

This document is designed to make the start-up and programming of the M-Rotary as easy as possible by collecting all the pertinent information from the various parts of the manual.

Because the M-Rotary can be programmed to perform a general task in various ways, it becomes important that the subtleties of the application and the task at hand are fully understood before proceeding.

Wiring and Scaling

Wiring of the drive and encoders. (refer to page 2-4 and 3-5 in the manual)

Speed signal input:

The M-Rotary is designed for standard regenerative DC drives and Servo amplifiers. These types of drives have two types of speed signal requirements. Regenerative DC drives usually expect a three wire control input from a potentiometer. Servo drives usually have a differential input that requires a two wire speed input. Some manufacturers have accommodated both types of input on their drives. If available use the two wire differential input.

Consult the drive manufacturer's manual and ascertain which of the above types of input are required. Compare this with the generic diagrams (fig 1 and fig 2) and hook up the unit as shown.

Jumper placement to match M-Rotary output to the drive's input: (refer to page 2-4 in the manual)

The M-Rotary has two positions for "ISOLATOR VOLTAGE REFERENCE".

These are described as "internal reference" and "auto-range reference".

Isolator voltage reference: This refers to the M-Rotary terminals to which the drive is wired. (Connector J1 pins 8,9 and 10.) See fig 3 in this document.

Internal reference voltage: The reference voltage for the speed signal will be taken from inside the M-Rotary. This setting is used for differential inputs.

Auto-range reference: The reference voltage for the speed signal will be taken from the drive itself. This setting is used for potentiometer inputs.

Encoder signal input:

The M-Rotary will accept an open collector NPN sinking signal. This may be an incremental or quadrature type device. Consult the manufacturers literature for your encoder/feedback device and determine its type.

Incremental Signal: The device has one channel and hence has only one signal line.

Quadrature Signal: The device has two channels and hence has two signal lines.

Refer to (fig 4) for the correct jumper position for the appropriate signal type.

Refer to (fig 5) to find the physical location of wiring terminals for the drive, encoders and sync. pulses.

***** IMPORTANT *****

YOU MUST FOLLOW STANDARD PRACTICES FOR THE WIRING OF MICROPROCESSOR BASED CONTROLLERS AT ALL TIMES. USE APPROPRIATE SHIELDING, ROUTING AND SUPPRESSION TECHNIQUES.

Motor drive setup:

- 1) Adjust the drives IR-Comp to its' minimum effectiveness and set its accel and decel to their minimum time.
- 2) Place M-Rotary in direct scaling mode. Record the value in CP-14 and then enter a "6".
- 3) Enter a positive direct mode value of 400 into CP-12.
- 4) Initiate the run state. If the follower motor is not going in the direction of normal operation (fwd) then initiate stop and rewire the drive/motor to achieve this.
- 5) Once the motor is going in the correct direction observe the polarity of the value in MV-42. If it is negative then switch the A and B channel (J3 pins 7 and 9) of the feedback device.
- 6) Enter a value of 3686 into CP-12. Enter the correct PPR of the feedback device into CP-18. Initiate run and record the value in MV-43. Initiate stop.
- 7) Enter 0 (zero) into CP-12 and return CP-14 to its' original value.
- 8) Enter the value from MV-43 that you found in step 6 into CP-19.
- 9) Rotate the lead motor in the direction of normal operation and observe the polarity of the value in MV-41. If the value is negative then switch the lead encoder channels A and B. (J3 pins 3 and 5)

Programming

The M-Rotary has 4 basic operating modes, however for the purposes of this guide we will address only two modes. Execute the non-sync mode even if your eventual goal is a sync mode application.

"NON-SYNC ROTARY FOLLOWER" (w/o profiling action, see fig 6)

Configure the M-Rotary for this mode.

Set CP 14 = 1

Refer to fig. 6 for a representation of this system. For this example, the following assumptions have been made. Substitute your own values after reading the explanations for our "example" values.

Lead nip roll diameter = 3.0 inches
Lead reference encoder = 600 ppr.
Slave rotary knife diameter = 6.9 inches
Slave feedback encoder = 600 ppr.
Both geared-motors = 1750 rpm @ 5:1 ratio

In the setup section you will have already entered values into CP 18 and CP 19. In this example:

Thus CP 18 = 600 and CP 19 = 350.

The preferred starting point is a configuration where the surface speed of the rotary knife matches the surface speed of the web. The result of this will be a cut length equal to the circumference of the rotary knife.

The "Follower lines/cut - CP 17" will be "600" because of the 600 toothed gear is mounted on the shaft of the rotary knife.

Thus CP 17 = 600

The "Engineering Units - CP 15" or length of cut per rotation of the rotary knife will be equal to its' circumference.

Rotary Knife Circumference = $\pi \times \text{diameter}$
= 3.142×6.9
= 21.680 inches

Thus CP 15 = 21.680

The lead nip rolls will also have to rotate a circumferential distance of 21.680 inches to achieve this cut length.

Nip Roll Circumference = $\pi \times \text{diameter}$
= $3.142 \times 3.0 \text{ inches}$
= 9.426 inches

Therefore for the nip rolls to feed 21.680 inches they will have to turn:

Number of revolutions = $\frac{21.680}{9.426}$
= 2.3 revolutions

This means that the 600 tooth gear or encoder mounted on the same shaft of the nip rolls will also do 2.3 revolutions, and hence the number of "Lead lines/cut - CP 16" would be $2.3 \times 600 = 1380$.

Thus CP 16 = 1380

You now need to enter a setpoint which will command this length.

Thus CP 01 = 21.680

Verify that you can now achieve a running state that has the surface speeds of the nip roll, web and die all matched.

Before proceeding read the section on tuning, and optimize for a stable running condition.

2) "SYNCHRONIZED ROTARY FOLLOWER" (w/o profiling action fig 7)

It is highly recommended that you completed the "Non-Sync Rotary Follower" section before going through this section.

First, review where we are at this moment. The parameters were entered as follows;

CP 01 = 21.680 (21.680 inches cut length)
CP 14 = 1 (non-sync rotary follower mode)
CP 15 = 21.680 (engineering units)
CP 16 = 1380 (lead lines per cut)
CP 17 = 600 (follower/slave lines per cut)
CP 18 = 600 (pulses per revolution of follower/slave)
CP 19 = 350 (max RPM of follower encoder)

Right now, if the machine were running, it would be cutting a 21.680 inch length piece of material without synchronization.

In fig 7 you will see some printing on the web, and the knife must synchronize to this. If the printing on the web was conveniently at the 21.680 inch spacing the problem would be easy, but, it is most unusual to get that lucky.

Therefore let's assume that the printing is at 9.427 inch spacing and we wish to synchronize to it. The conveniently printed registration mark on the web, and the blade on the die can be used to generate sync pulses via prox switches or photo eyes.

Now, if we wanted to cut a piece of material of a different length this would require that the knife rotate faster or slower. At this point assume that there is no need to match speed during the cut. When we are required to match speed during the cut a profiling action will be needed. This will be addressed later.

We must first tell the unit that it is now going to be required to be a synchronized follower.

Thus CP 14 = 3

Set the cut length command (setpoint)

Thus CP 01 = 9.427

Now the machine will be synchronizing the proximity switches and cut a piece of material 9.427 inches long. Verify this by observing the front panel LED's. the "Sync Error" LED is out and the REF and FDBK (feedback) SYNC LED's are blinking in unison. If the cut is not lined up with the position where you want to cut, then the phase shift capability (CP - 31) can be used to move it.

Also note that the rotary die is rotating faster in order to achieve this cut length and is not matching surface speed during the cut. It will change its' rotational speed for every different cut length and will only match surface speeds when the cut length equals the rotary die circumference.

3) "SYNCHRONIZED ROTARY FOLLOWER" (with profiling see fig 7)

It is highly recommended that you have completed the "Sync Rotary Follower" section before going through this section.

First, to review where we are at this moment, the parameters are entered as follows;

CP 01 = 9.427 (9.427 inches cut length)
CP 14 = 3 (sync rotary follower mode)
CP 15 = 21.680 (engineering units)
CP 16 = 1380 (lead lines per cut)
CP 17 = 600 (follower/slave lines per cut)
CP 18 = 600 (pulses per revolution of follower/slave)
CP 19 = 350 (max RPM of follower/slave motor)

If you made an adjustment to CP-31 in the previous section return this parameter to 0 (zero) before proceeding.

In some applications it is necessary to match surface speed during the cutting or printing action for any given cut length.

In this section we will make the unit match surface speed during the cut with the 9.427 inch cut length. Review these conceptual assumptions first so as to maintain a clear understanding.

- a) The web is the lead and the rotary die is the follower/slave.
- b) The cut length (9.427) refers to the web (lead) and not the rotary die (follower/slave).
- c) From the statement in (b) it follows that whenever you change the setpoint the controller THINKS the lead job size (web) changed and adjusts the ratio accordingly, the net result being that the required cut length is achieved.

d)An important concept in the discussion of profile capabilities is: THE DISTANCE THE LEAD (WEB) HAS TRAVELLED PAST THE POINT AT WHICH IT'S REGISTER MARK TRIGGERED THE LEAD SYNC PULSE SENSOR, WHEN THE WEB HAS ARRIVED AT THE PROPER LOCATION TO BE CUT BY THE ROTARY KNIFE. This distance is measured in LEAD ENCODER LINES. Also determine when the knife must start matching speed and for how long. For example start 1 inch before impact and finish 1 inch after. (Dimensions B & C)

These codes must be calculated:

CP 93 - Start match point

and CP 94 - End match point

Note: these two codes are entered in lead web lines measured from the lead sync pulse sensor location.

Review application data:

- a)The lead nip roll has a circumference of 9.427 inches
- b)It rotates 2.3 times per 21.680 inches
- c)The lead job space is 1380 lines for a 21.680 inch cut
- d)From the above we have:

$$\text{Lead web lines per inch} = \frac{1380}{21.680} = 63.65 \text{ lines per inch circumference}$$

- e)The follower/slave has a circumference of 21.680 inches.
- f)The follower/slave job space is 600 lines.
- g)From the above we have:

$$\text{Follower lines per inch} = \frac{600}{21.680} = 27.68 \text{ lines per inch circumference}$$

- h)In this example (9.427 inch cut), the controller knows the lead job space is now:

$$9.427 \times 63.65 = 600 \text{ lines}$$

Refer to Fig 10. To correctly find dimensions A,B and C the following method could be followed. Move the web by hand in the direction that the web would travel in production until the place where the cut should take place is directly under the center of the rotary die, then measure dimension A which is defined as from the center of the proximity switch or photo eye to the nearest registration mark going in the direction the web would travel in normal production. We decide dimension B and C will be 1 inch each for a 2 inch match speed zone.

The knife must match for 2 inches and have the impact point in the middle. In this example we will use 4.7135 inches as dimension "A" from the lead sync pulse. We want to match from 3.7135 inches (dimension A-B) to 5.7135 inches (dimension A+C).

The start and end match points in lead sensor lines are:

$$3.7135 \times 63.65 = 236 \text{ lines}$$

$$\text{and } 5.7135 \times 63.65 = 364 \text{ lines}$$

$$\text{Thus CP 93} = 236$$

$$\text{and CP 94} = 364$$

We now need to tell the controller what ratio to adopt when it is doing the matched speed section of the profile.

When 2 inches of lead go by we have (2 X 63.65) lines going by and when 2 inches of follower/slave go by have (2 X 27.67) lines go by.

The ratio is then: follower lines divided by lead lines

$$\frac{2 \times 27.67}{2 \times 63.65} = 0.435$$

$$\frac{2 \times 27.67}{2 \times 63.65}$$

$$\text{Thus CP 90} = 0.435$$

Confirm that the "Setpoint - CP 01" is set to command this cut length.

$$\text{Thus CP 01} = 9.427$$

Verify machine operation:

The knife slows to match speed as the web target point passes under the impact point and a 9.427 inch cut length is achieved. If the knife blade is not at the impact point during the matched speed section of the profile, use the "Phase shift - CP 31" to move it into alignment with the web target position.

TUNING

This section will discuss the three parameters that effect the tuning or response of the controller, they are:

CP 65 - Proportional Gain - Gain - "P"
CP 66 - Integral Gain - Reset - "I"
CP 67 - Derivative Gain - Rate - "D"

Because the M-Rotary will be commanding your drive motor and machine combination to do different geometric moves depending on the cut length specified, the dynamics of the system are different for every combination.

Therefore, focus on a specific condition for the initial tuning. As you are already aware, there is always a cut length that results in a flat speed profile. In this example this is a cut length of 21.680 inches. This is the preferred place to do the tuning. If it was done while profiling it would be very difficult to distinguish between the actual profile taking place and what could be instability in the combination.

This exercise is an empirical approach; judge the performance of the system, make some changes, and repeat.

First, try to get an intuitive feel for the P,I and D and ERROR since you must adjust the correct gain for the right reasons.

Proportional Gain (remember the word "BIG")

This gain is really interested in how BIG the error is at a given moment. It is not interested in how long it has been there nor how quickly it is growing or diminishing.

Integral Gain (remember the word "HISTORY")

This gain is really interested in how long the error has been there, or how much HISTORY it has. It is not interested in how big it is nor how quickly it is growing or diminishing.

Derivative Gain (remember the word "CHANGE")

This gain is really interested in how quickly the error is growing or diminishing, or its' rate of CHANGE. It is not interested in how big it is nor how long it has been there.

Now lets look at different kinds of loads and how they react.

1) If we had a big solid steel roller that we were controlling.

Think about the dynamics. Because it is so heavy it would be impossible to make BIG speed changes, and, if it did alter speed it would take a while and have HISTORY, and, because it took a while to alter it would not CHANGE fast.

Sol for high inertia loads the analysis would be that there would be no BIG, but lots of HISTORY and little CHANGE. This would mean that the INTEGRAL GAIN (CP-66) is the most sensitive control parameter. Start with a small number in CP-66, then increase it in small steps. P and D are less sensitive, although high Derivative gain may help.

2) If we had a light plastic roller that we were controlling.

Think about the dynamics. Because it is so light it would be able to make BIG changes, and, it could make them quickly so there would be no HISTORY, and, because it altered speed quickly there would be a high rate of CHANGE.

Sol for low inertia loads the analysis would be that there would be lots of BIG, and no HISTORY, but lots of CHANGE. This would mean that the PROPORTIONAL (CP-65) and DERIVATIVE GAINS (CP-67) are the most sensitive control parameters. Adjust CP-65 first starting with a small value and increase it in small steps, then adjust CP-67. (Note: CP-67 is often best left at zero). The I term is less sensitive.

One should also keep in mind that a drive with a slow response time makes the load look more like a high inertia load to the controller and a high response drive makes the load look like a low inertia load to the controller. It is always helpful to run the machine and reason out what to do based on:

- What type of drive do you have? (response time).
- What kind of load do have? (high to low inertia).
- What action is the system trying to perform? (steady state to cyclic).

Use this reasoning and experiment until you are able to come up with good settings for the P,I and D terms in the controller.

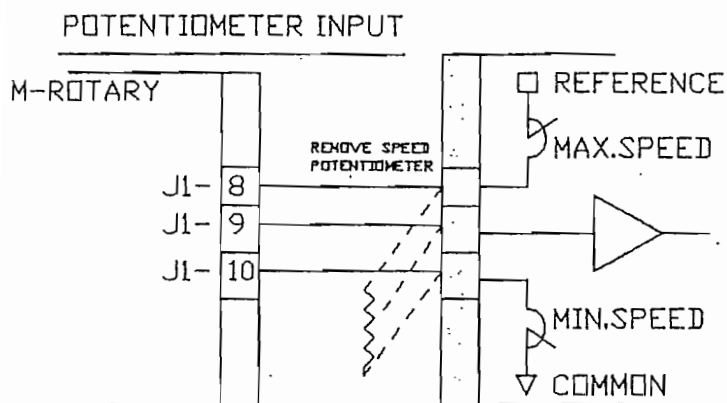


FIG 1

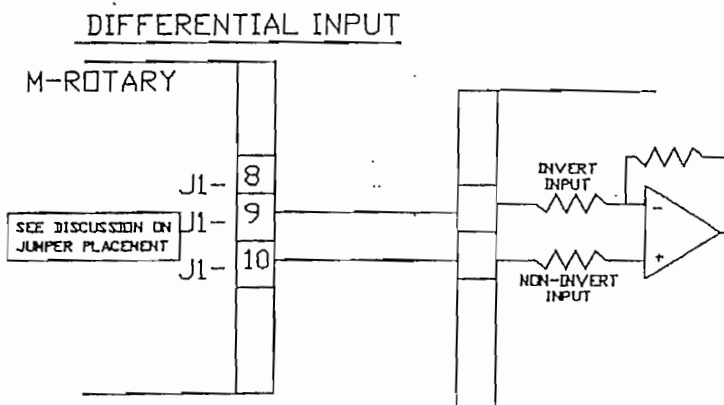


FIG 2

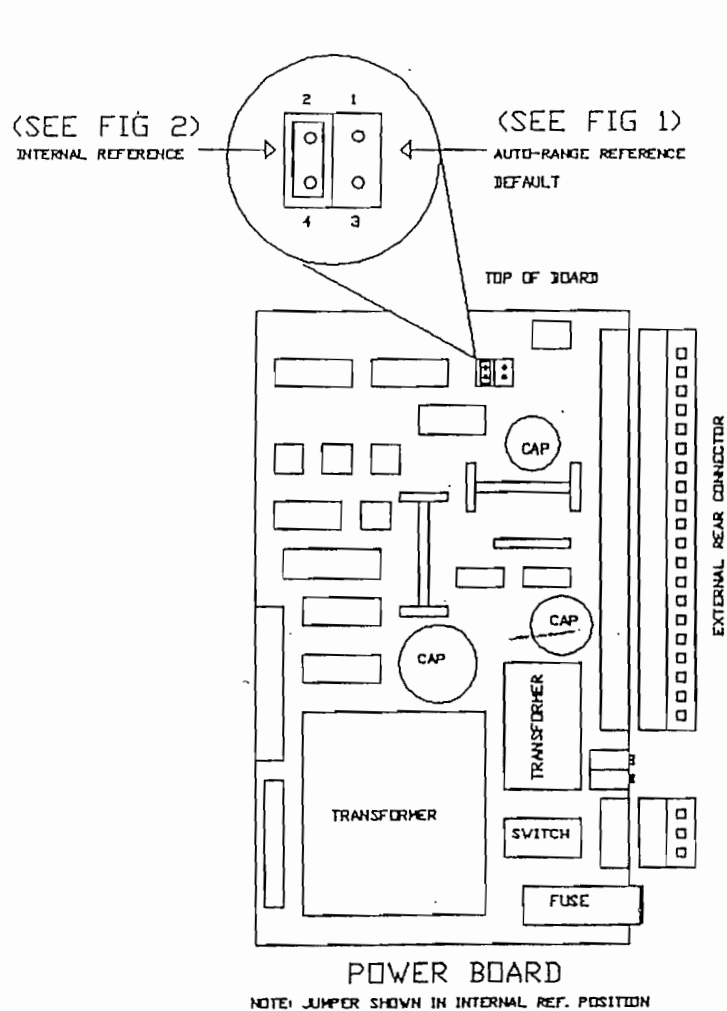


FIG 3

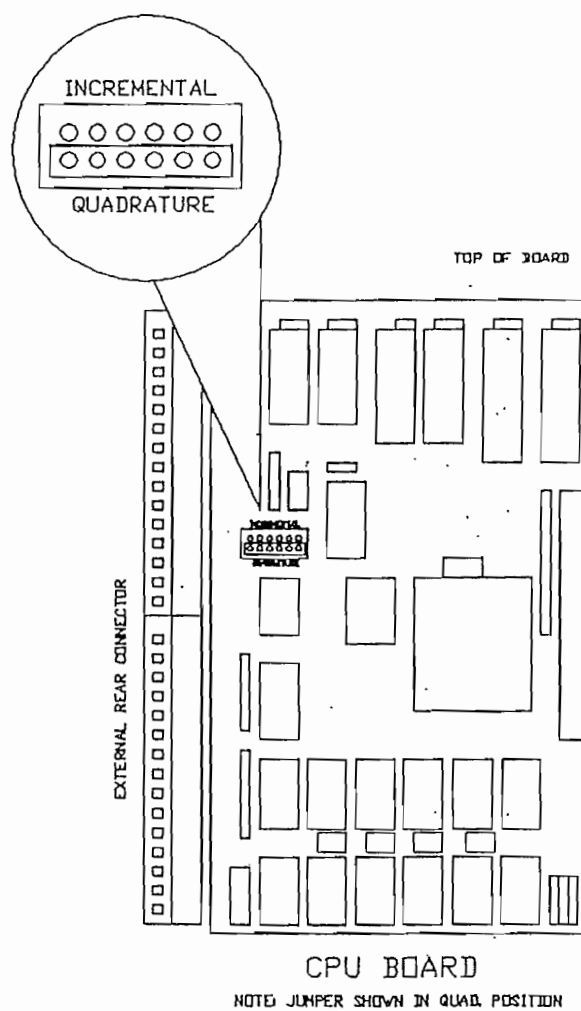


FIG 4

SIMPLIFIED CONNECTION DIAGRAM

SYNC ROTARY FOLLOWER MODE

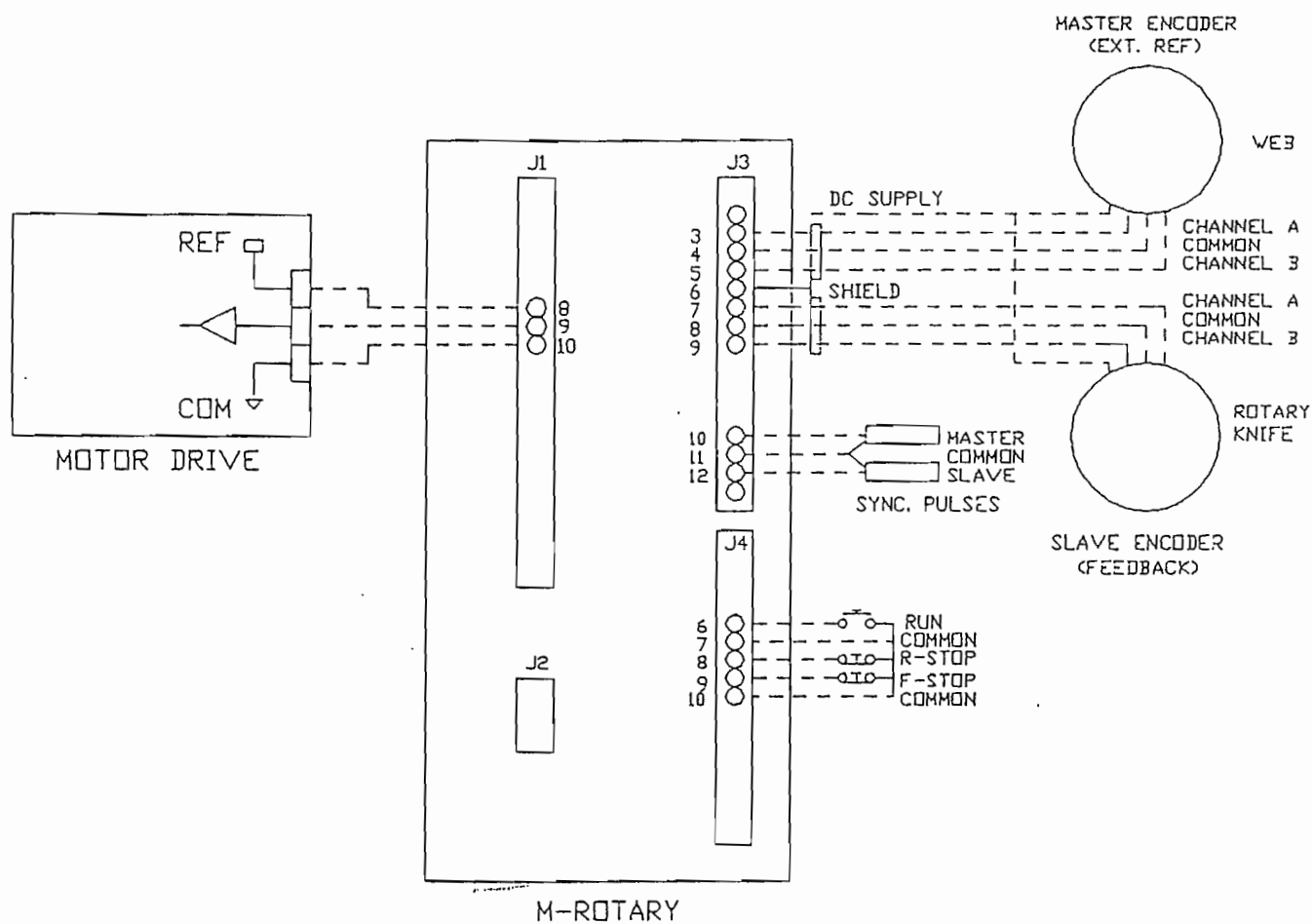
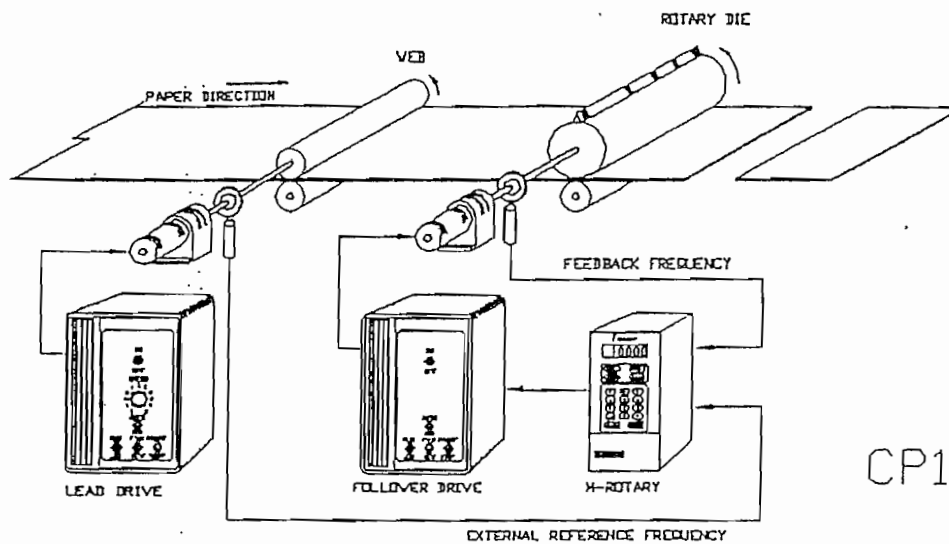
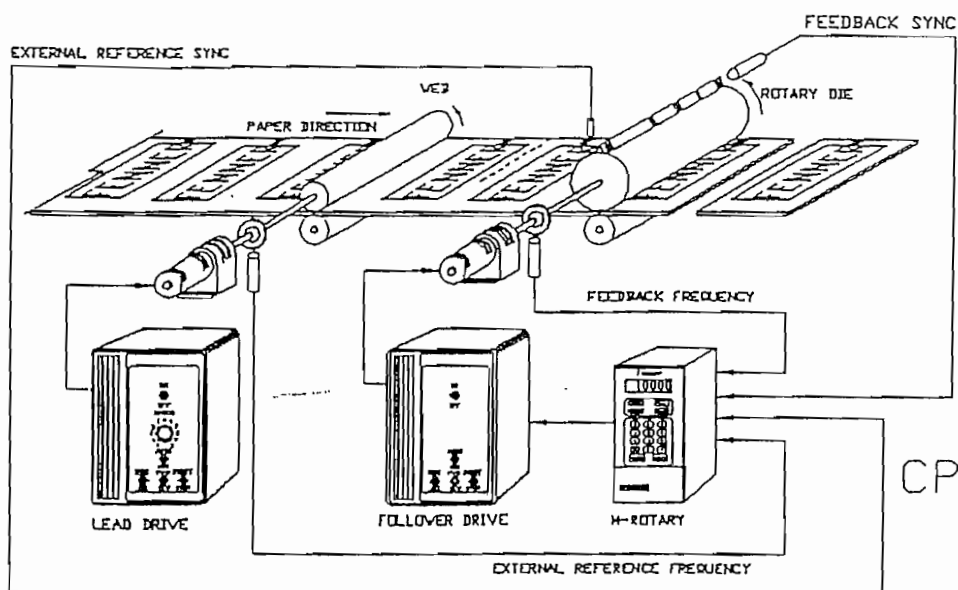


FIG. 5



CP14 = 1

NON-SYNC ROTARY FOLLOWER
FIG 6



CP14 = 3

SYNC ROTARY FOLLOWER
FIG 7

