FANUC Robot series

R-30*i*B CONTROLLER

Press Interlock

OPERATOR'S MANUAL

B-84364EN/01

ORIGINAL INSTRUCTIONS

Thank you very much for purchasing a FANUC robot.

Before using the robot, be sure to read the, *FANUC Robot series SAFETY HANDBOOK (B-80687EN)* and understand its contents.

The products in this manual are controlled based on Japan's “Foreign Exchange and Foreign Trade Law”. The export from Japan may be subject to an export license by the government of Japan. Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government. Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed. Please assume that any operations that are not explicitly described as being possible are not possible.

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to enable the safe use of the robot. Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell. For safe use of FANUC robots, you must read and follow the instructions in the *FANUC Robot series SAFETY HANDBOOK (B-80687EN)*.

PERSONNEL

Personnel can be classified as follows:

Operator:

- Turns the robot controller power on/off
- Starts the robot program from the operator panel

Programmer or Teaching operator:

- Operates the robot
- Teaches the robot inside the safeguarded space

Maintenance technician:

- Operates the robot
- Teaches the robot inside the safeguarded space
- Performs maintenance (repair, adjustment, replacement)

The operator is not allowed to work in the safeguarded space.

The programmer or teaching operator and maintenance technician are allowed to work in the safeguarded space. Work carried out in the safeguarded space include transportation, installation, teaching, adjustment, and maintenance.

To work inside the safeguarded space, the person must be trained on proper robot operation.

Table s-1 lists the work outside the safeguarded space. In this table, the symbol "o" means the work is allowed to be carried out by the specified personnel.

Table s-1 Work Performed Outside the Safeguarded Space

	Operator	Programmer or Teaching Operator	Maintenance Technician
Turn power ON/OFF to Robot controller	o	o	o
Select operating mode (AUTO, T1, T2)		o	o
Select remote/local mode		o	o
Select robot program with teach pendant		o	o
Select robot program with external device		o	o
Start robot program with operator's panel	o	o	o

Start robot program with teach pendant		○	○
Reset alarm with operator's panel		○	○
Reset alarm with teach pendant		○	○
Set data on teach pendant		○	○
Teaching with teach pendant		○	○
Emergency stop with operator's panel	○	○	○
Emergency stop with teach pendant	○	○	○
Operator Panel maintenance			○
Teach Pendant maintenance			○

During robot operation, programming and maintenance, the operator, programmer, teaching operator and maintenance engineer take care of their own safety using at least the following safety protectors:

- Use clothes, uniform, overall adequate for the work
- Safety shoes
- Helmet

DEFINITION OF SAFETY NOTATIONS

To ensure the safety of workers and prevent damage to the machine, this manual indicates each precaution on safety according to its severity. Read the contents of each **Warning** and **Caution** before attempting to use the robot.

⚠WARNING

Indicates a hazard resulting in the death or serious injury of the user could occur if he or she fails to follow the approved procedure.

⚠CAUTION

Indicates a hazard resulting in the injury of the user or damage to equipment could occur if the user fails to follow the approved procedure.

Note

Indicates a supplementary explanation not related to any WARNING or CAUTION.

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1 OVERVIEW

Press Interlock is a software option that allows FANUC robots integrated into a press line to interact automatically amongst each other as well as with the presses between them.

Figure 1 shows a typical press line. The areas highlighted in red are the zones of interference between the robots and the press. That is, these areas are in the workspace of two robots and a press. In order to provide the best line throughput, it is beneficial to have both robots and the press active in these interference zones simultaneously. In other words, allowing only one robot or the press to be active in the interference zone is safe but has a severe impact on performance.

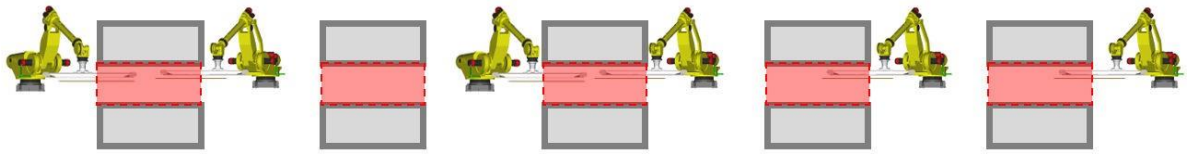


Figure 1 Typical Press Line

Press Interlock manages robot and press motion, including interference zones in order to maintain machine protection while attempting to optimize line throughput and improve robot life.

Press Interlock takes the tedious and error-prone task of optimizing the press line interactions away from the operator and does it automatically. The main benefits of this approach are listed here:

1. Press line is easier to commission. Only easily measurable quantities are required, with no tweaking or adjustment required by the operator.
2. Chasing performance and interlock angles are optimized based on the path taught by the operator, leading to good performance not affected by amount of time spent in commissioning or skill level of the operator.
3. Press line is robust to path and speed changes. Press Interlock automatically detects and accounts for path changes after initial commissioning, automatically re-synchronizing the line without any further intervention required by the operator.
4. Robot override can be adjusted without sacrificing synchronization. Press Interlock automatically takes override into account and maintains synchronization with varying robot overrides as long as it is safe and effective to do so.
5. Press Interlock improves robot life by overriding the programmed speed to a lower value if it is safe and effective to do so. By minimizing high acceleration and deceleration rates in situations that do not require them, Press Interlock is able to limit vibration and improve robot life while maintaining the same level of performance.

1.1 FEATURES

1.1.1 Robot to Pick Press Synchronization

Press Interlock attempts to synchronize the arrival of the robot at the press boundary with the arrival of the press at its Pick Interlock Angle. The ultimate goal of robot to pick press synchronization is illustrated in Figure 1.1.1. Using an encoder connected to the press, the robot is able to learn the press profile and adjust its own timing so as to arrive inside the press just as the press clears its Pick Interlock Angle. Press

Interlock is able to automatically calculate the Pick Interlock Angle from the robot path and a given mapping of press angle to slide position.

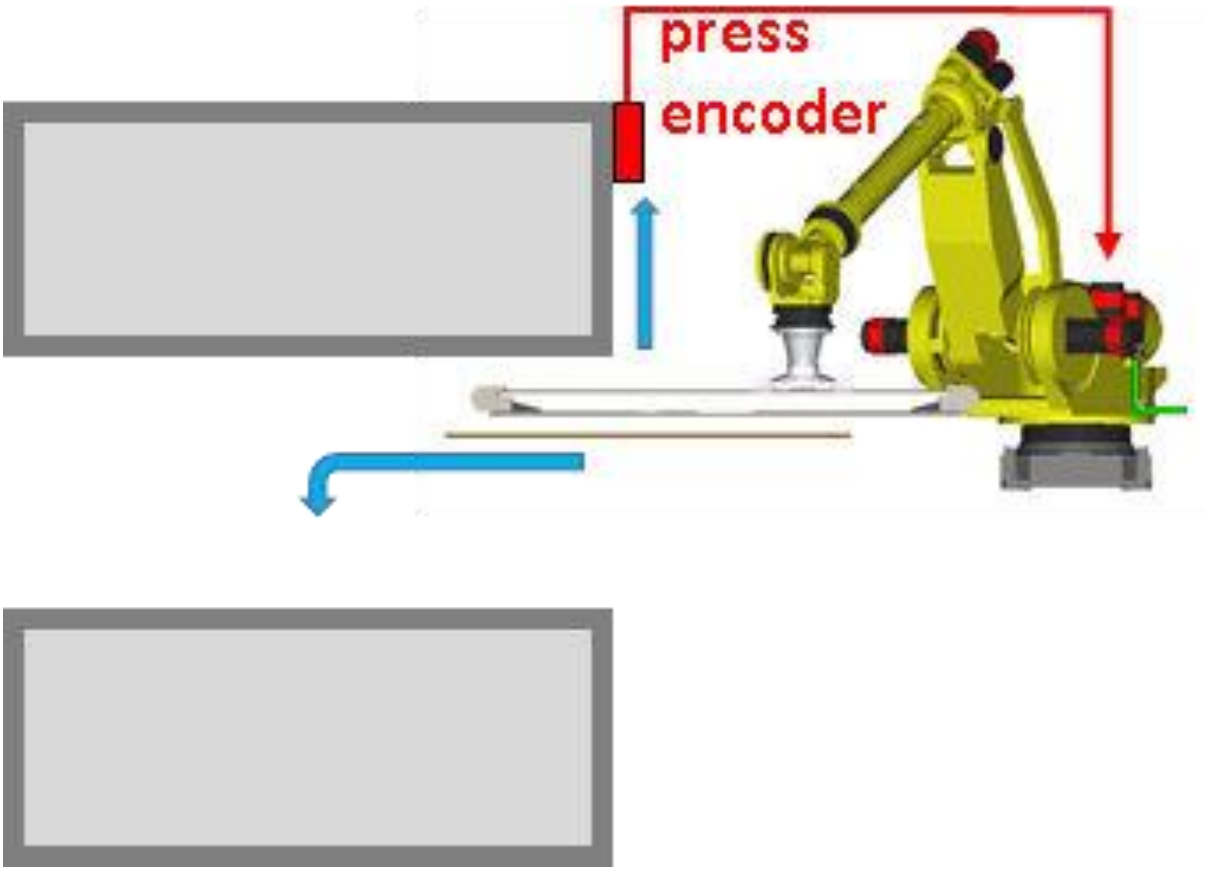


Figure 1.1.1 Pick Press Synchronization

1.1.2 Robot to Robot Synchronization

Within the press, after the pick robot has picked an already stamped part, it is beneficial for the drop robot to drop off the next (unstamped) part into the press. This synchronization area is known as robot to robot chasing. With the help of an Ethernet connection between the robots, Press Interlock can adjust the drop robot timing so as to optimize this chasing in such a way that the robots spend the minimal amount of time inside the press given the path programmed by the operator and the part and tool dimensions. The chasing synchronization is depicted in Figure 1.1.2.

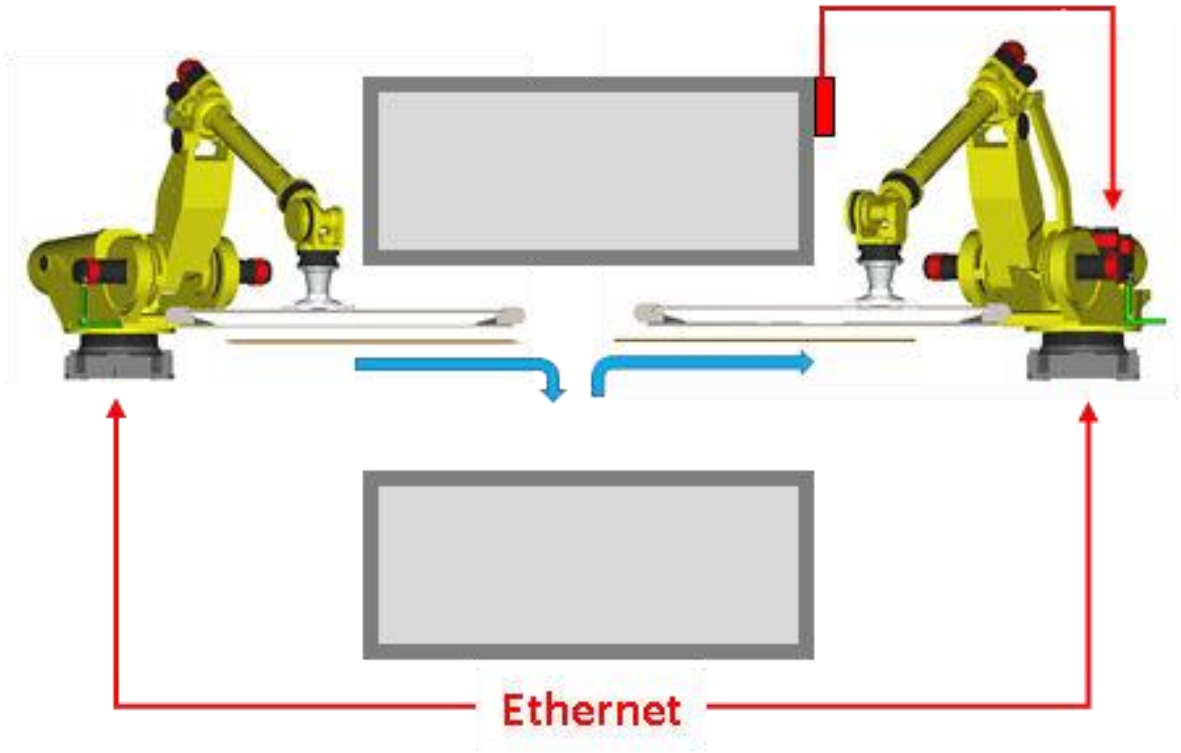


Figure 1.1.2 Robot to Robot Chasing Synchronization

1.1.3 Robot to Drop Press Synchronization (Optional)

Using the press encoder and knowledge of the robot path, Press Interlock can figure out the proper time for the press to start coming down as the drop robot is leaving the press. The goal of this synchronization is for the robot to exit the press just before the press reaches its Drop Interlock Angle. Press Interlock can figure out the Drop Interlock Angle automatically based on the robot path and a mapping of press degrees to slide position. Robot to drop press synchronization is shown in Figure 1.1.3.

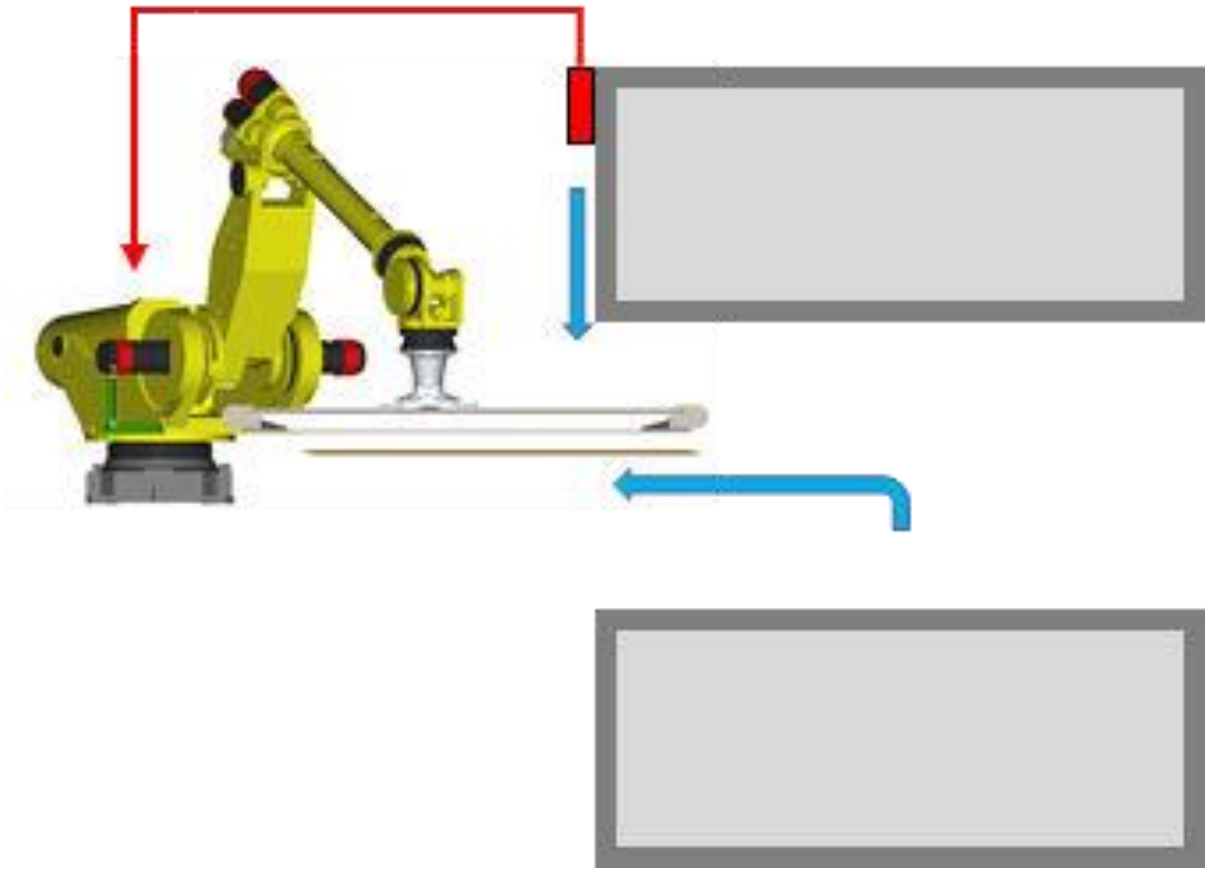


Figure 1.1.3 Drop Robot to Press Synchronization

1.1.4 Machine Protection

Press Interlock monitors neighboring robots and presses for various fault condition and can take preventative measures in some cases. These protections can prevent damage to equipment despite operator mistakes.

1.1.4.1 Robot to Pick Press

The pick robot can hold or E-Stop itself while approaching the pick press if the press profile suddenly changes or if the press comes to an unplanned stop.

1.1.4.2 Robot to Robot Chasing

The drop robot monitors that its relationship to the pick robot it is chasing is within bounds. If an error condition is detected, the drop robot can hold itself in some cases and E-Stop itself in more severe cases.

1.1.4.3 Robot to Drop Press (Optional)

After signaling the drop press to come down, Press Interlock can monitor the press and issue an external signal to stop the press which can be used by a PLC or other external control device to stop the press. Press Interlock has greater capability to predict fault conditions than manual programming would.

1.2 REQUIREMENTS

1.2.1 Press Encoder

For each press on the press line, there should be an encoder attached to the press in the following manner:

1. The encoder should be on a shaft which moves if and only if the press slide is moving.
2. The encoder should be attached to one or both of the controllers that interact with that press. Press Interlock will automatically communicate encoder information to neighboring robots if the encoder they need is not directly connected.
3. The encoder can be incremental or absolute.

1.2.2 Communications

Press Interlock employs Ethernet networking to implement I/O exchange between neighboring robots as well as FTP. Each robot must be on the same Ethernet network as its neighboring robots (upstream and downstream). Practically, all robots on the press line should be on the same network. A typical system architecture is depicted in Figure 1.2.2. PLCs and other devices may be connected to the network as well.

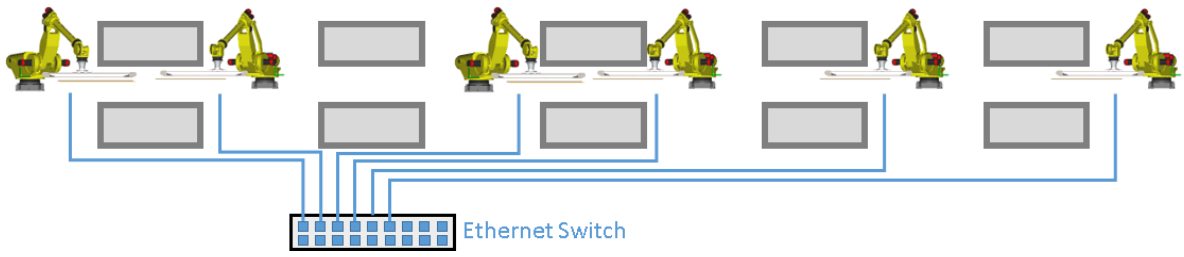


Figure 1.2.2 Typical Press Interlock Network Architecture

1.2.3 Supported Robots

The following robots are currently supported to be used with Press Interlock:

- M900iA/200P with LPT
- TR510iA/500S
- TR510iA/500M
- TR510iA/500L

- R-2000/100P

1.2.4 Supported Press Types

Press Interlock can support the following press type:

Stop and Go Mechanical Press with the following characteristics:

- The press stops at Top Dead Center and waits for continue. Press Interlock can provide the signal or it can be provided externally.
- Cycle time efficiency provided from using Press Interlock is best when the press position vs time profile is consistent. This is because the motion profile is learned during the Press Interlock learn mode. If the cycle varies too much from what is learned, Press Interlock will have to re-learn the new cycle. This causes the robots to enter “drop learn” mode, which means the robots will wait for the press to fully cycle prior to entering, negatively impacting cycle time. Variance in the position vs time profile can be accounted for by adjusting parameters in Press Interlock, such as the TDC tolerance.

1.2.5 Included Software

The following options are included with Press Interlock:

- Intelligent Interference Check (R759)
- Line Tracking (J512)
- Ethernet/IP Scanner (R785)
- Constant Path (R663)

The following options are also included if using the Press Interlock Advanced option (R893):

- Auto Backward Exit (R861)
- 4D graphics (R674)

1.3 LIMITATIONS

Please keep in mind the following Press Interlock limitations:

- Press Plugin is only available on SpotTool+
- Press Interlock does not support Advanced Constant Path
- Press Interlock does not support multi-group systems
- Press Interlock can only slow down the customer taught program, it cannot speed it up
- Press Interlock supports only line flows along the World X or Y direction of the robot, not diagonal

2 SETUP

2.1 GENERAL

In general, the setup of the press system is broken down into two sections: The line setup and the recipe setup. Line setup items are items which are static and do not change from one part to the next. Recipe setup items are unique to a specific part configuration for the line. Line setup includes 5 categories: Robots, Presses, Tool I/O, Pick I/O, and Drop I/O. The robot information is spacing relative to its neighboring presses, and how the robot is mounted relative to the flow of parts through the line. Press information is the Top Dead Center value in degrees, the tolerance for Top Dead Center, the encoder scale which relates encoder counts to degrees, the width of the press, and the robot which this press's encoder is connected.

In order for a cell to run, all robots must have the items configured and actions taken as described below.

1. Press must be the selected application.

   Select the application from controlled start. If this step is not done the press item will not display in the setup menu, and the press plugin is not active.

2. RIPE must be configured.

   It is recommended that robots are in order from upstream to downstream. So the most upstream robot is first in the ring, the next downstream robot is second, etc.

3. Relevant I/O must be mapped to devices.

   Digital I/O, as well as Group I/O which are used by Press Interlock to communicate to upstream and downstream robots, as well as the PLC

4. Press Interlock press profile files on `fr:\`

   a. `PK_ANG_MM.DAT` – This file maps press angles to linear distance values for the pick press. Must be present on any robot which picks a part from a press.

   b. `DRP_ANG_MM.DAT` – This file maps press angles to linear distance values for the drop press. Must be present on any robot which drops a part onto a press.

   c. If these files are not present, `TMSN-016` error will post when the `START_SYNC()` program is called.

5. Press Plugin line setup complete

   a. This generates two files on `fr:\press\` one is called `linesetup.xml` and one is called `presssyncio.xml`

   b. `Linesetup.xml` contains physical dimensions related to the physical layout of the press line. These dimensions don't change from part to part.

   c. `presssyncio.xml` contains the I/O information which press sync uses to communicate with other robots and with the PLC.

   d. Line setup items include robot information, press information, and Press Interlock I/O configuration information

   e. Verify all of the I/O configured is valid and mapped I/O

6. Press Recipe information complete for at least one recipe

   a. Press Recipe files reside in `fr:\press\` and will have a name such as `style001.xml`, and all data has been entered.

b. TP programs must exist and must be named `PRESS_Snnn` where `nnn` is the recipe number. Example: recipe 1 has `PRESS_S001.tp`.

c. It is recommended that the teach pendant program is run at low speeds in teach mode first to verify accuracy of positions taught.

7. Active recipe is set by the PLC

a. Recipe GI from PLC must be set to the numeric value matching the recipe number desired

b. Recipe change DI must be toggled from OFF to ON in order to load the recipe number set in the Recipe GI from PLC

c. If the `stylennn.xml` (where `nnn` is replaced by the recipe number) file exists on `fr:\press\` the press application will automatically create a TP program which is a copy of `press_s000.tp` and rename it for the active recipe. It will also add this program to the style table at that index.

2.2 LINE/ROBOT ONE-TIME SETUP

Prior to configuring any press specific items, the press application must be selected at controlled start. Do this by restarting the controller while holding the **F1** and **F5** keys. It should bring up a menu which has four choices, one of which is **controlled start**. Once the controller is in controlled start, press **MENU**, then navigate to **Appl-select** and you should see a screen similar to the one below. **Press** should be set to TRUE, all other application choices should be set to FALSE in most cases. Figure 2.2 shows the application selection menu at cold start, with **Press** enabled and other applications disabled.

Figure 2.2 Application Selection at Cold Start

Configure RIPE communication prior to configuring line setup

For more information about RIPE, refer to the *Internet Options Setup and Operations Manual (MAROUIN9010171E)* or to the *Ethernet Function OPERATOR'S MANUAL (B-82974EN)*. For Press applications, controller 1 (furthest upstream) should be the master. Controllers should be in upstream to downstream order in the RIPE configuration. You may also use the Press application UI to create the `rosipcfg.xml` file. To create this file using the Press application UI, go to **MENU** > **SETUP** > **Press**,

then select **Utilities**, then **Robot Communication Setup**. You may also use this screen to verify that the configuration is correct. Once `md:/rosipcfg.xml` has been created on one controller, copy it to each controller's `MD:` directory. You must cycle power on each controller after creating/copying this file.

2.2.1 Line Setup - Number of Equipment Entry

This section describes the usage of the **Line Setup** screens. From the main Press application menu (**MENU** > **SETUP** > **Press**), select **Configure Line**, you will see a screen similar to the one shown below. On this screen, enter the number of robots and number of presses in the line. The number of robots should only include robots which interact with a press, so the number is typically 1 more than the number of presses. You may also add a name to the line. Select **F4, OK** to get to the main line setup screen. This line configuration can be completed from any teach pendant in the line, data will automatically be sent to all controllers when the line configuration is saved.

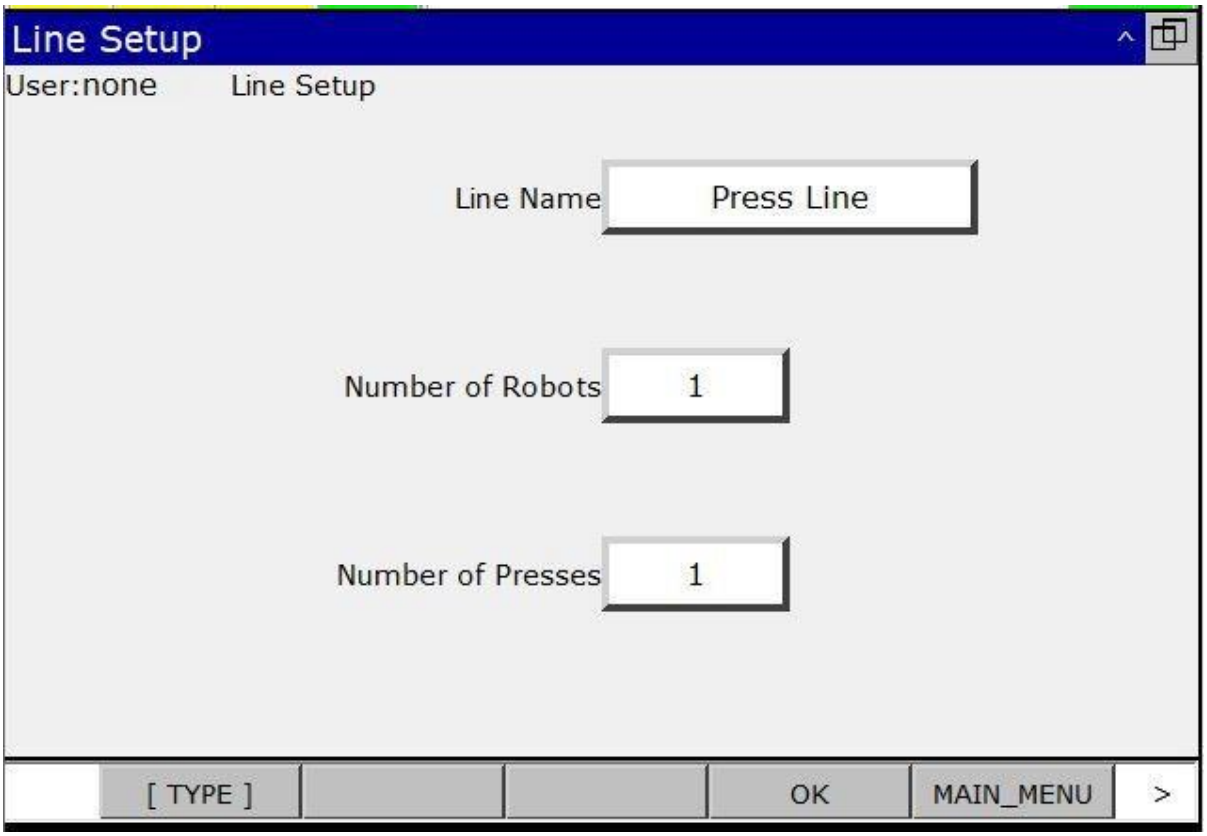


Figure 2.2.1 Line Setup Equipment Entry

2.2.2 Line Setup - Choose Equipment

Figure 2.2.2 shows the main screen for line setup. From here, you should navigate to the different equipment types and set them up accordingly. This screen also lets you know if the data entered is valid or not. Keep in mind that in many cases 0 can be a valid value.

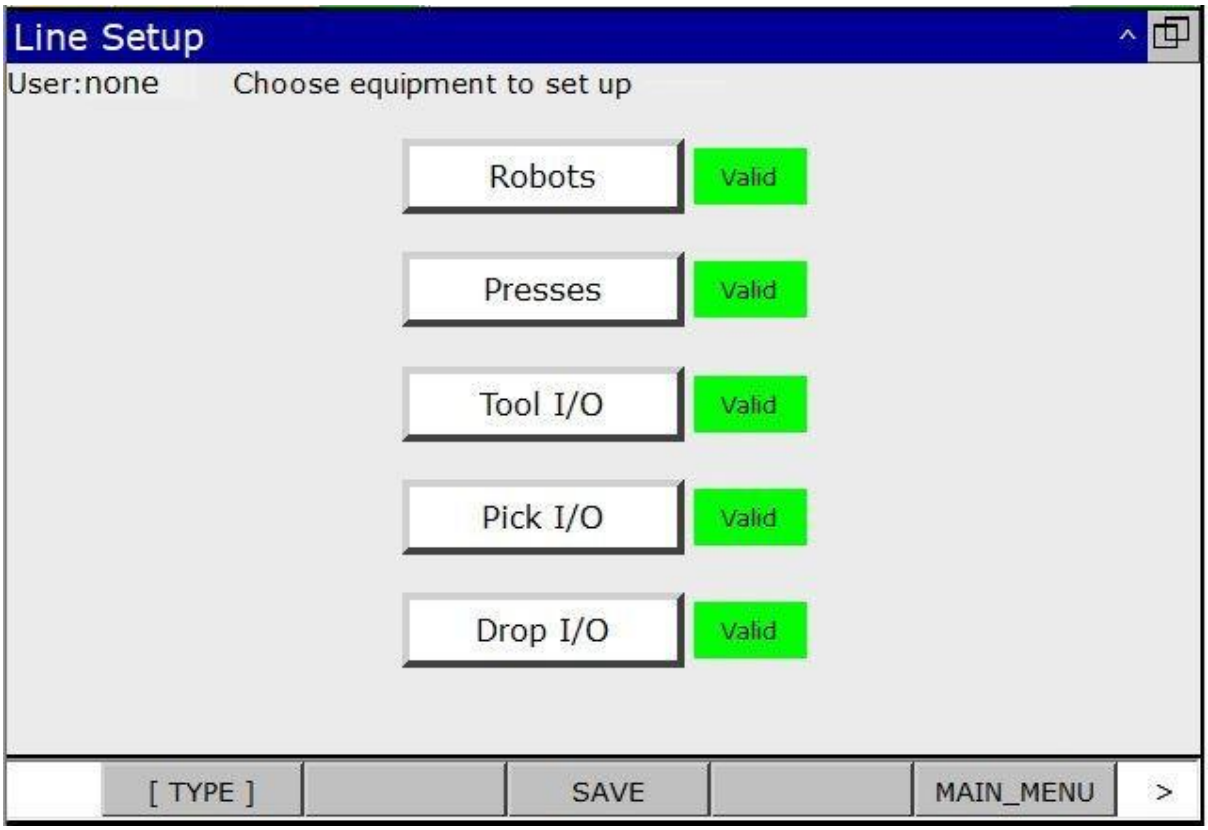


Figure 2.2.2 Line Setup Home Screen

2.2.3 Line Setup - Robot Information

On the screen shown in Figure 2.2.3 enter information for the robot's relationship to the press, the part flow direction relative to the robot, and a robot name if desired. This information is used to set up the Intelligent Interference Check (IIC) boundaries so the robot will know when it is inside of the press. Use the **F2, PREV_RBT** and **F4, NEXT_RBT** keys to scroll through the robots in the line, entering data for each one. If you are unsure of what a value means be, clicking the text with a letter in parentheses will show you a graphical input page. From the graphical input page you can press **F4, OK** to return to this screen. When you are finished entering robot data for all robots in the line, press **F5, LINE_HOME** to return to the main line setup screen. Parameters for press data should be set up next.

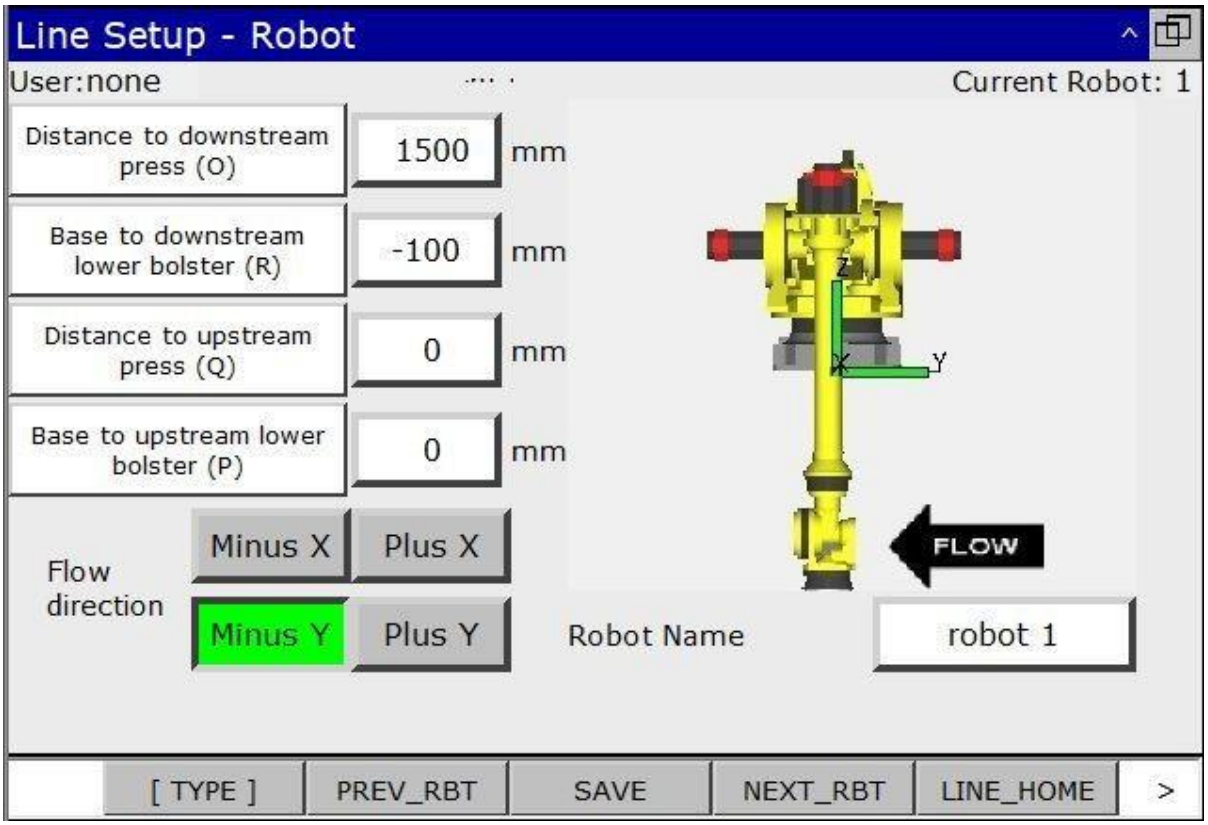


Figure 2.2.3 Line Setup, Robot Screen

⚠WARNING

Please validate the information entered is accurate. If any dimensional value is incorrect, it can lead to robot crashes and/or equipment damage.

⚠CAUTION

If modifying flow direction using a browser in Windows 10, there is a known issue with the toggle buttons. You may need to click them twice in order to change their state.

2.2.4 Line Setup - Press Information

Enter all press information on the screen shown in Figure 2.2.4. Use the **F2, PREV_PRS** and **F4, NEXT_PRS** buttons to scroll through the presses on the line. Once all press information is entered for all presses, press **F5, LINE_HOME** to return to the main line setup page. The **Width (W)** button can be pressed to show a graphical help screen with more information explaining the width value.

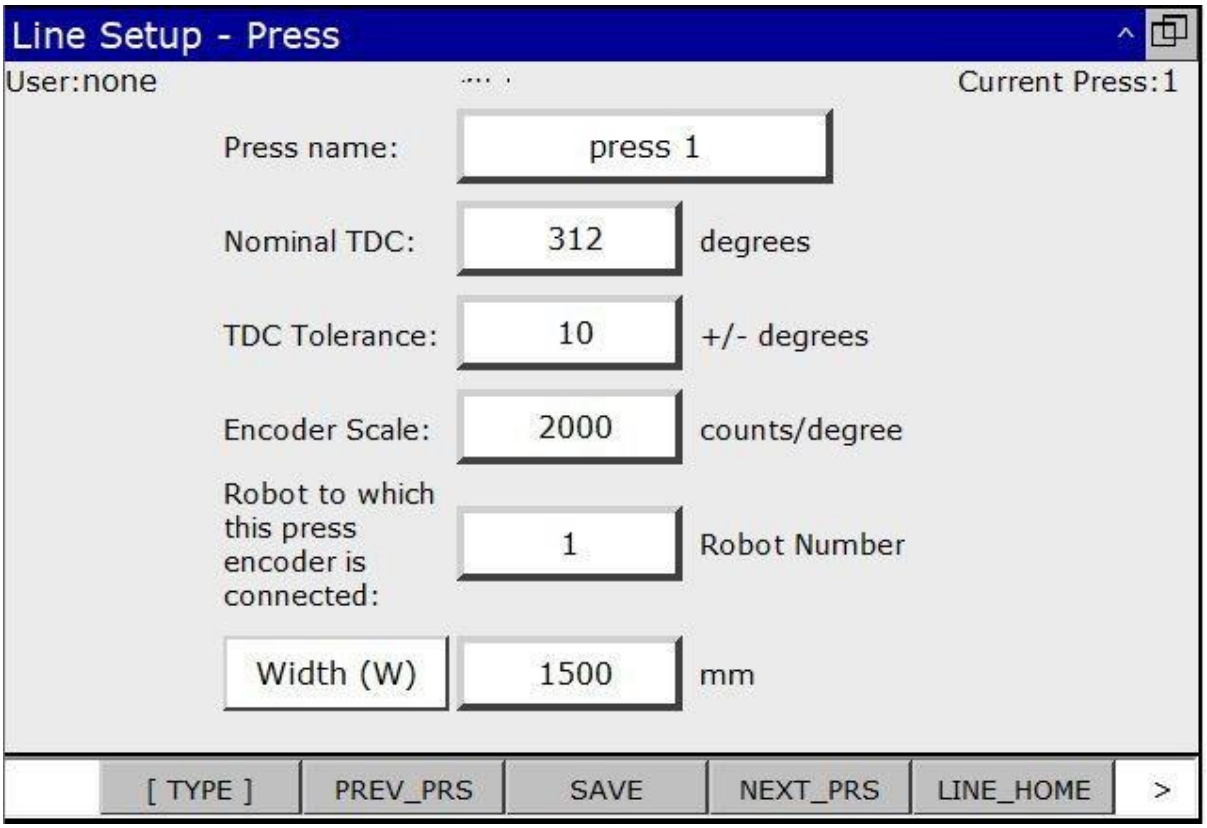


Figure 2.2.4 Line Setup, Press Screen

The nominal TDC (Top Dead Center) value is the angle in degrees reported by the press when it is in the topmost position. The TDC tolerance is the number of degrees +/- from the nominal that the press can still be considered in the top dead center position. This basically accounts for any drift or inaccuracies of the press in stopping at exactly top dead center. The encoder scale is the number of encoder counts per 1 degree. The robot to which this press encoder is connected is the robot which has the physical connection to the encoder. The press width is used in conjunction with the robot to press distances in order to calculate the robot to robot distance which press sync uses, so these measurements should not have any overlap. The press width is also used to calculate the IIC boundary of the die width.

2.2.5 Line Setup - Tool I/O Information

The screen shown in Figure 2.2.5 is for configuring the outputs and inputs used by any tooling/grippers which are used by a robot in the line. This allows a novice user to set up part recipes without requiring that user to know which outputs are used for gripper activation and part presence checking. Select either **RO** or **DOUT**, depending on the electrical configuration of the robot. This configures which grippers are toggled when the `prs_grip` and `prs_ungrip` programs are run from the TP program. Once finished, press **F5, LINE_HOME** to return to the main line setup screen.

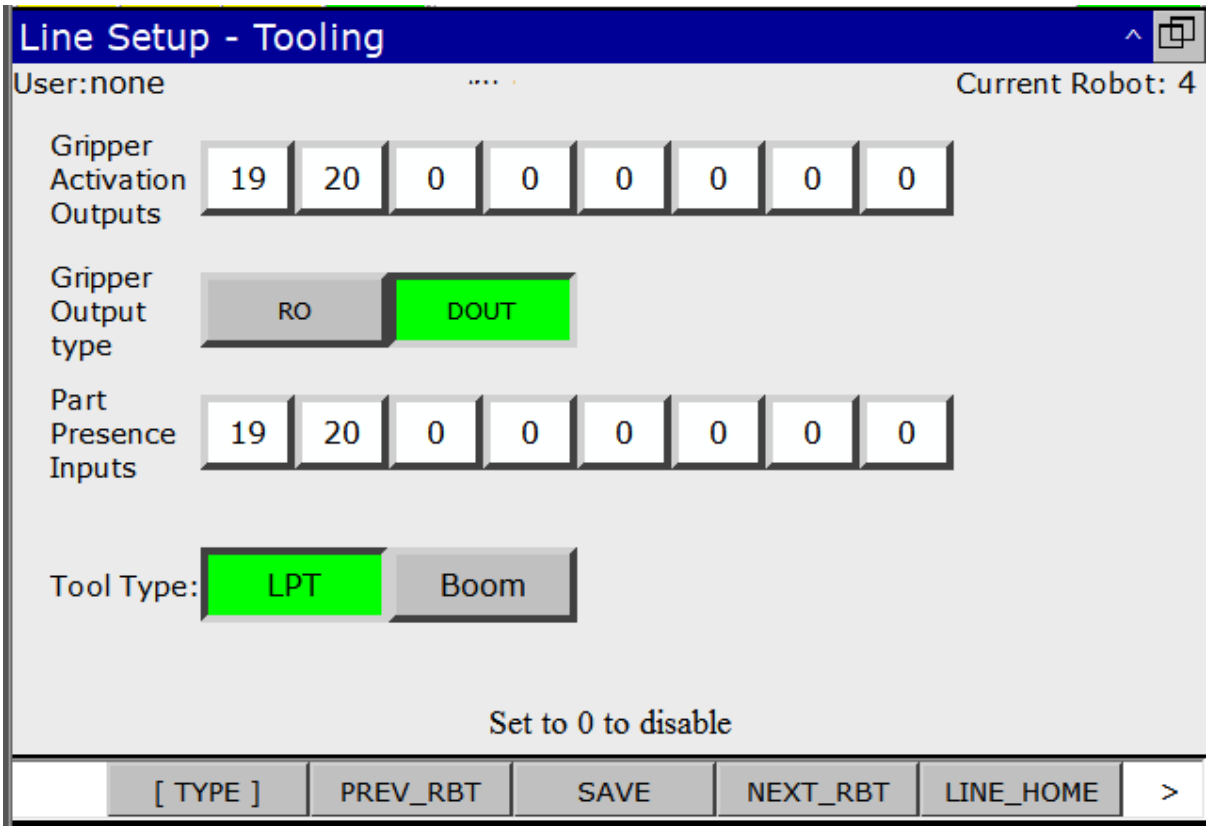


Figure 2.2.5 Line Setup, Tooling Items

2.2.6 Line Setup - Pick and Drop Press Interlock I/O

The screens in Figure 2.2.6 (a) and Figure 2.2.6 (b) are used to set up the I/O that Press Interlock uses for robot to robot communication, as well as which group inputs the press angle and slide adjust values will come from. It also sets comments for the I/O which Press Interlock uses for status information (**Drop Press I/O**, **PLC DIN start** and **PLC DOUT start**). Default data exists for these values, and they may not need to be modified at all. Most of the Press Interlock Group Inputs (GI) and Group Outputs (GO) use Ethernet I/O to communicate from one robot to its upstream or downstream neighbor.

Once all line setup information has been entered on each screen, you should see a green **VALID** next to each button on the main setup screen. At this time, press **F3, SAVE**. All data is sent to each controller in the line, and each controller sets the appropriate system variables based on this information.

Figure 2.2.6 (a) Line Setup, Pick Press I/O

Table 2.2.6 (a) Pick Press I/O Screen Descriptions

Description on TP screen	Associated system variable	What it does
Pick override GO	*$PRSN_VARS.$gen_ovr_go*	Sends the robot override speed to the upstream robot. This allows the robots to adjust their speed together.
Pick time to downstream GO	*$PRSN_VARS.$pck_time_go*	Sends the upstream robot the pick time
Pick status to downstream GO	*$PRSN_VARS.$pck_stat_go*	Tells the downstream robot the current Press Interlock pick status
Pick enter DO	*$PRSN_VARS.$pck_entr_do*	This is ON when the robot is not under the pick press, and OFF when the robot is under the pick press.
Pick encoder GI	*$PRSN_VARS.$pck_enc_gi*	Input for pick press angle if not directly connected to this robot
Pick angle GI	*$PRSN_VARS.$pck_ang_gi*	Input from the upstream robot which tells this robot the press angle in degrees multiplied by 10
Pick encoder GO	*$PRSN_VARS.$pck_enc_go*	Output to downstream robot of the pick press encoder angle if the pick press encoder is directly connected to this robot

Description on TP screen	Associated system variable	What it does
Pick E-stop DO	*$PRSN_VARS.$pck_estp_do*	DO which is OFF if the pick press needs to e-stop
Pick Fault DI	*$PRSN_VARS.$pck_flt_di*	DI which is OFF if pick press is faulted (comes from the PLC to allow robot to stop early)
Pick Slide Adjust GI	*$PRSN_VARS.$pck_sadj_gi*	The slide adjust is defined as the distance between the top of the bottom bolster and the bottom of the slide when the slide is at Bottom Dead Center. The values input should be the value in mm divided by 10 and rounded up.
Pick Bound GI	*$PRSN_VARS.$up_bnd_gi*	Input from the upstream robot which tells this robot the upstream boundary
Pick Bound GO	*$PRSN_VARS.$up_bnd_go*	
Pick Time GI	*$PRSN_VARS.$pck_time_gi*	Input from downstream robot of pick time
Pick Status GI	*$PRSN_VARS.$pck_stat_gi*	Input from downstream robot of pick state
Pick mode GO	*$PRSN_VARS.$pck_mode_go*	Output to downstream pick robot of sync mode
Pick Mode GI	*$PRSN_VARS.$pck_mode_gi*	Input from downstream pick robot of sync mode
Pick Override GI	*$PRSN_VARS.$pick_ovr_gi*	Input from downstream pick robot to tell this robot its override speed

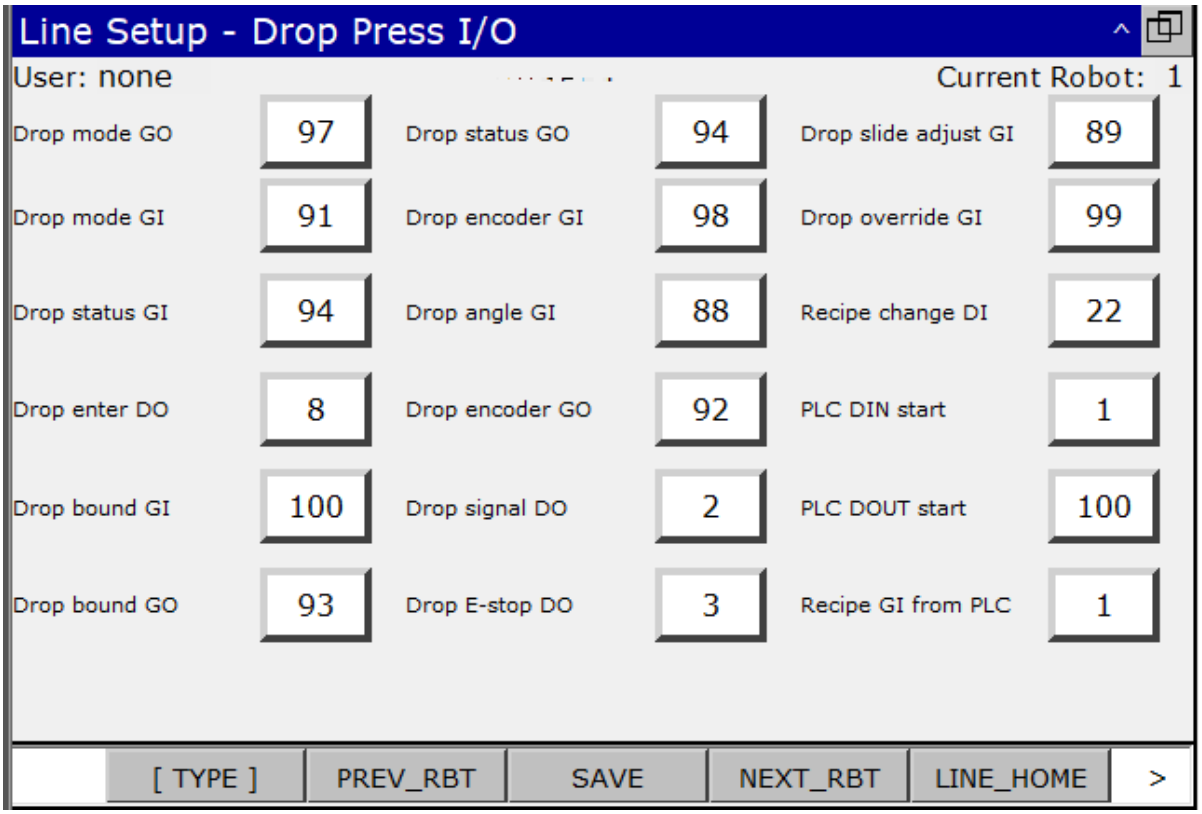


Figure 2.2.6 (b) Line Setup, Drop Press I/O and PLC I/O

Table 2.2.6 (b) Drop Press I/O Screen Descriptions

Description on TP screen	Associated system variable	What it does
Drop mode GO	*$PRSN_VARS.$drp_mode_go*	Output to upstream drop robot of sync mode
Drop mode GI	*$PRSN_VARS.$drp_mode_gi*	Input from downstream robot of drop mode
Drop status GI	*$PRSN_VARS.$drp_stat_gi*	Receives the downstream robot current status (faulted, running, etc.)
Drop enter DO	*$PRSN_VARS.$drp_entr_do*	This DOUT is ON unless the robot is entering the drop press. It is triggered when the robot tool model enters the Intelligent Interference Check model for the press
Drop bound GI	*$PRSN_VARS.$dwn_bnd_gi*	Input of current upstream boundary from downstream robot
Drop bound GO	*$PRSN_VARS.$dwn_bnd_go*	Output of current downstream boundary
Drop status GO	*$PRSN_VARS.$drp_stat_go*	Sends the current robot status to the downstream robot
Drop encoder GI	*$PRSN_VARS.$drp_enc_gi*	Receives the downstream robot encoder value for this robot's drop press

Description on TP screen	Associated system variable	What it does
Drop angle GI	*$PRSN_VARS.$drp_ang_gi*	Input from the downstream robot which tells this robot the press angle of the drop press in degrees multiplied by 10
Drop encoder GO	*$PRSN_VARS.$drp_enc_go*	Sends the downstream robot the encoder value from this robot
Drop signal DO	*$PRSN_VARS.$drp_sig_do*	DOUT to tell the drop press to cycle
Drop E-stop DO	*$PRSN_VARS.$drp_estp_do*	This DOUT is turned OFF if the drop press needs to E-stop
Drop Slide Adjust GI	*$PRSN_VARS.$drp_sadj_gi*	The slide adjust is defined as the distance between the top of the bottom bolster and the bottom of the slide when the slide is at Bottom Dead Center. The values input should be the value in mm divided by 10 and rounded up.
Drop override GI	*$PRSN_VARS.$gen_ovr_gi*	This receives the downstream robot's current general override % value.
Recipe change DI	[prsmain]prsrccfg.rec_chg_di	When setting the active recipe, the GI needs to be changed, then this DI needs to toggle. This helps with synchronizing all of the robots to switch to the recipe
PLC DIN start	*$PRSN_VARS.$plc_inpt_di*	Press Interlock uses a block of DINs which start at this number, they are used to communicate information to the PLC, described in more detail in 4.2.8.3
PLC DOUT start	*$PRSN_VARS.$plc_otpt_do*	Press Interlock uses a block of DOUTs which start at this number, they are used to communicate information to the PLC, described in more detail in 4.2.9.6
Recipe GI from PLC	[prsscrnctrl]GIstyle	This is the group input the robot receives from the PLC to signify what recipe number to load. It is loaded when the "Recipe change DI" toggles from OFF to ON.

2.2.7 Line Configuration Parameters

2.2.7.1 Flow Direction

Press Interlock supports part flow direction along +Y, -Y, +X, and –X in the world frame of the robot. Figure 2.2.7.1 (a) illustrates some valid part flow directions relative to the robot world frame whereas Figure 2.2.7.1 (b) illustrates some invalid ones. Flow direction is set individually for each robot from the Press Interlock GUI application Line Layout screen.

⚠WARNING

Incorrectly entering the line flow direction could lead to collision between robots and neighboring robots or robots and presses.

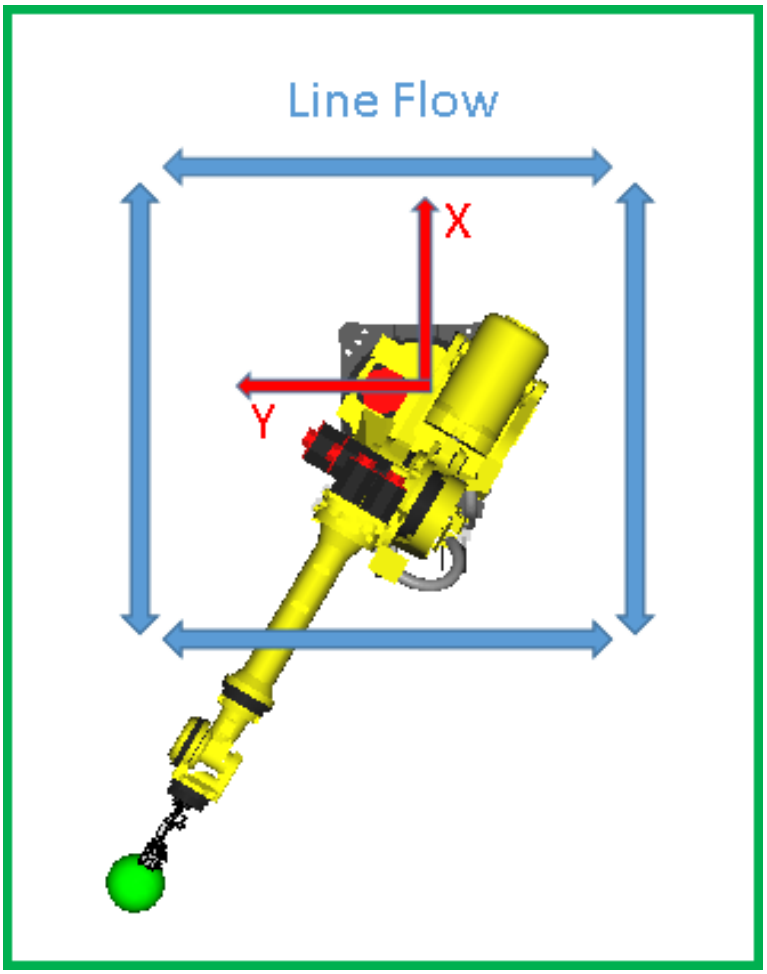


Figure 2.2.7.1 (a) Acceptable Line Flow Directions

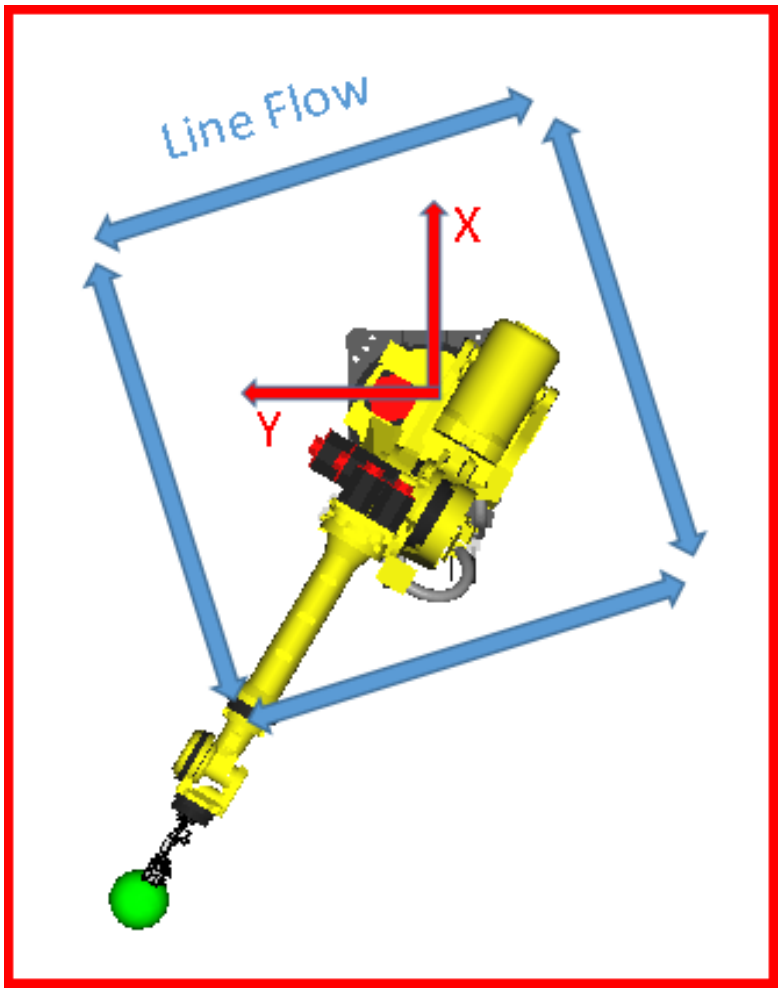


Figure 2.2.7.1 (b) Unacceptable_Line_Flow_Directions

2.2.7.2 Robot to Robot Distance

The robot to robot distance is calculated based on the robot to press distance, the press width, and the neighboring robot's robot to press distance. It should be the distance between the origin of one robot and the origin of a neighboring robot. An example is shown in Figure 2.2.7.2.

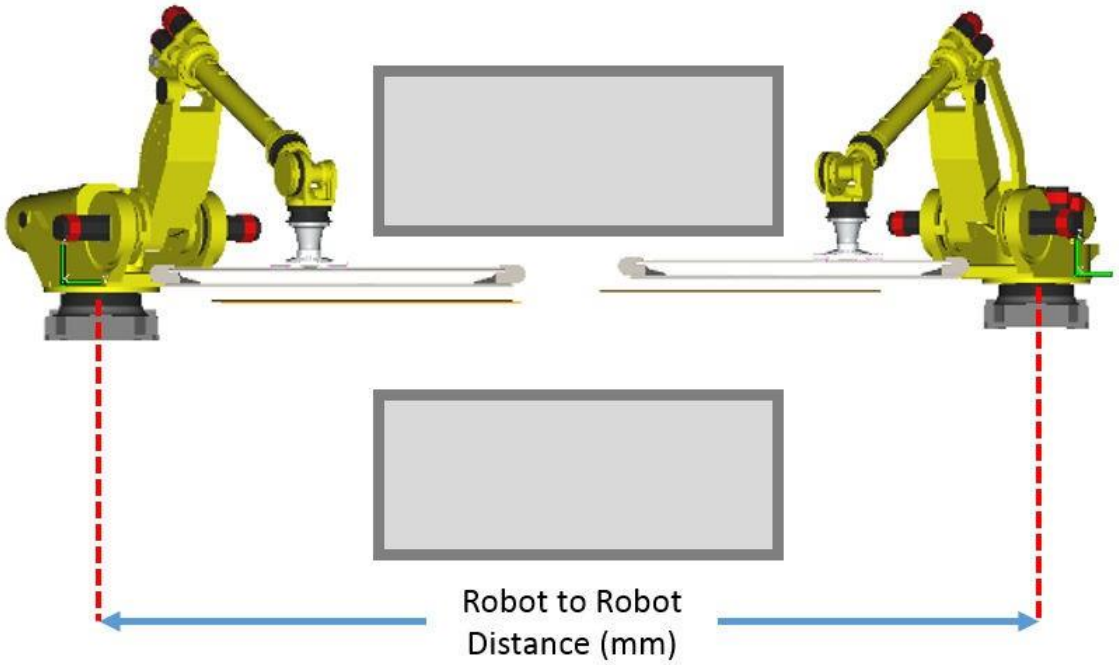


Figure 2.2.7.2 Robot to Robot Distance measurement

⚠WARNING

Robot to robot distance is important for performance and machine protection. Incorrectly entering the distance could lead to collisions between robots. Accurate measurements are important.

2.2.7.3 Robot to Press Distance

For each robot, the operator must enter the distance in millimeters along the flow direction to its upstream and downstream press, so long as they exist. The distance is measured from the middle of the base of the robot to the closest edge of the press that should be protected. This may include any equipment mounted on the side of the slide. The distance to be measured is illustrated on the Press application UI. The robot to press distance is entered on the **Press application GUI Line Setup** screen. An example of the robot to press distance is shown in Figure 2.2.7.3.

⚠WARNING

Robot to press distance is important for machine protection. Incorrectly entering the distance could lead to collisions between robots and presses. Accurate measurements are important.

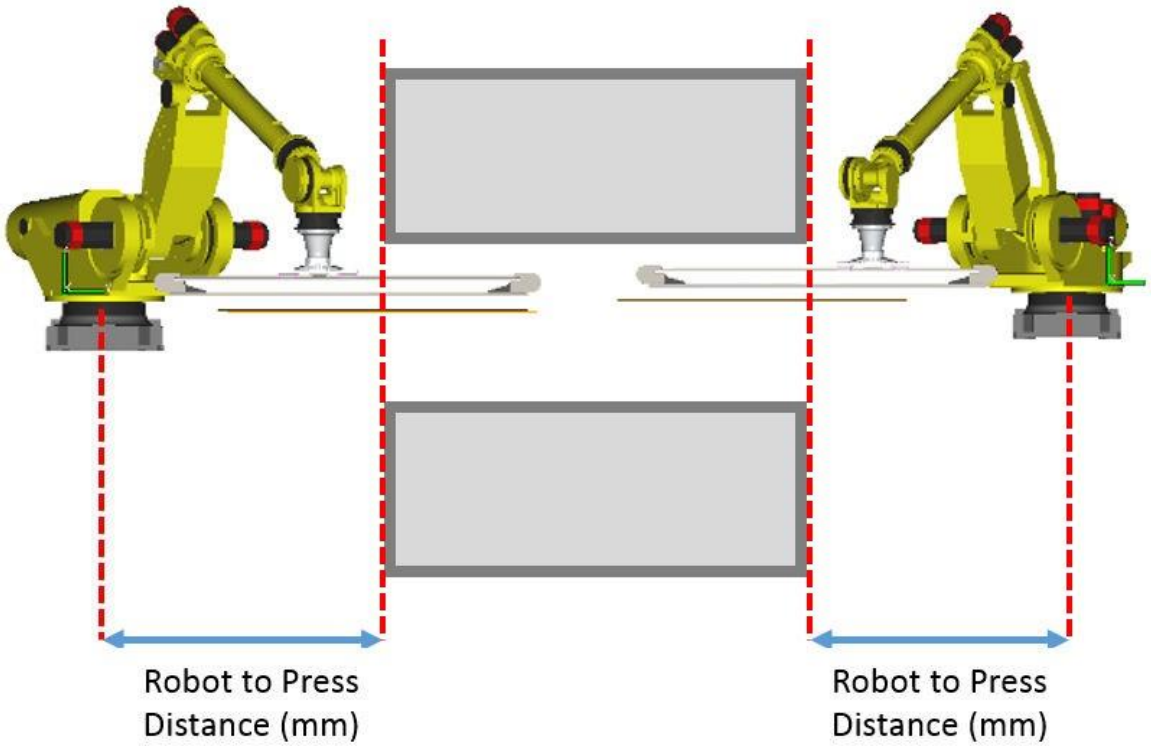


Figure 2.2.7.3 Robot to Press Distance Measurement

2.2.7.4 Robot Base to Bolster Distance

In order to be able to calculate press interlock angles automatically, each robot needs to know the offset along the z from the bottom of its base to the top of the bottom bolster along the z direction. The required distance is illustrated in and entered in the **Press application GUI line setup** screen. If the top of the bolster is below the robot base, a negative value for the distance is expected.

2.2.8 Required IO Signals

2.2.8.1 Press Angles

Although a FANUC encoder is used for Press Interlock, an external input of the press angle is required. This is done so that presses do not need to be mastered and to minimize the chance that the FANUC press encoder slowly drifts from the correct angle of the press due to slippage or other mechanical factors.

The PLC input angles are expected as Group Inputs with a value 10x the actual angle. For example, a press angle of 213.8 should be sent on a group input as 2138.

The GIs used to read the angle are specified as follows:

Pick Press: *$PRSN_VARS.$PCK_ANG_GI*
Drop Press: *$PRSN_VARS.$DRP_ANG_GI*

2.2.8.2 Press Slide Adjust Values

In order to correctly figure out interlock angles, Press Interlock needs the slide adjust value of each press. The slide adjust is defined as the distance between the top of the bottom bolster and the bottom of the slide when the slide is at Bottom Dead Center. Slide adjust values differ from part to part, as it is dependent on the dies and parts. The required measurement is shown in Figure 2.2.8.2.

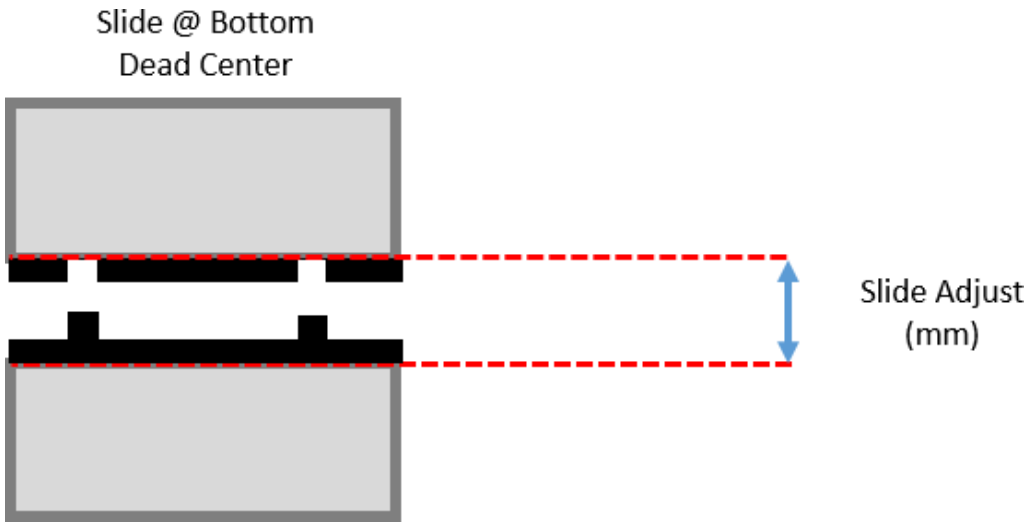


Figure 2.2.8.2 Illustration of Slide Adjust Value

The slide adjustment values are expected as group inputs. The values input should be the value in mm divided by 10 and rounded up. For instance a slide adjust of 1325mm should be a GI of 133. The GIs used to read the slide adjust are as follows:

Pick Press: *$PRSN_VARS.$PCK_SADJ_GI*
Drop Press: *$PRSN_VARS.$DRP_SADJ_GI*

2.2.8.3 Press State Inputs

Press state inputs allow the user to influence the behavior of Press Interlock by inputting information about the press states. The inputs are defined by assigning an initial DI for a set of 16 inputs to the system variable *$PRSN_VARS.$PLC_INPT_DI*. The meaning of each DI is shown in the table below.

Digital Input	Meaning
Initial DI = *$PRSN_VARS.$PLC_INPT_DI*	Pick Press state is “Empty”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 1	Pick Press state is “Part Loaded”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 2	Pick Press state is “Part Ready”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 3	RESERVED
DI = *$PRSN_VARS.$PLC_INPT_DI* + 4	Drop Press state is “Empty”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 5	Drop Press state is “Part Loaded”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 6	Drop Press state is “Part Ready”

Digital Input	Meaning
DI = *$PRSN_VARS.$PLC_INPT_DI* + 7	RESERVED
DI = *$PRSN_VARS.$PLC_INPT_DI* + 8	Pick Press speed change
DI = *$PRSN_VARS.$PLC_INPT_DI* + 9	Pick Press ignore speed
DI = *$PRSN_VARS.$PLC_INPT_DI* + 10	Pick Press “Idle”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 11	RESERVED
DI = *$PRSN_VARS.$PLC_INPT_DI* + 12	Drop Press speed change
DI = *$PRSN_VARS.$PLC_INPT_DI* + 13	Drop Press ignore speed
DI = *$PRSN_VARS.$PLC_INPT_DI* + 14	Drop Press “Idle”
DI = *$PRSN_VARS.$PLC_INPT_DI* + 15	RESERVED

2.2.8.3.1 Press State Definitions

Empty Press has no part, is at Top Dead Center, and pick robot is clear of the press. The drop robot is free to drop the next part.

Part Loaded: Press has a part in it but not ready to pick. The pick robot will pick the part after it sees the press move and then stop at TDC.

Part Ready: The part is ready to be picked, the press is at TDC, and the drop robot is clear of the press. The pick robot is free to pick the part.

Idle: The press is idle. It does not need to cycle between drop and pick. The drop robot will not signal to cycle the press. The pick robot will not wait for the press to cycle, instead entering as soon as the drop robot is clear of the press.

2.2.8.3.2 Other Definitions

Press Speed Change: The press will be a different speed the following cycle. This should only be changed when the robots are not in motion, as modifying the speed will interfere with the Press Interlock learned profile. Speed changes with robots in motion will cause timing errors which will fault the robots. This is checked when the press is at TDC. If the input is on, the press profile is forgotten and re-learned after the next cycle. This is particularly important for the drop press. The drop robot will signal the press to cycle while still inside the press. If a press speed change is detected while the robot is inside the press, the robot will signal the press to e-stop. If the e-stop signal is not used, a collision could occur.

Ignore Press Speed: If this signal is on, the currently executing press profile is ignored and the previously recorded one is maintained. This is useful if the press is being moved manually so that the robot does not learn the wrong profile.

2.2.9 Optional IO Signals

2.2.9.1 Re-initialize Press States

By default, Press Interlock will only read press states from the I/O described in Section 2.2.8.3, Press State Inputs when executing through a `START_SYNC` instruction in the TP program. However, the user

may specify a DI such that Press Interlock will also check the press states on resuming a Press Interlock program if the DI is on. This is useful for exception conditions which may occur during operation. For instance, part faults, manually adding or removing a part from a press, etc. will lead to Press Interlock having a wrong understanding of press states.

The DI used to signify re-initializing press states on resume is defined in the system variable *$PRSN_VARS.$INIT_PRS_DI*.

2.2.9.2 Pick Press Fault DI

In order to decrease the chance of collision between a robot and its pick press, a Pick Press Fault DI can be configured which should turn OFF if the press is in a stop fault condition for whatever reason. The effect of the signal being turned off is that if the robot had already been signaled to enter the pick press but had not yet entered it, the robot would be immediately e-stopped. Even without defining the Pick Press Fault DI, Press Interlock will look for fault condition in these situations and try to stop the robot before any collision. However, the PLC may know that the press is stopping before Press Interlock can and this DI allows that information to be used to decrease chance of collision.

To define the DI signaling a Pick Press Fault, enter the number of the DI in the system variable:

$PRSN_VARS.$PCK_FLT_DI

2.2.9.3 Drop Press Signal DO

Press Interlock can signal the drop press of the robot to cycle at the proper time based on learned robot path data, press profile data, and calculated signal delay. This is one of the main features of Press Interlock so it’s highly recommended that it’s used. To define a DO signifying the press signal cycle, use the following system variable:

$PRSN_VARS.$DRP_SIG_DO

2.2.9.4 Drop Press E-Stop DO

If the drop robot is moving inside the press while the press is moving, Press Interlock looks at several factors to try to determine if a collision between the robot and press is possible. If collision conditions are detected, Press Interlock can turn OFF a user-defined press E-stop signal. The signal is normally ON. To define an E-Stop signal DO, use the following system variable:

$PRSN_VARS.$DRP_ESTP_DO

2.2.9.5 Pick Press E-stop DO

If the pick robot is inside the press zone and Press Interlock detects that a collision between the pick slide and the robot is possible, it can turn OFF a user-defined press e-stop signal. the signal is normally ON. To define an E-Stop signal DO, use the following system variable:

$PRSN_VARS.$PCK_ESTP_DO

2.2.9.6 Press Interlock Status DOs

For the purpose of annunciation to user HMIs, Press Interlock provides outputs about current operating status. The signals are defined by selecting an Initial DO for 8 consecutive DOs of output information. The DOs and their meaning are defined in the table below:

Digital Output	Meaning
Initial DO = *$PRSN_VARS.$PLC_OTPT_DO*	Press Interlock in LEARN mode
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 1	Press Interlock in SYNC mode
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 2	Press Interlock in DROP_LEARN mode
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 3	Pick Press profile has been learned.
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 4	Drop Press profile has been learned.
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 5	RESERVED
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 6	RESERVED
DO = *$PRSN_VARS.$PLC_OTPT_DO* + 7	RESERVED

2.3 PART PARAMETERS

2.3.1 Press Application Edit Recipe Screens

The Press application Edit Recipe screens allow you to do initial set up of all data associated with a given part, or modify data for an existing part. From the **Press Main** application menu, select **Edit Recipe**. Press application allows you to access any recipe data from any robot on the press line, so you need to enter the recipe number and the robot number on the screen shown in Figure 2.3.1 first. Pressing **OK** will load that recipe's data for editing. It is recommended that each screen's data is filled out before saving the recipe. You do not need to select save on each individual screen.

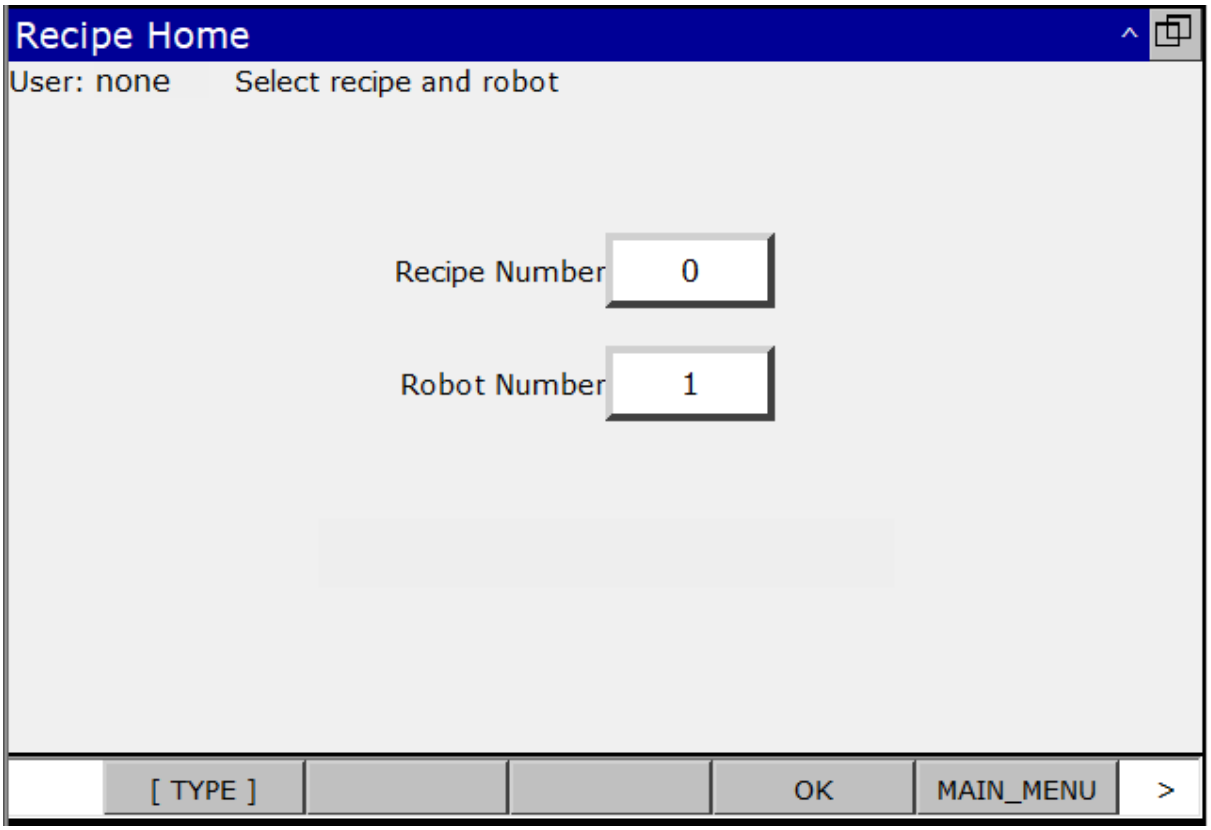


Figure 2.3.1 Recipe_Selection_Screen

When creating a new recipe, recipe 0 data is used as a base. Recipe 0 should contain “worst case scenario” data. This protects the equipment if the user fails to enter new data, or wants to use the default data from recipe 0. This also means that the `press_s000` TP program is used as a template. There are some useful implications of this. If additional positions, functionality, or logic is required for all programs(or even most programs), it is recommended that the `press_s000` template be modified with these changes prior to creating additional recipe files. This will save the trouble of adding the functionality to every recipe TP program, since programs are copied from the `press_s000` template. When a recipe is set as the active recipe, the position registers, numeric registers, and flags are all set according to the values which are saved for that recipe. If the system receives the cycle start signal, the `press_snnn` template program will be started, where `nnn` is the recipe number.

2.3.2 Edit Recipe Parameter Selection

Figure 2.3.2 shows the main page for recipe edit functions. From here, you can navigate to the setup pages for different aspects of the recipe data. Every recipe edit sub-page links back to this screen with the **F5, RCP_HOME** key. Sub-pages will display either a red or green bar across the top and bottom of the screen. Green indicates you are accessing data from the robot which the teach pendant is connected to. Red indicates you are accessing a different robot. Take extra care when modifying data from a different robot. Any data entered on recipe screens is not saved to the recipe until the **F3, SAVE** button is selected. It is not necessary to save data on each recipe data screen, as the data is temporarily stored until the **F3, SAVE** button is pressed.

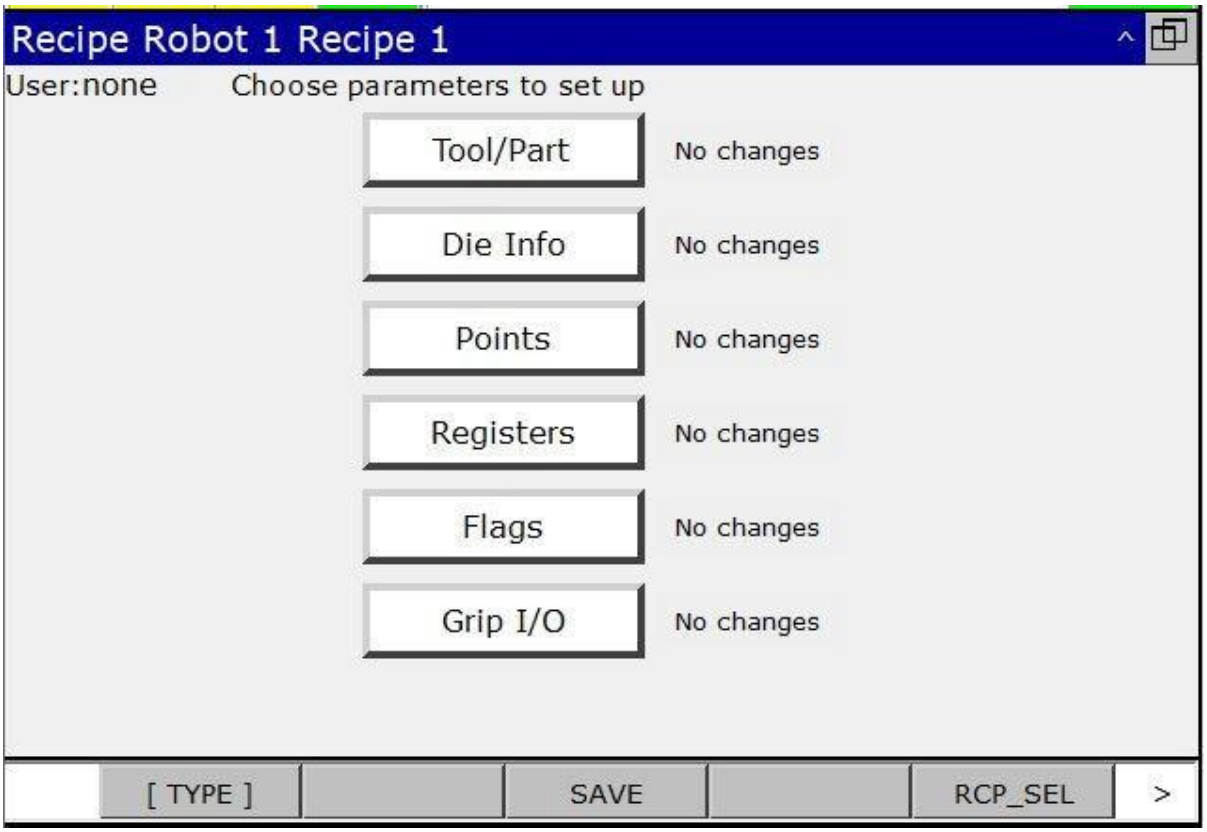


Figure 2.3.2 Recipe_Parameter_Home_Screen

2.3.3 Edit Recipe Tool and Part Information

Use Figure 2.3.3 (a) to enter dimensional information for the tooling and the part, as well as the payload with and without the part. If you click any of the text boxes which have a letter in parentheses (A-J are used on this screen), a graphical input display will be shown which explains the dimensions more clearly. Several of these dimensions are illustrated using the same graphic. Once all information is entered, press the **F5, RCP_HOME** key to return to the recipe setup selection screen to continue setting up the rest of the information for this recipe.

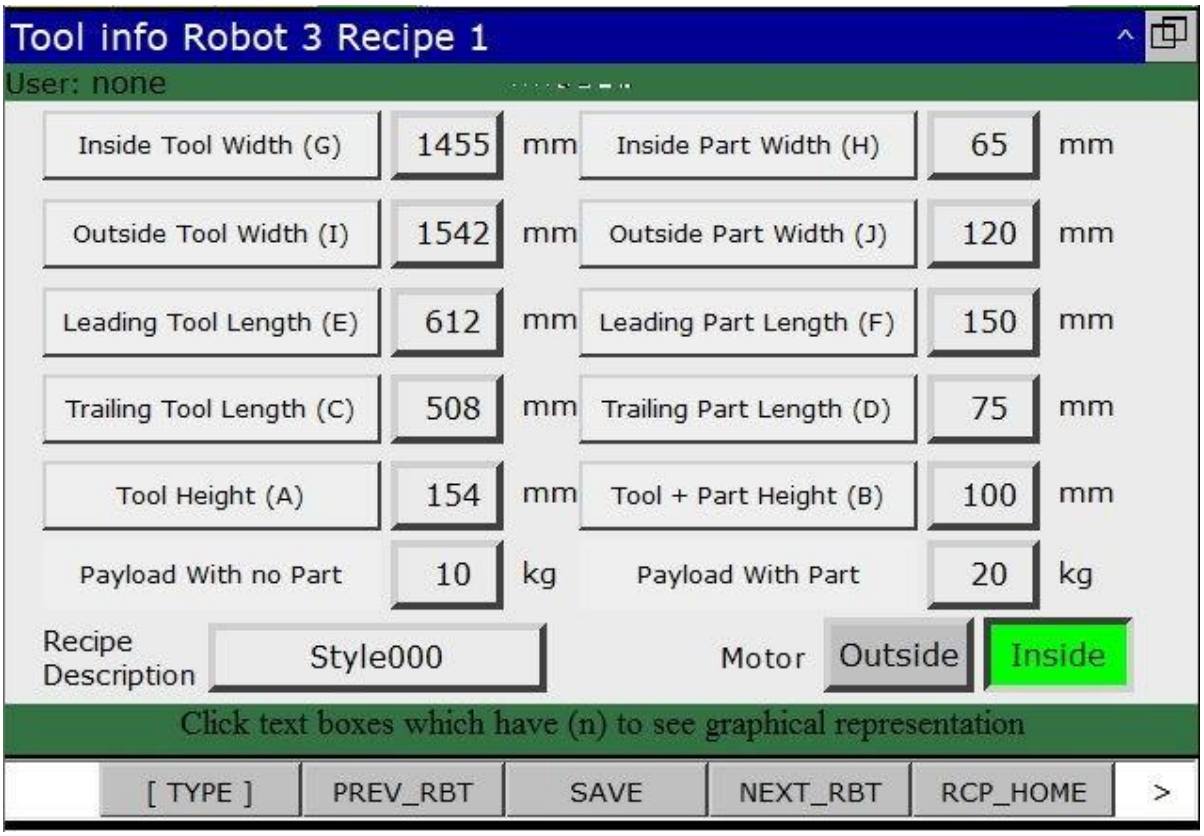


Figure 2.3.3 (a) Recipe_Tool_Information_Setup_Screen

Motor Outside/Inside refers to the positioning of the motor with respect to the robot's world frame. **Motor Outside** means the motor for the LPT is facing away from the robot relative to the world frame. **Motor Inside** means the motor for the LPT is facing towards the robot relative to the world frame.

If you have configured your robot tool in the line configuration setup to be a boom tool, instead of **Motor Outside/Inside** you will see a button for Boom setup. When this button is selected, the **Boom Info** screen will be displayed, as shown in Figure 2.3.3 (b) below. Boom end of arm tooling requires additional information in order to correctly configure the Intelligent Interference Check (IIC) models.

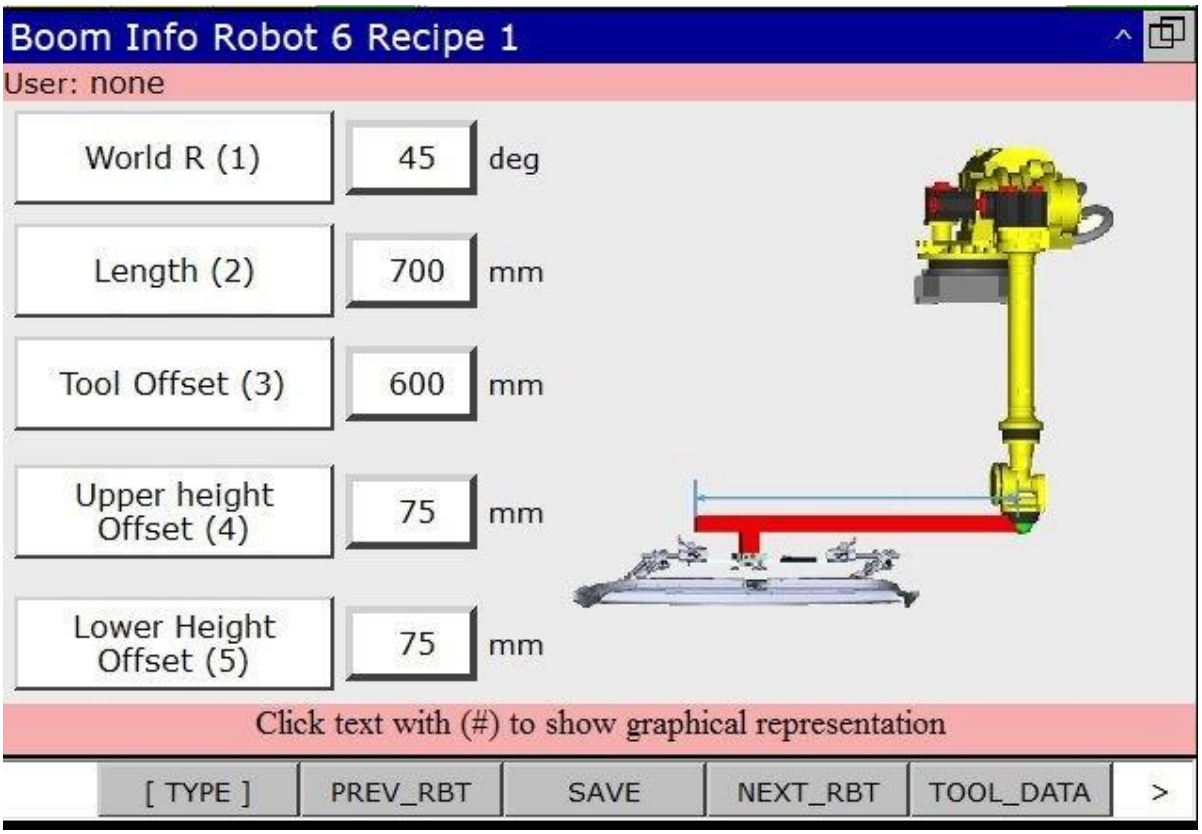


Figure 2.3.3 (b) Boom_Setup_Screen

⚠CAUTION

If modifying motor inside/outside using a browser in Windows 10, there is a known issue with the toggle buttons. You may need to click them twice in order to change their state.

2.3.4 Edit Recipe Die Information

Use the screen shown in Figure 2.3.4 to enter dimensional information for the dies used for this part. This data includes the upper die height and width for the upstream and downstream press dies relative to this robot. If the robot is not picking from an upstream press, or is dropping the part on something which is not a press, enter 0 for the appropriate height. Press **F5, RCP_HOME** when finished entering data on this screen, to continue setting up the rest of the recipe information.

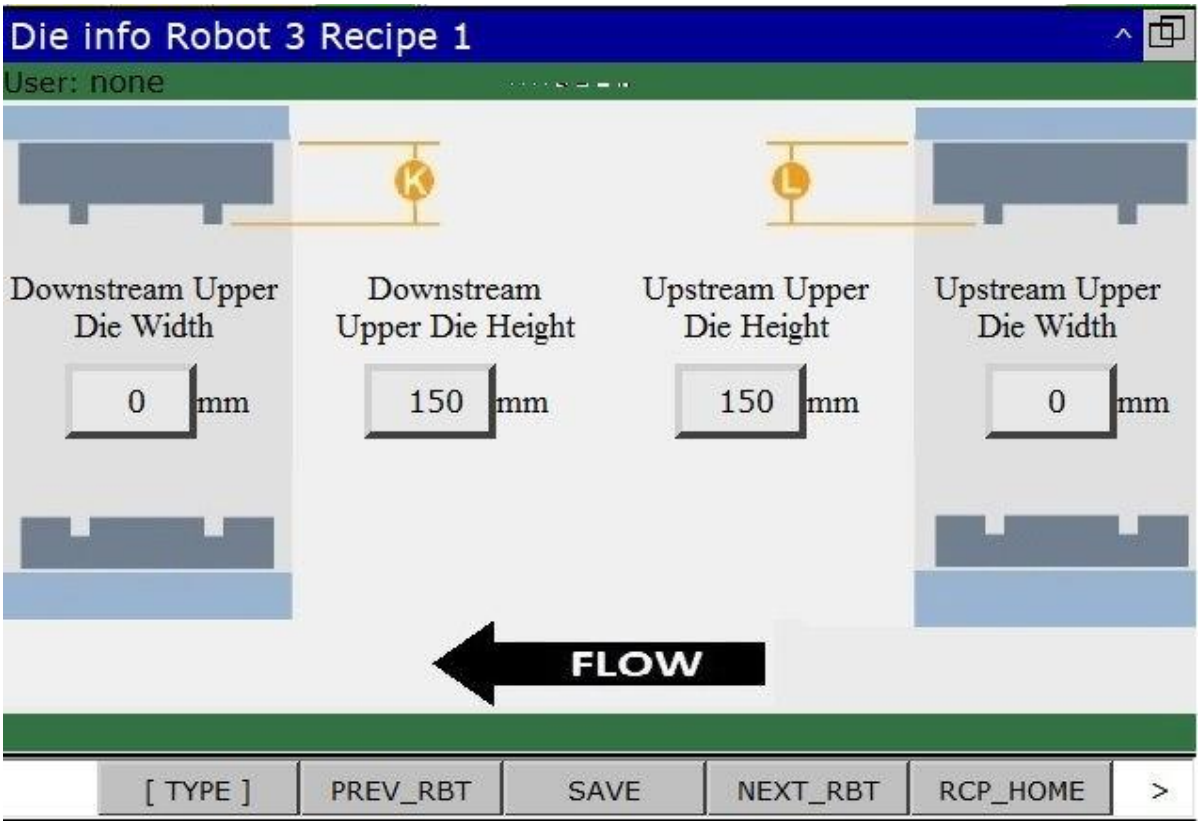


Figure 2.3.4 Recipe Die Information Setup Screen

2.3.5 Edit Recipe Positions

The screens shown in Figure 2.3.5 (a) and Figure 2.3.5 (b) allow you to teach the path positions rather than directly editing the TP program. This is beneficial because it does not require the user to find the program and the specific line number used to move to the positions they wish to edit. The press plugin reserves a block of position registers (by default this is PR[1] through PR[20]) for use in the TP programs. Use the **F2, PREV_POS** and **F4, NEXT_POS** keys to scroll through the positional data. The robot's current position is displayed on this screen for reference, as well as whether or not the robot is currently clear of its pick and drop presses. If the 4D graphics option is installed, a 4D graphics scene is displayed which graphically shows the robot position, as shown in Figure 2.3.5 (b). This indicator is very helpful when teaching the pounce positions, as the positions must be clear of the press, but must also be close to the press. You may manually enter position data one value at a time, move to the position you are currently editing, or record the robot's current position. Once you are finished recording positions, press the **RCP_HOME** key to return to the main recipe selection menu.

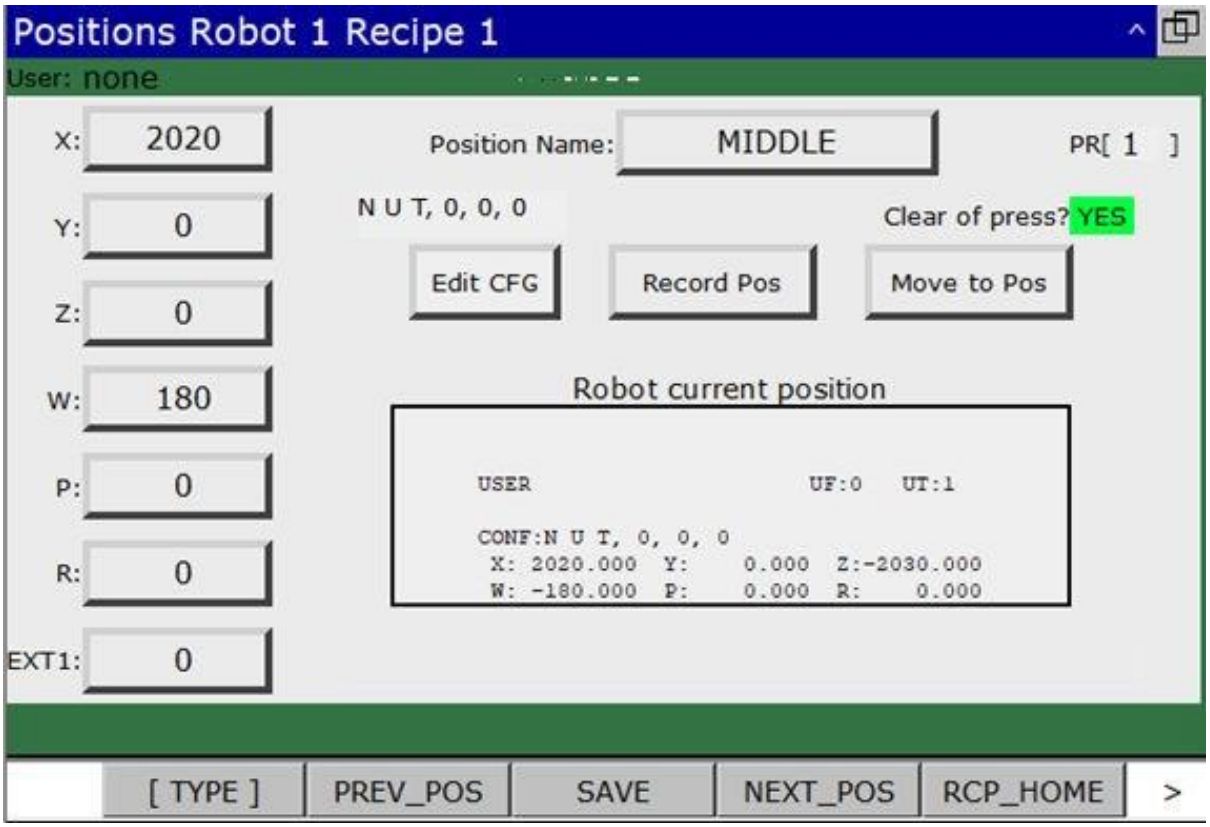


Figure 2.3.5 (a) Recipe Position Teach Screen (Basic Version)

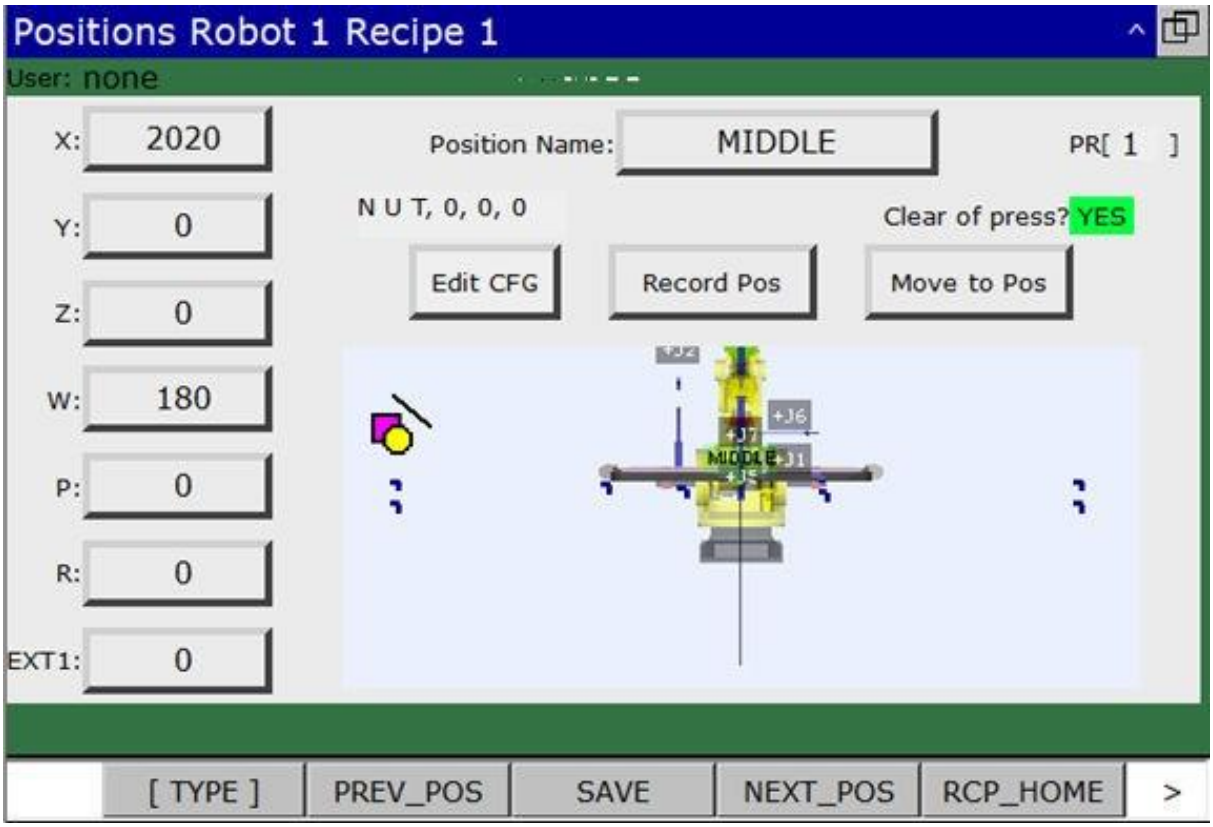


Figure 2.3.5 (b) Recipe Position Teach Screen (Advanced version using 4D graphics option)

If you would like to move to the position being taught using this screen several conditions must be true.

- You must be editing a position for the robot this teach pendant is connected to (green bars at top and bottom of screen, not red).
- You must be in teach mode on the controller.
- You must hold the shift key and the deadman switch.
- Teach pendant is enabled.

Note

Motion between points using the teach screen may vary from motion when running the press program due to robot speed, termination type, and other positions in the path. It is recommended to run the program in teach mode at low speeds to verify motion is correct prior to running with parts.

Pressing the **Edit CFG** button on the recipe position teach screen will take you to a screen as shown in Figure 2.3.5 (c). This screen allows you to edit the configuration of the position. This is most useful for TR-510*i*A robot types, as they will switch configuration throughout a typical robot path. From this screen you may change the configuration string the robot will use when moving to this position. You may use the **F2, PREV_POS** and **F4, NEXT_POS** keys to scroll through the PR[] data. Pressing the Back button will return to the recipe position teach screen.

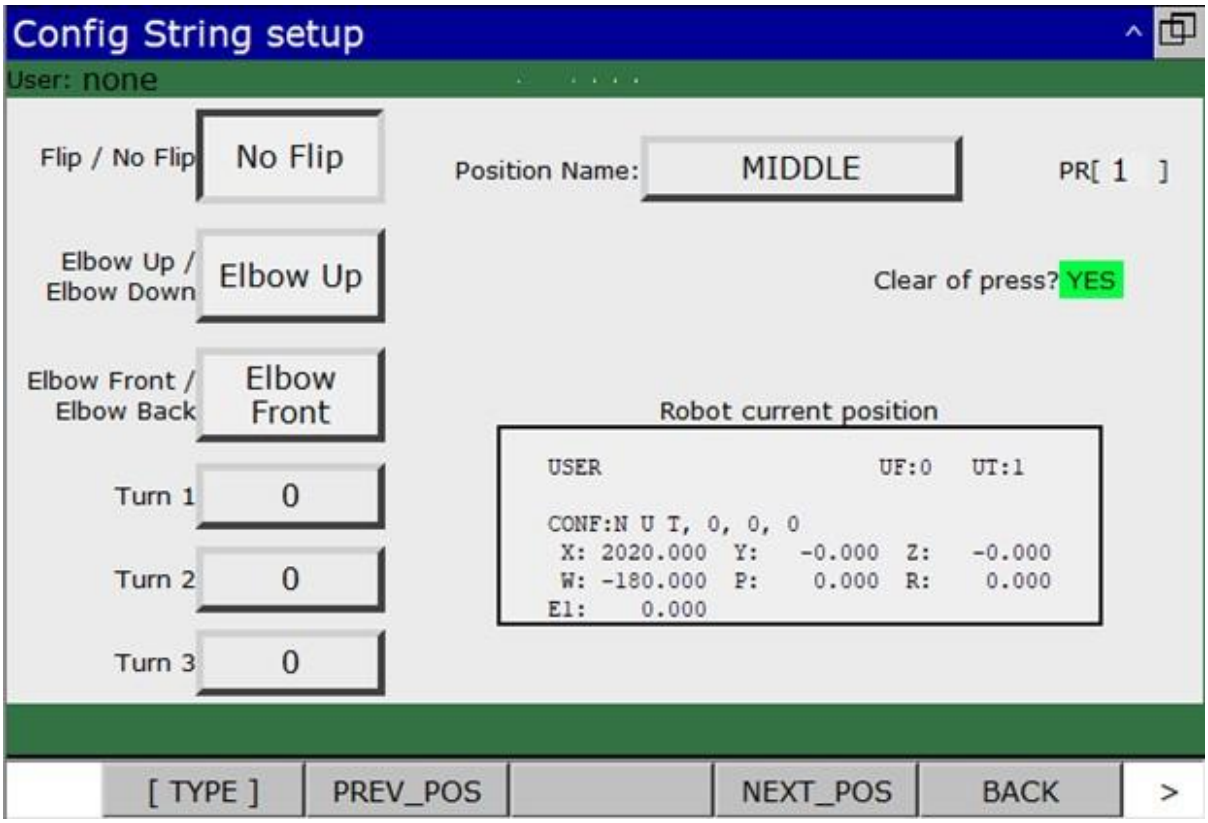


Figure 2.3.5 (c) Recipe Position Teach Screen (Config String)

2.3.6 Edit Recipe Registers

The screen shown in Figure 2.3.6 is used to enter numeric register information for a recipe. Registers contain data which is used in the TP template program to control various behaviors of the program. By default, the press plugin reserves a block of 50 registers starting from index 10. Some of these registers are used for position speeds (% of max speed) as part of the default template program. If a new register is

desired, an UNUSED one should be used. It is the responsibility of the programmer to add this register functionality into the teach pendant program for this part. The program is automatically created as a copy of the template (`Press_S000`) once the recipe data is saved, so it is recommended that the register data be entered first, and then modify the TP program to utilize that register.

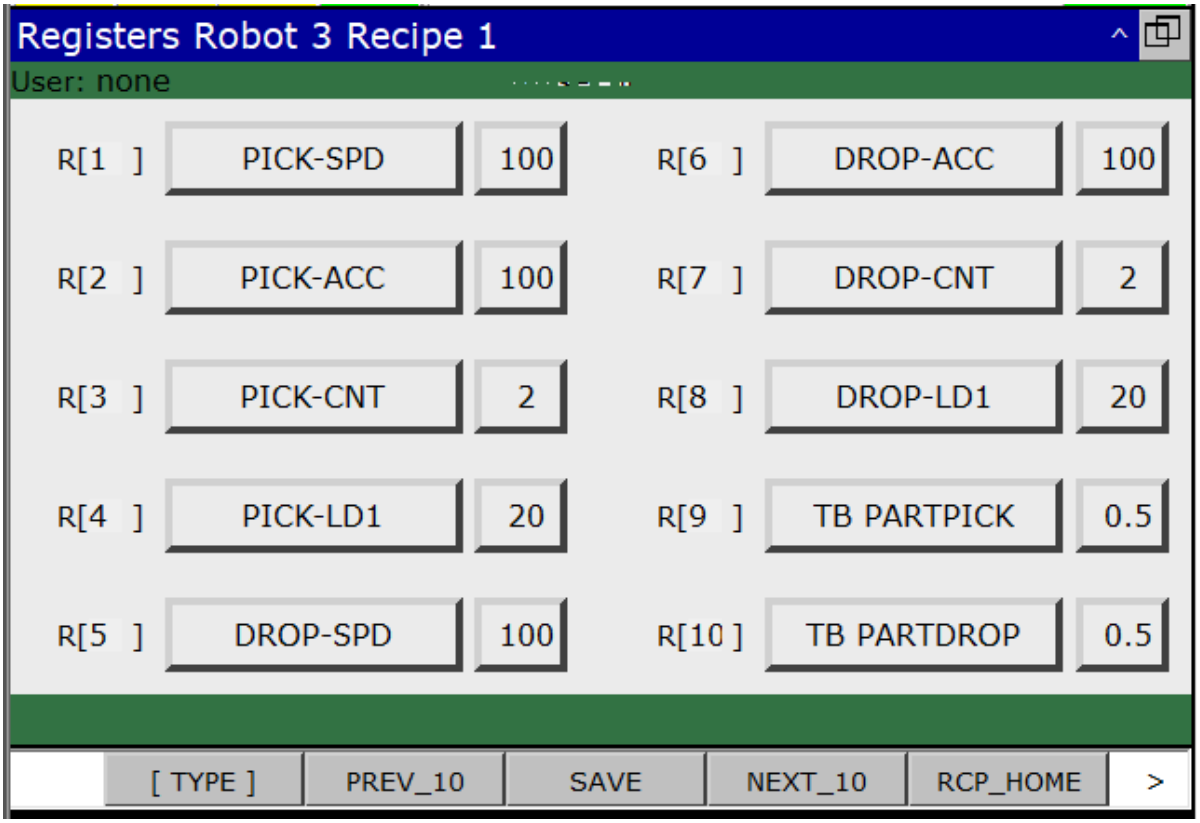


Figure 2.3.6 Recipe_Register_Setup_Screen

WARNING

When saving modifications to the recipe, it will overwrite any changes made to position register values and numeric register values. The data will be stored in the recipe xml file when saved, and if modifying the active recipe the changes will take effect immediately.

2.3.7 Edit Recipe Flags

The screen shown in Figure 2.3.7 is used to enter flag data for a recipe. Flags can be used for Boolean logic in the teach pendant program. By default no flags are used in the template program, but these are available for use if needed.

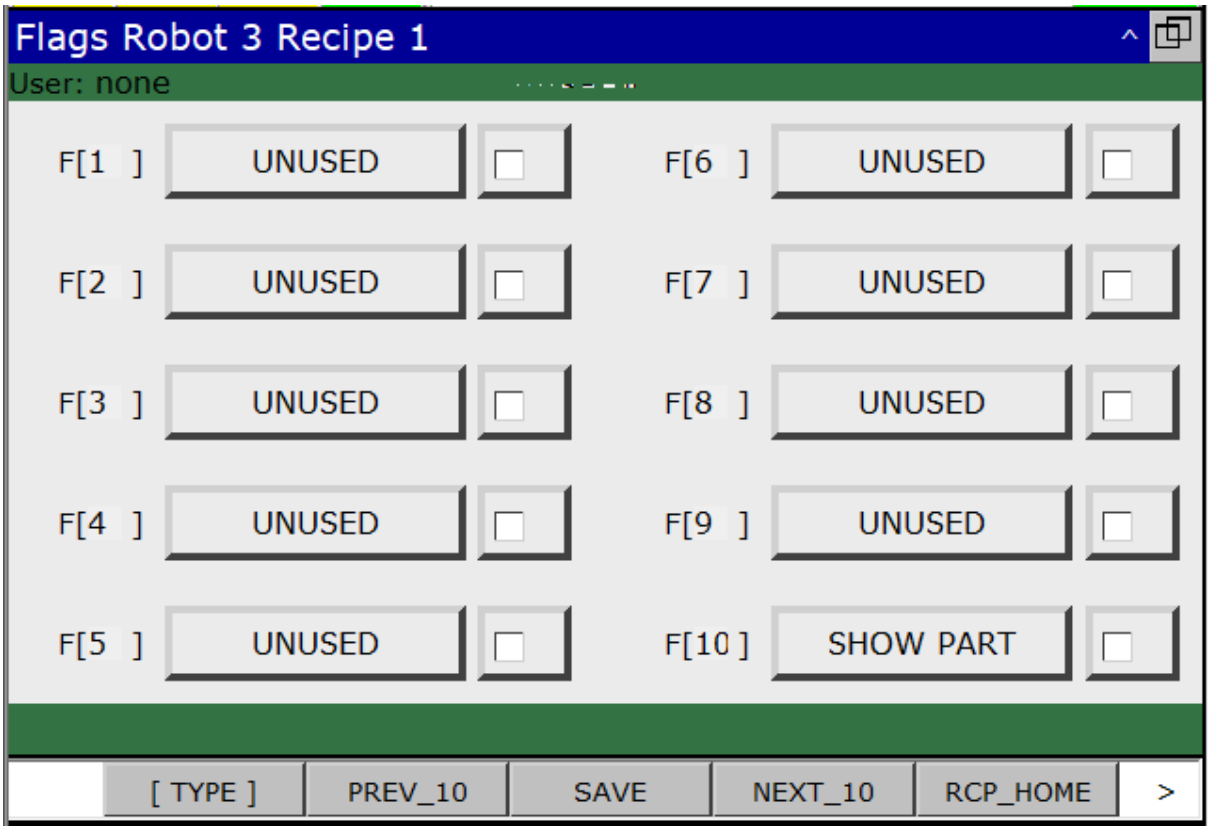


Figure 2.3.7 Recipe Flag Setup Screen

2.3.8 Edit Recipe Gripper Inputs and Outputs

On the screen shown in Figure 2.3.7, select which gripper outputs are used and which part presence inputs are used. It will only display I/O which was configured as part of the line setup (up to 8 inputs and 8 outputs). The Press application template program contains a program call `CALL PRSGRIP` which toggles the selected gripper outputs on, and `CALL PRSUNGRIP` which turns the selected gripper outputs off. The program also contains macro calls `Part Present` and `Check No Part`. These will check if the configured inputs are on or off, respectively. If you'd like to use your own macros for these functions, uncheck all boxes and modify your TP program with your own macros. You may want to modify your template program (`press_s000`) if this is desired by default.

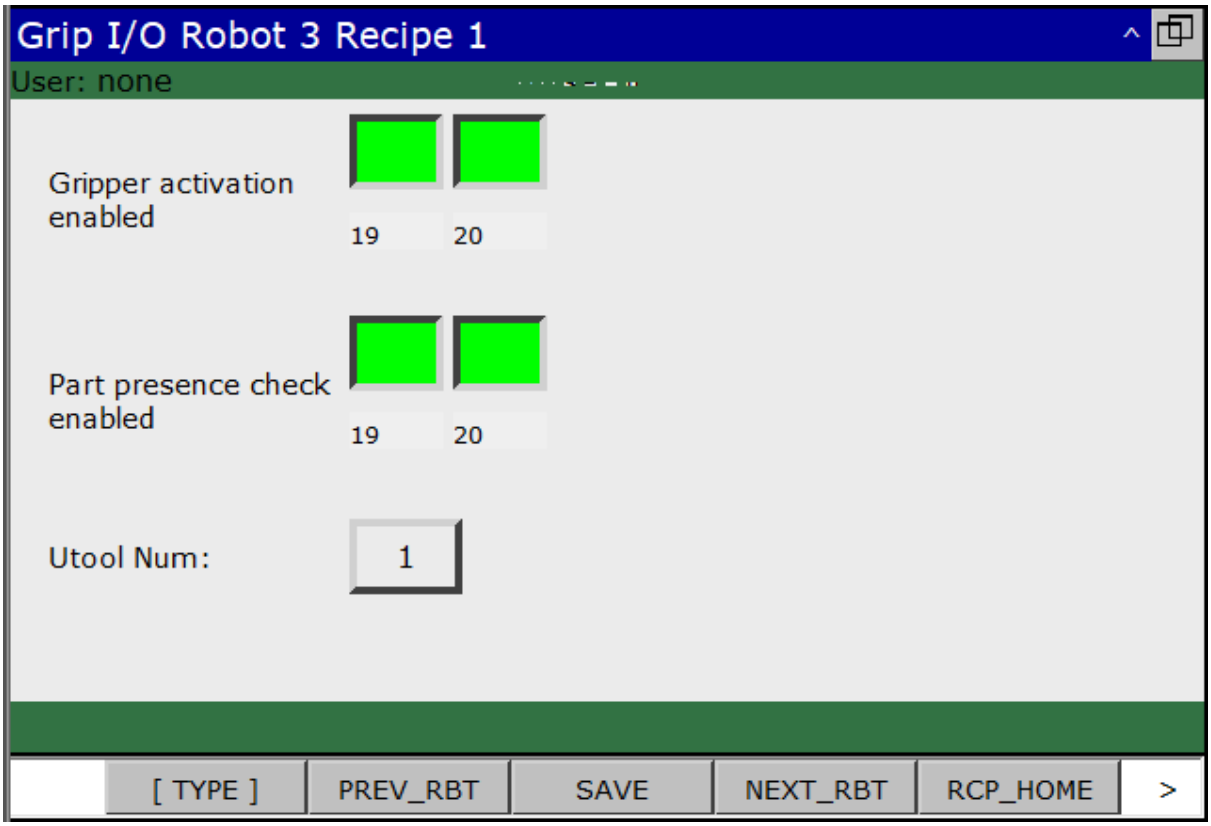


Figure 2.3.8 Recipe Gripper I/O Selection Screen

Once all data has been set up, press **F3, SAVE** to save all changes made to this recipe on this robot. This can be done from any recipe edit subscreen, or from the recipe selection screen. You should briefly see a screen which confirms the data has been saved, then automatically return to the main recipe select screen. A warning alarm indicating a recipe has been modified is also posted for alarm logging purposes.

2.4 TEACH PENDANT PROGRAMMING

2.4.1 Taught Point Requirements

2.4.1.1 Pounce Positions

Pounce positions must be outside of the IIC zone that defines the press. If the pounce position is taught inside the press, Press Interlock will stop program execution and post an error notifying the operator. Press Interlock defines the pounce point as the point immediately preceding the `ENTER DROP` or `ENTER PICK` Macro. See Section 2.4.2.1.4, ENTER_DROP and Section 2.4.2.1.5, EXIT_DROP for more detail.

2.4.2 Example Teach Pendant Program

Below is an example of a teach pendant program for a robot which has both a pick and a drop press. If a robot does not have a pick press, the program calls `ENTER_PICK`, `PICK_PART_OK`, and `EXIT_PICK`

should be removed. Similarly, if a robot does not have a drop press, ENTER_DROP, DROP_PART_OK and EXIT_DROP should be removed.

```
  UTOOL_NUM=1 ;
J PR[1:MIDDLE] 100% FINE    ;
  CALL START_SYNC(X) ;
  LBL[1] ;
J PR[2:PICK-POUNCE] 100% CNT100 SyncTime(GI[99],0)    ;
  CALL ENTER_PICK    ;
J PR[3:PICK-APPROACH] 100% CNT100    ;
J PR[4:PICK] R[10:PICK-SPD]% CNT R[12:PICK-CNT] ACC R[11]
TB    .05sec,CALL PRS_GRIP    ;
  Part Present(.25) ;
  UTOOL_NUM=2 ;
J PR[5:PICK-DEPART] 100% CNT100    ;
  CALL PICK_PART_OK    ;
  CALL EXIT_PICK    ;
J PR[6:PICK-CLEAR] 100% CNT100    ;
J PR[7:DROP-POUNCE] 100% CNT100 SyncTime(GI[99],0)    ;
  IF (F[10:SHOW PART]=OFF),JMP LBL[3] ;
  LBL[2] ;
  CALL STOP_SYNC    ;
J PR[12:SHOW-PART] 100% FINE    ;
J PR[7:DROP-POUNCE] 100% FINE    ;
  CALL START_SYNC    ;
  JMP LBL[3] ;
  LBL[3] ;
  CALL ENTER_DROP    ;
J PR[8:DROP-APPROACH] R[20:DRP_APPR_SPD]% CNT R[22:DRP_APPR_CNT] ACC
R[21]    ;
J PR[9:DROP] R[14:DROP-SPD]% CNT R[16:DROP-CNT] ACC R[15]
TA    .05sec,CALL PRS_UNGRIP    ;
  Check No Part    ;
  UTOOL_NUM=1 ;
  CALL DROP_PART_OK    ;
J PR[10:DROP-DEPART] R[26:DRP_DPRT_SPD]% CNT R[28:DRP_DPRT_CNT] ACC
R[27]    ;
  CALL EXIT_DROP    ;
J PR[11:DROP-CLEAR] R[23:DRP_CLEAR_SPD]% CNT R[25:DRP_CLEAR_CNT]    ;
  JMP LBL[1] ;
  CALL STOP_SYNC    ;
```

Figure 2.4.2 Typical Press Interlock TP Program Using Press Application Default Template Data

2.4.2.1 START_SYNC()

2.4.2.1.1 START_SYNC(X)

The START_SYNC(X) macro is used to start Press Interlock for a new job. Press Interlock loads part parameters and begins the job. X defines the style number and should correspond to the style number entered at the Press Interlock GUI for the same job.

The macro should be used just before the first segment that's part of the cyclical press path. That is, the first position after START_SYNC(X) should be a position that the robot would typically visit as part of the press path.

2.4.2.1.2 START_SYNC

The START_SYNC macro used without a parameter also starts Press Interlock but without loading new part parameters. Instead, it uses the already loaded parameters. This is meant to be used inside the program where special positions are desired. Any positions not on the typical press path should have a STOP_SYNC before moving to the special positions and a START_SYNC before resuming the normal press path. Refer to the SHOW-PART position in Figure 2.4.2

2.4.2.1.3 STOP_SYNC

Use the STOP_SYNC macro when Press Interlock is active and when the next segment is not part of the regular SYNC path.

2.4.2.1.4 ENTER_DROP

Use the ENTER_DROP macro to signify that the following segment is the first one that enters this robot's downstream press. Press Interlock will use this information when deciding whether to allow the following segment to begin or not.

2.4.2.1.5 EXIT_DROP

Use the EXIT_DROP macro to signify that the following segment is the first one that exits this robot's downstream press.

2.4.2.1.6 ENTER_PICK

Use the ENTER_PICK macro to signify that the following segment is the first one that enters this robot's upstream press. Press Interlock will use this information when deciding whether to allow the following segment to begin or not.

2.4.2.1.7 EXIT_PICK

Use the EXIT_PICK macro to signify that the following segment is the first one that exits this robot's upstream press.

2.4.2.1.8 PICK_PART_OK

Use the PICK_PART_OK macro to signify that the drop robot can now start moving in. This macro should be called in the program once the pick robot has the part (if using part checking, after the part check occurs).

2.4.2.1.9 DROP_PART_OK

Use the `DROP_PART_OK` macro to signify that the drop robot has successfully dropped the part into its downstream press and the press now has a part loaded. The pick robot for the corresponding press will then wait until the press cycles and is clear for the pick robot to enter the press to pick the next part.

2.4.2.1.10 SyncTime Segments

The `SyncTime(GI[X], N)` motion option following a segment allows Press Interlock to adjust the speed of that segment under certain conditions. This is typically used on the long moves from press to press where the speed may not be important because the downstream or upstream press is not yet ready to accept the robot. The GI number (X) is ignored by Press Interlock if Press Interlock is enabled. If Press Interlock is disabled, the number is used to adjust the time to complete the segment to be the same as the value of the specified GI in milliseconds.

2.4.2.1.11 Tips and Tricks

The Macros defined in Section 2.4.2.1.2, START_SYNC can be renamed to any convention the user chooses by adding them to the system macro table.

3 NORMAL OPERATIONS

Press Interlock has three main modes that determine the behavior of the robots: LEARN mode, SYNC mode, and DROP_LEARN mode. In addition to these basic modes, the operation is also affected by whether the press profile is learned or not. Each mode is described in this section. Transitions between the modes are done automatically so this guide is for informational purposes only.

3.1 PRESS PROFILES

Press Interlock uses knowledge about the press position vs time to better time pick entrances and when to signal the press to cycle as the robot exits. When starting a new job, the press profile has not been learned. Typically, it will become learned and stay learned after the first cycle of the press after the job begins. The controller outputs `Pick Press Learned` and `Drop Press Learned` to reflect the respective states. Refer to Section 2.2.9.6, Press Interlock Status DOs for more details on the outputs. The behavior with the profile learned and not learned is discussed in the following sections.

3.2 LEARN MODE

LEARN mode is the expected mode when first running a new part. During this mode, the robot will record paths inside the press, calculate interlock angles, and determine other internal information. After a few cycles, the robot will go into SYNC mode. SYNC mode will cascade upstream as the most downstream robot will enter it first, followed by its upstream neighbor and so on.

Other triggers for LEARN mode are discussed in Section 3.2.2, LEARN Mode Triggers.

3.2.1 LEARN Mode Operating Characteristics

- No robot to robot chasing. The robot will not enter its drop press until the downstream robot is completely clear of it.
- Robot comes to a full stop at Pick Pounce and Drop Pounce.
- No press anticipation. Safe press operation.
  - Pick Press: Robot will enter only if press is at TDC.
  - Drop Press: Robot will only set signal to start press after it is totally clear of press.

3.2.2 LEARN Mode Triggers

3.2.2.1 LEARN Mode When Using START_SYNC Macro

- First time running a style (no stored data from previous runs).
- Part or tool parameters changed from the last run.
- Cell parameters (robot distances, press distances, etc.) changed since last run.

- Press stopping distance changed since last run
- Last time Press Interlock was active, it was in LEARN mode

3.2.2.2 LEARN Mode Real-Time Triggers

- TP program has lines inserted or deleted
- Taught position in sync path is changed
  - Touch-up of TP program (no margin for not entering LEARN mode)
  - Position offset is changed
- Speed/Acceleration profile of sync path is changed
  - ACC change
  - CNTXXX change
  - Programmed speed change

3.3 DROP_LEARN MODE

DROP_LEARN mode is expected when first starting a previously learned part. Each robot except the most downstream will enter DROP_LEARN mode to communicate to neighboring robots and ensuring it's using correct data. After one cycle or so, each robot should go into SYNC mode.

Other triggers for DROP_LEARN mode are discussed in Section 3.3.2, DROP LEARN Mode Triggers.

3.3.1 DROP LEARN Operation Characteristics

- No robot to robot chasing. The robot will not enter its drop press until the downstream robot is completely clear of it.
- Robot does not necessarily stop at Pick Pounce and Drop Pounce
- Press anticipation is active
  - Pick Press **Recorded**: Robot will time entrance into the press so as to synchronize arrival into the press with press arrival at `Pick Interlock Angle`.
  - Pick Press **Not Recorded**: Robot will begin segment entering the press only after the press passes `Pick Interlock Angle`.
  - Drop Press **Recorded**: Robot will signal press to start moving so as to synchronize its exit from the press with the press arrival at the `Drop Interlock Angle`.
  - Drop Press **Not Recorded**: Robot will signal the press to move once it is clear of the press.

3.3.2 DROP LEARN Mode Triggers

3.3.2.1 DROP_LEARN Mode When Using START SYNC Macro

If the robot has no downstream press and it would not otherwise go into LEARN mode

3.3.2.2 DROP LEARN Mode Real-Time Triggers

- Downstream robot enters LEARN mode
- Override of robot is changed
- Override of downstream robot is changed
- Chase following distance is adjusted

3.4 SYNC MODE

SYNC mode is the expected mode for each robot the majority of the time while running normal operation.

3.4.1 SYNC Mode Operating Characteristics

- Robot to robot chasing. The robot will chase the downstream robot inside the drop press.
- Robot does not necessarily stop at Pick Pounce and Drop Pounce
- Press anticipation is active
  - Pick Press **Recorded**: Robot will time entrance into press so as to synchronize arrival into press with press arrival at `Pick Interlock Angle`.
  - Pick Press **Not Recorded**: Robot will begin segment entering press only after press passes `Pick Interlock Angle`.
  - Drop Press **Recorded**: Robot will signal press to start moving so as to synchronize its exit from the press with the press arrival at the `Drop Interlock Angle`.
  - Drop Press **Not Recorded**: Robot will signal press to move once it is clear of the press.

3.4.2 SYNC Mode Triggers

3.4.2.1 SYNC Mode When Using START SYNC Macro

If the robot has no downstream press and it would not otherwise go into LEARN mode

3.4.2.2 SYNC Mode Real-Time Triggers

- Robot completes LEARN mode operations
- Robot completes DROP_LEARN mode operations

4 EXCEPTION CONDITIONS

Press Interlock uses internal robot information and communication between robots to detect fault conditions further in advance than could be done by the PLC. The fault conditions that are being looked for are discussed in this section.

4.1 HOLD SEVERITY FAULT CONDITIONS WHEN PRESS INTERLOCK IS ACTIVE

Note

Active as long as Press Interlock is active.

4.1.1 Hold Severity During Chasing

During chasing, the drop robot will be held if any of the following conditions are detected:

- Drop robot override changes
- Pick robot override changes
- Pick robot is held
- Pick robot has a non servo-off fault which stops motion
- Pick robot enters LEARN mode
- Drop robot enters LEARN mode

4.1.2 Hold Severity While Packing

While picking, the pick robot will be held in the following scenario:

- Pick robot has been allowed to enter the pick press but has not yet entered and
  1. Pick press profile is lost (speed profile is different than remembered)
  2. Robot override changes
  3. Pick press has a press encoder malfunction
  4. Pick robot goes into LEARN mode

4.2 E-STOP SEVERITY FAULT CONDITIONS

4.2.1 Robot E-Stop When Press Interlock is Enabled

Note
Active Always as long as Press Interlock is enabled.

Press Interlock E-Stops the robots in the following conditions:

1. A robot is too close to its downstream neighbor. The allowable distance is discussed in Section 4.2.2, Interference Detection Distances.
2. A robot is too close to its upstream neighbor. The allowable distance is discussed in Section 4.2.2, Interference Detection Distances.
3. If the robot is in SYNC mode or DROP_LEARN and it crosses the press boundary while the press position is before the pick interlock angle (upstream side) or not at Top Dead Center (downstream side).
4. If the robot is in LEARN or being jogged and it crosses the press boundary while the press is not at Top Dead Center.

4.2.2 Interference Detection Distances

Press Interlock detects interference and E-Stops the robot if it is too close to either its upstream or downstream neighbor, regardless of process or press state. The distance used for this checking depends on whether the robots are both in a press and whether a fault has occurred while chasing. The distances are explained in the table below.

Situation	Interference Distance
Robot is in downstream press and downstream robot is in the same press under normal conditions	Minimum of (chasing distance – 25mm) and 100mm
Robot is in downstream press and downstream robot is in the same press under fault conditions	500mm
Robot is in upstream press n upstream robot is in the same press	500mm
Robot is not inside a press or neighboring robot is outside the intermediate press	100mm

4.2.3 Robot E-Stop When Press Interlock is Active

Note

Active as long as Press Interlock is active.

Press Interlock E-Stops the robots in the conditions outlined in this section.

4.2.3.1 Entering Drop

If after having been allowed to enter the drop press but before actually entering the press, the drop press moves away from Top Dead Center, the robot is immediately E-Stopped.

4.2.3.2 Robot E-Stop During Chasing

If the drop robot is in the drop press, the following conditions lead to immediate e-stop:

1. Downstream pick robot has a servo-off fault
2. Downstream robot is stopped or moving upstream

4.2.3.3 Robot E-Stop Entering Pick

After the robot has been allowed to enter the pick press but before it has physically entered, the following conditions lead to an immediate e-stop of the drop robot:

1. The pick press is in the downstroke (slide is moving down and not near Top Dead Center).
2. The fault bit from the PLC (if used) goes LOW.

4.2.4 Press E-Stop

Press Interlock E-Stops the press in the following conditions:

1. The press starts to cycle before the robot has signaled it to do so
2. Robot is inside its drop press and the press reaches the Drop Interlock Angle
3. Press profile is not LEARNED while drop robot is inside the press and the press is moving
4. Robot override is changed while it is inside its drop press and the press is moving
5. Robot is held while inside the drop press and the drop press moving
6. Robot is stopped due to a fault while inside the drop press and the drop press is moving
7. Robot goes into LEARN mode while the robot is inside its drop press and the press is moving

5 PRODUCTION STATUS

Press application offers the ability to monitor certain production status information for each equipment in the press line. To view general line status, go to the main Press application menu (**MENU** > **SETUP** > **Press**), then select **View Production Data**. From the **Production status** screen, you can view robot data by pressing **F2, RBT_STAT** or view press data by pressing **F4, PRS_STAT**. On each of these screens, there are PREV/ Next keys to scroll through each robot or press. You can also return to the main line status screen by pressing **F5, LINE_STAT**, and from the main line status screen you can return to the main menu. These screens are for information display, as shown in Figure 5 (a), Figure 5 (b), and Figure 5 (c).

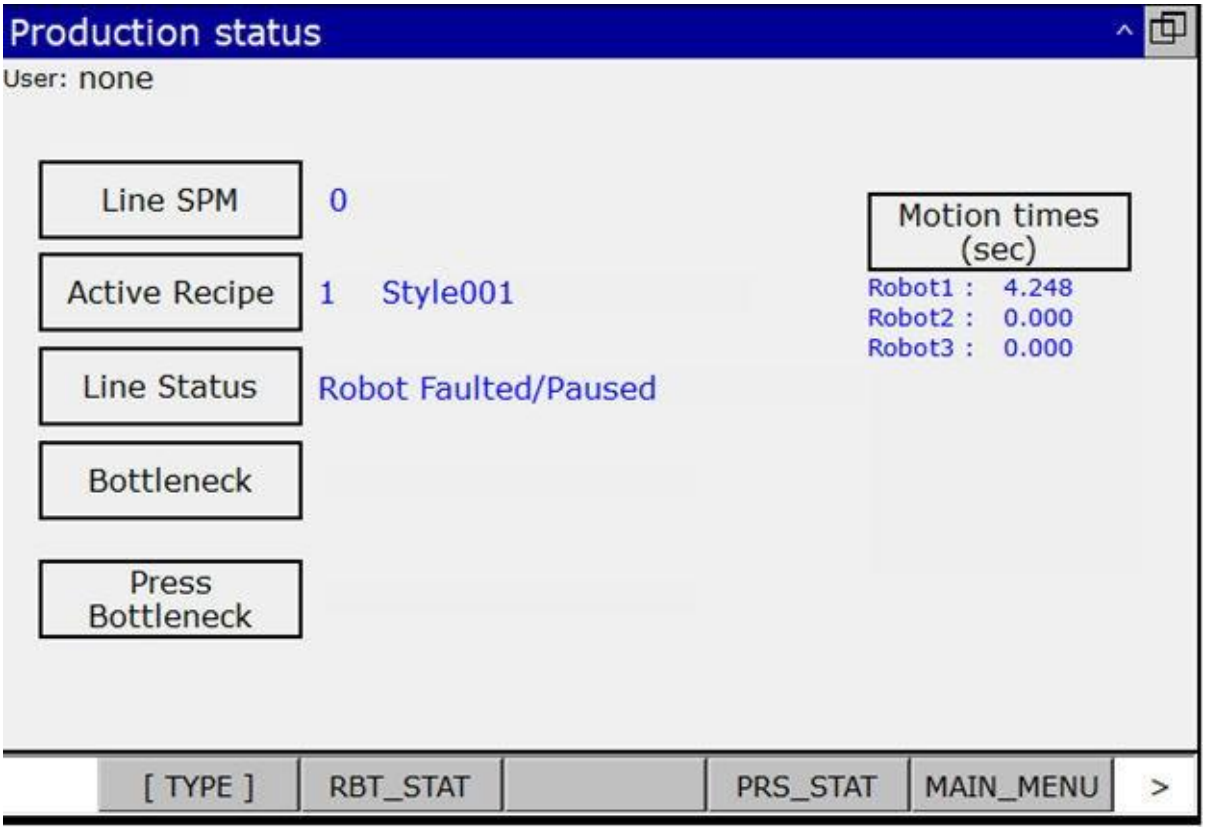


Figure 5 (a) Production Line Status Screen – Overview of Entire Line

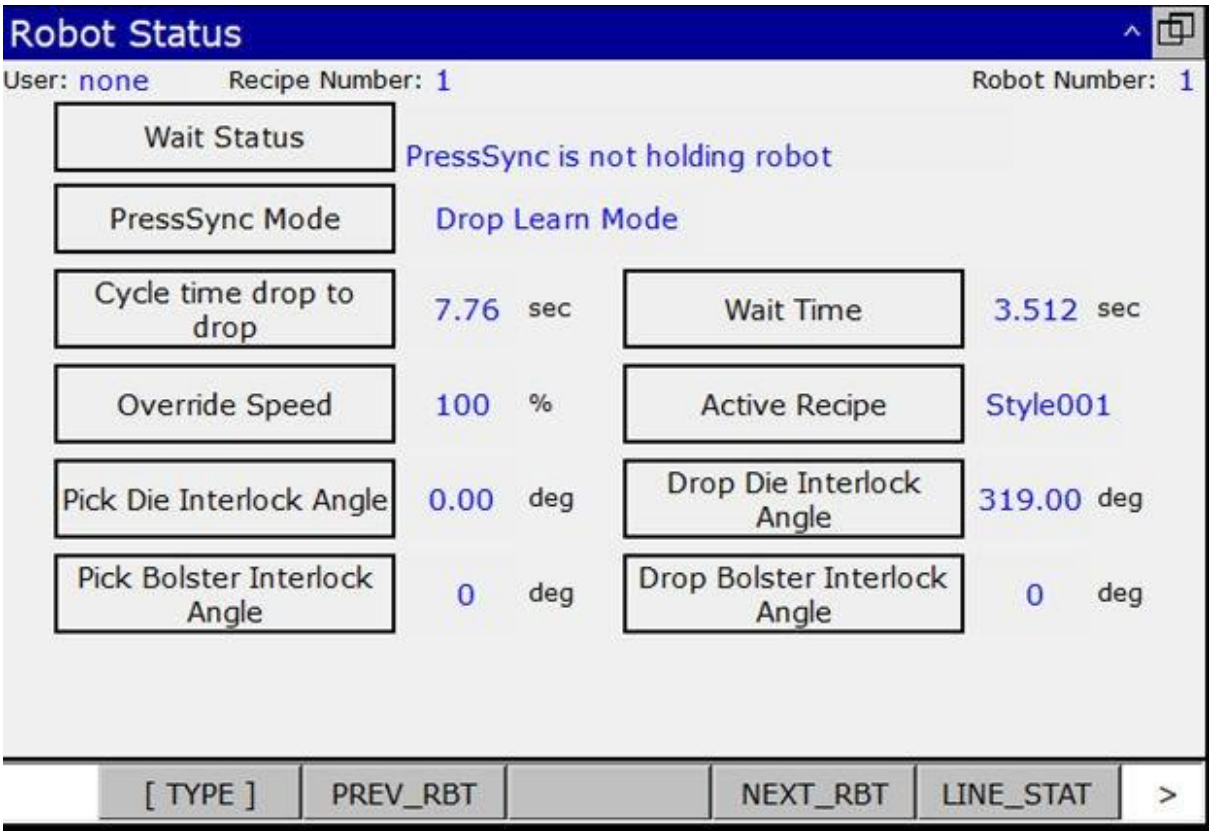


Figure 5 (b) Production Robot Status Screen – Information Pertaining to a Single Robot in the Line

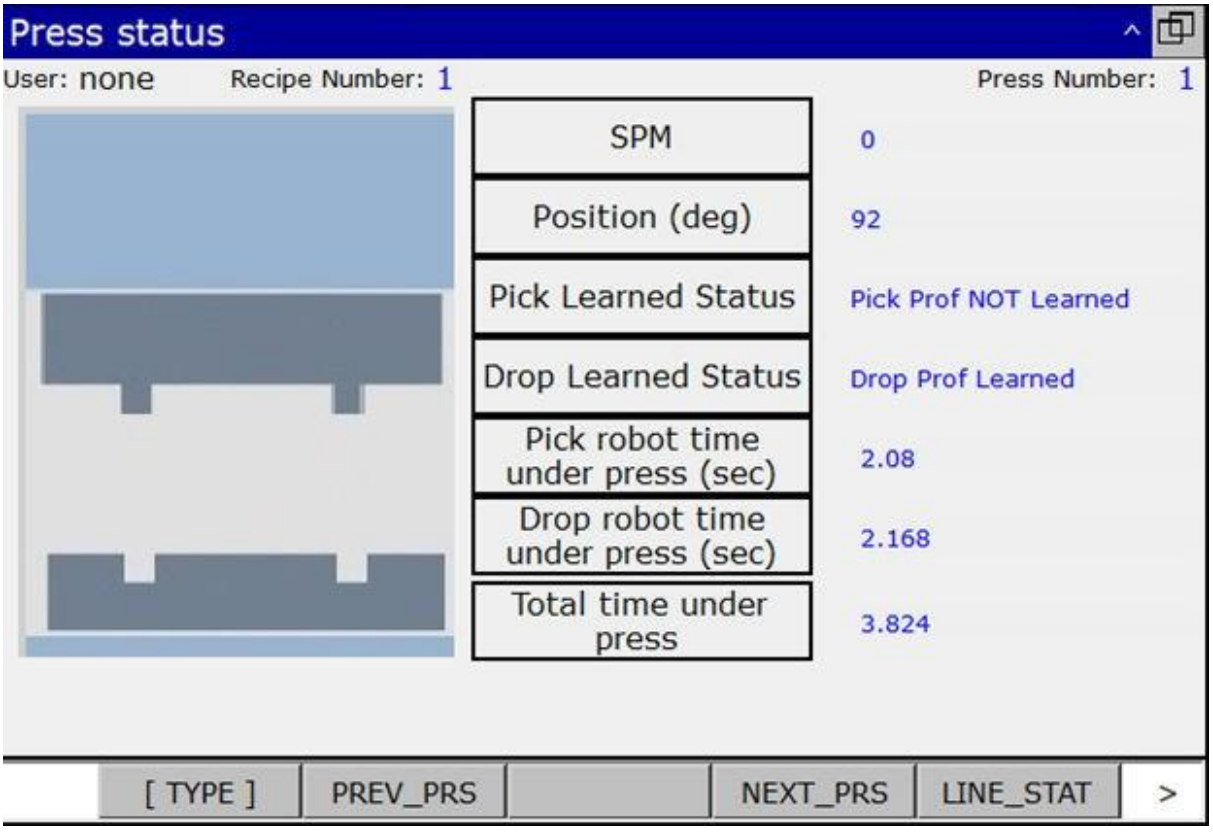


Figure 5 (c) Production Press Status Screen – Information Pertaining to a Single Press in the Line

6 PRESS APPLICATION ERROR RECOVERY

Press application utilizes the alarm recovery panel to offer error recovery options to certain alarms from the TMSN errors, as well as some PRSS errors. The alarm recovery panel choices are described below. In all cases, the robot should be fully reset before choosing a recovery option. In certain cases, a fault causes the system to be unable to continue the process. In these cases only 1) and 2) are available recovery choices. Figure 6 displays an example of the alarm recovery panel screen with the **F4, [CHOICE]** key pressed.

1. **Cancel and auto exit** – This recovery choice utilizes the auto backwards exit option to execute the same path the robot took to go into a press, but in reverse. The macro calls in the TP program which control when this path starts and stops being recorded are `Rec Path Start` and `Rec Path end`. If this error recovery choice is selected, the last recorded auto backward exit path will execute with a maximum speed of 250 mm/s, and then the robot will return to the P[1] point taught in `PRESS_BWDEX`. If it is not desired to return to P[1], this line can simply be deleted, and the robot will return to the first recorded position in the auto backwards exit path. There are additional auto exit parameters which may be adjusted at controlled start to modify the frequency at which points which are recorded.
2. **Cancel and drop part here** – This recovery choice aborts the program and turns off the gripper outputs.
3. **Retry** – This choice resumes the TP program.
4. **Ignore and Continue** – This special recovery choice for part present checking errors temporarily ignores the part presence sensors for one cycle and resumes the TP program.

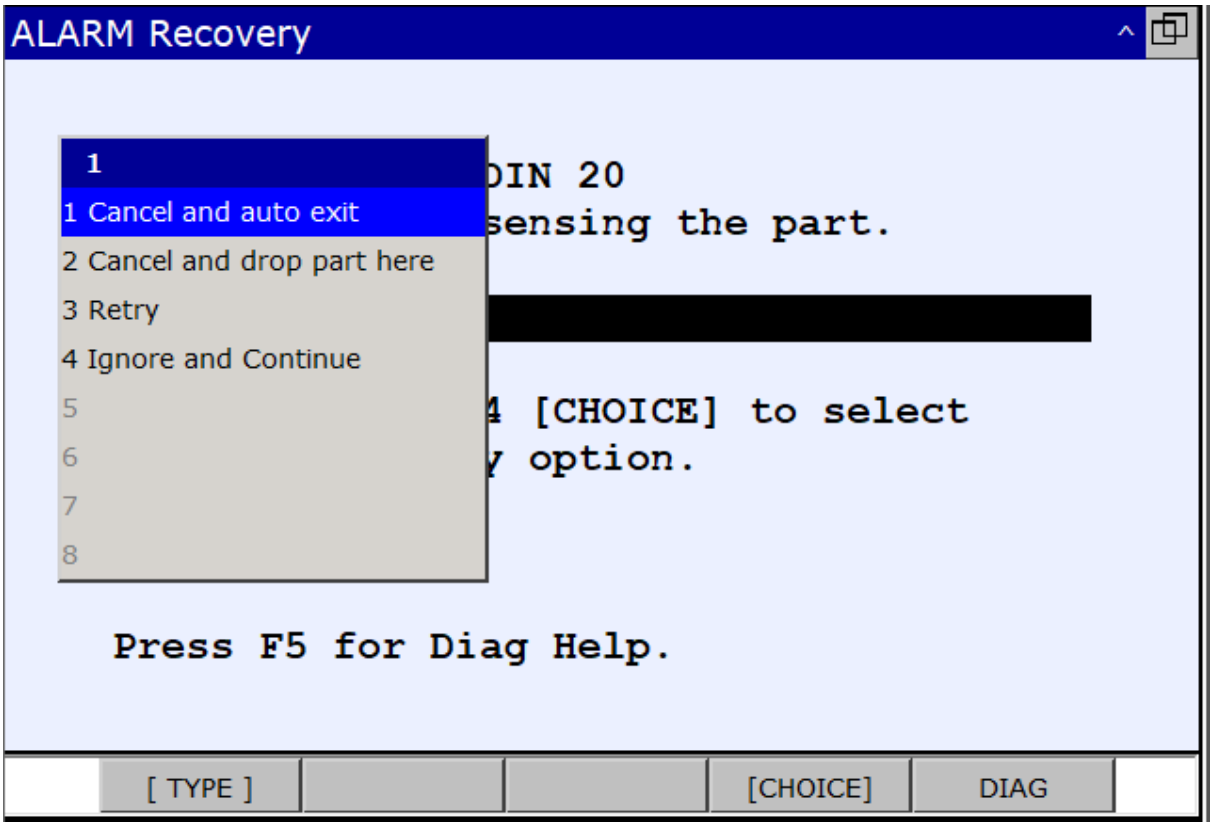


Figure 6 Alarm Recovery for `PRSS-219 Part Present "20" Not Reading Part`

⚠WARNING

Prior to utilizing error recovery choice **1 Cancel and auto exit**, verify that the P[1] position in `PRESS_BWDEX` is appropriate and clear of equipment. The point should be taught such that the end of arm tooling is clear of any presses, free from collision with obstacles for any part the robot may be processing. If moving to this position is not desired, you may delete it from the `PRESS_BWDEX` program.

7 PRESS APPLICATION UTILITIES

7.1 PRESS RECIPE IMPORT/BACKUP UTILITY

From the **Press Main** menu you can navigate to the utility screen, and from the **Press Utilities** screen there are several useful tools. The **Backup Recipes** and **Import Recipes** utilities are very useful. Press recipe data is stored in `fr:\press\` on each robot. Each robot controller has its own files with the same names. If you use the backup robot utility you can copy files from one or all robots to a memory device such as a USB stick. You select which robot you wish to back up (or check **all robots** to backup the whole line), which recipe you wish to back up, which device to back up to, then select **F3, BACKUP**. Copying files from all robots may take some time, and there will be an indicator to tell you it is in process, which changes once it is completed, it returns to blank afterward. Files are copied to the device in a new folder on the root directory, so it will be something like `UD1:\PRESS\ROBOT_1`, each robot will have its own folder with its own recipe files in that folder. The `linesetup.xml` file will also be copied to the directory of whichever robot you used to back up the files. Figure 7.1 (a) and Figure 7.1 (b) show the backup recipes and import recipes screens.

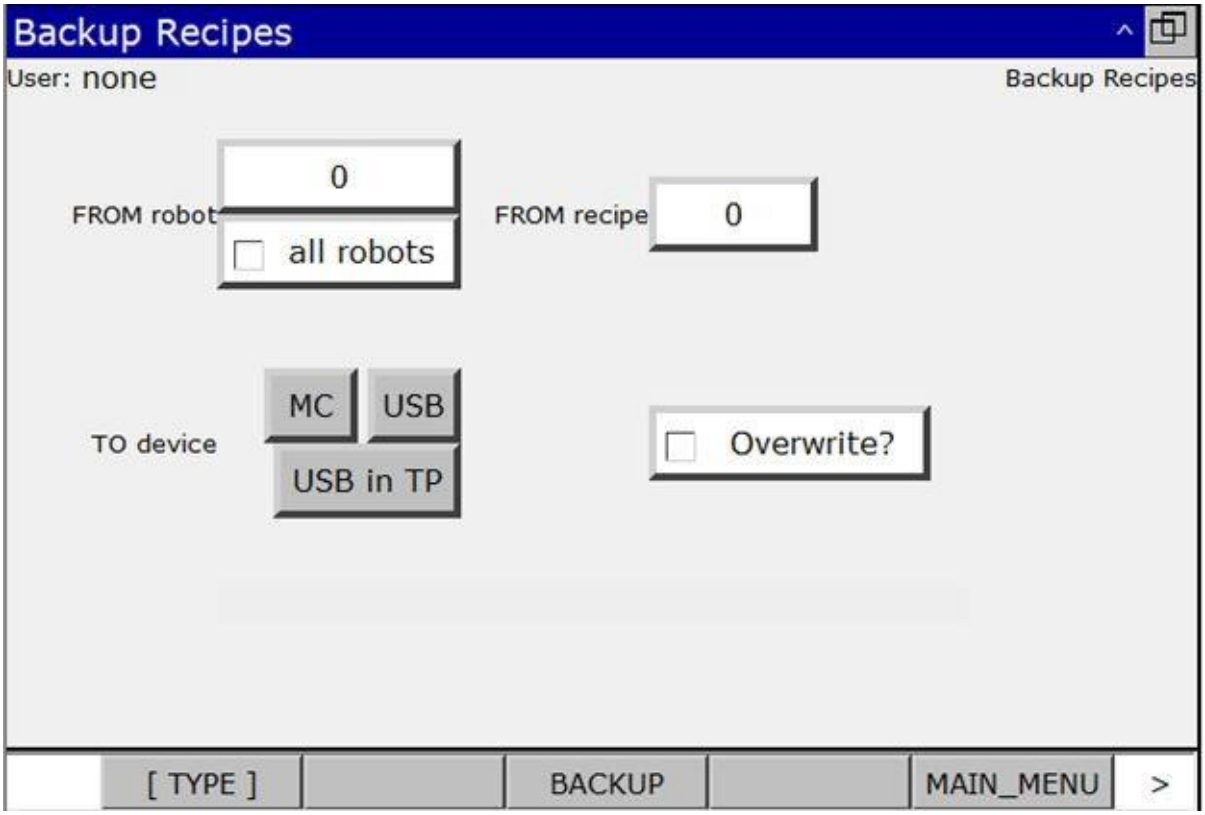


Figure 7.1 (a) Backup Recipes Screen

Once you have the files backed up, you may easily import them back into the line (or an identical line which uses the same parts) by using the **Import Recipes** utility. This works very similarly to the backup recipes utility. You select the robot (or check **all robots** for all), select the recipe number, and select the device you are importing from. You also must select **Overwrite?** if you wish to overwrite any existing files.

Note

Files must be in the same directory structure the backup utility creates, for example robot 1 files in `UD1:\PRESS\ROBOT_1`, robot 2 files in `UD1:\PRESS\ROBOT_2` etc. or the import utility will not find the files.

Note

You must check **Overwrite?** if you wish to overwrite existing files on the controller.

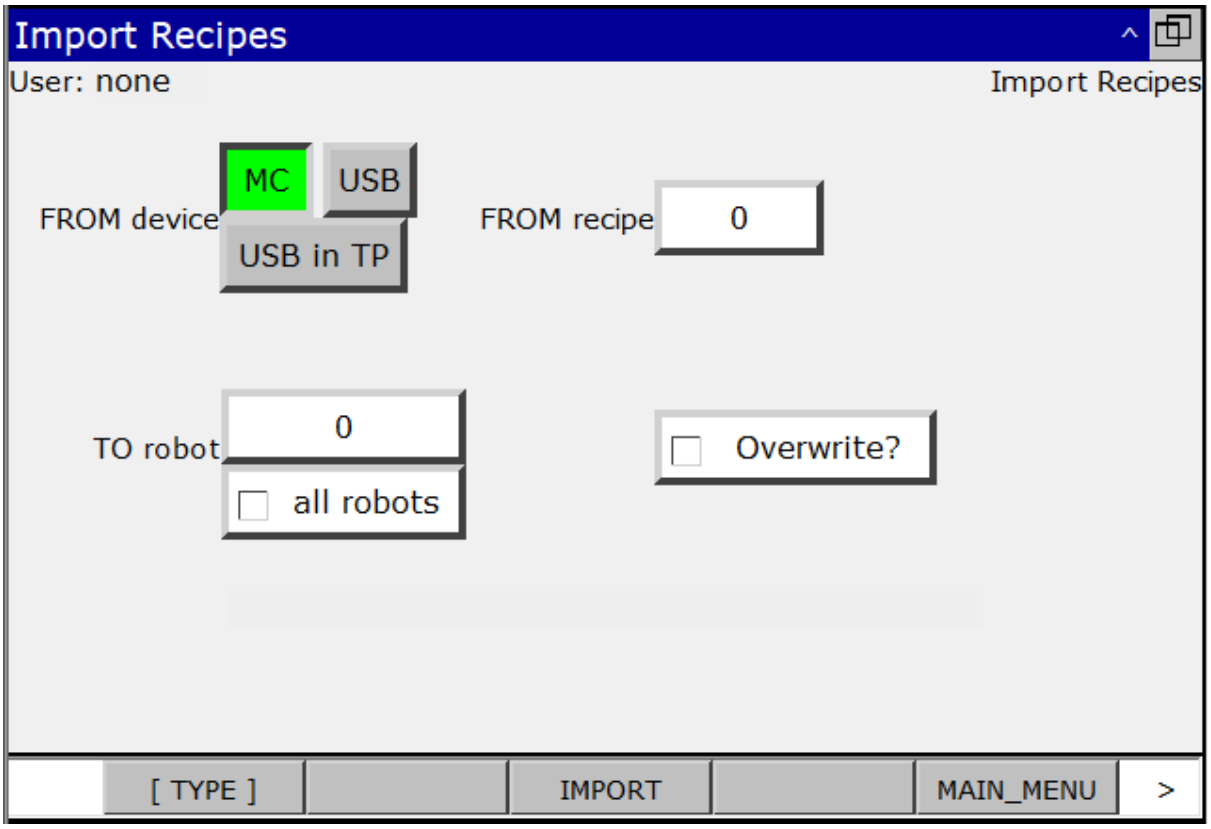


Figure 7.1 (b) Import Recipes Screen

7.2 PRESS PROFILE BACKUP UTILITY

The screen shown in Figure 7.2 is used to copy the most recent press profiler data for a given recipe number from any robot. This data contains information regarding the motor life, and can be used to check whether or not a part's motion path could be damaging the robot over time.

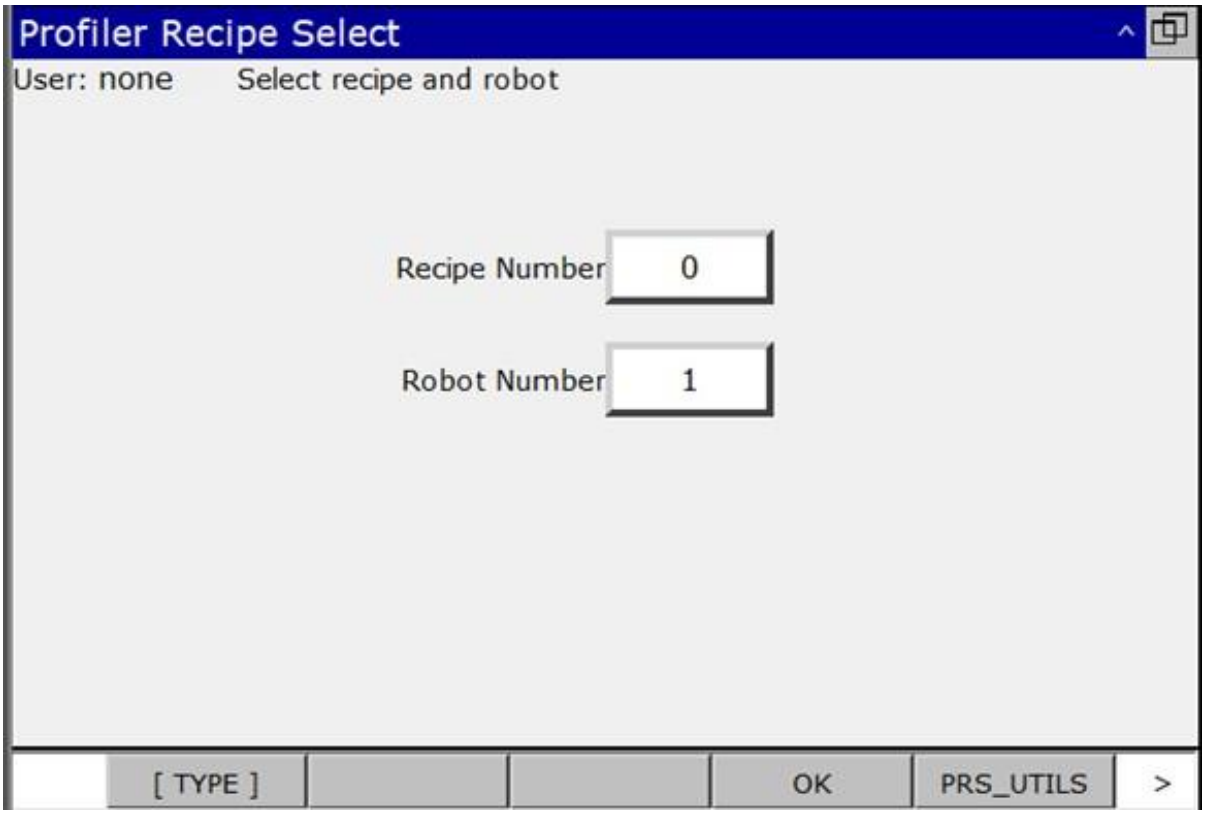


Figure 7.2 Press Profile Backup Screen

8 COMMON TASKS

8.1 SET UP A NEW PART TO RUN WITH PRESS APPLICATION

8.1.1 Set Up a New Part to Run With Press Application - GUI Setup

About this task
Use this procedure to setup the GUI.

Procedure

1. From the **Press Main** application screen (**MENU** > **SETUP** > **Press**), and select **Edit Recipe**.
2. Enter the robot and recipe number which you want to enter part information for.
3. Enter information into all fields for a robot, for all recipe setup screens.
4. Select **F3, Save**. The recipe data will save to that robot controller.
5. Repeat Steps 2-4 for all robots. This can be done from a single teach pendant

8.1.2 Set Up a New Part to Run With Press Application - TP Setup

About this task
Use this procedure to setup the TP.

Procedure

1. Start with a copy of the Press application template program, `Press_S000`, adding or removing logic specific to your recipe.
   If your TP program does not require logic changes, skip this step.
2. Use the Press application GUI to set up recipe parameters, including position data, register data which can be used for speeds, ACC values, and other numeric parameters, and (if necessary) flags for Boolean logic.
3. Save the recipe once you are done.

If you want to test the recipe you may load these parameters by setting the appropriate recipe change inputs. The default recipe change inputs are GIN[1] for the recipe number, and DIN[22] to tell the Press application to load the parameters from that recipe and set the appropriate registers.

8.2 DELETE A PART RUNNING WITH PRESS APPLICATION

8.2.1 Delete a Part Running With Press Application - TP Setup

About this task

Use this procedure to setup the TP

Procedure

1. To remove a job from the robot, delete the TP program associated with it.
2. Delete the recipe file on the controller, located at `FR:\Press\`.

   The recipe file will follow the naming convention `style` then a 3 digit number for the recipe, then `.xml`, for example `style001.xml`.

8.3 MODIFY AN EXISTING PART RUNNING WITH PRESS APPLICATION

8.3.1 Modify an Existing Part Running With Press Application - GUI Setup

About this task

Use this procedure to setup the GUI

Procedure

1. From the **Press Main** application menu (**MENU** > **SETUP** > **Press**), then select **Edit Recipe**.
2. Enter the recipe number and robot number you wish to edit. Press **OK**.
3. Navigate the recipe screens and edit the data you wish to change.
4. Press **Save**, data will be saved to that robot for that recipe.
5. If necessary to make changes on other robots, repeat steps 2-4 for each robot.

8.3.2 Modify an Existing Part Running With Press Application - TP Setup

Recipe changes that require TP modification are things like adding extra logic, adding additional positions, changing macro calls, etc. If numeric values need to change such as tool or part dimensions, use the Press application Edit Recipe screens. If exist points need to be modified, adjust the points using the **Press application Points** page from the **Edit Recipe** section. Press Interlock will determine path changes automatically and re-learn. See Part Parameters for more information.

8.4 USING PRESS APPLICATION WITH INTERNET EXPLORER

Press application supports browser access with Internet Explorer. Other browsers are not currently supported. To access the Press application menus in your browser, browse to the robot homepage (by typing in the IP Address of the robot as a URL).

Figure 8.4 (a) Example Address for a Robot Homepage

From the robot homepage, click the link in the **ROBOT TOOLS** section that says **Press Setup Tool**. When accessing the Press application menus in this way, all of the function keys are replaced with javascript buttons with the exact same functionality.

Figure 8.4 (b) ROBOT TOOLS Section of the Robot Homepage

9 TROUBLESHOOTING

9.1 PRESS ENCODER MISMATCH

The controller error `TMSN-054 Press encoder #XX mismatch detected` occurs because the controller's calculation of the press angle is significantly different than the PLC's calculation of the press angle. Most often, this is because of encoder mounting issues which lead to slippage or sticking of either the PLC or controller encoder.

The operator can reset and continue after this fault. However, as conditions worsen, the alarm may start coming up every press cycle.

The long-term solution is to inspect and fix encoder mounting or replace encoders. In order to continue running production before this can be done, the following procedure can be used.

1. Browse to the encoder screen from the Teach Pendant (**MENU** > **SETUP** > **Encoders**).
2. Use the **ENCODER** soft key.
3. Find the encoder corresponding to the encoder plugged in to that controller. This will typically be Encoder 1.
4. Set **1. Encoder Axis** to 0.

The effect will be that the press profile is never learned. Performance will suffer but the line can continue in Auto until encoder problems are fixed.

9.2 INTERFERENCE DETECTION

`TMSN-044 Interference with Press Detected` and `TMSN-029 Interference with XXX detected` mean that Press Interlock has detected a E-Stop severity fault and E-Stopped the robot.

This may happen normally in the following situations:

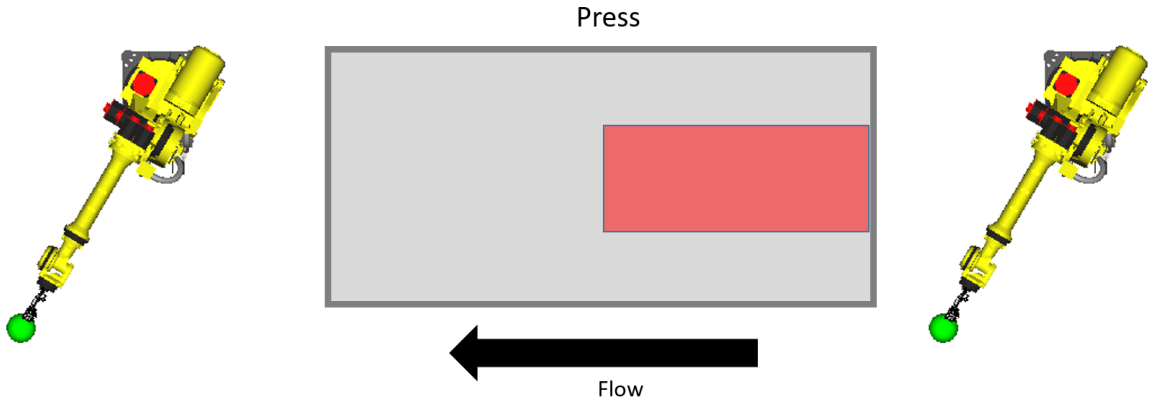
1. The pick robot stops unexpectedly while being chased. In this case:
   - **a.** Ensure the condition which led to the pick robot stopping is resolved
   - **b.** Reset
   - **c.** Continue
2. The pick press stops unexpectedly as the robot is attempting to enter it. In this case:
   - **a.** Resolve the press stopping issue
   - **b.** Reset
   - **c.** Continue
3. In jogging, the robot crosses the boundary of the press while it is not at Top Dead Center. In this case:
   - **a.** Reset
   - **b.** Jog in the opposite direction
   - **c.** Move press to TDC to jog into the press
4. In jogging if the robot gets too close to a neighboring robot. In this case:
   - **a.** Reset
   - **b.** Jog in the opposite direction

If it happens for another reason, please contact a software engineer.

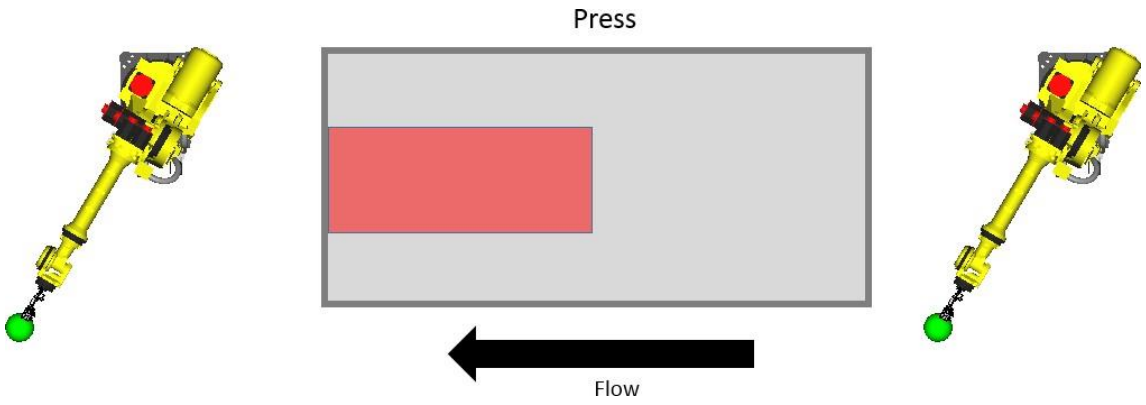
9.3 PERFORMANCE (SPEED) ISSUES

If the press line is not performing as well as required, there are several steps one can take to improve performance.

1. Ensure that the die height measurements are not too conservative. The die height should include any part of the die the robot can interfere with. Usually the best approach is to measure the die height where the robot could physically hit the die itself. This region is typically in the area shown in red in Figure 9.3.



The lowest part of the die should be measured in the red area for the drop robot.



The lowest part of the die should be measured in the red area for the pick robot.

Figure 9.3 Diagram_of_the_Die_Height_Area_of_Importance

2. Ensure that the press profiles are consistently learned. Check that each robot's **Pick Press Learned** and **Drop Press Learned** outputs are consistently on. If not, ensure that the robot is not in press safe mode. If there are still issues, discuss with a PLC programmer.
3. Discuss with a robot programmer if decreasing Press Stop Distance is appropriate.

9.4 TROUBLESHOOTING PRESS MENU NOT DISPLAYED

Make sure that the Press application is a selected application. To set this, restart the controller in controlled start by holding the **F1** and **F5** keys during a power cycle. Once the controller powers on, press **MENU** > **Next page** > **Appl-select**. Then, verify that **Press** is TRUE. If it is not set to TRUE, set it to TRUE, then Press **FCTN**, then **1 START (COLD)** to cold start the controller.

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GLOSSARY

BCD	Bottom Dead Center. The position when the press is fully down.
Bolster	The bolster is the part of the press which does not change when stamping different parts. It is a fixed piece of the press to which dies are attached.
Chasing	Chasing refers to the robots moving in the same direction very closely to each other, specifically when both robots are under a press at the same time.
Die	This is the device which is attached to the press bolster in order to shape the part(s) to their form.
IIC	Intelligent Interference Check. This robot option is used in order to allow the robots to know where objects are, and thus avoid hitting them. Press Interlock uses this in order to know where the press dies are, as well as other robots and their parts.
Interference Zone	A zone in which the robot would hit an object, be it another robot, the press, or a part held by another robot. These zones are used in order to prevent equipment damage by reducing collisions.
Press Plugin	This is the application which allows the user to set up various items required for Press Interlock to work properly, including IIC models, I/O, and communication between robots and the PLC.
Press Interlock	Press Interlock is the software which manages the press robot timing and speed to reduce wear and tear on equipment and reduce collisions.
Slide Adjust	Slide adjust is the distance between the bottom bolster and top bolster when the press is in the fully closed (Bottom dead center) position.

REVISION RECORD

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