2 Energy conditions of FTP-608 series

A. FTP-608 series paper sensitivity characteristic



B. FTP-608 series printing speed correction



C. FTP-608 series example of energized pulse width

(Conditions: 176 Ω, number of simultaneously energized dots: 64 dots)

(unit: msec)

Note) Shaded portion is prohibited area

Voltage (V)	Temp (℃)	400	600	800	1000	1200	1400	1600	1800	2000
4.2	−20	9.01	7.43	6.59	6.07	5.72	5.46	5.27	5.12	5.00
	−10	7.83	6.46	5.73	5.28	4.97	4.75	4.58	4.45	4.34
	0	6.81	5.62	4.98	4.59	4.32	4.13	3.98	3.87	3.78
	10	5.91	4.87	4.32	3.98	3.75	3.58	3.46	3.36	3.28
	20	5.11	4.22	3.74	3.45	3.25	3.10	2.99	2.90	2.84
	30	4.40	3.63	3.22	2.97	2.79	2.67	2.57	2.50	2.44
	40	3.76	3.10	2.75	2.54	2.39	2.28	2.20	2.14	2.09
	50	3.19	2.63	2.33	2.15	2.02	1.93	1.86	1.81	1.77
	60	2.66	2.20	1.95	1.80	1.69	1.62	1.56	1.51	1.48
	70	2.19	1.81	1.60	1.48	1.39	1.33	1.28	1.24	1.21
4.5	−20	7.85	6.47	5.74	5.29	4.98	4.76	4.59	4.46	4.35
	−10	6.82	5.63	4.99	4.60	4.33	4.14	3.99	3.88	3.78
	0	5.93	4.89	4.34	4.00	3.77	3.60	3.47	3.37	3.29
	10	5.15	4.24	3.77	3.47	3.27	3.12	3.01	2.92	2.86
	20	4.45	3.67	3.26	3.00	2.83	2.70	2.61	2.53	2.47
	30	3.83	3.16	2.81	2.58	2.43	2.33	2.24	2.18	2.13
	40	3.28	2.70	2.40	2.21	2.08	1.99	1.92	1.86	1.82
	50	2.78	2.29	2.03	1.87	1.76	1.68	1.62	1.58	1.54
	60	2.32	1.91	1.70	1.56	1.47	1.41	1.36	1.32	1.29
	70	1.91	1.57	1.40	1.29	1.21	1.16	1.12	1.08	1.06
5.0	−20	6.36	5.24	4.65	4.29	4.04	3.86	3.72	3.61	3.53
	−10	5.53	4.56	4.04	3.73	3.51	3.35	3.23	3.14	3.07
	0	4.80	3.96	3.52	3.24	3.05	2.91	2.81	2.73	2.66
	10	4.17	3.44	3.05	2.81	2.65	2.53	2.44	2.37	2.31
	20	3.61	2.97	2.64	2.43	2.29	2.19	2.11	2.05	2.00
	30	3.11	2.56	2.27	2.09	1.97	1.88	1.82	1.76	1.72
	40	2.66	2.19	1.94	1.79	1.69	1.61	1.55	1.51	1.47
	50	2.25	1.85	1.65	1.52	1.43	1.36	1.32	1.28	1.25
	60	1.88	1.55	1.38	1.27	1.19	1.14	1.10	1.07	1.04
	70	1.54	1.27	1.13	1.04	0.98	0.94	0.90	0.88	0.86

Voltage (V)	Temp (℃)	400	600	800	1000	1200	1400	1600	1800	2000
5.5	−20	5.25	4.33	3.84	3.54	3.34	3.19	3.07	2.99	2.91
	−10	4.57	3.77	3.34	3.08	2.90	2.77	2.67	2.60	2.53
	0	3.97	3.27	2.91	2.68	2.52	2.41	2.32	2.26	2.20
	10	3.45	2.84	2.52	2.32	2.19	2.09	2.02	1.96	1.91
	20	2.98	2.46	2.18	2.01	1.89	1.81	1.74	1.69	1.65
	30	2.57	2.12	1.88	1.73	1.63	1.56	1.50	1.46	1.42
	40	2.19	1.81	1.61	1.48	1.39	1.33	1.28	1.25	1.22
	50	1.86	1.53	1.36	1.25	1.18	1.13	1.09	1.06	1.03
	60	1.55	1.28	1.14	1.05	0.99	0.94	0.91	0.88	0.86
	70	1.28	1.05	0.93	0.86	0.81	0.77	0.75	0.73	0.71
6.0	−20	4.41	3.64	3.23	2.98	2.80	2.68	2.58	2.51	2.45
	−10	3.84	3.17	2.81	2.59	2.44	2.33	2.25	2.18	2.13
	0	3.34	2.75	2.44	2.25	2.12	2.02	1.95	1.90	1.85
	10	2.90	2.39	2.12	1.95	1.84	1.76	1.69	1.65	1.61
	20	2.50	2.07	1.83	1.69	1.59	1.52	1.47	1.42	1.39
	30	2.16	1.78	1.58	1.45	1.37	1.31	1.26	1.23	1.20
	40	1.84	1.52	1.35	1.24	1.17	1.12	1.08	1.05	1.02
	50	1.56	1.29	1.14	1.05	0.99	0.95	0.91	0.89	0.87
	60	1.31	1.08	0.96	0.88	0.83	0.79	0.76	0.74	0.72
	70	1.07	0.88	0.78	0.72	0.68	0.65	0.63	0.61	0.59
6.5	−20	3.76	3.10	2.75	2.54	2.39	2.28	2.20	2.14	2.09
	−10	3.27	2.70	2.39	2.20	2.08	1.98	1.91	1.86	1.81
	0	2.84	2.34	2.08	1.92	1.81	1.72	1.66	1.62	1.58
	10	2.47	2.03	1.81	1.66	1.57	1.50	1.44	1.40	1.37
	20	2.13	1.76	1.56	1.44	1.36	1.29	1.25	1.21	1.18
	30	1.84	1.52	1.34	1.24	1.17	1.11	1.08	1.04	1.02
	40	1.57	1.30	1.15	1.06	1.00	0.95	0.92	0.89	0.87
	50	1.33	1.10	0.97	0.90	0.84	0.81	0.78	0.76	0.74
	60	1.11	0.92	0.81	0.75	0.71	0.67	0.65	0.63	0.62
	70	0.91	0.75	0.67	0.62	0.58	0.55	0.53	0.52	0.51

Voltage (V)	Temp (℃)	400	600	800	1000	1200	1400	1600	1800	2000
7.2	−20	3.07	2.53	2.24	2.07	1.95	1.86	1.79	1.74	1.70
	−10	2.67	2.20	1.95	1.80	1.69	1.62	1.56	1.51	1.48
	0	2.32	1.91	1.70	1.56	1.47	1.41	1.36	1.32	1.29
	10	2.01	1.66	1.47	1.36	1.28	1.22	1.18	1.14	1.12
	20	1.74	1.43	1.27	1.17	1.10	1.06	1.02	0.99	0.96
	30	1.50	1.23	1.10	1.01	0.95	0.91	0.88	0.85	0.83
	40	1.28	1.06	0.94	0.86	0.81	0.78	0.75	0.73	0.71
	50	1.08	0.89	0.79	0.73	0.69	0.66	0.63	0.62	0.60
	60	0.91	0.75	0.66	0.61	0.58	0.55	0.53	0.52	0.50
	70	0.74	0.61	0.55	0.50	0.47	0.45	0.44	0.42	0.41
7.5	−20	2.83	2.33	2.07	1.90	1.79	1.71	1.65	1.61	1.57
	−10	2.46	2.03	1.80	1.66	1.56	1.49	1.44	1.40	1.36
	0	2.14	1.76	1.56	1.44	1.36	1.30	1.25	1.21	1.18
	10	1.85	1.53	1.36	1.25	1.18	1.12	1.08	1.05	1.03
	20	1.60	1.32	1.17	1.08	1.02	0.97	0.94	0.91	0.89
	30	1.38	1.14	1.01	0.93	0.88	0.84	0.81	0.78	0.77
	40	1.18	0.97	0.86	0.80	0.75	0.72	0.69	0.67	0.65
	50	1.00	0.82	0.73	0.67	0.63	0.61	0.58	0.57	0.55
	60	0.84	0.69	0.61	0.56	0.53	0.51	0.49	0.47	0.46
	70	0.69	0.57	0.50	0.46	0.44	0.42	0.40	0.39	0.38
8.0	−20	2.48	2.05	1.82	1.67	1.58	1.51	1.45	1.41	1.38
	−10	2.16	1.78	1.58	1.46	1.37	1.31	1.26	1.23	1.20
	0	1.88	1.55	1.37	1.27	1.19	1.14	1.10	1.07	1.04
	10	1.63	1.34	1.19	1.10	1.03	0.99	0.95	0.93	0.90
	20	1.41	1.16	1.03	0.95	0.89	0.85	0.82	0.80	0.78
	30	1.21	1.00	0.89	0.82	0.77	0.74	0.71	0.69	0.67
	40	1.04	0.86	0.76	0.70	0.66	0.63	0.61	0.59	0.58
	50	0.88	0.72	0.64	0.59	0.56	0.53	0.51	0.50	0.49
	60	0.73	0.61	0.54	0.50	0.47	0.45	0.43	0.42	0.41
	70	0.60	0.50	0.44	0.41	0.38	0.37	0.35	0.34	0.33

Voltage (V)	Temp (℃)	400	600	800	1000	1200	1400	1600	1800	2000
8.5	−20	2.20	1.81	1.61	1.48	1.40	1.33	1.29	1.25	1.22
	−10	1.91	1.58	1.40	1.29	1.21	1.16	1.12	1.09	1.06
	0	1.66	1.37	1.22	1.12	1.06	1.01	0.97	0.94	0.92
	10	1.44	1.19	1.06	0.97	0.92	0.88	0.84	0.82	0.80
	20	1.25	1.03	0.91	0.84	0.79	0.76	0.73	0.71	0.69
	30	1.07	0.89	0.79	0.72	0.68	0.65	0.63	0.61	0.60
	40	0.92	0.76	0.67	0.62	0.58	0.56	0.54	0.52	0.51
	50	0.78	0.64	0.57	0.52	0.49	0.47	0.46	0.44	0.43
	60	0.65	0.54	0.48	0.44	0.41	0.39	0.38	0.37	0.36
	70	0.53	0.44	0.39	0.36	0.34	0.32	0.31	0.30	0.30

Note) The above table shows estimated values under predetermined conditions. Adjustments are required depending on individual usage.