TOUCHSENSE AND ACCUFAST WITH MACRO JOBS INSTRUCTIONS

Upon receipt of the product and prior to initial operation, read these instructions thoroughly, and retain for future reference.

MOTOMAN INSTRUCTIONS

MOTOMAN-INSTRUCTIONS
OPERATOR'S MANUAL
MAINTENANCE MANUAL

The operator's manual above corresponds to specific usage.
Be sure to use the appropriate manual.

Part Number: 166153-1CD
Revision: 0

YASKAWA
MOTOMAN ROBOTICS

MANUAL NO.
166153-1CD ⓪

MANDATORY

- This manual explains the starting point detecting function of the NX100/DX100 system. Read this manual carefully and be sure to understand its contents before handling the NX100/DX100.
- General items related to safety are listed in Section 1 of the NX100/ DX100 instructions. To ensure correct and safe operation, carefully read the section before reading this manual.

CAUTION

- Some drawings in this manual are shown with the protective covers or shields removed for clarity. Be sure all covers and shields are replaced before operating this product.
- The drawings and photos in this manual are representative examples and differences may exist between them and the delivered product.
- YASKAWA may modify this model without notice when necessary due to product improvements, modifications, or changes in specifications.
- If such modification is made, the manual number will also be revised.
- If your copy of the manual is damaged or lost, contact a YASKAWA representative to order a new copy. The representatives are listed on the back cover. Be sure to tell the representative the manual number listed on the front cover.
- YASKAWA is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids your product's warranty.

Notes for Safe Operation

Read this manual carefully before installation, operation, maintenance, or inspection of the Yaskawa Motoman robot.

In this manual, the Notes for Safe Operation are classified as “WARNING”, “CAUTION”, “MANDATORY”, or “PROHIBITED”.

WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel.
CAUTION	Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury to personnel and damage to equipment. It may also be used to alert against unsafe practices.
MANDATORY	Always be sure to follow explicitly the items listed under this heading.
PROHIBITED	Must never be performed.

Even items described as “CAUTION” may result in a serious accident in some situations.

At any rate, be sure to follow these important items.

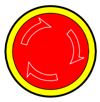
NOTE To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as "CAUTION" and "WARNING".

⚠ WARNING

- Before operating the manipulator, check that servo power is turned OFF by pressing the emergency stop button on the programming pendant.
  When the servo power is turned OFF, the SERVO ON LED on the programming pendant is OFF.

Injury or damage to machinery may result if the emergency stop circuit cannot stop the manipulator during an emergency. The manipulator should not be used if the emergency stop button does not function.

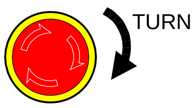
Figure 1: Emergency Stop Button



- Once the emergency stop button is released, clear the cell of all items which could interfere with the operation of the manipulator. Then turn the servo power ON.

Injury may result from unintentional or unexpected manipulator motion.

Figure 2: Release of Emergency Stop



- Observe the following precautions when performing teaching operations within the P-point maximum envelope of the manipulator:
  – View the manipulator from the front whenever possible.
  – Always follow the predetermined operating procedure.
  – Ensure that there is a safe place to retreat in case of emergency.

Improper or unintended manipulator operation may result in injury.

- Confirm that no person is present in the P-point maximum envelope of the manipulator and that you are in a safe location before:
  – Turning on the power for the controller.
  – Moving the manipulator with the programming pendant.
  – Running the system in the check mode.
  – Performing automatic operations.

Injury may result if anyone enters the P-point maximum envelope of the manipulator during operation. Always press an emergency stop button immediately if there is a problem.

The emergency stop button is located on the programming pendant.

WARNING

- Since detected voltage (200V), welding current, and welding voltage are applied to the starting point detecting unit, install the unit securely so that it does not fall.
- Failure to observe this warning may result in an electric shock or damage to the unit.
- Before connecting the inter-unit cables and the welding cables, be sure to turn OFF the power supply to the controller and the welder.
- Failure to observe this warning may result in an electric shock.
- Special attention should be paid during starting point detection, since 200 VDC is applied across the wire and the workpiece (welding jig).
- Failure to observe this warning may result in an electric shock.
- Do not place any object directly on the cable of the starting point detecting unit.
- Failure to observe this warning may result in an injury or damage caused by the disconnection of the cable.
- Attach the cable of the starting point detecting unit for the wire feeder with the wire stand, to protect it from robot movement. If interference between the cable and the peripheral devices are unavoidable, cover the cable with a rubber plate or spiral tube, etc.
- Failure to observe this warning may result in an electric shock, an injury, or damage to the cable.
- Do not lay the cable of the starting point detecting unit directly on the floor, but install them in a pit or duct or shield the cable with a protective cover.
- Failure to observe this warning may result in an injury or damage to the cable.
- Since a high current flows through the welding cable, separate it from the cables of the control circuit system. If the cables cannot be separated, take preventative measures such as using metallic ducts or tubes on the cables of the control circuit system.

CAUTION

- Perform the following inspection procedures prior to conducting manipulator teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.
  - Check for problems in manipulator movement.
  - Check for damage to insulation and sheathing of external wires.
- Always return the programming pendant to the hook on the cabinet of the controller after use.
- The programming pendant can be damaged if it is left in the manipulator's work area, on the floor, or near fixtures.
- Read and understand the Explanation of Warning Labels in the NX100/DX100 Instructions before operating the manipulator.

Definition of Terms Used Often in This Manual

The Yaskawa Motoman manipulator is an industrial robot product.

The manipulator usually consists of the controller, the programming pendant, and supply cables.

In this manual, the equipment is designated as follows:

Equipment	Manual Designation
NX100/DX100 controller	NX100/DX100
NX100/DX100 programming pendant	Programming pendant
Cable between the manipulator and the controller	Manipulator cable

Descriptions of the programming pendant, buttons, and displays are shown as follows:

Equipment		Manual Designation
Programming Pendant	Character Keys	The keys which have characters printed on them are denoted with [ ]. ex. [ENTER]
	Symbol Keys	The keys which have a symbol printed on them are not denoted with [ ] but depicted with a small picture. ex. [page key]  The cursor key is an exception, and a picture is not shown.
	Axis Keys & Number Keys	“Axis Keys” and “Number Keys” are generic names for the keys for axis operation and number input.
	Keys pressed simultaneously	When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them, ex. [SHIFT]+[COORD]
	Displays	The menu displayed in the pro-gramming pendant is denoted with { }. ex. {JOB}

Description of the Operation Procedure

In the explanation of the operation procedure, the expression “Select • • •” means that the cursor is moved to the object item and the SELECT key is pressed, or that the item is directly selected by touching the screen.

Registered Trademark

In this manual, names of companies, corporations, or products are trademarks, registered trademarks, or bland names for each company or corporation. The indications of (R) and TM are omitted.

Table of Contents

1 Introduction 1-1
1.1 Overview 1-1
1.1.1 Seam Finding 1-2
1.1.2 Macro Jobs 1-3
1.2 Features 1-4
1.2.1 Improved Control 1-4
1.3 About this Document 1-4
1.4 System Requirements 1-5
1.5 Learning Seam Finding with Macro Jobs 1-5
1.6 Reference to Other Documentation 1-5
2 Setup and Operation 2-1
2.1 Touch Sense 2-1
2.2 AccuFast 2-1
2.2.1 Setting the Q1 Focal Length: 2-2
2.3 Job Setup 2-4
2.4 AutoTeach 2-6
3 TCH Macro, One Touch (1TCH) Routine 3-1
3.1 Features 3-1
3.1.1 Limitations 3-2
3.2 AutoTeach Mode 3-2
3.3 Macro Job Setup 3-3
3.4 Interface 3-5
3.5 Programming Instructions 3-6
4 TCH Macro, Two Touch (2TCH) Routine 4-1
4.1 Features 4-1
4.1.1 Limitations 4-2
4.2 AutoTeach Mode 4-2
4.3 Macro Job Setup 4-5
4.4 Interface 4-7
4.5 Programming Instructions 4-8
5 EDGE: Edge Finding Routine 5-1
5.1 Features 5-1

5.2 Limitations... 5-2

5.3 Macro Job Setup.. 5-3

5.4 Interface... 5-5

5.5 Programming 5-8

5.6 AutoTeach 5-10

5.6.1 AutoTeach 1 (Robot Position 2) 5-11

5.6.2 AutoTeach 2 (Robot Position 3) 5-15

6 R1 CIRCLE: Circle Touch Routine... 6-1

6.1 Features 6-1

6.1.1 Three Touch Routine.. 6-1

6.1.2 Shift Amount - Center of Circle... 6-1

6.1.3 AutoTeach Mode 6-1

6.1.4 Limitations 6-2

6.2 Programming Requirements.. 6-2

6.3 Job Setup 6-2

6.4 Interface.. 6-4

6.5 Programming 6-6

6.5.1 Programming AutoTeach for the R1CIRCLE Macro.. 6-6

6.5.1.1 Setup Macro Instruction and Detect Robot Position 1............................ 6-7

6.5.1.2 Detect Robot Position 2 6-10

6.5.1.3 Detect Robot Position 3 6-10

7 Application Examples... 7-1

7.1 T-Joint... 7-1

7.2 Cylinder to Plate 7-3

8 Programming Suggestions... 8-1

8.1 Perpendicular Search Paths 8-2

8.2 Pattern Type and AutoTeach Descriptions.. 8-4

8.2.1 Pattern Type 0... 8-4

8.2.1.1 AutoTeach 1 8-4

8.2.1.2 AutoTeach 2 8-4

8.2.1.3 AutoTeach 0 8-5

8.2.2 Pattern Type 1... 8-5

8.2.2.1 AutoTeach 1 8-5

8.2.2.2 AutoTeach 2 8-6

8.2.2.3 AutoTeach 0 8-6

8.2.3 Pattern Type 2 8-7
8.2.3.1 AutoTeach 1 8-7
8.2.3.2 AutoTeach 2 8-7
8.2.3.3 AutoTeach 0 8-8
8.2.4 Pattern Type 3 8-8
8.2.4.1 AutoTeach 1 8-8
8.2.4.2 AutoTeach 2 8-9
8.2.4.3 AutoTeach 0 8-9
8.2.5 Pattern Type 4 8-10
8.2.5.1 AutoTeach 1 8-10
8.2.5.2 AutoTeach 2 8-10
8.2.5.3 AutoTeach 0 8-11
8.2.6 Pattern Type 5 8-11
8.2.6.1 AutoTeach 1 8-11
8.2.6.2 AutoTeach 2, Step Offset 0 8-12
8.2.6.3 AutoTeach 2, Step Offset > 0 8-12
8.2.6.4 AutoTeach 0 8-13
9 Target for TCP Update for AccuFast 9-1
9.1 Requirements 9-1
9.2 Objective of Function 9-1
9.3 Overview 9-1
9.4 Breakdown of Procedure 9-2
9.5 Detailed Usage 9-3
9.6 Adjust Settings of ACCUFAST - TCP - UPDATER robot job 9-4
9.6.1 Program the user Frame to be used by the Macro Manager Function's Robot Job 9-5
9.6.2 Set and Program the AccuFast - TCP - UPDATER Robot Job 9-6
9.7 Run the Robot Job in Train Mode 9-11
9.8 Run the Robot Job in Calc Mode 9-14
9.9 Update Robot Positions in AccuFast Macro Instructions 9-14
9.10 TCP Detection Mode (Optional) 9-15
Appendix A ARG Target Values A-1
Appendix B Value B Variables B-1
Appendix C AccuFast Verify Routine (Optional Function) C-1
C.1 Overview C-1

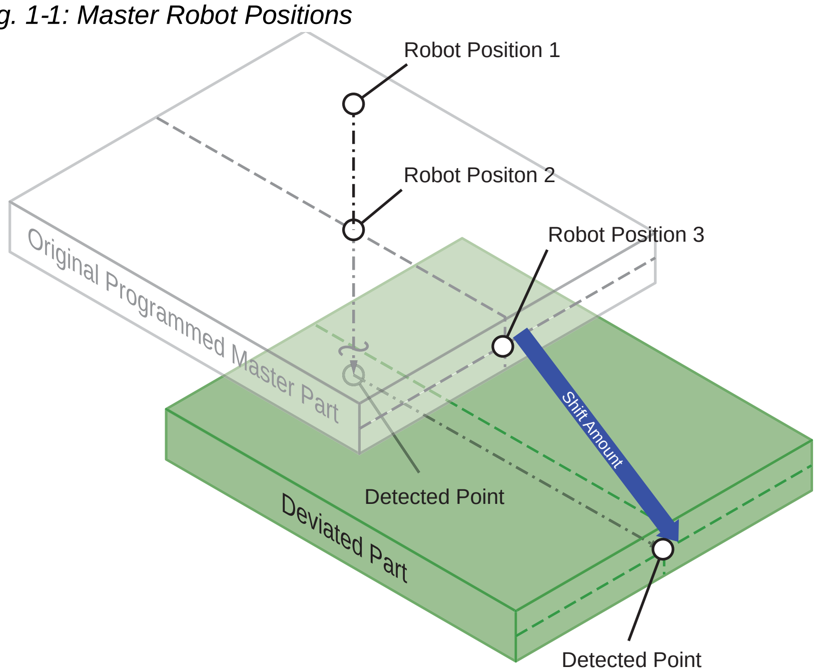
1 Introduction

1.1 Overview

A macro job is a job that runs in the background of the robot controller. Seam finding macro jobs are used to locate deviated weld seams, gaps, and edges. These macro jobs work for most work piece sizes, dispersion, and setting positions. There may be some issues on materials that have high reflectivity with the AccuFast laser system. The seam finding macro jobs use the Search function to create calculated offsets that can later be used to shift programmed job points from the original programmed points to new deviated part points.

These shift amounts are calculated by programming robot positions on a master part. The robot positions are programmed so that the sensing device detects/touches the surface of the master part. As new parts are presented for work, the robot searches as it moves toward the previously programmed robot positions and stops when it detects the surface of the new part.

Fig. 1-1: Master Robot Positions



When the surface of the new part is detected and the robot stops its search motion, the robot records the newly detected position and compares it to the location of the robot position. A shift amount is then calculated based on the distance between these two positions (original robot position and detected robot position).

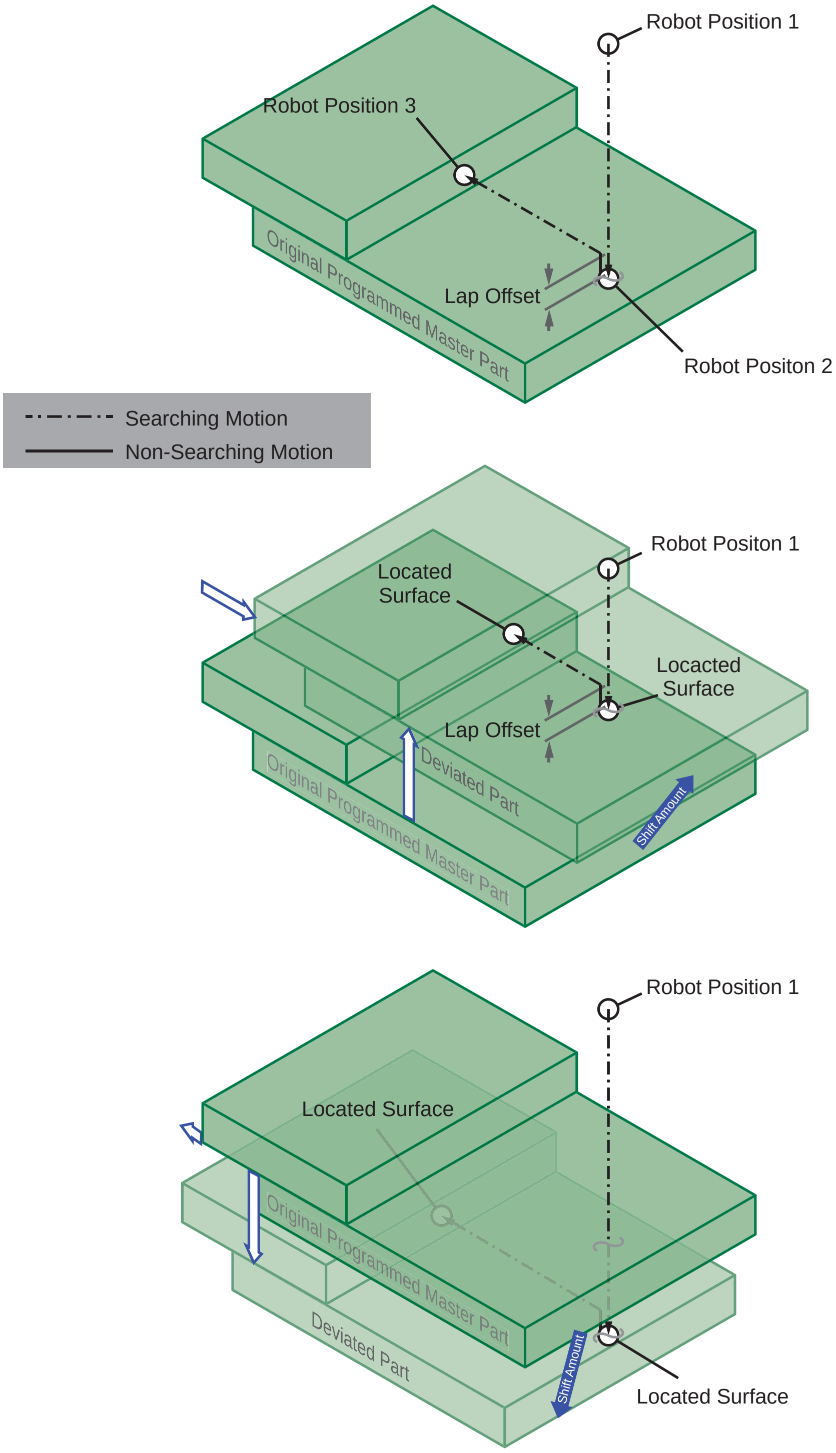
Once the seam finding macro routine successfully detects the part's surface, calculates the shift amount, and saves the shift amount to a variable, the robot job executes a Shift On instruction or Sytem Shift instruction and shifts the weld path.

To prevent gross errors in part placement, a search window is defined. A start robot position (Robot Position 1) is programmed to define the beginning of the search motion. The distance between the start position (Robot Position 1) and the surface 1 position (Robot Position 2), plus a “maximum shift amount parameter,” defines the search window.

1.1.1 Seam Finding

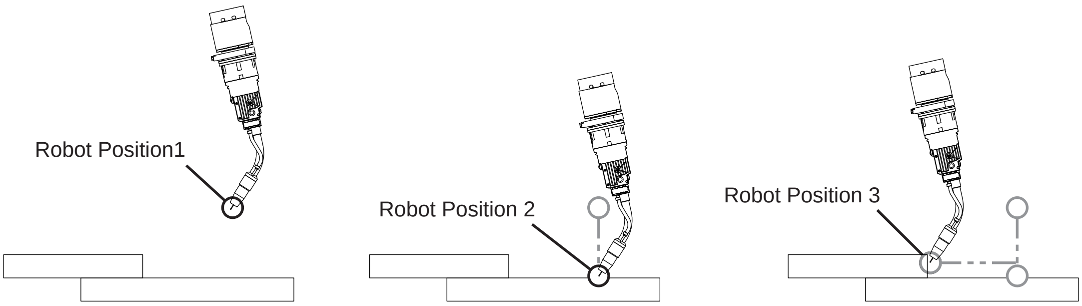
In the most basic seam finding application, the robot begins a search motion from a pre-programmed start robot position towards the next programmed robot position. When the weldment is detected, either by touchsense or laser, a signal is immediately sent to the robot controller. The robot quickly stops its search motion and captures its new position. Depending on the macro being used, the robot may be directed to; search, move in a new direction, or calculate a shift amount.

Fig. 1-2: Simple Seam Finding



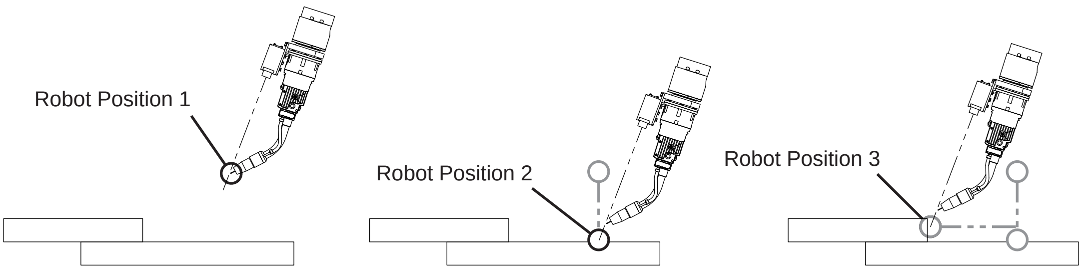
- **Touch Sense**
  For most welding applications, seam finding is performed using touch sense. With this technique, electrical power is provided by a welding power supply or an external touch sense box to either the welding electrode (welding wire) or the gas nozzle. As the robot moves from the start robot position towards the next programmed robot position(s), high voltage is supplied to the welding torch (power is limited to provide only low current levels). When the electrode or gas nozzle contacts the weldment, current flows and a signal is immediately sent to the robot. The robot quickly stops its search motion and captures the new position.

Fig. 1-3: Touch Sense



- **AccuFast**
  Another technology used for part detection uses a 1D laser sensor (AccuFast). The laser sensor is used in a similar manner as the welding wire with voltage. Seam finding can be performed with the end of the laser beam (just like the end of the welding wire) or the side of the laser beam (just like the side of the welding wire).

Fig. 1-4: Laser Sensing



1.1.2 Macro Jobs

Both Touch Sense and AccuFast, communicate with the robot controller using a Rapid Input signal. The Rapid Input signal has a quick response time to any change in signal status, making it ideal for applications involving robot motion. Because both touch sense and the AccuFast sensor use the same interface signal to the robot controller, the same macro job routines are used, and macro job usage is identical for both technologies.

Multiple positions and parameters are put into to the macro job for each location on the weldment that is to be measured. These robot positions and parameters are passed to the macro job via the macro instruction. The macro instruction is available from the Inform List and is inserted into the robot job to instruct the robot controller to detect the weld seam to be welded.

Robot motion during seam finding can vary from simple to complex depending on the features of the macro routine. The TCH macro job provides either a single, straight line search routine or a two-touch routine that can be used to locate a T-joint or lap joint. In contrast, the EDGE macro can touch the surface of a part 10 or more times during a single macro event.

Seam finding using touch sense is most often used in welding applications. However, seam finding can be used in a variety of other applications as well, including those using non-contact detection devices such as laser sensors, ultrasonic sensors, or vision systems. Depending on the sensor, routines similar to the macros described in this manual can be created for these applications.

1.2 Features

The benefits of transitioning to macro jobs include:

- AutoTeach mode
- Increased level of control
- Reduced length of robot program code
- Reduced programming time
- Increased programming accuracy

1.2.1 Improved Control

The transition to macro job-based-routines allows for a higher level of control of seam finding parameters. The following controls are provided in select macros:

- Seam Finding Speed: on a given weldment, certain areas may require slow speeds while others allow for higher speeds to be used.
- AutoTeach Parameters: for turning AutoTeach ON/OFF and for setting related parameters.
- Maximum Shift Amount: allows the routine to only search for the specified distance and to only generate a shift amount inside of this limit.
- Destination P Variable: defines the robot Position Variable used to store the shift amount.
- Weld Joint-Specific-Parameters: include controls for lap offset, edge detect step size, etc.

1.3 About this Document

This manual is intended as an introduction and overview for personnel who are familiar with the operation of their Yaskawa Motoman robot model and robot programming.

This User’s Manual provides a description of functionality, usage instructions, as well as application examples for the touch sense and AccuFast function using macro jobs. For detailed information on specific system components listed in this document, please refer to the documentation package included with the system.

1.4 System Requirements

- Controller software - NS3.31(JP_US)-44
  All DX controller software versions supported
- Macro Job function enabled

1.5 Learning Seam Finding with Macro Jobs

Yaskawa Motoman provides a variety of options to help you learn to use TouchSense and AccuFast with Macro Jobs, including training and technical support.

1.6 Reference to Other Documentation

For additional information refer to the following:

- NX100 Controller Manual (P/N 149201-1CD)
- DX100 Controller Manual (P/N 155494-1CD)
- NX100 Maintenance Manual (P/N 150133-1CD)
- DX100 Maintenance Manual (P/N 155492-1CD)
- NX100 Operator's Manual for Arc Welding (P/N 149235-1CD)
- DX100 Operator's Manual for Arc Welding (P/N 155490-1CD)
- NX100 Concurrent I/O Parameter Manual (P/N 149230-1CD)
- DX100 Concurrent I/O Parameter Manual (P/N 155491-1CD)
- NX100 Independent/Coordinated Control Manual (P/N 149648-1CD)
- DX100 Independent/Coordinated Control Manual (P/N 156431-1CD)
- NX100 INFORM User’s Manual (P/N 150078-1CD)
- DX100 INFORM User’s Manual (P/N 155493-1CD)
- Vendor manuals for system components not manufactured by Yaskawa Motoman.

2 Setup and Operation

2.1 Touch Sense

The robot controller's weld board (MEW02, XEW02, YEW02) turns a digital output ON while the robot is searching for the surface of the part. This digital output must be wired to the SEARCH input on the touch sense power supply (ComArc unit, welding power supply, etc.). The touch sense power supply has its own digital output signal which turns ON when the welding wire (or for some applications, gas nozzle) makes contact with the surface of the part. This digital output signal from the touch sense power supply is wired to the robot controller's Rapid Input signal. When the welding wire or gas nozzle contacts the weldment's surface, this Rapid Input signal is received by the robot controller, the robot position data is saved and the macro job continues with its pre-programmed logic.

The robot controller is configured to allow for seam finding as required by the seam finding macro jobs. The Search function is enabled in the controller and seam finding macro jobs (ie. R1-TCH.JBI, R1-EDGE.JBI, etc.) and the macro instruction configuration file (MACRO.DAT) are loaded into the robot controller.

2.2 AccuFast

The SICK laser sensor uses a user-specified set point value to determine the detection position for the sensor. The sensor measures the distance the sensor is from the surface.

> NOTE
> Measurements are based on how far the surface is away from the 'zero' point, which is a point corresponding with the farthest point away that the sensor can see.

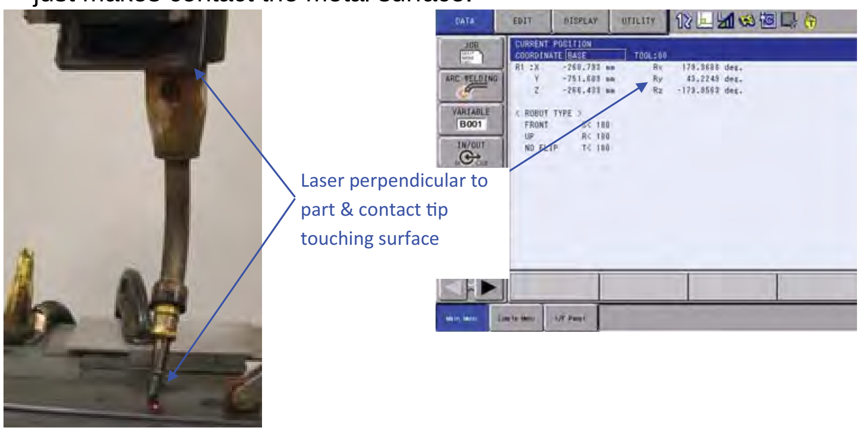
When the measured distance becomes equal to or greater than the set point value, the sensor sends an output to the robot controller. This digital output from the SICK sensor is wired to a Rapid Input signal in the robot controller (for each seam finding macro instruction deployment, the robot programmer must set the rapid input number to be used). For the SICK sensor, there are two set point values that can be configured, each tied to their own digital output signal and connected to two rapid input signals.

Setting of the SICK sensor set point(s) must be done prior to programming the first seam finding routine.

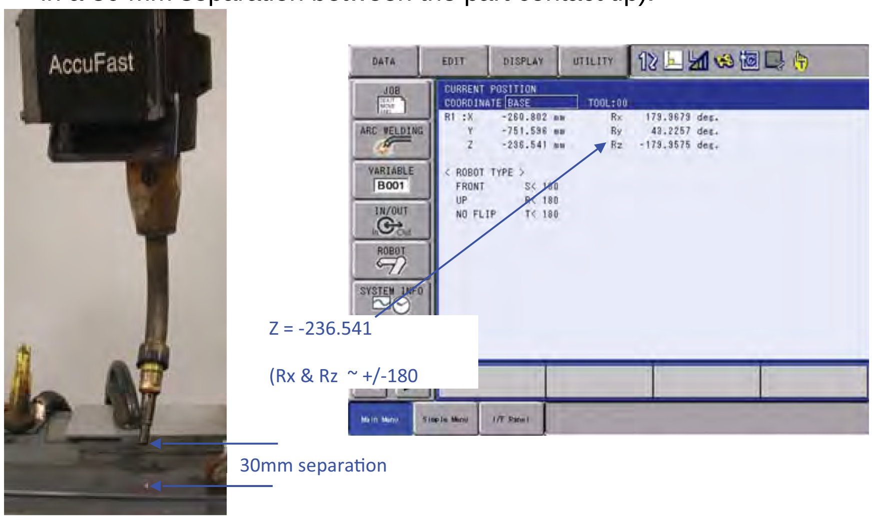
The standard Yaskawa mounting location places the laser beam at an angle relative to the welding torch so that the laser passes within 30 mm of the tip of the welding wire (30 mm from the TCP of the welding torch).

2.2.1 Setting the Q1 Focal Length:

1. For each AccuFast in the system, turn on the specified output to open the AccuFast's door. The laser light should already be on and a laser dot should become visible.
2. With the door open, slide the lens holder from in-front of the laser sensor. Slide the lens from the side of the enclosure allowing access to push buttons on the side of the laser sensor. REPLACE THE LENS HOLDER OVER THE LASER OUTPUT BEFORE PROCEEDING.
3. Press the “Select” button and hold it (3-5 seconds) until the sensor transitions from “Run” mode to “Teach” mode.
4. Press the “Select” button until the LED next to “Q1” illuminates.
5. Trim or retract the welding wire until it is flush with the contact tip.
6. With the laser sensor in “Teach” mode and lens over the laser, position the robot over a clean piece of metal, jog the robot until the laser sensor is perpendicular to part, drive the contact tip until the contact tip just makes contact the metal surface.



7. With the contact tip touching the part, note the robot's “Current Position” in base frame.
8. Jog the robot away from the part in world coordinates Z-DIRECTION ONLY until a 30 mm change in the Z direction is noted. (This will result in a 30 mm separation between the part contact tip).



9. While maintaining servo power and the 30 mm separation, momentarily press the “Set” button on the laser sensor to set the “Q1” focal length. Once pressed, the LED for Q1 should flash once.
10. This concludes setting the focal length for Q1. If Q2 needs to be set (not required in most applications). Press the “Select” button until the “Q2” LED is illuminated, jog the robot to desired “Q2” focal length then press the “Set” button momentarily. The “Q2” LED will flash once indicating that the focal length has been set.
11. To exit “Teach” mode and return to “Run” mode (required for normal operation), press and hold the “Select” button for 3-5 seconds until the “Run” LED is illuminated.
12. Replace the lens on the side of the enclosure allowing access to the push buttons on the side of the laser sensor and replace the lens over the front of the laser sensor.

2.3 Job Setup

Each seam finding macro job incorporates a setup section located at the top of the macro job (.jbi) program. During robot system setup, this data may need to be modified depending on the application. It is good practice to verify these parameter settings when installing a seam finding technology (touch sense or AccuFast) into the robot system. At the top of the macro job is an area provided for user configuration. This area is bound by “Setup Section...begin”. Do not modify job data outside of this zone! The macro jobs have the following setup sections:

Table 2-1: R1-TCH

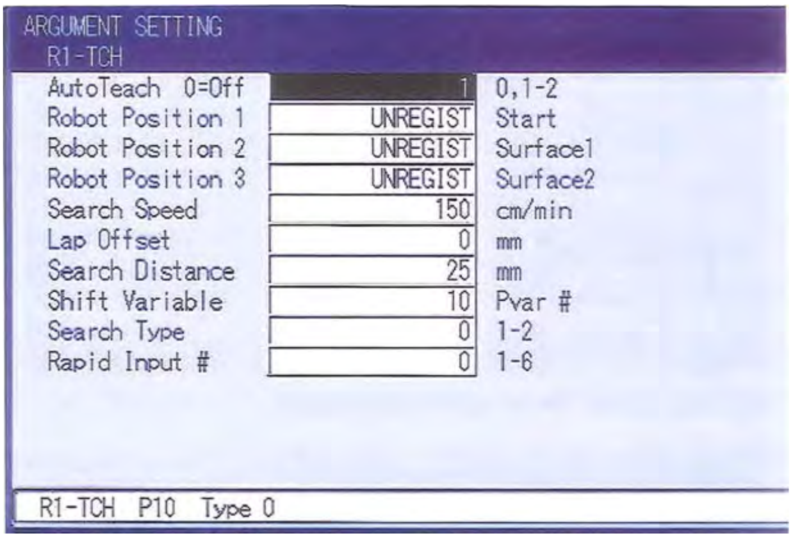
Instruction	Explanation
NOP	
‘--	
‘-----DX-------------------------------	Controller
'- --ver.2.0.0 ------------------------	Version
'- --Yaskawa America Inc.--------	
'----Motoman Robotic Div.--------	
‘----2013May06; TL---------------	Revision Date / Developer
‘--	
'- For use with Touch Sensing	
' - and/or 1D laser sensor	
‘	
'--	
'---- Setup Section ... begin -----	
'--	
‘	
' LI8 = Robot Number (ie. R1)	Set to Robot Number in the system.
SET LI008 1	
‘	
‘ If using a laser sensor instead	Value of Rapid input number AccuFast is wired to. Set to “0” if using touch sense.
‘ of touch sense, LI13 = rapid	
' input # for laser sensor. Set	
' LI13 to 0 if touch sensing is	
' used	
SET LI013 0	
'	
' output door is wired to	Output number laser is wired to set to amount of offset desired for Auto Teach units = mm.
' SET LI014 21	
'	
' LI6 = auto teach offset	
' SET LI006 10	
' SET LD000 LI006	
'	
' LI0 = non search speed	Speed value for robot to use during air moves. Units mm/sec. max= 3000 of user frame to be created.
SET LI000 3000	
'	

Instruction	Explanation
' LB7 = userframe number	Value of user frame to be created
SET LB007 0	
'	
'---	
'- Setup Section ... complete ---	
'--	
'---Do not modify below here---	

To access the parameters associated with the macro instruction, the macro instruction should first be inserted into the robot job. Access the macro instruction as follows:

1. Open the robot job that macro instruction is desired.
2. Open the [INFORM LIST] and select {MACRO}.
3. Select the macro instruction desired.
4. Press [INSERT] > [ENTER].
5. Cursor to the instruction side (right side) and press [SELECT] > [SELECT] on the macro instruction name. The Argument Setting screen appears.

Fig. 2-1: Argument Settings



6. Cursor to the parameter to change and press [SELECT].
7. Type in the value desired to use and then press [ENTER] (or press [MODIFY] > [ENTER] in the case of a robot position). The value changes from UNREGIST to REGIST.
8. Once all changes have been made, save the data to the robot controller by pressing [ENTER] > [ENTER].

NOTE Pressing ENTER only one time does not save the data. For data to be saved, ENTER must be pressed twice. Pressing ENTER a third or forth time, etc. affects nothing.

2.4 AutoTeach

The AutoTeach feature is used to define the robot positions at the exact location of the part. During initial teaching, the Robot Position 1 is programmed near the surface desired to detect. The macro job is then ran in AutoTeach mode. The robot searches, detects the part surface, and prompts the user to modify the Robot Pos2 in the TCH macros argument setting screen.

If the robot is not programmed exactly to the master part during initial teaching, or if the seam finding paths are not taught in specific directions, inaccuracies are fed directly to the weld path leading to reduced weld quality.

Additional problems can arise during seam finding operations at high speeds where robot “overshoot” can occur. When teaching the master part, the programmer teaches the robot position with the weld wire lightly touching the surface of the part. During high speed playback (e.g. 500 cm/min), when the robot controller detects the surface of the new part and sends the signal to stop robot motion, inertia can cause the robot to continue moving for a small distance before stopping. This small continuation of motion drives the welding electrode firmly into the surface of the part and may even slightly bend the electrode. This deviation amount and possible wire bend introduces error which can lead to reduced weld quality.

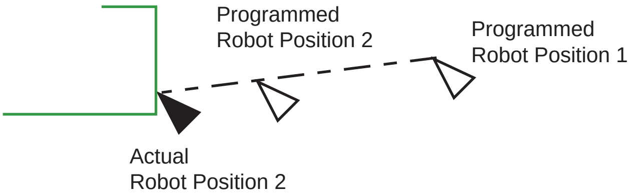
To eliminate these problems associated with robot overshoot, the AutoTeach macro mode defines the teaching contact position(s) automatically using playback search motion speed. Any wire bend or overshoot deviation condition that would occur during Playback will occur during AutoTeach as well, thus minimizing this error.

3 TCH Macro, One Touch (1TCH) Routine

3.1 Features

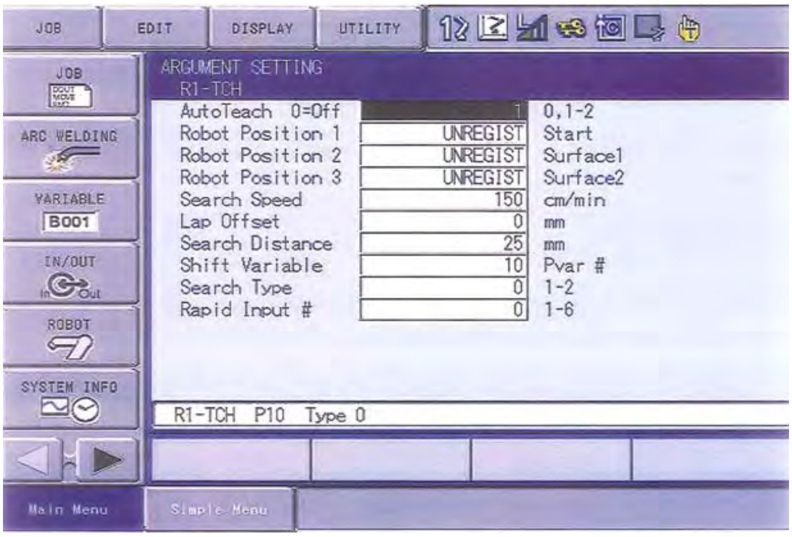
This section describes the TCH macro using One Touch (1TCH) routine. When using the One Touch routine, the robot moves from Robot Position 1 towards a Robot Position 2, stopping when the surface of the part is detected.

Fig. 3-1: TCH Macro, 1TCH Routine



The 1TCH routine AutoTeach feature defines the programmed detect position at the exact location of the part. During initial teaching, the Robot Position 2 is programmed near the surface to be detected. The macro job is then ran in AutoTeach mode. The robot searches, detects the part surface, and prompts the user to modify Robot Pos 2 in the TCH macros argument setting screen.

Fig. 3-2: Argument Settings



Two different AutoTeach modes are available for the 1TCH macro.

- A-to-B search routine (Search Type is set to 1).
  The robot starts at Robot Position 1, moves toward Robot Position 2 and stops when contact is detected.
- Perpendicular search routine (Search Type is set to 2)
  The robot touches the part's surface and defines a perpendicular search direction and the exact location of Robot Position 2.

After the macro has been ran in AutoTeach mode and the programmed Robot Position 2 has been modified, the TCH macro in 1TCH routine is ready for playback.

3.1.1 Limitations

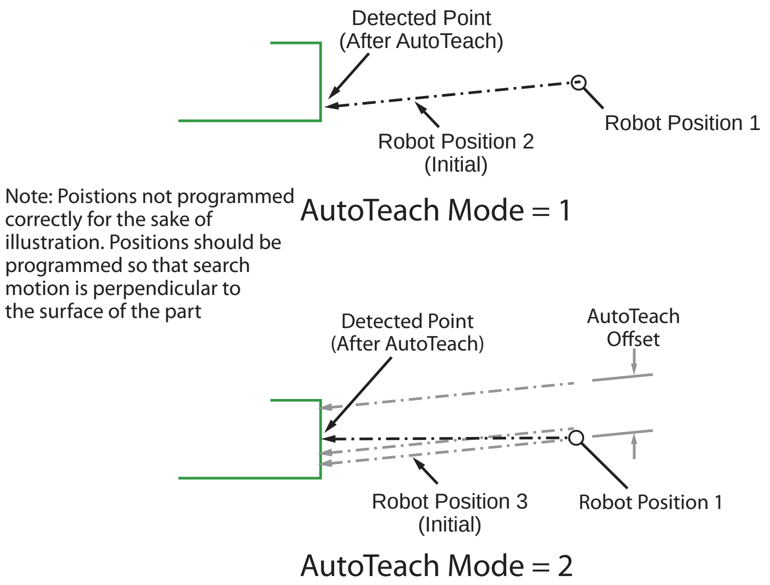
The AutoTeach perpendicular mode (Search Type is set to 2) defines a search motion that is perpendicular to a surface, but for some applications there may not be enough room to use this detection mode (ie. detecting the edge of a 6 mm steel plate). During playback of the AutoTeach perpendicular mode, the robot senses the surface four times, moving an offset distance between each search. If the size of the surface area is too small, there may not be enough room for the robot to move the offset distance between searches. In this case, use the AutoTeach A-to-B mode (Search Type is set to 1).

The R1-TCH macro provides X, Y, and Z (translational) shift amounts. It does not provide R_X, R_Y, and R_Z (rotational) shift amounts.

3.2 AutoTeach Mode

With the TCH macro in 1TCH routine, AutoTeach mode defines the exact location of the Robot Position 2. When AutoTeach mode is set to 1, the robot moves from the starting position (Robot Position 1) to Robot Position 2 while searching for the surface of the part. When the part surface is detected, the robot stops and a message is displayed at the bottom of the teach pendant screen prompting the user to modify Robot Pos 2, set TEACH to 0, thereby disabling the AutoTeach mode. The correct location of Robot Position1 and Robot Position 2 is shown in *Figure 3-3*.

Fig. 3-3: AutoTeach Modes



When AutoTeach mode is set to 2, the mode touches the surface of the part four times, developing a search motion that is perpendicular to the surface of the part from the Robot Position 1. The AutoTeach Offset parameter is used to set the distance between the first three touches.

3.3 Macro Job Setup

The Touch Sense and AccuFast options are installed at the factory prior to shipment. To locate and view the macro jobs that are available in the controller, proceed as follows:

1. Switch to MANAGEMENT mode.
2. From the MAIN MENU, press {JOB} >{SELECT MACRO JOB}. The TCH macro job(s) appear in the job list.
3. Open a robot job (ie. R1) then open the [Inform List] and press [MACRO]. The TCH macro instruction(s) appear in the list.

Table 3-1: R1-TCH Macro Setup

Instruction	Explanation
NOP	
‘--	
‘-----DX-------------------------------	Controller
'- --ver.2.0.0 ------------------------	Version
'- --Yaskawa America Inc.--------	
'----Motoman Robotic Div.--------	
‘----2013May06; TL---------------	Revision Date / Developer
‘--	
'- For use with Touch Sensing	
' - and/or 1D laser sensor	
‘	
'--	
'---- Setup Section ... begin -----	
'--	
‘	
'LI8 = Robot Number (ie. R1)	Set to Robot Number in the system.
SET LI008 1	
‘	
‘If using a laser sensor instead	Value of Rapid input number AccuFast is wired to. Set to “0” if using touch sense.
‘of touch sense, LI13 = rapid	
' input # for laser sensor. Set	
' LI13 to 0 if touch sensing is	
' used	
SET LI013 0	
'	
' output door is wired to	Output number laser is wired to set to amount of offset desired for Auto Teach units = mm.
' SET LI014 21	
'	
' LI6 = auto teach offset	
' SET LI006 10	
' SET LD000 LI006	
'	
' LI0 = non search speed	Speed value for robot to use during air moves. Units mm/sec. max= 3000 of user frame to be created.
SET LI000 3000	
'	

Instruction	Explanation
' LB7 = userframe number	Value of user frame to be created
SET LB007 0	
'	
'---	
'- Setup Section ... complete ---	
'--	
'---Do not modify below here---	

4. Select one touch. (Search Type 1).

Table 3-2: R1-TCH Call Job

Line	Instruction	Explanation
0000	NOP	
	MOVJ	Approach position.
	R1-TCH P25 Type 0	R1-TCH macro instruction with shift amount saved to P-Variable #25 (P025) with 1 dimension search selected.
	MOVJ	Approach Position for welding.
	SFTON P025	Shift amount from R1-TCH macro.
	MOVJ	Weld Start position.
	ARCON	

3.4 Interface

The 1TCH macro instruction argument setting screen contains the following controls.

Fig. 3-4: Argument Settings R1-TCH (1 Dimension Search)

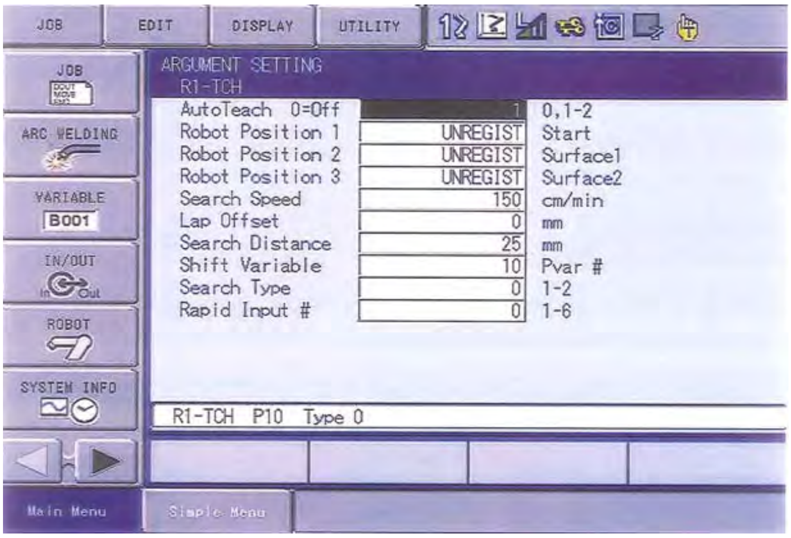


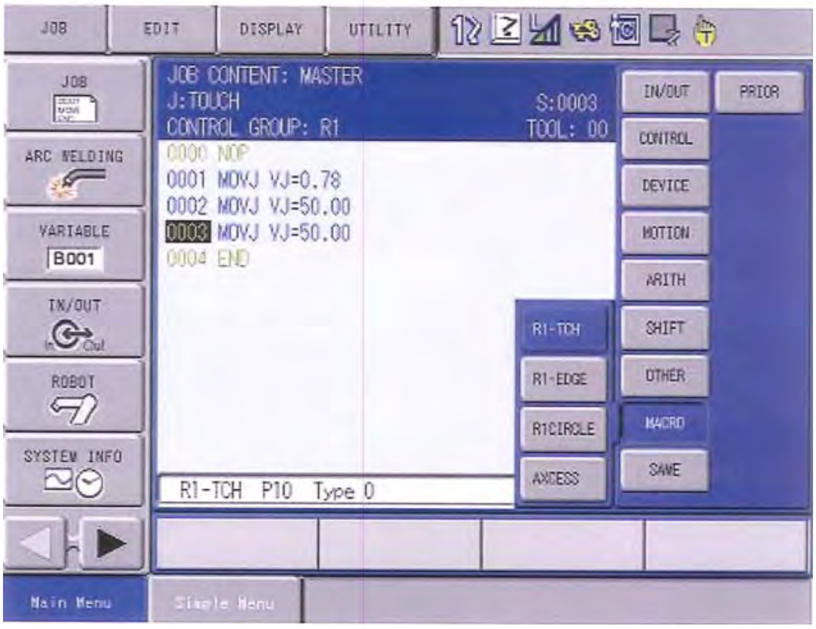
Table 3-3: Argument Settings R1-TCH (1 Dimension Search)

Name	Description	Default Setting	Allowable Setting Range
Auto Teach 0 = off	Auto Teach mode0=Auto Teach off 1=Auto Teach - first surface 2=Auto Teach - second surface	1	0,1,2
Robot Position 1	Start position of search. The distance placed from the surface(s) of the part determines the search window.	UNREGIST	UNREGIST, REGIST
Robot Position 2	The position the robot moves toward while searching for the surface of the part. In 1TCH mode, this positionis compared with the detected position to calculate the shift amount.	UNREGIST	UNREGIST, REGIST
Robot Position 3	Position taught on surface next to Robot Position 1. Even though this position is not used for shift amount calculation, it must still be taught. It is also used for the AutoTeach =2 (perpendicular search).	UNREGIST	UNREGIST, REGIST
Search Speed	Speed used during search motion. Units are cm /mm.	150	1-1000
Lap Offset	Not used for 1TCH routine	0	0-100
Search Distance	Distance past the programmed Robot Position 2 the robot moves during search. Units: mm.	25	1-100
Shift Variable	P-variable number used to store the calculated shift amount data.	10	0-127
Search Type	Set value to 1 for 1 dimension search.	0	1or 2
Rapid Input #	Select rapid input to be used.	0	1-5

3.5 Programming Instructions

1. While in TEACH mode, open the robot weld job and select: [INFORM LIST] > {MACRO} > {R1-TCH}.

Fig. 3-5: R1-TCH



2. Insert the TCH macro instruction into the job ([ENTER] or [INSERT] > [ENTER]).

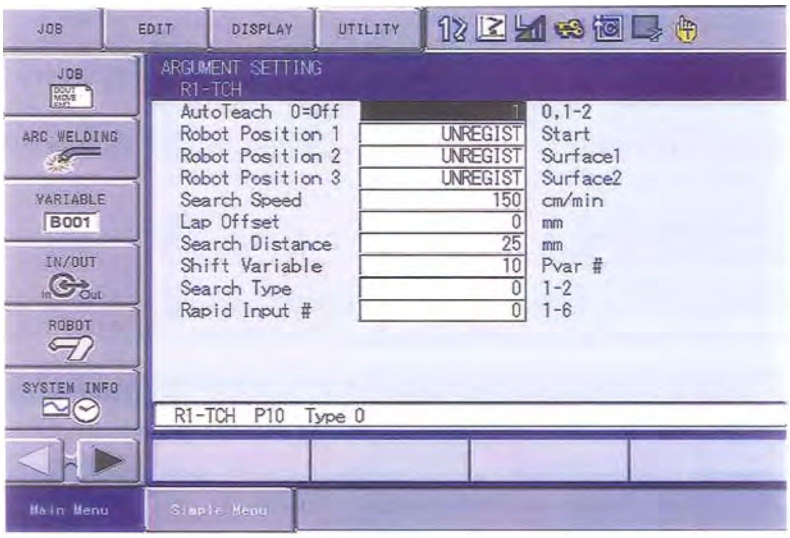
3. Edit argument data:

   a) Cursor to the Instruction side of the robot job.

   b) Cursor to the R1-TCH macro instruction.

   c) Press [SELECT] > [SELECT]. The Argument Setting screen appears.

Fig. 3-6: Argument Settings



   d) Verify arguments are set properly for the application. To modify arguments, cursor to argument and press [SELECT]. Type in the numerical data and press [ENTER].

e) Cursor to Robot Position 1. Jog the robot to the desired seam finding start position (note: the distance between the Robot Position 1 and the surface of the part defines the search window, which impacts effectiveness and cycle time) and press [MODIFY] > [ENTER].

f) Cursor to Robot Position 2. Jog the robot towards surface desired to detect and press [MODIFY] > [ENTER]. Cursor to Robot Position 3 and press [MODIFY] > [ENTER] (This position must be taught, but its exact location will not be used for surface detection and is never re-taught as a result of AutoTeach).

g) Set AutoTeach mode to a value of 1. Place the cursor on the Auto Teach argument and press [SELECT]. Enter 1 and press [ENTER].

4. Save the argument data in robot job. From the Argument Setting screen press [ENTER] > [ENTER].
5. Execute the TCH macro. Press [INTER LOCK] +[TEST START].
6. When the part surface is detected, the robot stops and a message is displayed at the bottom of the teach pendant screen prompting the user to Modify Robot Pos2; set TEACH to 0.

a) Re-open the Argument Setting Screen.

- Cursor to R1-TCH macro instruction on instruction side of robot job.
- Press [ENTER] > [ENTER]

b) Cursor to the Robot Position 2 argument and press [MODIFY] > [ENTER].

c) Set AutoTeach mode to 0.

d) Set Shift Variable to the Point Variable (P variable) number desired to save the shift data.

e) From the Argument Setting screen, press [ENTER] > [ENTER].

The 1TCH macro is now ready for playback mode.

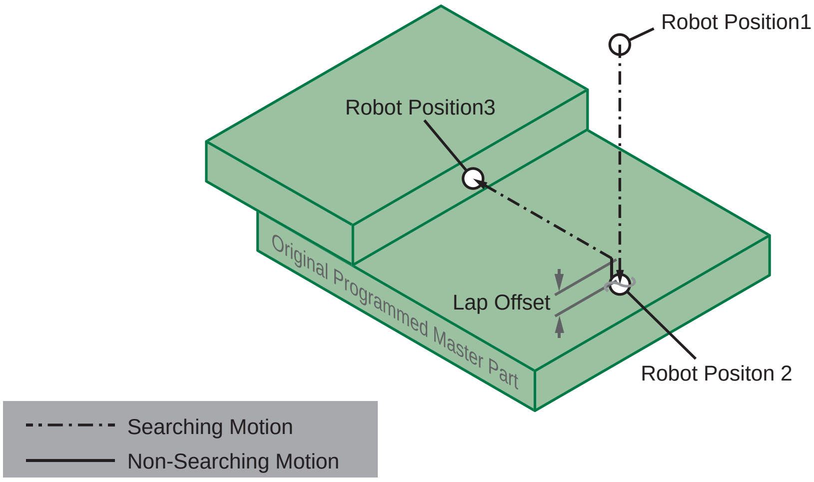
Program the weld path using a Shift On (SFTON) instruction. Use the P-variable number set above.

4 TCH Macro, Two Touch (2TCH) Routine

4.1 Features

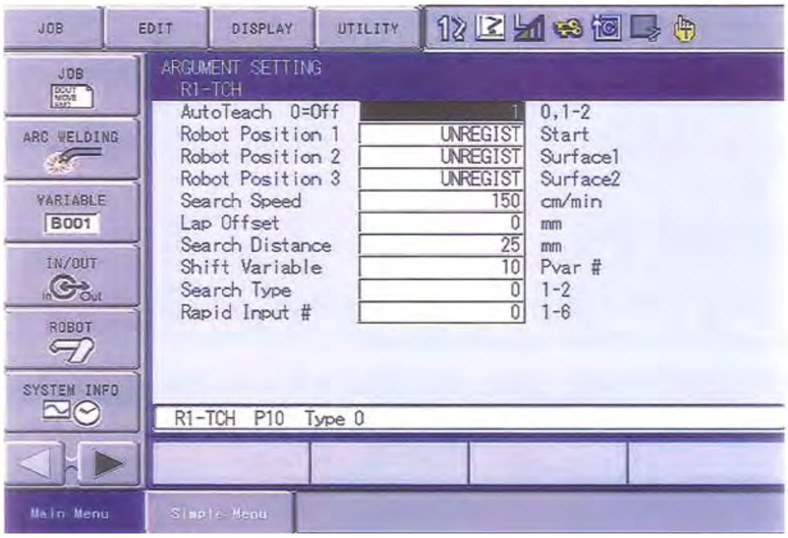
This section describes the TCH macro when using Two Touch routine. The two touch (Search Type = 2) routine of the TCH macro is used to detect the location of a weld joint using two contact positions. It moves from a starting Robot Position 1 towards the Robot Positions 2, momentarily stopping when it detects the surface of the part. It then moves a short Lap Offset distance (specified in millimeters) back towards Robot Position 1. Finally, it moves toward the lap leg / adjacent surface, stopping when it detects the surface of the part (Robot Position 3).

Fig. 4-1: TCH Macro, Weld Joint Location



The AutoTeach feature of this macro job defines the exact location of Robot Position 2 and Robot Position 3. During initial teaching, the Robot Position 2 and Robot Position 3 are programmed close to the surfaces to detect. The macro job is then placed into either of two teach routine and executed. The robot searches to detect the proper location of either the First Detection or Lap Detection positions and then prompts the user to modify ([MODIFY] > [ENTER]) these points in the R1-TCH macros argument setting screen.

Fig. 4-2: Argument Settings



The AutoTeach mode has two sequential modes: 1- First Detection and 2- Lap Detection. After teaching the exact location for Robot Position 1 and the approximate locations of Robot Position 2 and Robot Position 3, the R1-TCH macro instruction is placed into First Detection mode (Auto Teach 1). In this position the robot touches the surface four times to define a perpendicular search direction and the exact location of Robot Position 2. The programmer then re-teaches the Robot Position 2 argument in the R1-TCH macro instruction. Next, the R1-TCH macro is placed into Lap Detection (Auto Teach = 2). In this routine the robot touches the surface of the lap leg three times, developing the exact location of Robot Position 3 as perpendicular to the Robot Position 2 search direction. Finally, the programmer re-teaches the Robot Position 3. After this stage the R1-TCH macro instruction is ready for routine Playback.

4.1.1 Limitations

The R1-TCH macro provides X, Y, and Z (translational) shift amounts. It does not provide R_X, R_Y and R_Z (rotational) shift amounts.

4.2 AutoTeach Mode

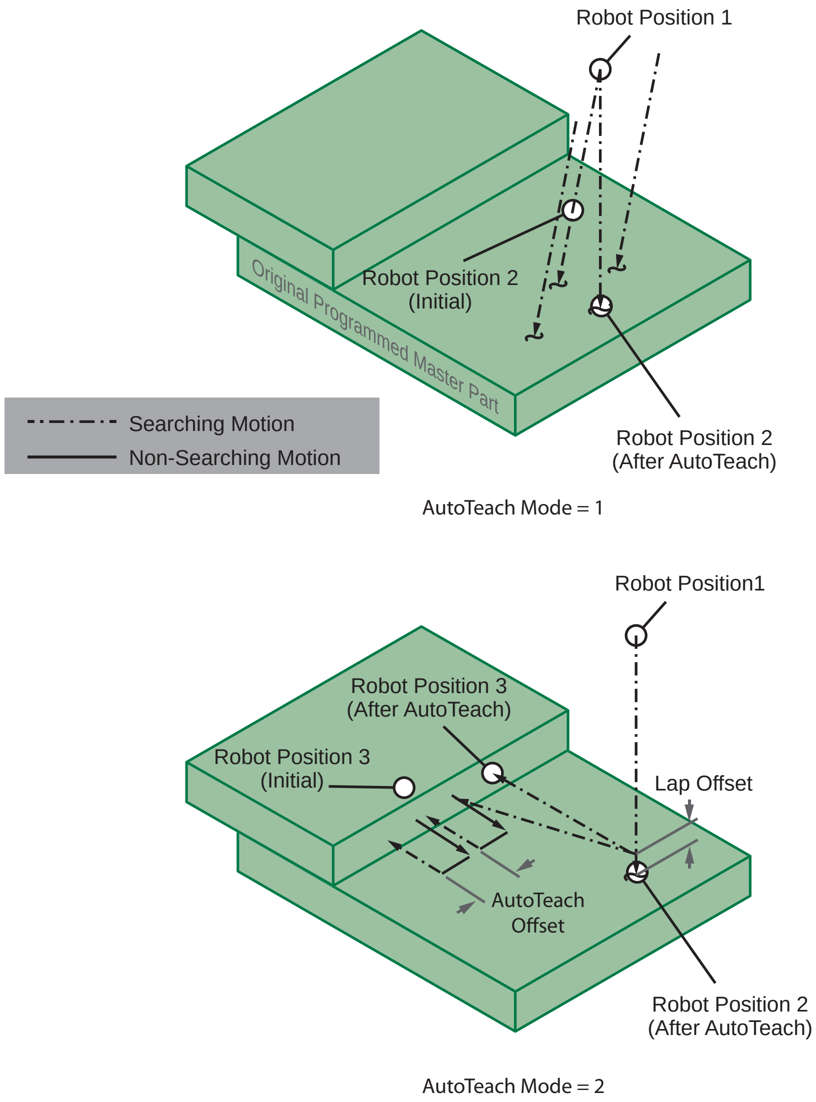
As stated previously, the AutoTeach feature defines the exact location of Robot Position 2 and Robot Position 3. When AutoTeach is set to mode 1, the robot detects the exact position for Robot Position 2. The proper location of Robot Position 2 is calculated by defining a line from Robot Position 1 that is perpendicular to the non-lap surface.

When AutoTeach is set to mode 2, the robot detects the exact point for Robot Position 3. The proper location of Robot Position 3 is calculated by defining a line, offset from the non-lap surface.

- Perpendicular to the line between Robot Position 1 and Robot Position 2 (thus parallel to the non-lap surface)
- Perpendicular to a line on the lap surface - a line that is offset from the non-lap surface by the Lap Offset 0=off argument

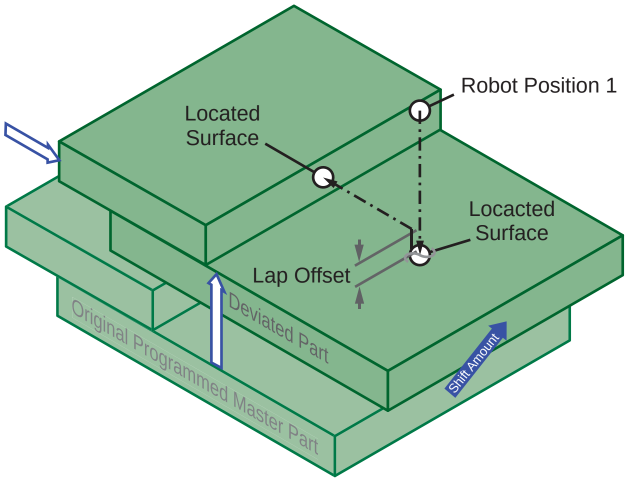
The correct locations of Robot Position1, Robot Position 2, and Robot Position 3 are shown in the following figures.

Fig. 4-3: AutoTeach Modes



Playback of the Search Type =2 routine uses simpler motion than that of the AutoTeach modes. The robot moves to the Robot Position 1, then moves while searching for the Robot Position 2 position, next moves up the Robot Position 3, and then moves toward the lap surface while searching. This motion is shown in the figure below.

Fig. 4-4: TCH macro, Search Type = 2



4.3 Macro Job Setup

The Touch Sense and AccuFast options are installed at the factory prior to shipment. To locate and view the macro jobs that are available in the controller, proceed as follows:

1. Switch to MANAGEMENT mode.
2. From the MAIN MENU, press {JOB} > {SELECT MACRO JOB}. The TCH macro job(s) appear in the job list.
3. Open a robot job (ie. R1) then open the [INFORM LIST] and press {MACRO} The TCH macro instruction(s) appear in the list.

Table 4-1: R1-TCH Macro Setup

Instruction	Explanation
NOP	
'--	
'-----DX-------------------------------	Controller
'- --ver.2.0.0 ------------------------	Version
'- --Yaskawa America Inc.--------	
'----Motoman Robotic Div.--------	
'----2013May06; TL---------------	Revision Date / Developer
'--	
'- For use with Touch Sensing	
' - and/or 1D laser sensor	
'	
'--	
'---- Setup Section ... begin -----	
'--	
'	
'LI8 = Robot Number (ie. R1)	Set to Robot Number in the system.
SET LI008 1	
'	
'If using a laser sensor instead	Value of Rapid input number AccuFast is wired to. Set to "0" if using touch sense.
'of touch sense, LI13 = rapid	
' input # for laser sensor. Set	
' LI13 to 0 if touch sensing is	
' used	
SET LI013 0	
'	
' output door is wired to	Output number laser is wired to set to amount of offset desired for Auto Teach units = mm.
' SET LI014 21	
'	
' LI6 = auto teach offset	
' SET LI006 10	
' SET LD000 LI006	
'	
' LI0 = non search speed	Speed value for robot to use during air moves. Units mm/sec. max= 3000 of user frame to be created.
SET LI000 3000	
'	

Instruction	Explanation
' LB7 = userframe number	Value of user frame to be created
SET LB007 0	
'	
'--	
'- Setup Section ... complete ---	
'---	
'---Do not modify below here---	

4. Select two touch (Search Type =2).

Table 4-2: R1-TCH Call Job

Line	Instruction	Explanation
0000	NOP	
	MOVJ	Approach position.
	R1-TCH P25 Type 2	R1-TCH macro instruction with shift amount saved to P-Variable #25 (P025) with 2 dimension search selected.
	MOVJ	Approach position for welding.
	SFTON P025	Shift amount from R1-TCH macro.
	MOVJ	Weld Start position.
	ARCON	

5. Select a two dimension search by setting the argument (Search Type) to a value of 2.

Sample Job

Line	Instruction	Explanation
0000	NOP	
	MOVJ	Approach position.
	R1-TCH P25 Type 2	R1-TCH macro instruction. Shift amount is saved to P variable #25 (P025) with 2 dimension search selected.
	MOVJ	Approach point for welding.
	SFTON P025	Enable shift amount from R1-TCH macro.
	MOVJ	Weld start position.
	ARCON	

4.4 Interface

The R1-TCH macro instruction has the following controls in the argument setting screen.

Fig. 4-5: Argument Settings R1-TCH (2 Dimension Search)

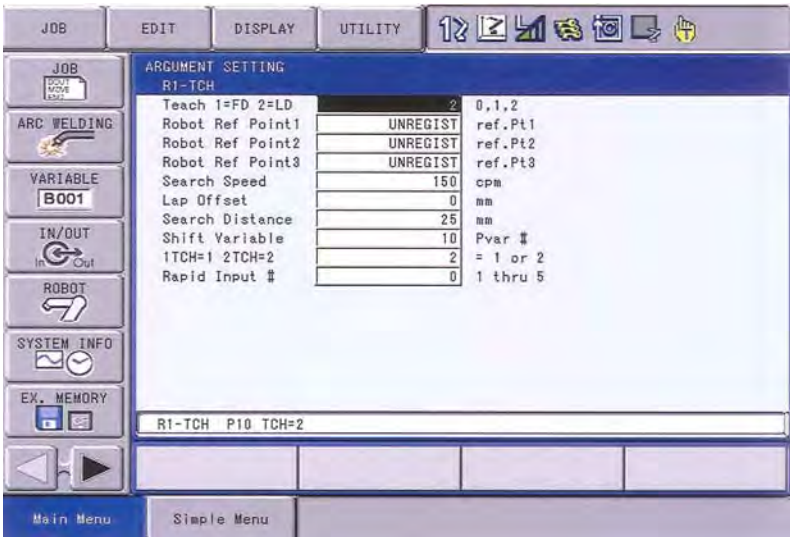


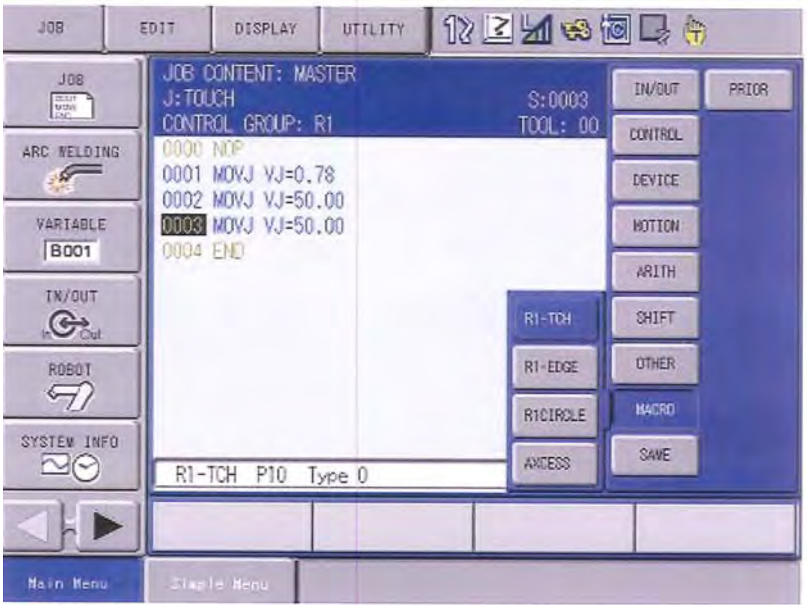
Table 4-3: Argument Settings R1-TCH

Name	Description	Default Setting	Allowable Setting Range
Auto Teach 0 = off	Auto Teach Mode 0 = Auto Teach Off 1 = Auto Teach first surface 2 = Auto Teach second surface	1	0,1,2
Robot Position1	Start position of search. The distance this position is placed from the surface(s) of the part determines the search window.	UNREGIST	UNREGIST, REGIST
Robot Position 2	Position the robot moves toward while searching for the surface of the part.	UNREGIST	UNREGIST, REGIST
Robot Position 3	Position taught on second surface.	UNREGIST	UNREGIST, REGIST
Search Speed	Speed used during search motion. Units cm/min.	150	1-100
Lap Offset	Offset distance from first detected surface. If set to 0mm, after the robot detects Robot Position 2, it moves back to Robot Position 1 before searching across toward Robot Position 3.	0	0-100
Search Distance	Distance past the programmed Robot Position 2 the robot moves during search. Units: mm.	25	1-100
Shift Variable	P-variable number used to store the calculated shift amount data.	10	0-127
Search Type	Set value to 2 for 2 dimension search.	0	1 or 2
Rapid Input #	Select rapid input to be used.	0	1-5

4.5 Programming Instructions

1. While in TEACH mode, from a robot job select: [INFORM LIST] > {MACRO} >{R1-TCH}.

Fig. 4-6: R1-TCH Macro



2. Insert R1-TCH macro instruction into job [ENTER] or [INSERT] > [ENTER].
3. Edit argument data:
   a) Cursor to the Instruction side of the robot job.
   b) Cursor to the R1-TCH macro instruction.
   c) Press [SELECT] > [SELECT]. The Argument Setting screen appears.
   d) Verify arguments are set properly for the application. To modify arguments, cursor to argument, press [SELECT], type in the numerical data, and press [ENTER].
   e) Cursor to Robot Position 1. Jog the robot to the desired start point and press [MODIFY] > [ENTER].
   f) Cursor to Robot Position 2. Jog robot towards surface (non-lap leg) desired to detect and press [MODIFY] > [ENTER].
   g) Cursor to Robot Position 3. Jog robot towards lap surface desired to detect and press [MODIFY] > [ENTER].
   h) Set Auto Teach mode (detailed description below) to a value of 1 cursor to Auto Teach argument, press [SELECT], type the number, and press [ENTER].
4. Save argument data into robot job. From the Argument Setting screen press [ENTER] > [ENTER].
5. Execute R1-TCH macro in Auto Teach = 1 Mode. Press [INTER LOCK] + [TEST START].

6. When the part surface is detected, the robot stops and a message is displayed at the bottom of the teach pendant screen prompting the user to Modify Robot Pos 2, set TEACH to 2.
    a) Re-open the Argument Setting Screen
        - Cursor to R1-TCH macro instruction on instruction side of robot job.
        - Press [ENTER] > [ENTER].
    b) Cursor to the Robot Position 2 argument, press [MODIFY] > [ENTER].
    c) Set AutoTeach mode (Auto Teach) to a value.
7. Save argument data into robot job. From the Argument Setting screen press [ENTER] > [ENTER].
8. Execute R1-TCH macro in Auto Teach: press [INTER LOCK] + [TEST START].
9. When the part surface is detected, the robot stops and a message is displayed at the bottom of the teach pendant screen prompting the user to Modify Robot Pos3, set TEACH to 0.
    a) Re-open the Argument Setting Screen.
        - Cursor to R1-TCH macro instruction on instruction side of robot job.
        - Press [ENTER] > [ENTER].
    b) Cursor to the Robot Position 3 argument, press [MODIFY] > [ENTER].
    c) Set AutoTeach mode to a value of 0.
    d) Set Shift Variable to the Position Variable (P variable) number to save the shift data.
    e) From the Argument Setting screen press [ENTER] > [ENTER].

The R1-TCH macro is now ready for playback mode.

Program the weld path using a Shift On instruction. Use the P variable number set above by the Shift Variable argument.

5 EDGE: Edge Finding Routine

5.1 Features

The EDGE macro is used to detect the location of an edge on a flat surface. Several different pattern types are available to assist in the detection of the surface's edge. Some of the pattern types offer the ability to detect the orientation of the flat surface before scanning across to locate the edge. Some pattern types use a step motion to locate the edge, others use a drag motion (for use with a laser sensor). There are pattern types that measure the width of the weld joint gap and others that detect and react to the orientation of the part's surface.

Regardless of the pattern type, the EDGE macro always uses three taught robot positions. These three positions are used to develop search directions and calculate the edge deviation amount based on a previously taught robot position. The edge deviation amount is used as a shift offset. The searching motion begins at Robot Position 1 and moves toward Robot Position 2 while searching for the surface. Then, if enabled by the user, the macro searches three more times for the orientation of the surface of the part.

Once the location (and optionally the orientation of the surface) is detected, the robot moves parallel to the surface (using either step or drag motion) and the edge of the surface is located. Another optional function can be executed to locate the width of the weld joint gap (in the case of a groove weld). Finally, the detected edge (or detected middle of the joint gap) is compared to the original programmed position and an edge-deviation-amount is calculated and placed into a user-specified P variable. This P variable can then be used to shift the weld path or used in other weld path calculations.

Fig. 5-1: EDGE Detection Mode

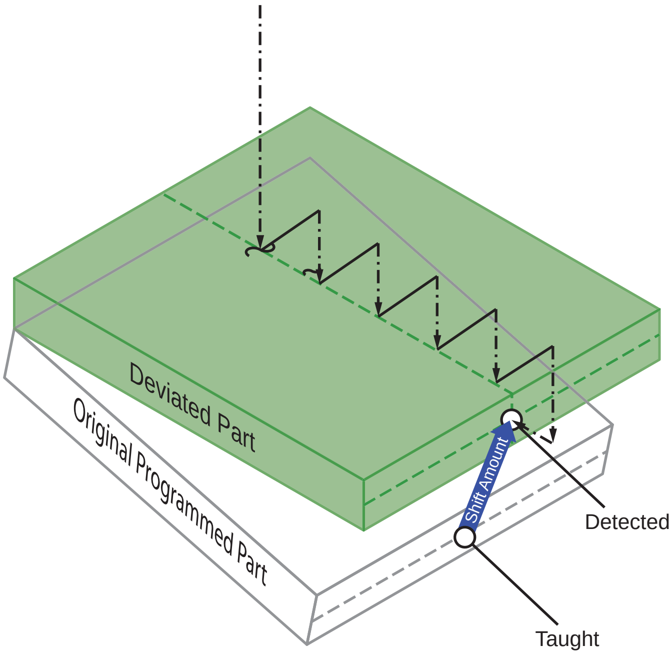
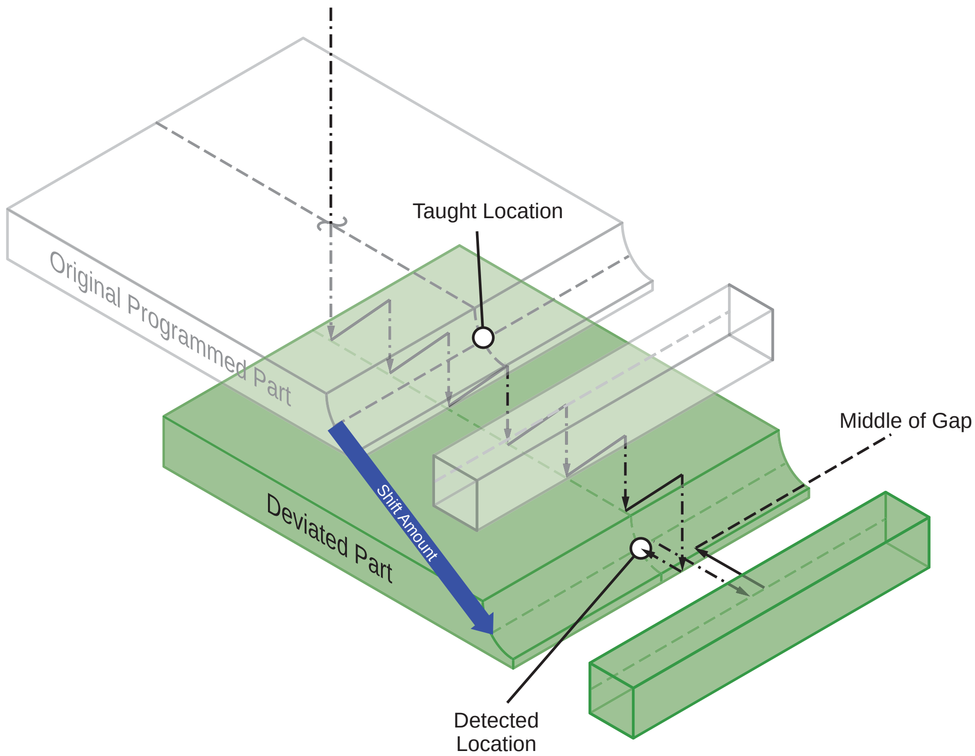


Fig. 5-2: EDGE with Gap Detection



The EDGE macros AutoTeach mode re-defines the location of both the Robot Position 2 and Robot Position 3. Detection of Robot Position 2 always incorporates a routine to ensures the search direction between Robot Position 1 and Robot Position 2 is perpendicular to the part's surface.

5.2 Limitations

The EDGE macro provides X, Y, and Z (translational) shift amounts. It does not provide R_X, R_Y, and R_Z (rotational) shift amounts.

5.3 Macro Job Setup

New systems from Yaskawa Motoman that includes either the Touch Sense option or the AccuFast option, the EDGE routine should already be placed into the robot controller. To verify that the macro job is available in the controller (1) switch to MANAGEMENT mode and then, from the MAIN MENU, press {JOB} > {SELECT MACRO JOB} (should see the EDGE macro job(s) listed) and then (2) open a robot job (ie. R1) then open the [INFROM LIST] and press {MACRO} (should see the EDGE macro instruction(s) listed).

If any of the global settings need changed in the EDGE macro job(s) in the robot controller, first open the macro job (MAIN MENU > {SELECT MACRO JOB} > then select it from the directory list). It is recommend to only change the last value of the SET instructions, and only change the SET instructions that are at the top of the job between the "---- Setup Section … begin ---" and "-- Setup Section … complete -- " sections.

Table 5-1: R1-Edge Macro Setup

Instruction	Explanation
NOP	
'--	
'-----DX-------------------------------	Controller
'- --ver.2.0.0 ------------------------	Version
'- --Yaskawa America Inc.--------	
'----Motoman Robotic Div.--------	
'----2013May06; TL---------------	Revision Date / Developer
'--	
'- For use with Touch Sensing	
' - and/or 1D laser sensor	
'	
'--	
'---- Setup Section ... begin -----	
'--	
'	
'LI8 = Robot Number (ie. R1)	Set to Robot Number in the system.
SET LI008 1	
'	
'If using a laser sensor instead	Value of Rapid input number AccuFast is wired to. Set to "0" if using touch sense.
'of touch sense, LI13 = rapid	
' input # for laser sensor. Set	
' LI13 to 0 if touch sensing is	
' used	
SET LI013 0	
'	
' output door is wired to	Output number laser is wired to set to amount of offset desired for Auto Teach units = mm.
' SET LI014 21	
'	
' LI6 = auto teach offset	
' SET LI006 10	
' SET LD000 LI006	

Instruction	Explanation
'	
' LI0 = non search speed	Speed value for robot to use during air moves. Units mm/sec. max= 3000 of user frame to be created.
SET LI000 3000	
'	
' LB7 = userframe number	Value of user frame to be created.
SET LB007 0	
'	
‘	
LD22 = gap adjustment (microns)	Enter the value of gap adjustment in microns.
SET LD022 1500	
'---	
'- Setup Section ... complete ---	
'--	
'---Do not modify below here---	
'--	

5.4 Interface

The EDGE macro instruction has the following controls inside the argument setting screen.

Fig. 5-3: Argument Settings R1-Edge

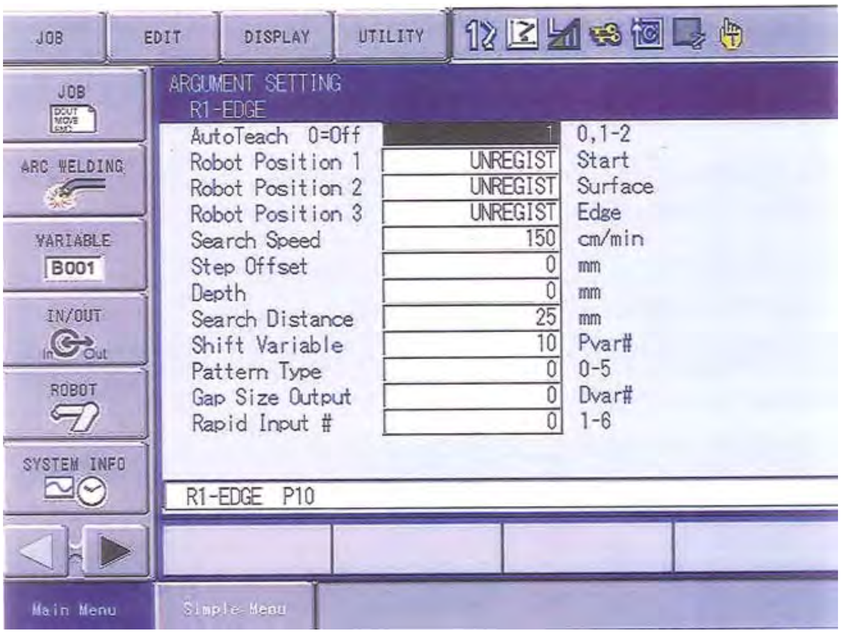


Table 5-2: Argument Settings R1-Edge

Name	Description	Setting; Default	Setting: Allowable Range
AutoTeach 0=off	Auto Teach Mode 0=Auto Teach off 1=Auto Teach first surface 2=Auto Teach second surface	1	0,1,2
Robot Position 1	Start position of search. The distance between Robot Position 1 and Robot Position 2, and between Robot Position 1 and Robot Position 3, define the search window.	UNREGIST	UNREGIST, REGIST
Robot Position 2	The position the robot moves toward while searching for the surface of the part.	UNREGIST	UNREGIST, REGIST
Robot Position 3	Position taught on second surface.	UNREGIST	UNREGIST, REGIST
Search Speed	Speed used during search motion. Units: cm/min	150	(1-1000)
Lap Offset	Offset distance from first detected surface. If set to 0mm, after the robot detects Robot Position 2, it moves back to Robot Position 1 before searching across toward Robot Position 3.	0	0-100

Table 5-2: Argument Settings R1-Edge

Name	Description	Setting; Default	Setting: Allowable Range
Step Offset	Distance between steps / size of each step of motion. Also, the distance between searches when searching for Robot Position 2	0	(0-100)
Depth	Distance below the detected flat surface of the part to be used for search motion.	2	(1-20)
Search Distance	Distance past the programmed Robot Position 2 the robot moves during search. Units: mm.	25	(1-100)
Shift Variable	P-variable number used to store the calculated shift amount data.	10	(0-127)
Pattern Type	This parameter references which motion type is to be used.	0	((0-5) Even numbers reference step motion. Odd number reference drag motion.
Gap Size Output	The number of the D Variable to receive the calculated gap amount	0	(1-99)
Rapid Input #	Rapid Input number to be used.	0	(1-5)

Each of the arguments for the EDGE routine are described below.

> **NOTE** When programming EDGE routines on systems with base axes (ie. B1), additional Robot Positions are included into the Argument Setting list. Each time a Robot Position, is taught ([MODIFY]>[ENTER]) a position for the base axis must also be taught.

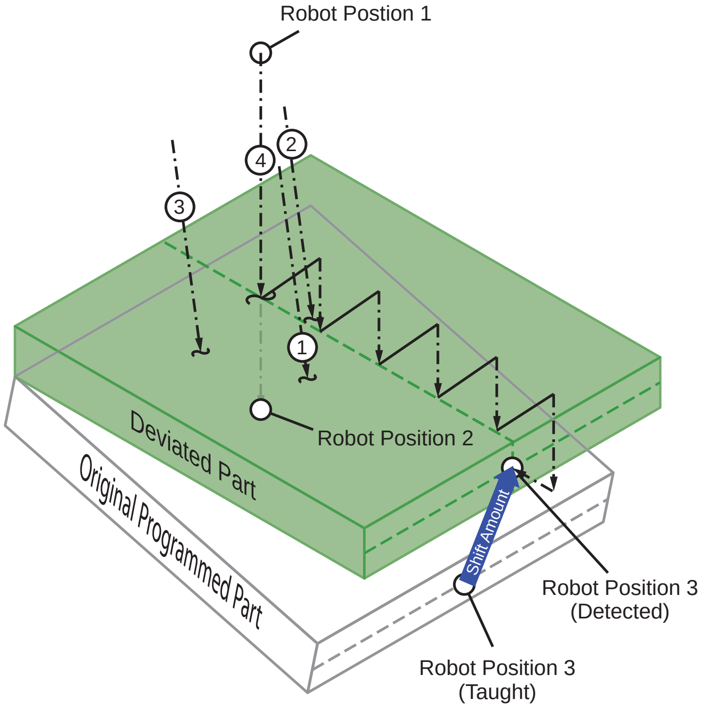
Place the EDGE macro instruction into a robot job, teach the exact location desired to use for the Robot Position 1 and the approximate positions needed for Robot Position 2 and Robot Position 3, and select the type of pattern that is needed for the application. Available pattern types are shown below.

Table 5-3: R1-Edge Call Job

Line	Instruction	Explanation
0000	NOP	
	MOVJ	Approach position
	R1-EDGE P25	Instance of EDGE macro instruction. Shift amount saved to P variable #25 (P025)
	MOVJ	Approach point for welding
	SFTON P025	Enable shift amount from EDGE macro
	MOVJ	Weld start position
	ARCON	

When using Pattern Type 2 or Pattern Type 3, the EDGE mode uses three contact positions to detect the location and orientation of the part's surface, followed by a fourth touch to execute search motion perpendicular to the part surface. From this position, the robot calculates a trajectory towards the edge of the surface, using a drag motion or a series of step movements. When step motion is selected, the size of these steps are based on the search offset distance parameter. The robot executes step motion to search for the edge of the surface. Once the search motion moves off the edge of the part's surface, the robot searches towards the surface edge. Once the edge is detected, this new location is compared to the location of the originally programmed Robot Position 3. The distance between these positions become the calculated shift amount, which is then placed into the P-variable number referenced by the Output P# parameter. An example of a typical playback mode is shown below.

Fig. 5-4: Playback mode for Pattern Type = 2 or 3



5.5 Programming

Programming consists of three elements: (1) insert macro instruction into robot job and set arguments, (2) teach exact position of Robot Positions (this is typically done semi-automatically using AutoTeach mode) and (3) setting the macro instruction to playback mode and deploying shift amounts for the weld path.

For systems with multiple robots or with external or base axes, select the relevant EDGE routine (ie. R2-EDGE).

Insert EDGE macro instruction:

1. While in Teach Mode, from a robot job select: [INFORM LIST] > {MACRO} > {R1-EDGE}.

Fig. 5-5: EDGE Macro

2. Insert EDGE macro instruction into job by pressing [ENTER] or [INSERT] > [ENTER].
   - Touch Sense
     For touch sense applications, it is customary to program a wire cut operation and then touch sense the weldment. After touch sensing of various weld joints is completed, weld passes are programmed and shift offsets developed during the touch sense events. In this situation, the robot programmer needs to lay out which P variables are to be used for which weld so that the same P variables are not used twice for a given touch sense-then-weld series.
   - AccuFast
     As the laser sensor needs no pre-seam finding preparation, the robot programmer has the liberty to seam find > weld > seam find > weld > etc. Thus, for some applications the robot programmer can re-use the same P variable over and over.
3. Edit argument data:
   a) Cursor to the Instruction side of the robot job.
   b) Cursor to the R1-EDGE macro instruction.
   c) Press [SELECT] > [SELECT]. The Argument Setting screen appears.

d) Verify arguments are set properly for the application. To modify arguments; cursor to argument, press [SELECT], type in the numerical data, and press [ENTER]. Set the value of the Pattern Type argument for desired application.

e) Cursor to Robot Position 1. Jog the robot to a position to use as the start position and press [MODIFY] > [ENTER].

f) Cursor to Robot Position 2. Jog the robot to a position near the flat surface to detect and press [MODIFY] > [ENTER].

g) Cursor to Robot Position 3. Jog the robot to a position near the edge of the surface (its best to move the robot slightly past the edge) desired to detect and press [MODIFY] > [ENTER].

h) Set AutoTeach Mode to a value of 1:

4. Save argument data into robot job: from the Argument Setting screen press [ENTER] > [ENTER].

5. Define new Robot Position 2.

a) Hold down [INTER LOCK] + [TEST START] while the cursor is on the R1-EDGE macro instruction.

b) After the robot has successfully located the new position, it will stop its motion and display an instruction at the bottom of the teach pendant screen prompting user to: Modify Robot Pos 2 set TEACH to 1. Follow the displayed instructions by re-opening the R1-EDGE macro instruction [SELECT] > [SELECT] from the instruction side of the macro instruction, cursor to the Robot Position 2 parameter and press [MODIFY] > [ENTER], then cursor to the Auto Teach mode parameter; press [SELECT] > 2 > [ENTER].

c) Save data to the robot job by pressing [ENTER] > [ENTER].

6. Define new Robot Position 3.

a) Hold down [INTER LOCK] + [TEST START] while the cursor is on the R1-EDGE macro instruction.

b) After the robot has successfully located the new position, it will stop its motion and display an instruction on the bottom of the teach pendant screen prompting user to: Modify at Robot Pos 3; set TEACH to 0. Follow the displayed instructions by re-opening the R1-EDGE macro instruction [SELECT] > [SELECT] from the instruction side of the macro instruction), cursor to the Robot Position 3 argument setting and then press [MODIFY] > [ENTER], then cursor to the Auto Teach argument setting and type [SELECT] > 0 > [ENTER].

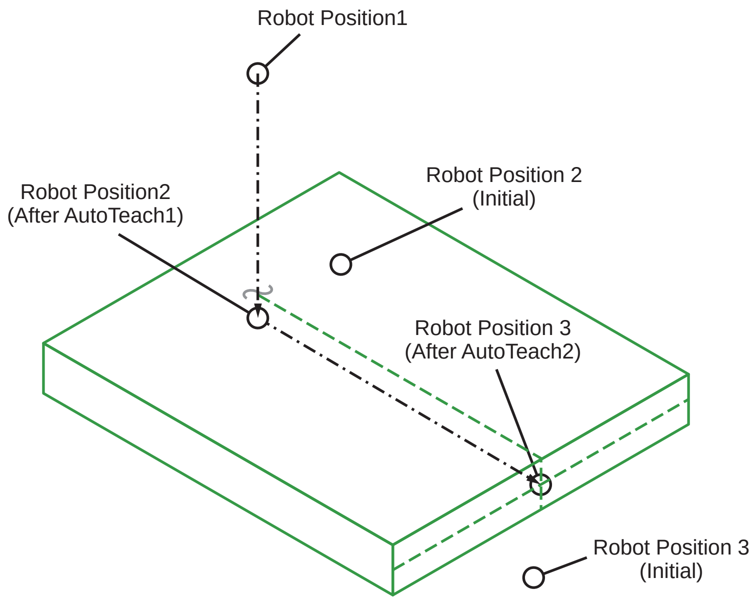
c) Save the above data to the robot job by pressing [ENTER] > [ENTER].

7. For this instance of the R1-EDGE macro instruction, teaching is now complete. It is now ready for routine playback.

5.6 AutoTeach

As stated previously, the AutoTeach feature defines the exact location of the Robot Position 2 and Robot Position 3. When AutoTeach is set to mode 1, the robot detects the exact position for Robot Position 2. When AutoTeach is set to mode 2, the robot detects the exact position for Robot Position 3. AutoTeach for EDGE Macro; Pattern Type = 1; Teach mode = 1 is shown in *Fig.5-6 AutoTeach for EDGE Macro*

Fig. 5-6: AutoTeach for EDGE Macro



Once the initial reference position are taught, the robot detects a new location for the Robot Position 2 and Robot Position 3 points using AutoTeach. The location of these positions are displayed in the drawings below. The exact location of these positions are dependent on the selected Pattern Type and Step Offset parameters. In general, the AutoTeach argument will:

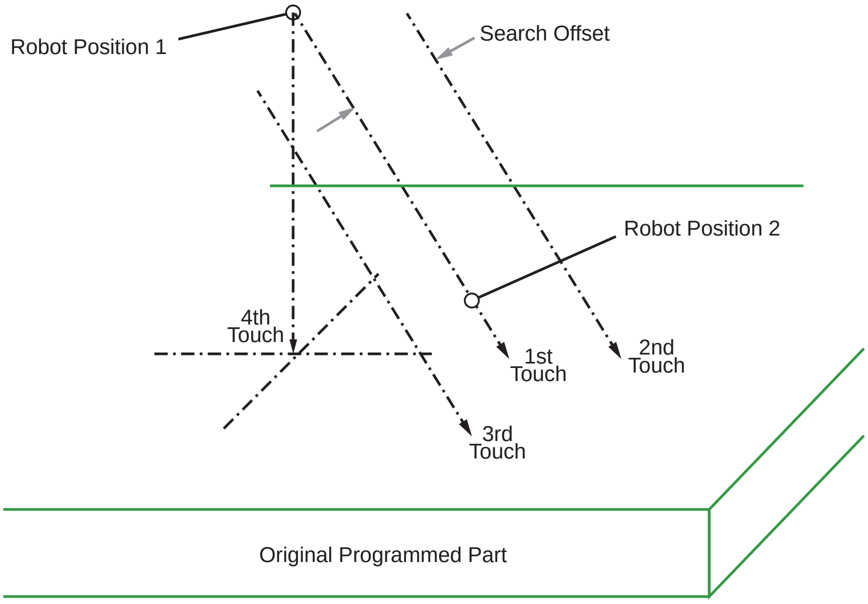
- Develop a search direction from Robot Position 1 to the surface of the part, while ensuring this motion is perpendicular to this surface.
- Develop a search direction from Robot Position 2 to Robot Position 3 that is perpendicular to the first search and perpendicular to the edge.

5.6.1 AutoTeach 1 (Robot Position 2)

AutoTeach mode 1 locates the exact location for Robot Position 2 by executing the following sequence:

1. Robot will touch or drag the surface three times to define the location and orientation of the part's surface.
2. Robot will then touch or drag a fourth time with a perpendicular search direction.

Fig. 5-7: Surface Detection



Searching - Part Surface

Examples

The following diagrams show the AutoTeach function with each pattern type available:

Fig. 5-8: Pattern Type 0, AutoTeach 1

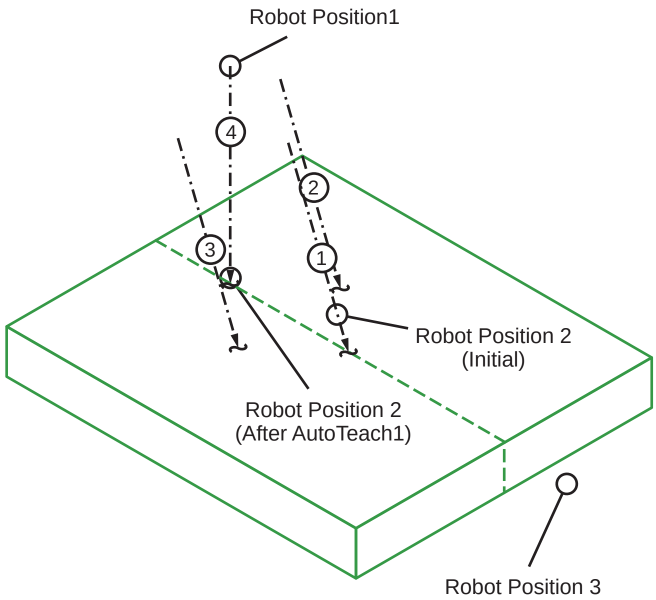


Fig. 5-9: Pattern Type 1, AutoTeach 1

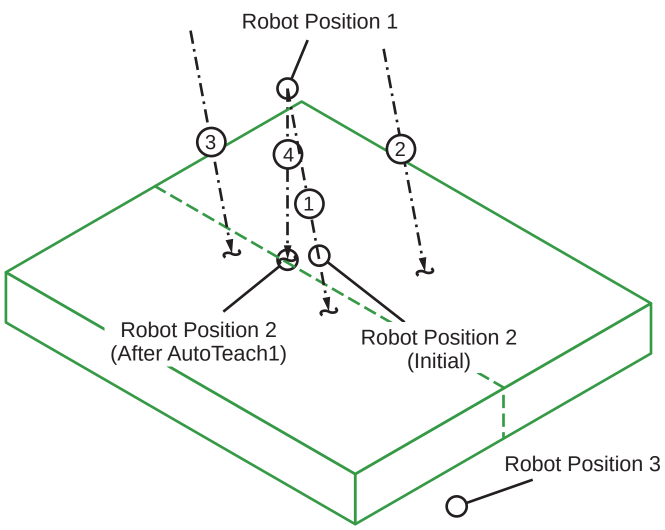


Fig. 5-10: Pattern Type 2, AutoTeach 1

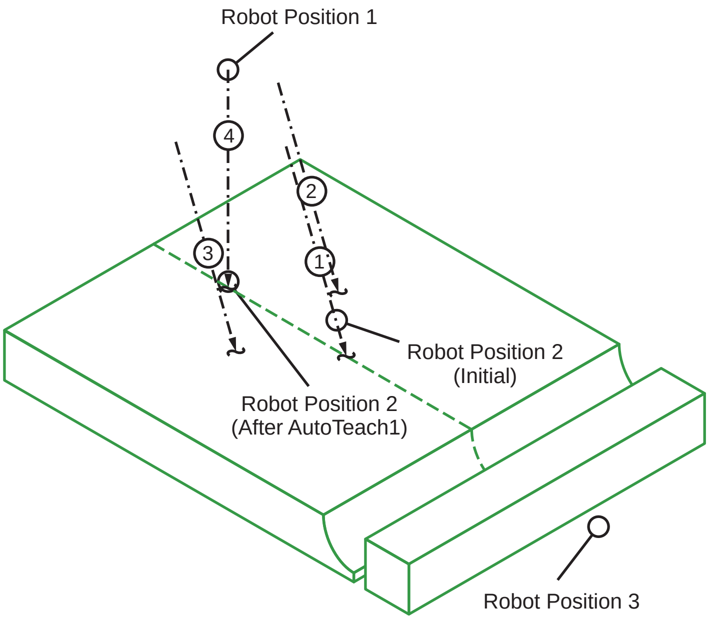


Fig. 5-11: Pattern Type 3, AutoTeach 1

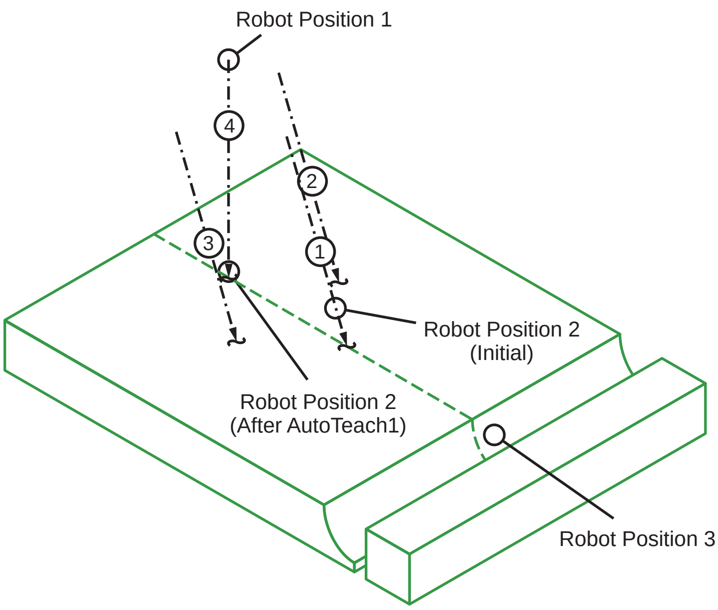


Fig. 5-12: Pattern Type 4, AutoTeach 1

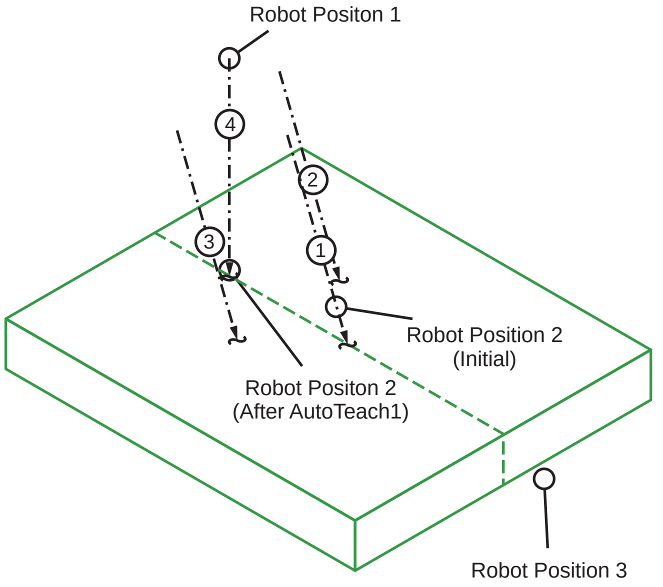
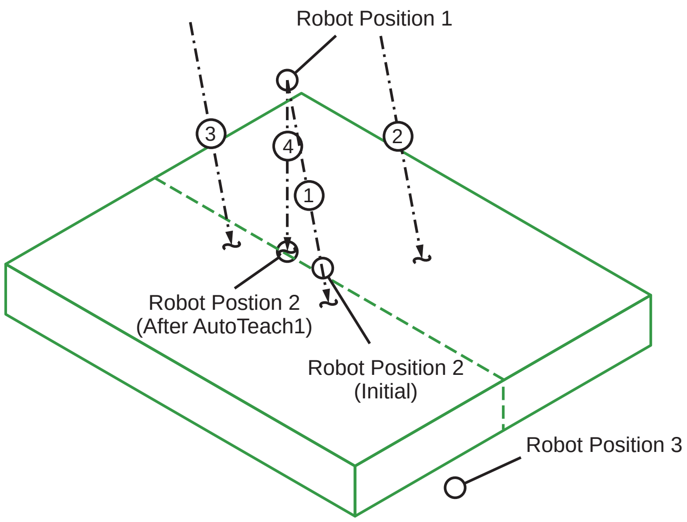


Fig. 5-13: Pattern Type 5, AutoTeach 1



- **Programming**

To define a new Robot Position 2 using AutoTeach 1, proceed as follows:

1. Place the cursor on the EDGE macro instruction and press and hold the [INTER LOCK] + [TEST START] buttons.
2. After the robot has successfully located the new position, it stops its motion and the following instruction is displayed at the bottom of the teach pendant screen prompting the user to: Modify Robot Pos 2; set TEACH to 1.
3. Follow the displayed instructions.
   a) Re-open the EDGE macro instruction by pressing [SELECT] > [SELECT] from the instruction side of the macro instruction.
   b) Cursor to the Robot Position 2 parameter and press [MODIFY] > [ENTER].
   c) Cursor to the Auto Teach mode parameter and type [SELECT] > 2 > [ENTER].

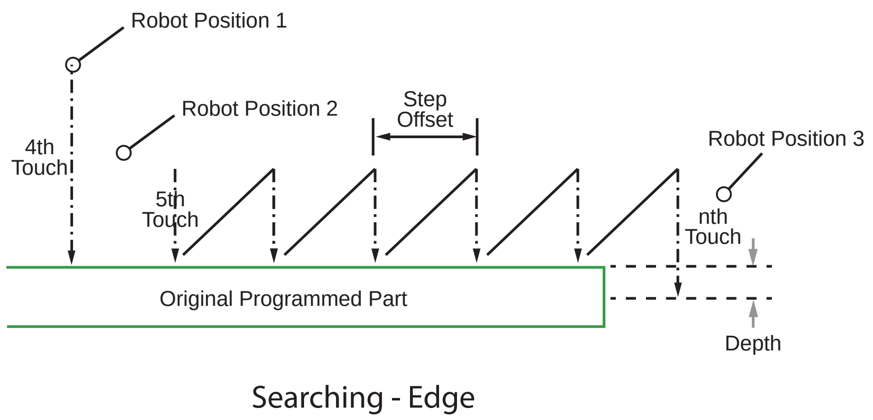
4. Save the above data to the robot job by pressing [ENTER] > [ENTER].

5.6.2 AutoTeach 2 (Robot Position 3)

AutoTeach mode 2 locates the exact location for Robot Position 3 by executing the following sequence:

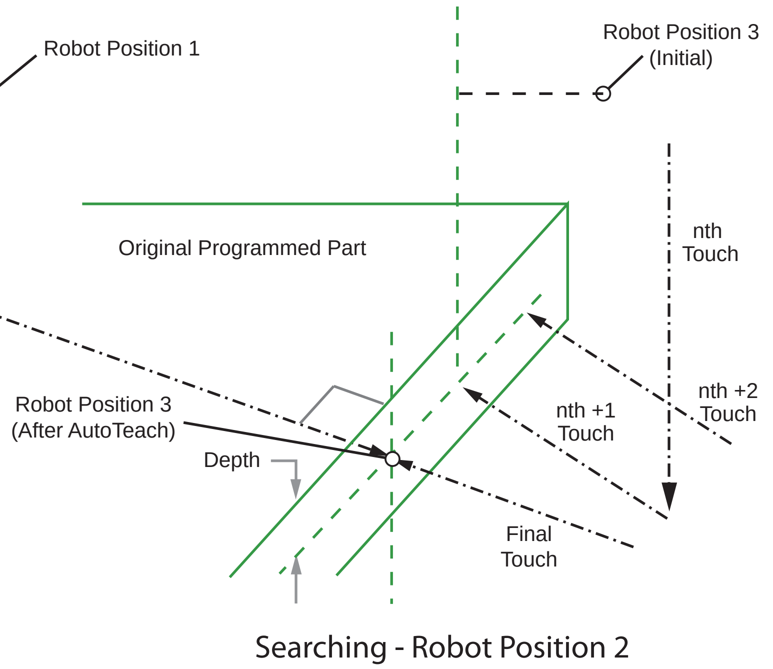
1. Robot will step or drag toward the pre-programmed edge of the work piece (Robot Position 3).
2. Once the robot searches off the edge of the part, the robot drops below the surface of the part.

Fig. 5-14: Edge Detection



3. Robot will touch or drag the edge surface two times to define the orientation of the edge surface.
4. Robot will then touch or drag a third time with a perpendicular search direction.

Fig. 5-15: Reference Position 3Detection



After the robot completes the search motion, a message is displayed at the bottom of the teach pendant screen prompting user to Modify Robot Pos 3; set TEACH to 0. After the robot programmer follows the instructions, this instance of the EDGE macro instruction is ready for Playback mode (Auto Teach argument =0.)

■ **Parameters**

The Search Distance argument defines the allowable distance of the calculated shift amount. The robot develops search motion so it does not search excessively beyond the Search Distance amount. The exact definition of the Search Distance amount is shown in the following three figures:

Fig. 5-16: Maximum Search Distance: OK

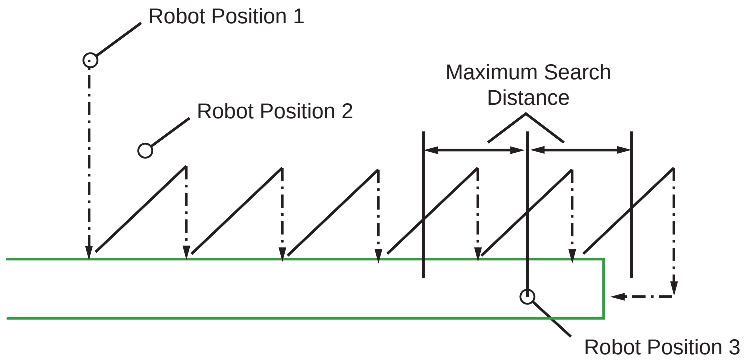


Fig. 5-17: Maximum Search Distance: Out of Limit

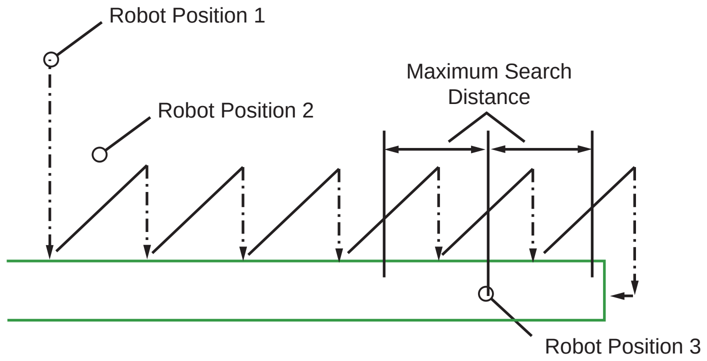


Fig. 5-18: Maximum Search Distance: Out of Limit

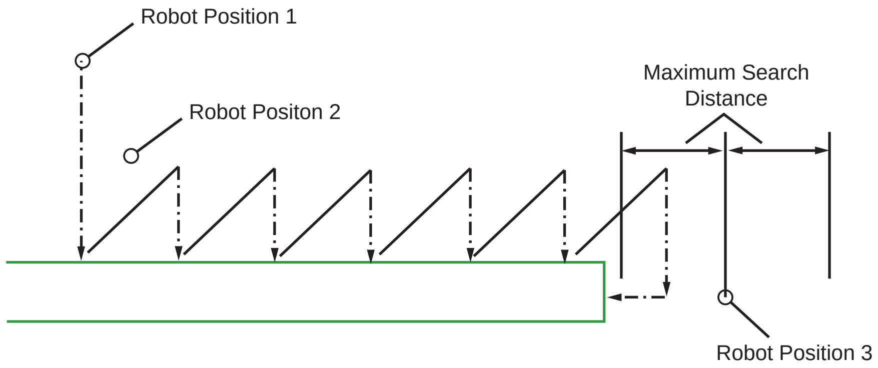
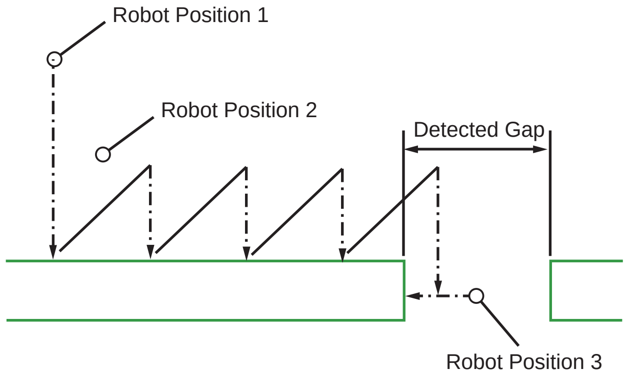


Fig. 5-19: EDGE with Gap Search Distance



■ **Examples**

The following diagrams show the AutoTeach function with each pattern type available:

Fig. 5-20: Pattern Type 0, AutoTeach 2

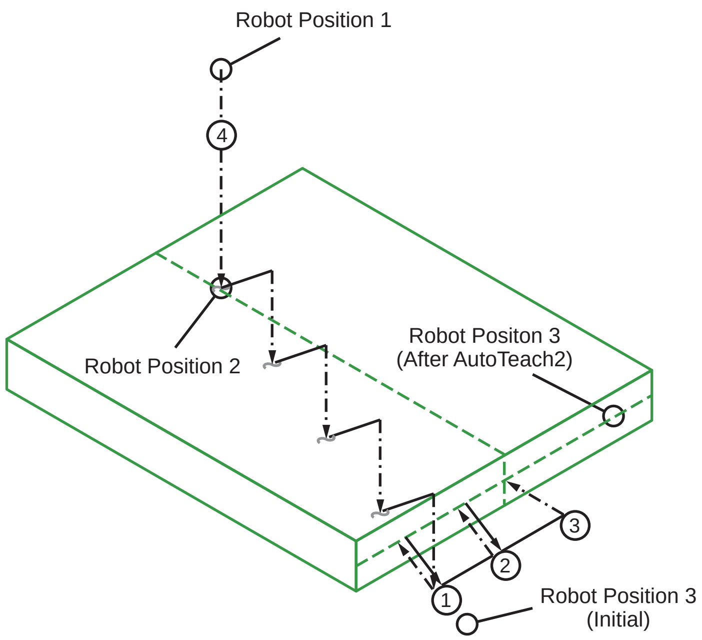


Fig. 5-21: Pattern Type 1, AutoTeach 2, Step Offset 0

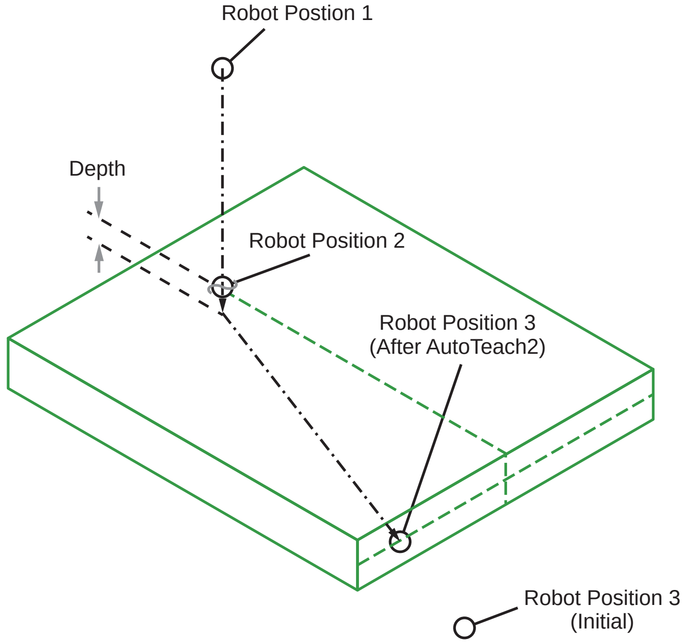


Fig. 5-22: Pattern Type 1, AutoTeach 2, Step Offset >0

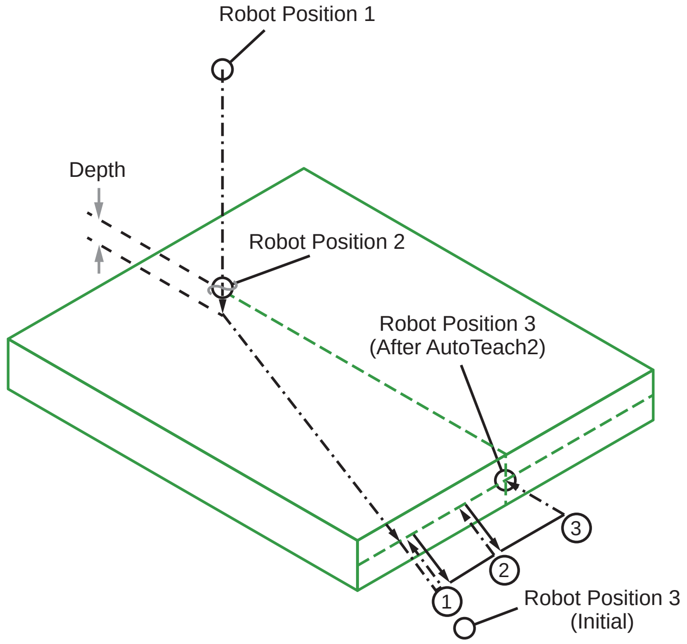


Fig. 5-23: Pattern Type 2, AutoTeach 2

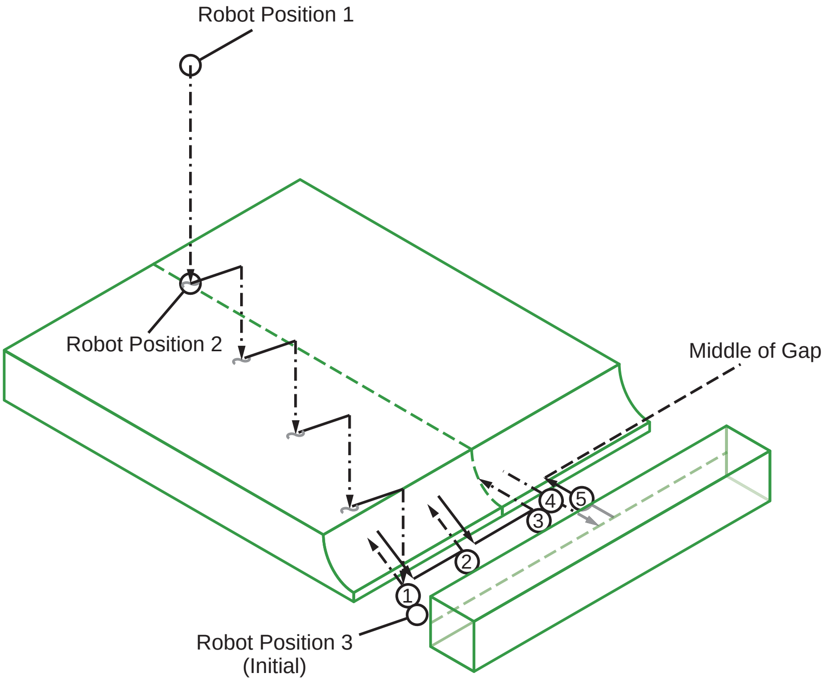


Fig. 5-24: Pattern Type 3, AutoTeach 2, StepOffset = 0

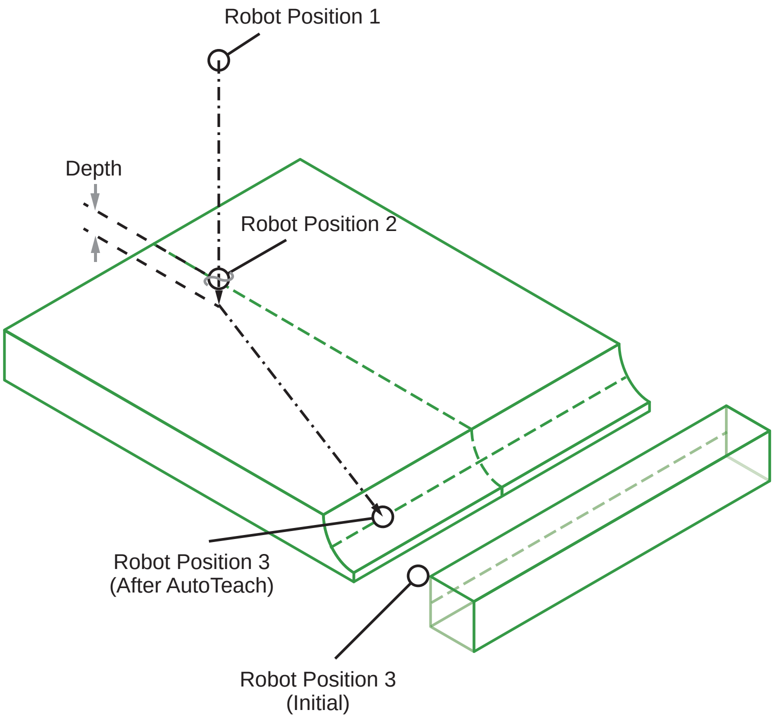


Fig. 5-25: Pattern Type 3, AutoTeach 2, Step Offset >0

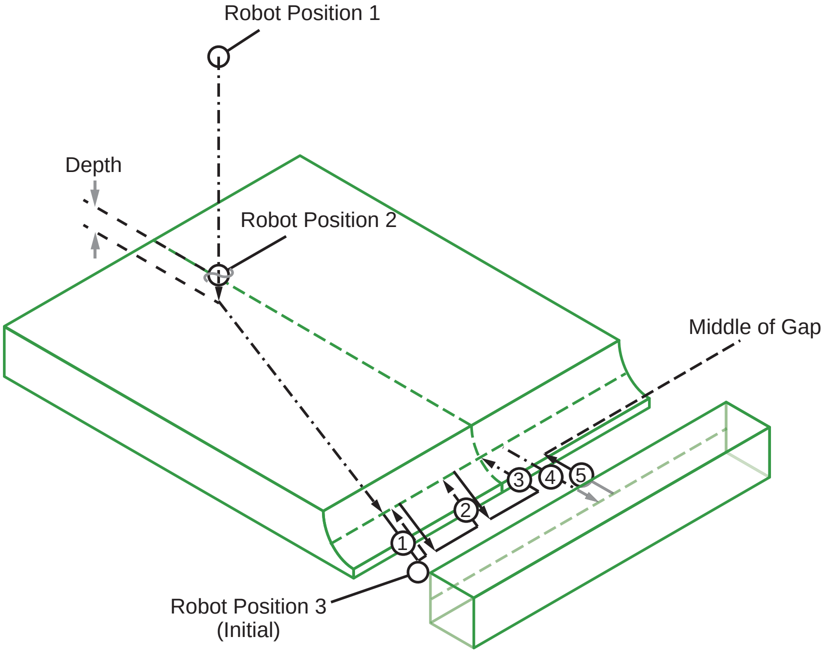


Fig. 5-26: Pattern Type 4, AutoTeach 2

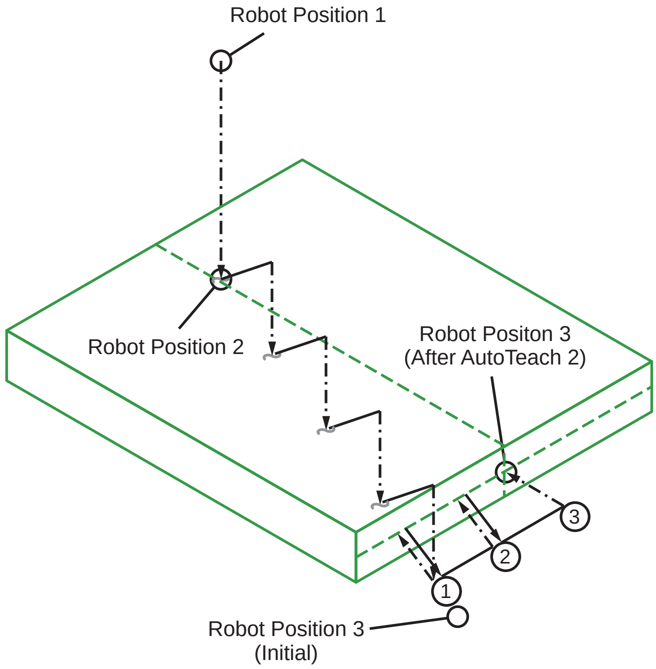


Fig. 5-27: Pattern Type 5, AutoTeach 2, Step Offset = 0

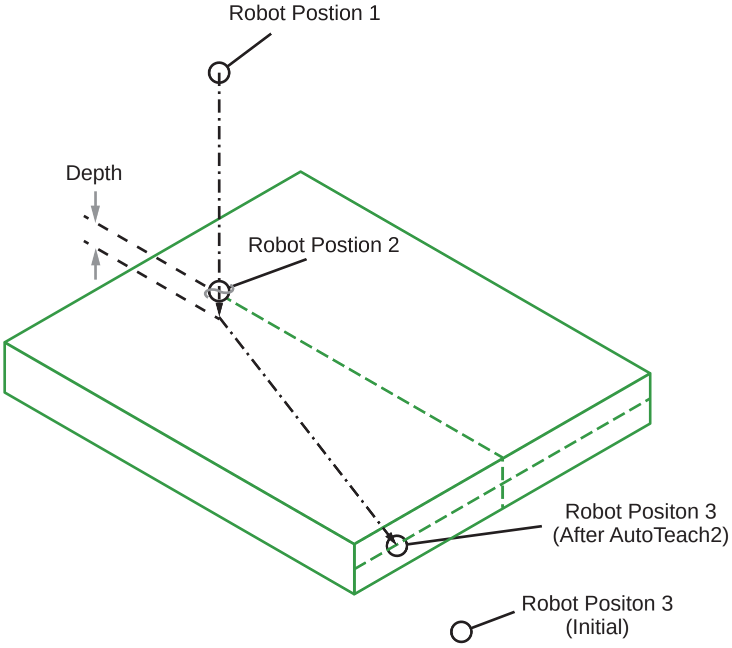
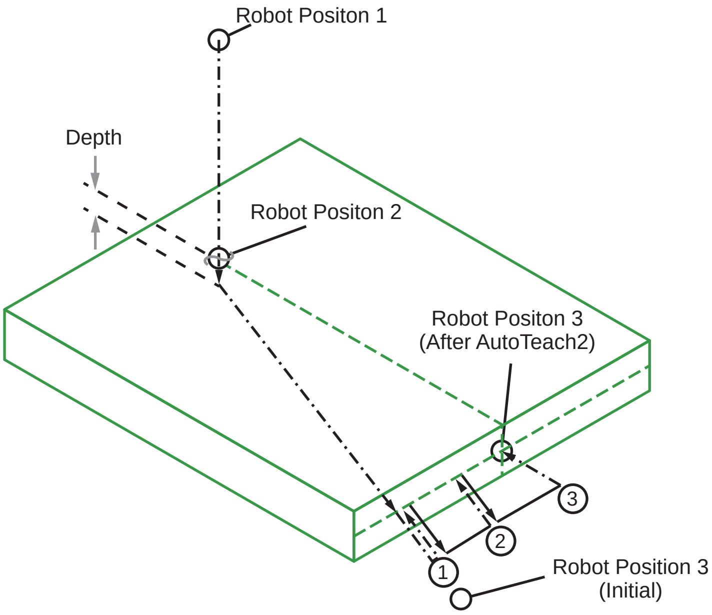


Fig. 5-28: Pattern Type 5, AutoTeach 2, Step Offset > 0



- **Programming**

1. Define a new Robot Position 3 by holding down [INTER LOCK] + [TEST START] while the cursor is on the EDGE macro instruction.
2. After the robot has successfully located the new position it stops motion and displays the following instructions on the bottom of the teach pendant screen: Modify Robot Pos 3; set TEACH to 0.

3. Follow the displayed instructions by re-opening the EDGE macro instruction.
    a) From the instruction side of the macro instruction, press [SELECT] > [SELECT].
    b) Cursor to the Robot Position 3 parameter and press [MODIFY] > [ENTER].
    c) Cursor to the teach mode parameter and type [SELECT] > 0 > [ENTER].
4. Save the above data to the robot job by pressing [ENTER] > [ENTER].

For this instance of the EDGE macro instruction, teaching is now complete.

Insert the [SFTON] instruction into the weld job. The Shift On instruction is located in the [INFORM LIST]> {SHIFT} > {SFTON}. Set the P variable number to the value used in the previously taught EDGE macro instruction.

NOTE: Calculations (combining / partitioning shift amounts) may be needed in order to develop the necessary shift amount for the weld seam. Such calculations are outside the scope of this manual. Yaskawa Motoman offers training classes that covers these types of scenarios.

6 R1 CIRCLE: Circle Touch Routine

6.1 Features

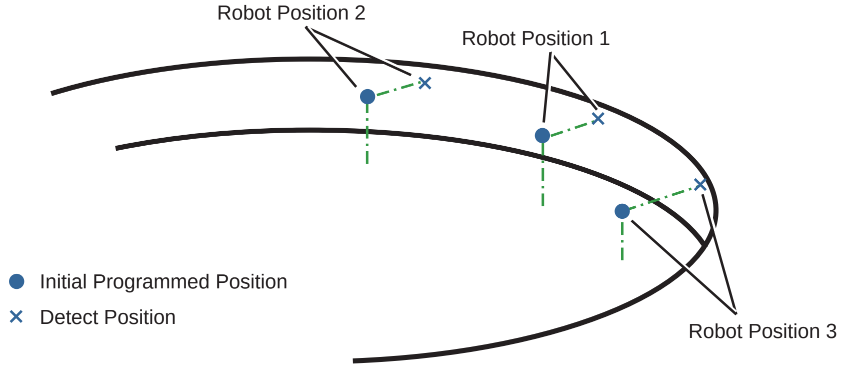
The R1CIRCLE macro detects positional deviations for curved (constant radius) surfaces. A part’s center of curvature (i.e. the center of a circle) is calculated using three detected positions along the surface of the curved part. These positions are then compared with that of a master part and a shift amount is calculated. This shift amount is based on the distance between the center of the master part and the center of the deviated part. This shift amount is then used to shift all positions programmed to the surface of the part (i.e. MOVCs).

The R1CIRCLE macro also detects the diameter of the curved surface and calculates a radial shift amount by comparing this diameter to the diameter of the master part. This shift amount can be used to shift all position ss programmed to the surface of the part (i.e. MOVCs) to account for a change in diameter of the part's surface.

6.1.1 Three Touch Routine

The location of the center of a circle is calculated based on the position of three macro reference positions. This routine touches three positions of a recessed (inside) circle. The first touch is made from the center of circle reference position toward the Robot Position 1. The 2nd and 3rd touches are perpendicular to the first touch-sensing path and also perpendicular to the Z direction of the base frame.

Fig. 6-1: Three Touch Routine



Position of Robot Positon in DIA-CALC Macro Instruction

6.1.2 Shift Amount - Center of Circle

The center of a circle is calculated based on three touches on the circle. The new center is compared to the center of the programmed master part and a shift amount is saved to a pre-determined P-Variable.

6.1.3 AutoTeach Mode

The AutoTeach macro mode has 3 teach modes for detection of the three macro reference positions. The user teaches the robot close to the locations on the wall of a circle and the robot detects these exact positions.

6.1.4 Limitations

The CIRCLE routine works only on circles that lie perpendicular to either the XY, YZ, or XZ plane. Cylinders / cylindrical surfaces where the axis of the cylinder is not perpendicular to the X, Y or Z axis of Base Frame are not supported by the macro.

6.2 Programming Requirements

The three detected positions must lie on a specific plane of the base frame or robot frame. These three positions must lie in either the XY plane, YZ plane, or XZ plane.

The three reference positions in the macro instruction must be programmed in a specific manner. These specifics are discussed in detail below.

The R1CIRCLE macro develops shift amounts based on X, Y, and Z directions.

The circle diameter argument is used to qualify if the calculated shift amount is within acceptable limits. It is possible for errors to exist in the calculation due to inaccurate detection of the curved surface. The inaccurate detections can occur due to the presence of weld tacks, larger spatter balls, etc. To limit the possibility of incorrect shift amounts being produced, the detected circle diameter is compared to the value of the circle diameter parameter, and if the calculated diameter is greater than 25% or more of the value of circle diameter, the shift amount is not stored into the P variable.

6.3 Job Setup

Table 6-1: R1 Circle Macro Setup

Instruction	Explanation
NOP	
‘--	
‘-----DX-------------------------------	Controller
'- --ver.2.0.0 ------------------------	Version
'- --Yaskawa America Inc.--------	
'----Motoman Robotic Div.--------	
‘----2013May06; TL----------------	Revision Date / Developer
‘--	
'- For use with Touch Sensing	
' - and/or 1D laser sensor	
‘	
'--	
'---- Setup Section ... begin -----	
'--	
‘	
'LI8 = Robot Number (ie. R1)	Set to Robot Number in the system.
SET LI008 1	
‘	

Instruction	Explanation
‘If using a laser sensor instead	Value of Rapid input number AccuFast is wired to. Set to “0” if using touch sense.
‘ of touch sense, LI13 = rapid	
' input # for laser sensor. Set	
' LI13 to 0 if touch sensing is	
' used	
SET LI013 0	
'	
' output door is wired to	Output number laser is wired to set to amount of offset desired for Auto Teach units = mm.
SET LI014 21	
'	
' LI6 = auto teach offset	
SET LI006 10	
SET LD000 LI006	
'	
' LI0 = non search speed	Speed value for robot to use during air moves. Units mm/sec. max= 3000 mm/sec of user frame to be created.
SET LI000 3000	
'	
‘ LR4=AllowShiftAmnt as a	Allowable shift amount in a percentage of the taught circle.
‘ % of Taught circle dia.	
Set LR004 10	
JUMP *ngDiachk IF LR004<1	
JUMP *ngDiachk IF LR004>20	
DIV LR004 100	
‘	
‘ Dvar Output for Diameter	Diameter measurement of circle out put number
‘ Measurement	
Set LB003 99	
'---	
'- Setup Section ... complete ---	
'--	
'---Do not modify below here---	
'--	

Table 6-2: R1 Circle Call Job

Instruction	Explanation
NOP	
MOVJ	//Approach position
R1CIRCLE	//instance of R1CIRCLE macro instruction. Shift amount saved to P variable #25 (P025)
MOVJ	//approach point for welding
SFTON PO25	//Enable change-in-center shift amount from R1CIRCLE macro
MOVJ	//Weld start position
ARCON	
MOVC	//second weld position
MOVC	//third weld position

6.4 Interface

The R1CIRCLE macro instruction includes the following controls inside the argument setting screen.

Fig. 6-2: Argument Settings R1Circle

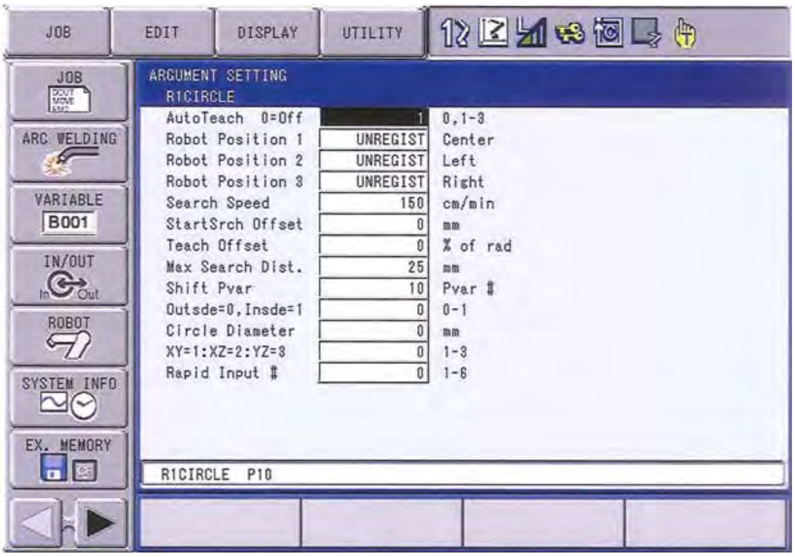


Table 6-3: Argument Settings R1Circle

Argument Name	Description	Default Setting	Allowable Setting Range
Auto Teach 0=off	Auto Teach Mode 0 = Auto Teach off 1 = Auto Teach first surface 2 = Auto Teach second surface	1	0,1,2,3
Robot Position 1	Reference position programmed in the center position on the arc surface.	UNREGIST	UNREGIST, REGIST
Robot Position 2	Robot Position programmed in the left position on the arc surface.	UNREGIST	UNREGIST, REGIST
Robot Position 3	Reference position programmed in the right position on the arc surface.	UNREGIST	UNREGIST, REGIST

Table 6-3: Argument Settings R1Circle

Argument Name	Description	Default Setting	Allowable Setting Range
Search Speed	Speed used during search motion. Units are cm/ min.	150	1-1000
StartSrch Offset	Distance the start position is away from surface. Units = mm	25	1-100
Teach Offset	Offset distance between 1st and 2nd, and between 1st and 3rd position. The distance is calculated by multiplying the diameter of the circle by the value of the Teach Offset argument. 50% ideal in most cases. Units =% of Rad	0	1-100
Max. Search Distance	Distance past the programmed Robot Position 2 the robot moves during search. Units: mm.	25	1-100
Shift Pvar	P-variable number used to store the calculated shift amount data.	10	0-127
Outside=0,Inside =1	Path type: 0 = searches outside of circle, 1 = searches inside of circle.	0	0 or 1
Circle Diameter	Diameter of circle being searched. The value of this argument should be set to as close to the actual diameter of the curved surface as possible in order to provide for accurate qualification of the maximum shift value.	0	minimum of 1
XY=1:XZ=2:YZ=3	Searching Plane circle is on.	0	1,2 or 3
Rapid Input #	Select rapid input to be used.	0	1-5

6.5 Programming

6.5.1 Programming AutoTeach for the R1CIRCLE Macro

1. Insert R1CIRCLE macro instruction into the robot job. The R1CIRCLE macro can be accessed from pressing [INFORM LIST] and then {MACRO}.

Fig. 6-3: R1CIRCLE Macro

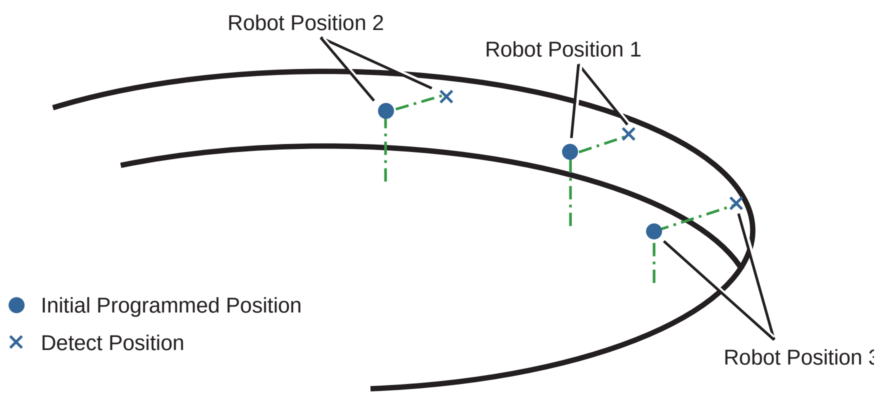
2. Cursor to the instruction side of the macro instruction and press [SELECT] > [SELECT]. The Argument Setting screen appears.

6.5.1.1 Setup Macro Instruction and Detect Robot Position 1

1. Cursor to Auto Teach. Enter 1 in the input field and press [ENTER].
2. Teach the initial positions for the three Robot Positions.
    a) Jog the robot to the approximate position of Robot Position 1 in the diagram below.
    b) Cursor to Robot Positions in the argument setting screen and press [MODIFY] > [ENTER].

Refer to *Figure 6-4* for proper programming locations when programming Robot Positions inside circles.

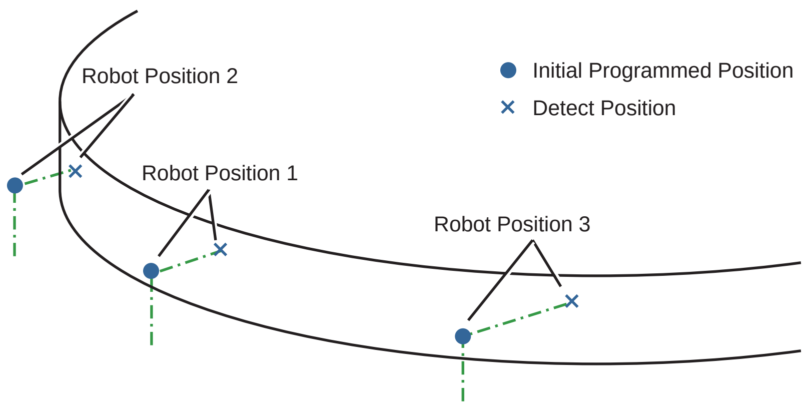
Fig. 6-4: Reference Positions for Inside Diameter



Position of Robot Positon in DIA-CALC Macro Instruction

Refer to *Figure 6-5* for proper programming locations when programming Robot Positions outside circles.

Fig. 6-5: Robot Positions for Outside Diameter

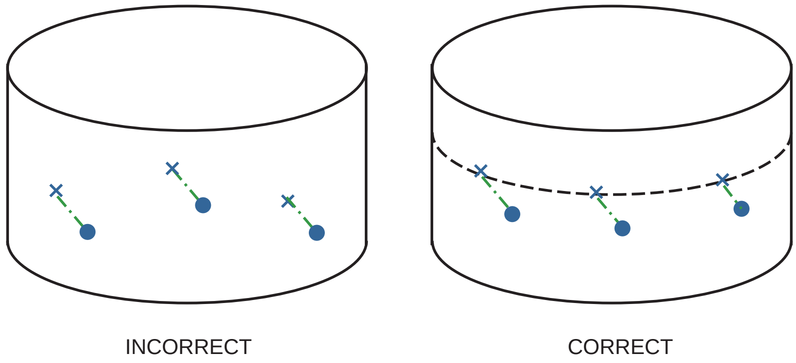


Position of Robot Positions in DIA-CALC Macro Instruction

c) Jog the robot to the approximate position for Robot Position 2 (see diagrams above).
d) Cursor to the Robot Position 2 and press [MODIFY] > [ENTER].
e) Jog the robot to the approximate positions of Robot Position 3 of the circle.
f) Cursor to Robot Position 3 in the argument setting screen and press [MODIFY] > [ENTER].

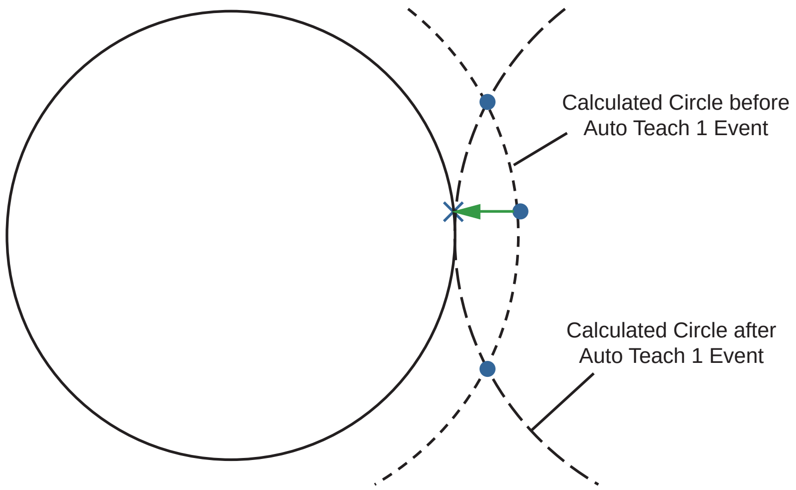
NOTE Program the three robot positions at a consistent height. Avoid having one robot position lower or higher than the other two.

Fig. 6-6: Consistent Programming Height



NOTE Program the initial robot position as close as possible to the surface of the part to avoid the following inverted path problem.

Fig. 6-7: Programming Error: Inverted Path



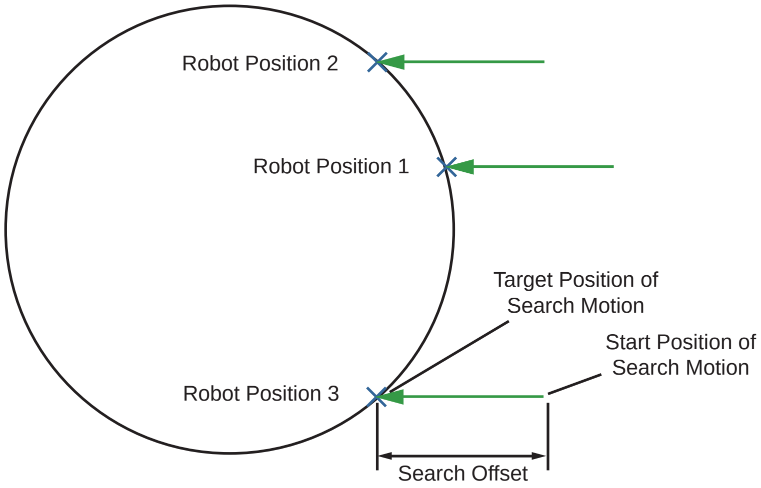
Avoid Inversion of Circle When Programming
Robot Positions with AutoTeach

g) Set Search Speed to a speed appropriate for application. Typical speeds range between 100 and 500 cm/min.

h) Set the Outside=0, Inside=1 parameter to the value correct for the part being programmed.
If programming an inside circle, where the robot positions are programmed between the detection surface and the center of the circle, set this parameter to 1.
If programming an outside circle, where the detection surface is between the robot positions and the center of the circle, then set this parameter to 0.

i) Define the search window. Set the Search Offset parameter to the amount desired to have the robot use as its search window. Set the Max Search Dist parameter to the distance desired for the robot to move past each robot position.

Fig. 6-8: Search Offset Parameter



Search Offset Parameter

> NOTE: In the event the robot detects a tack or flat spot, the calculated center or the circle will not match the actual circles center location. To reduce the magnitude of this error, the distance between Robot Position 1, Robot Position 2, and Robot Position 3 should be as large as possible.

j) For newer versions of this routine, the distance between three Robot Positions (detected during AutoTeach) are only adjustable from the SETUP section in the macro job.

k) Press [ENTER] > [ENTER] to save the Argument Setting Screen data to the robot job header.

l) Press and hold [INTERLOCK] + [TEST START] to execute the macro job. The robot detects three times to find the exact position of the circle. A message at the bottom of the teach pendant screen prompts user to Modify Robot Pos 1, set TEACH to 2.

6.5.1.2 Detect Robot Position 2

a) Open the Argument Setting screen by pressing [SELECT] > [SELECT] from the instruction side of the macro instruction. Modify Robot Position 2, set Auto Teach Mode to 2 and press [ENTER] > [ENTER] to save this new data.

b) Press and hold the [INTERLOCK] + [TEST START] keys to execute the macro job. The robot detects Reference Point 1 again and then touch-senses to find a new Point for Reference Point 2. The robot stops and a message is displayed at the bottom of the teach pendant seen prompting the user to Modify Robot Pos 2, set TEACH to 3.

6.5.1.3 Detect Robot Position 3

a) Access the Argument Setting screen by pressing [SELECT] >[SELECT] from the instruction side of the macro instruction. Modify Robot Position 2, set Auto Teach Mode to 3 and then press [ENTER] > [ENTER] to save this new data.

b) Press and hold the [INTERLOCK] + [TEST START] keys to execute the macro job robot position. The robot detects Robot Position 1 and Robot Position 2 and then moves to find a new position for Robot Position 3. The robot stops and a message is displayed at the bottom of the teach pendant screen prompting the user to Modify the Robot Pos 3; set TEACH to 0 thereby turning Auto Teach Mode OFF.

c) Open the Argument Setting screen by pressing [SELECT] > [SELECT] from the instruction side of the macro instruction.

d) Set the Max Shift Amount parameter accordingly.

e) Modify Robot Position 3, set Auto Teach to 0 and press [ENTER] >[ENTER] to save data. The macro instruction is now ready for Playback mode.

f) Program the Shift On (SFTON) instruction into the robot job.

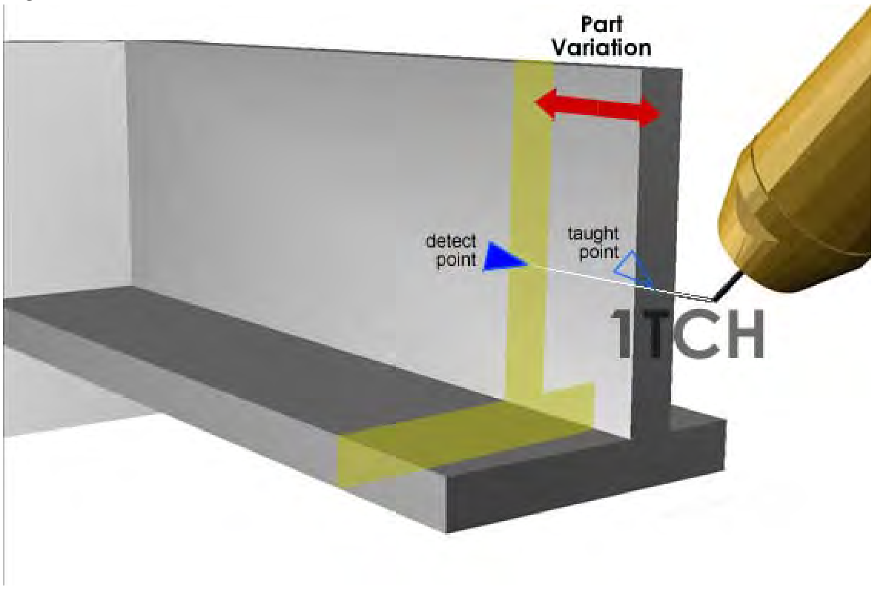
7 Application Examples

7.1 T-Joint

In order to account for variations at the end of a part, a 1TCH routine in tandem with a 2TCH routine can account for three dimensional variation. This process uses the 1TCH routine to detect the edge of the plate. The 2TCH routine is then shifted by the amount developed by the 1TCH routine Finally, the 2TCH routine is used to detect variations perpendicular to the 1TCH routines search direction.

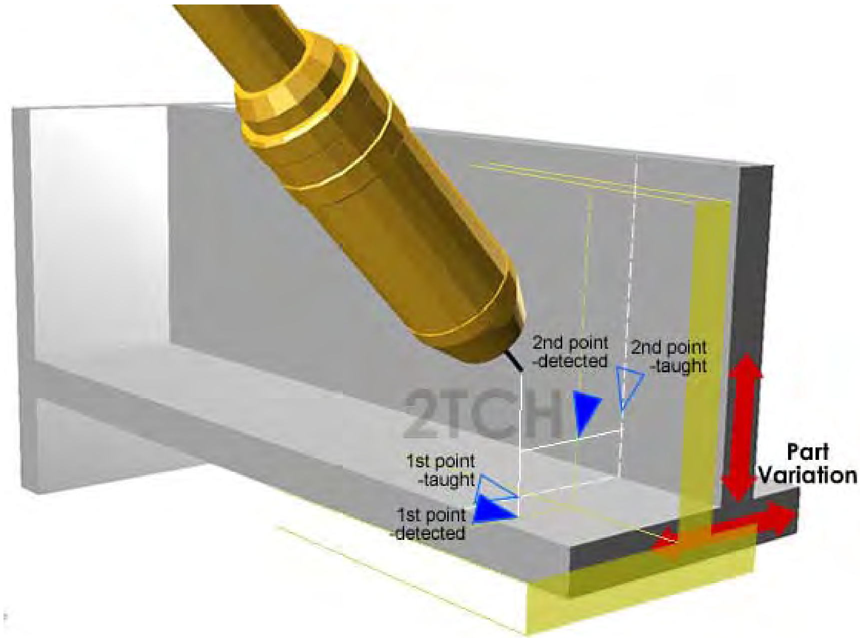
Line	Instruction	Explanation
0000	NOP	
	MOVL	Approach position for 1TCH routine
	1TCH P000	
	MOVL	Departure point for 1TCH routine
	SFTON P000	Execute 1TCH shift amount to shift 2TCH routine
	MOVL	Approach point for 2TCH routine
	2TCH P001	
	MOVL	Departure point for 2TCH routine
	SFTON P001	Execute combined shift amount from 1TCH and 2TCH routines
	MOVL	First weld point
	ARCON	

Fig. 7-1: 1TCH



The 1TCH routine, in this example, detects variations in the Part Variation direction shown in the figure. Results of 1TCH routine are saved to P variable P000. This shift amount is then used to shift the 2TCH routine.

Fig. 7-2: 2TCH



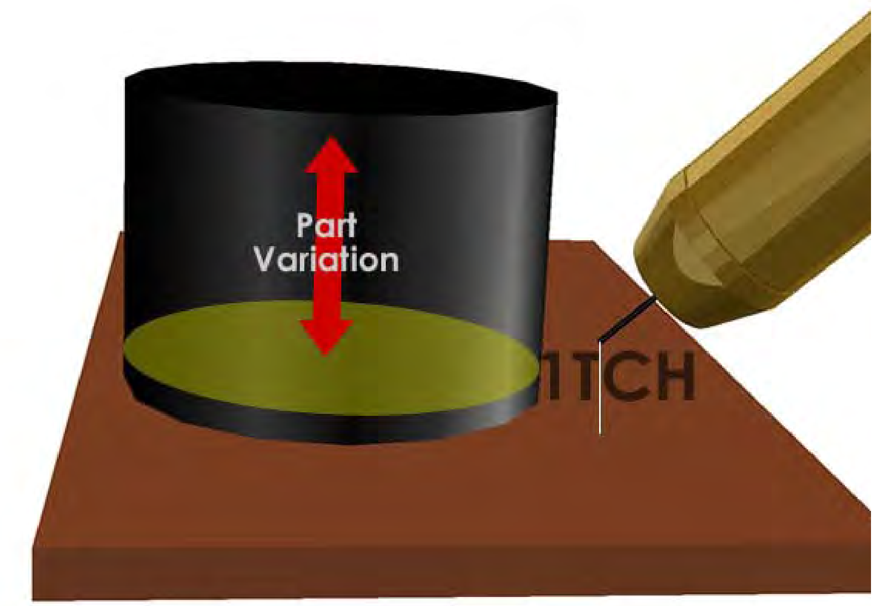
The 2TCH routine detects variations in part location described in the Part Variation directions shown in this figure. The 2TCH routine detects the shift amount, and places this shift amount plus the shift amount in P000 into the P variable P001. Because the 2TCH routine is shifted by the amount detected with the 1TCH routine, the calculated shift amount of the 2TCH routine is based on the amount in P000 added to the amount in P001.

7.2 Cylinder to Plate

The 1TCH routines used to detect vertical variations of the plate. This shift amount is then input into the R1CIRCLE routine, shifting this routine vertically. After execution of the R1CIRCLE routine, the offset is based on before, after and lateral variations, as well as the vertical offset developed by the 1TCH routine.

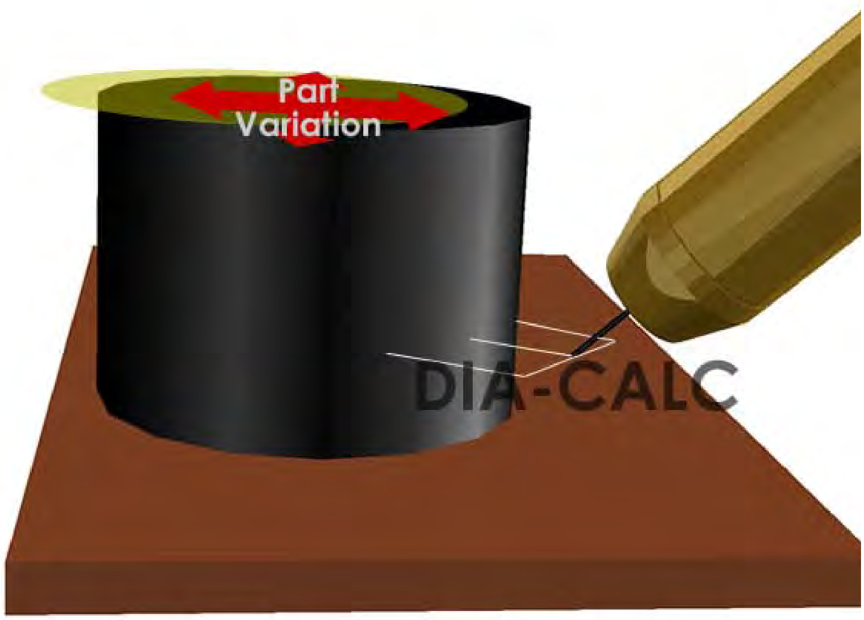
Line	Instruction	Explanation
0000	NOP	
	MOVL	Approach point for 1TCH routine
	1TCH P000	
	MOVL	Departure point for 1TCH routine
	SFTON P000	Execute 1TCH shift amount to shift DIA-CALC routine
	MOVL	Approach point for 2TCH routine
	2TCH P001	
	MOVL	Approach point for R1CIRCLE routine
	R1CIRCLE	
	MOVL	Departure point for R1CIRCLE routine
	SFTON P001 BF	Execute combined shift amount from 1TCH and R1CIRCLE routines. This moves the weld positions to account for positional variations of the part
	SFTON P002 TF	Execute the radial shift from the DIA-CALC routine to shift the weld positions to a larger or smaller diameter pattern
	MOVC	First weld point
	ARCON	
	MOVC	Second weld point
	MOVC	Third weld point
	MOVC	Fourth weld point
	ARCOF	

Fig. 7-3: Part Variation



The 1TCH routine, in this example, detects variations in the Part Variation direction shown in the figure. Results of 1TCH routine are saved to P variable P000. This shift amount is then used to shift the 2TCH routine.

Fig. 7-4: Part Variation R1CIRCLE



8 Programming Suggestions

Fig. 8-1: AccuFast Orientation (Lap Weld)

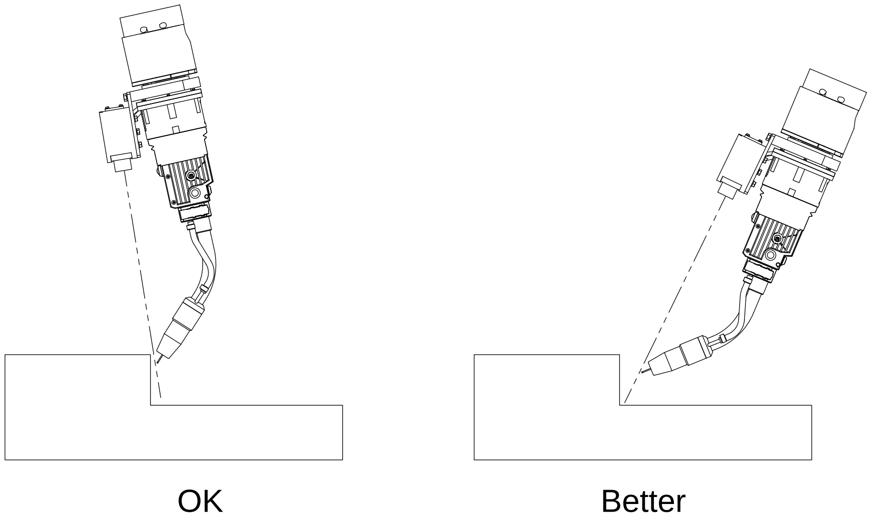


Fig. 8-2: AccuFast Orientation (Reflective Surface)

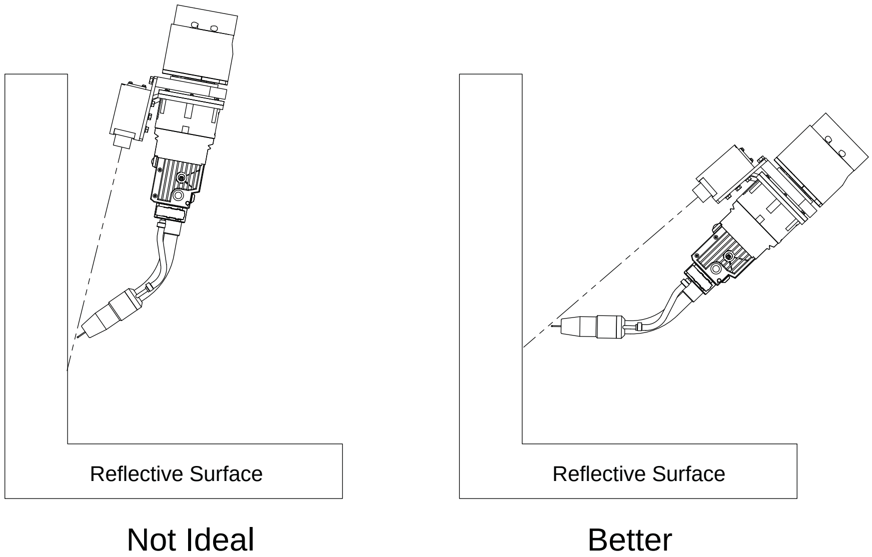
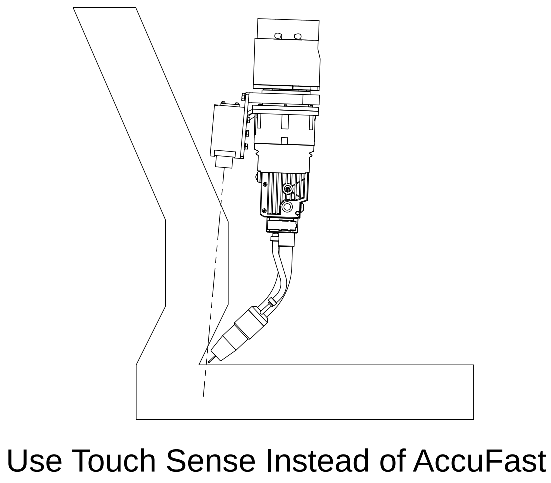


Fig. 8-3: Touch Sense Over AccuFast

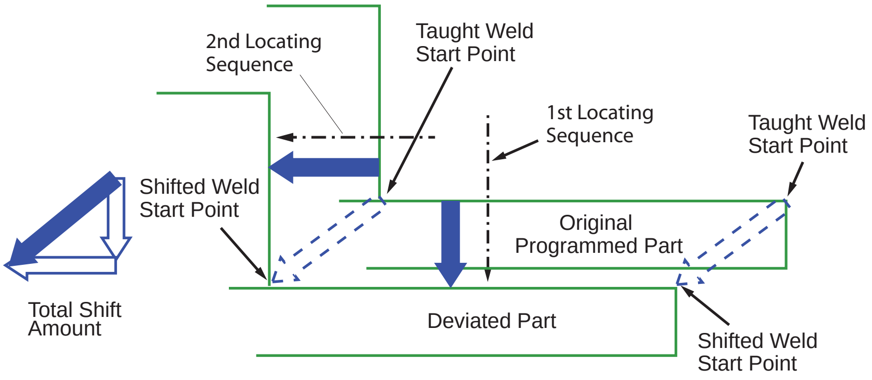


8.1 Perpendicular Search Paths

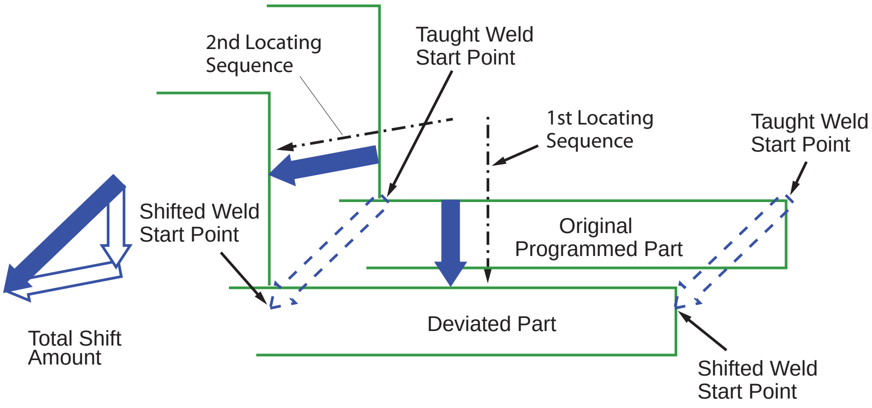
Another often overlooked problem occurs when search motion is not perpendicular to the surface of the part, or when offsets are added together but the motions associated with these searches are not mutually perpendicular. To avoid these problems, the following guidelines should be considered when programming motion.

- **Keep search motions perpendicular to each other.**
When using multiple detection, to develop a single shift amount (e.g. searching for X, Y, and Z variations for a weld start point), it is recommended to program search motions perpendicular to each other. The first search motion should be perpendicular to the first surface desired to detect. The second and third search motions should be perpendicular to each and also perpendicular to the first search motion. If motions are not mutually perpendicular, compounding of shift amounts can shift the weld path out of the weld seam.

Fig. 8-4: Mutually Perpendicular Search Paths



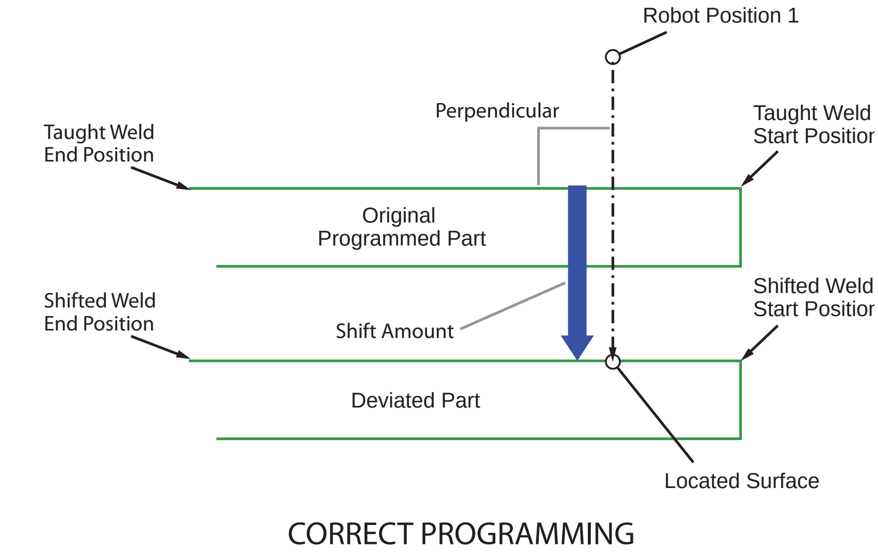
CORRECT PROGRAMMING

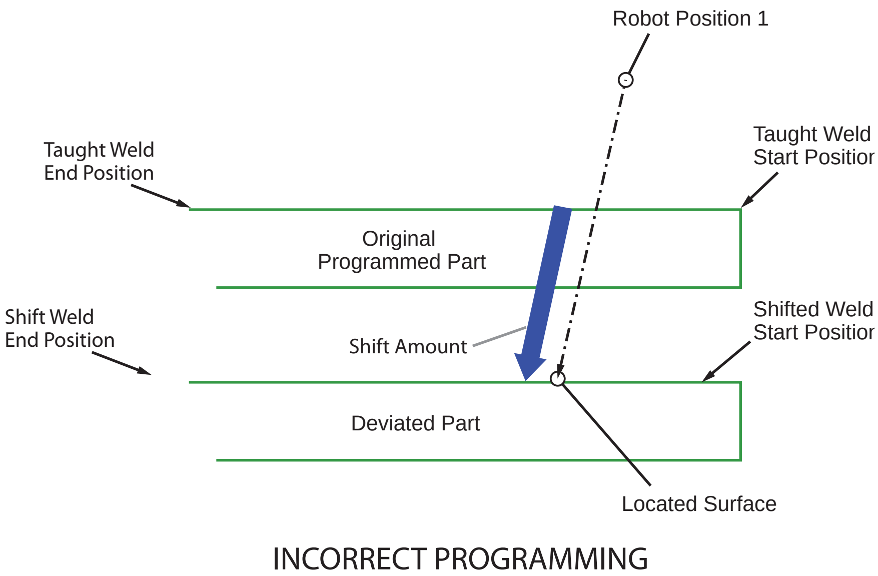


INCORRECT PROGRAMMING

- **Keep search motion perpendicular to the surface of the part**
  As long as the previous rule is not contradicted (where all search motion must be perpendicular to each other, when wishing to combine shift amounts), keep search motion perpendicular to the surface of the part.

Fig. 8-5: Perpendicular Search Paths





The seam finding macros discussed in this manual all contain routines where the previously mentioned errors are dramatically reduced, while at the same time realizing a reduction in teaching time. In summary, the AutoTeach routines offer the following benefits:

- Reduced programming time.
- Improved ease of programming.
- Automatic detection of shift motion perpendicular to the part surface.
- Accurate programming of the detecting positions during teaching via the AutoTeach routine.
- Reduced error associated with robot overshoot.

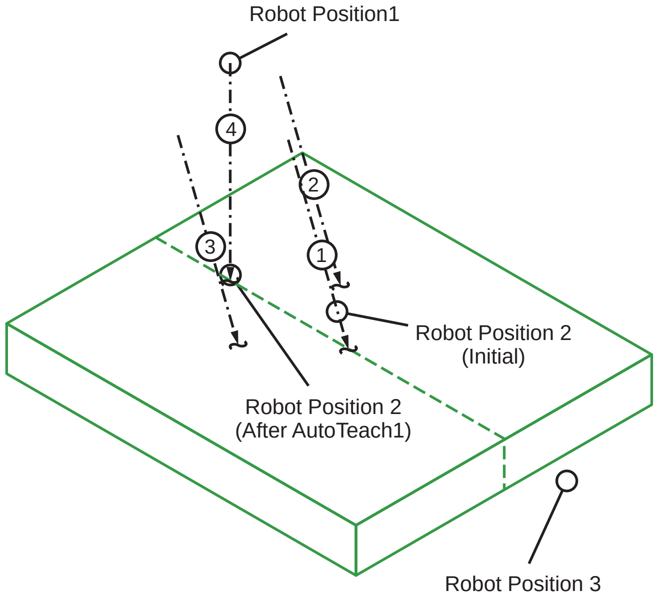
8.2 Pattern Type and AutoTeach Descriptions

8.2.1 Pattern Type 0

8.2.1.1 AutoTeach 1

AutoTeach 1 is used to redefine Robot Position 2.

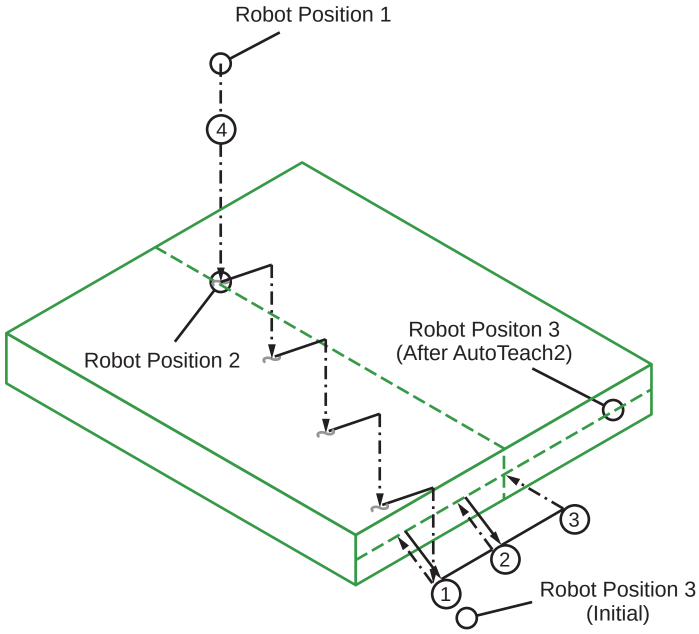
Fig. 8-6: Pattern Type 0, AutoTeach 1



8.2.1.2 AutoTeach 2

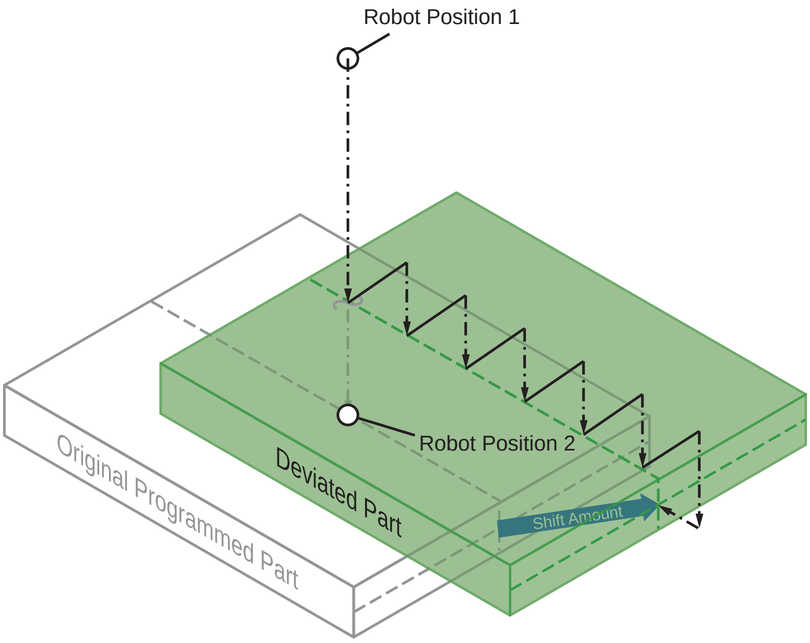
AutoTeach 2 is used to redefine Robot Position 3.

Fig. 8-7: Pattern Type 0, AutoTeach 2



8.2.1.3 AutoTeach 0

Fig. 8-8: Pattern Type 0, AutoTeach = 0 (Playback)

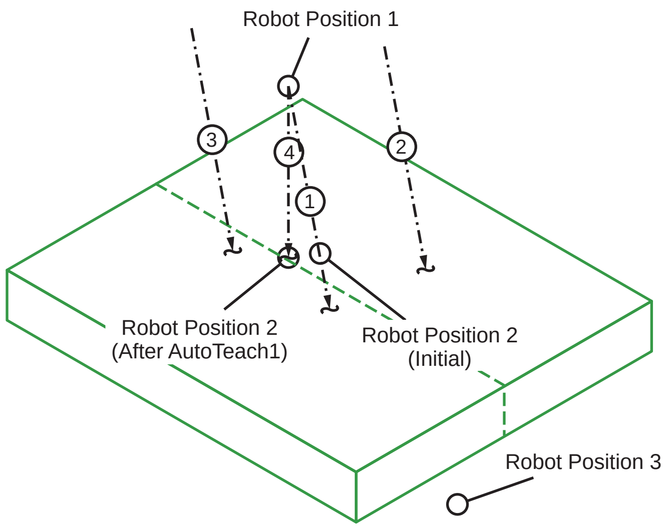


8.2.2 Pattern Type 1

8.2.2.1 AutoTeach 1

AutoTeach 1 is used to redefine Robot Position 2.

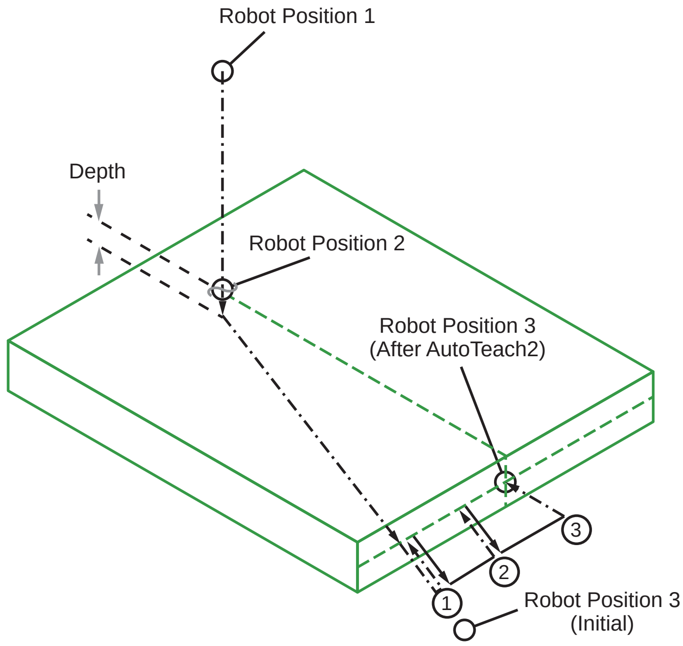
Fig. 8-9: Pattern Type 1, AutoTeach 1



8.2.2.2 AutoTeach 2

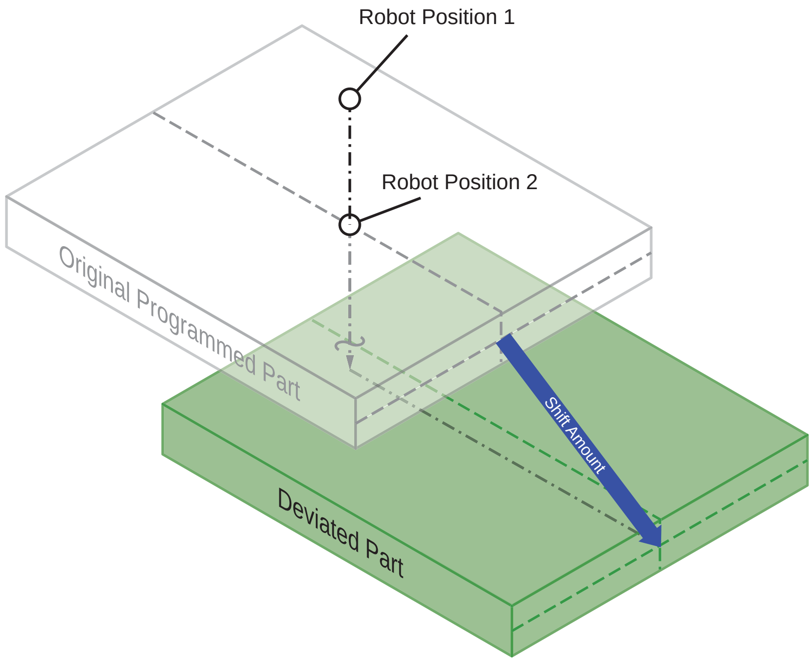
AutoTeach 2 is used to redefine Robot Position 3.

Fig. 8-10: Pattern Type 1, AutoTeach 2



8.2.2.3 AutoTeach 0

Fig. 8-11: Pattern Type 1, AutoTeach = 0 (Playback)

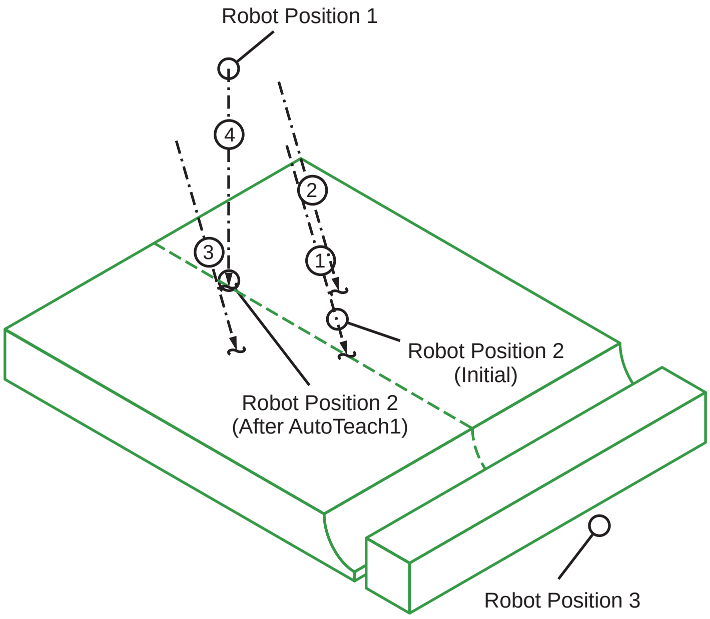


8.2.3 Pattern Type 2

8.2.3.1 AutoTeach 1

AutoTeach 1 is used to redefine Robot Position 2.

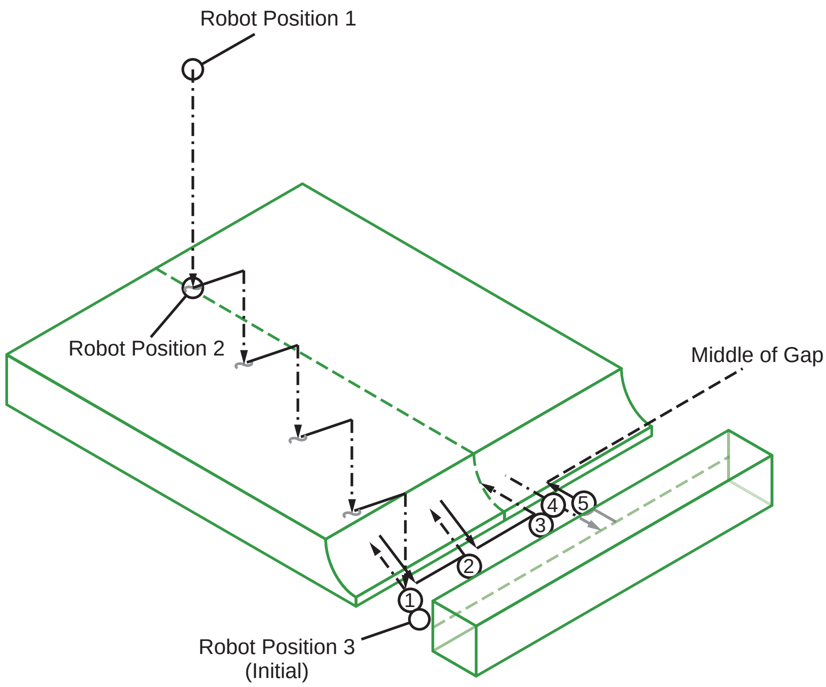
Fig. 8-12: Pattern Type 2, AutoTeach 1



8.2.3.2 AutoTeach 2

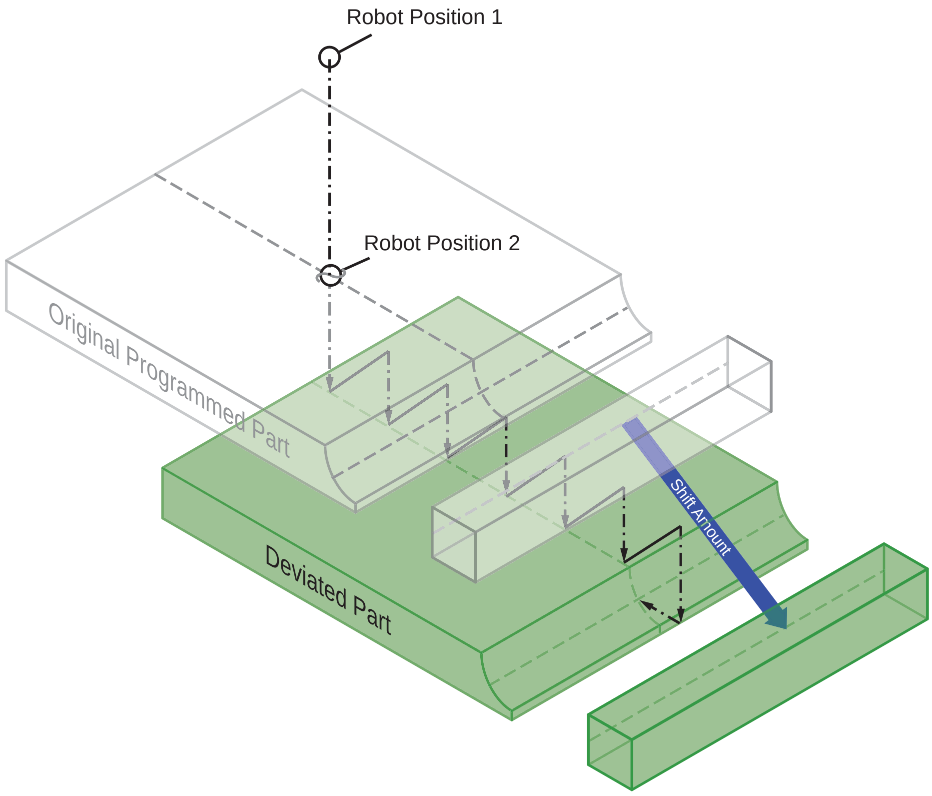
AutoTeach 2 is used to redefine Robot Position 3.

Fig. 8-13: Pattern Type 2, AutoTeach 2



8.2.3.3 AutoTeach 0

Fig. 8-14: Pattern Type 2, AutoTeach = 0 (Playback)

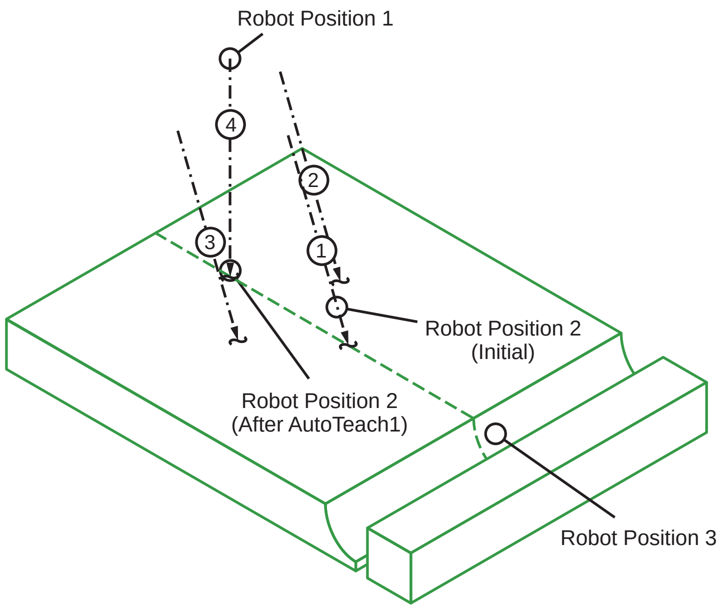


8.2.4 Pattern Type 3

8.2.4.1 AutoTeach 1

AutoTeach 1 is used to redefine Robot Position 2.

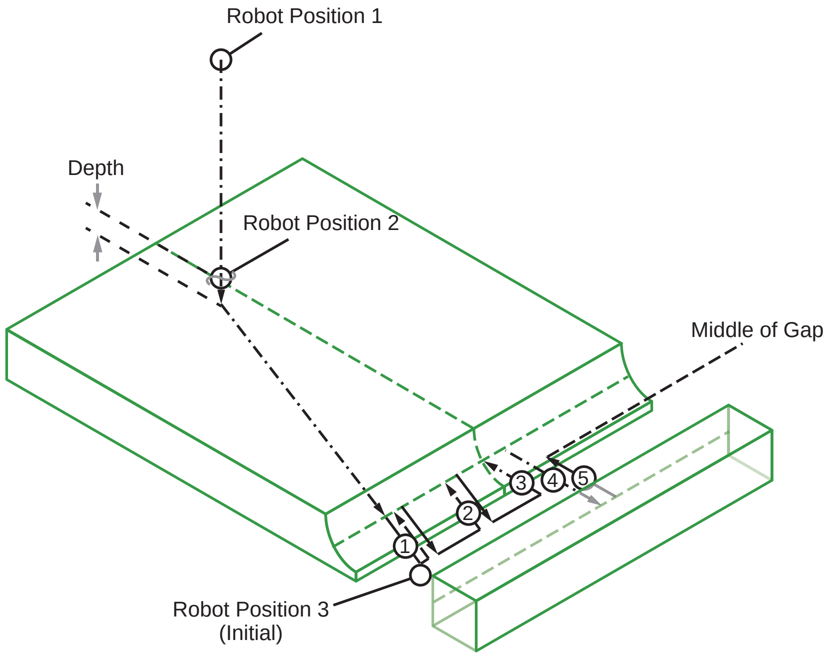
Fig. 8-15: Pattern Type 3, AutoTeach 1



8.2.4.2 AutoTeach 2

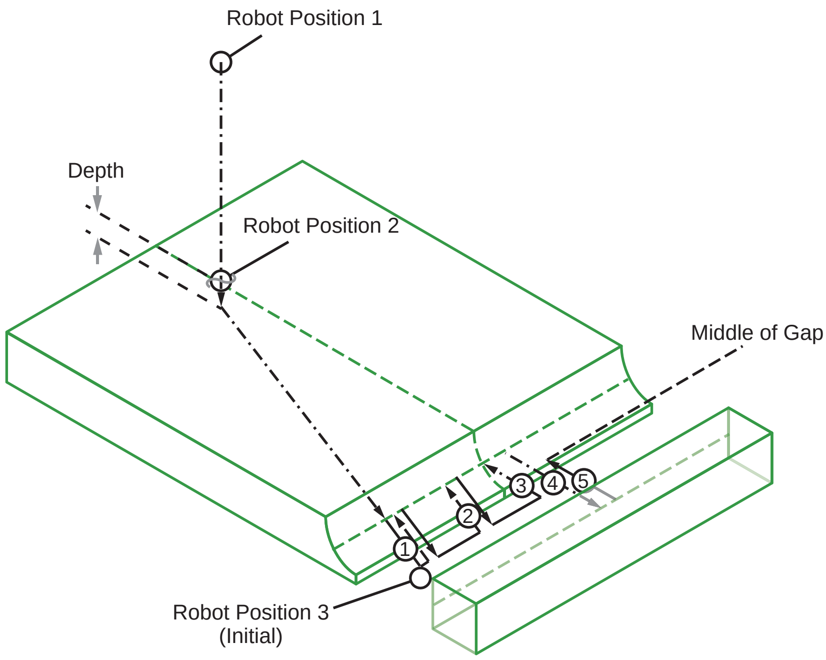
AutoTeach 2 is used to redefine Robot Position 3.

Fig. 8-16: Pattern Type 3, AutoTeach 2



8.2.4.3 AutoTeach 0

Fig. 8-17: Pattern Type 3, AutoTeach = 0 (Playback)

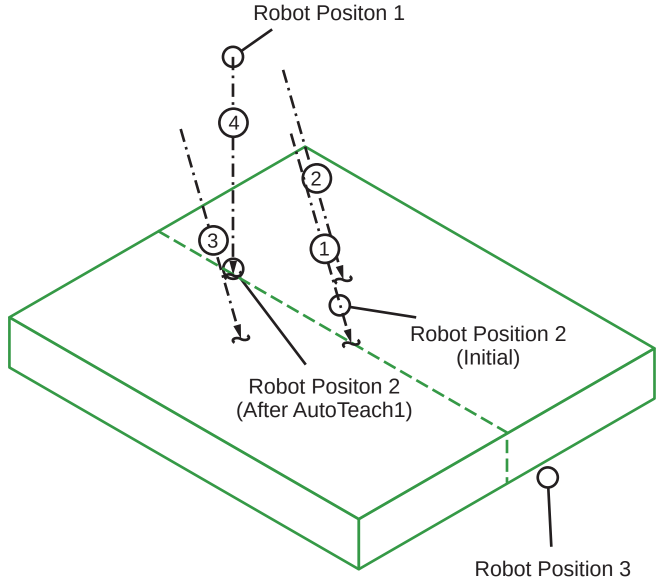


8.2.5 Pattern Type 4

8.2.5.1 AutoTeach 1

AutoTeach 1 is used to redefine Robot Position 2.

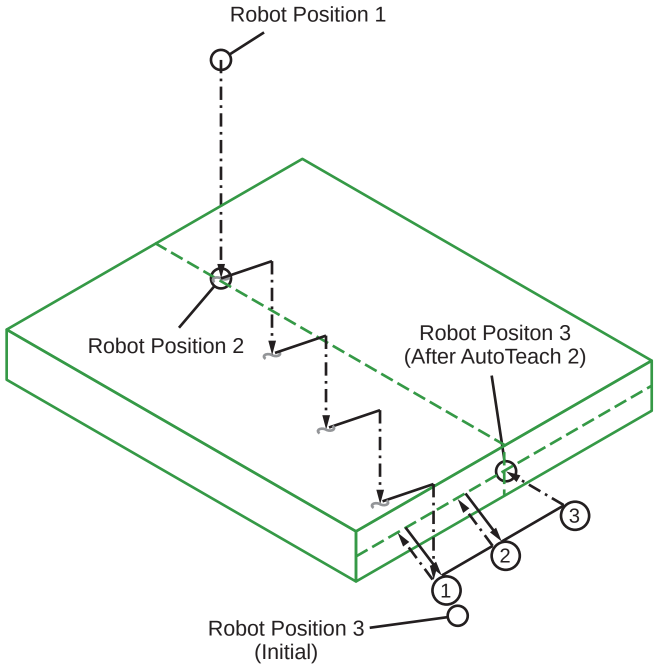
Fig. 8-18: Pattern Type 4, AutoTeach 1



8.2.5.2 AutoTeach 2

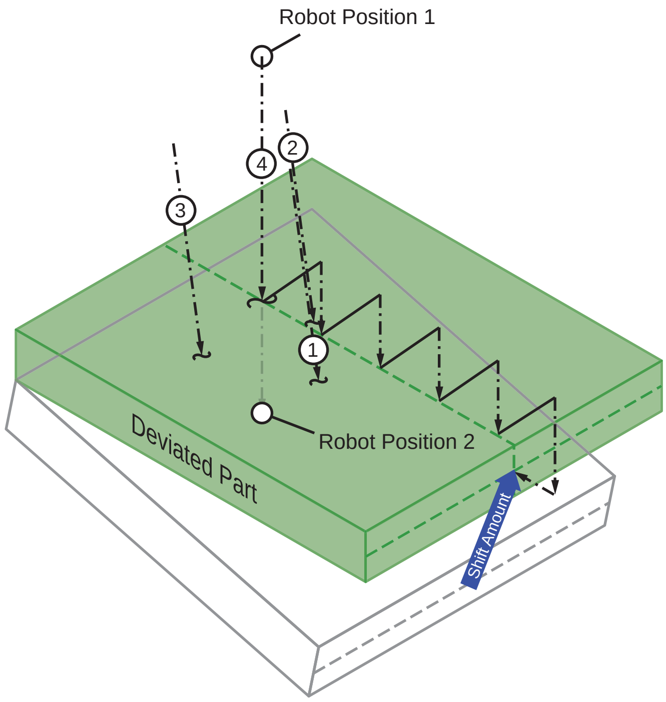
AutoTeach 2 is used to redefine Robot Position 3.

Fig. 8-19: Pattern Type 4, AutoTeach 2



8.2.5.3 AutoTeach 0

Fig. 8-20: Pattern Type 4, AutoTeach = 0 (Playback)

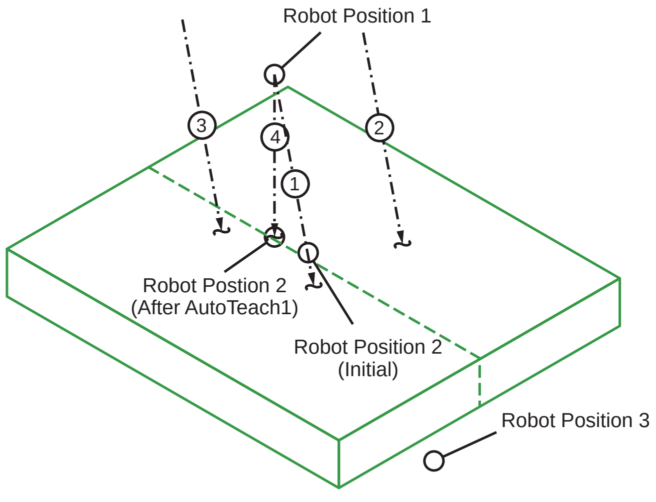


8.2.6 Pattern Type 5

8.2.6.1 AutoTeach 1

AutoTeach 1 is used to redefine Robot Position 2.

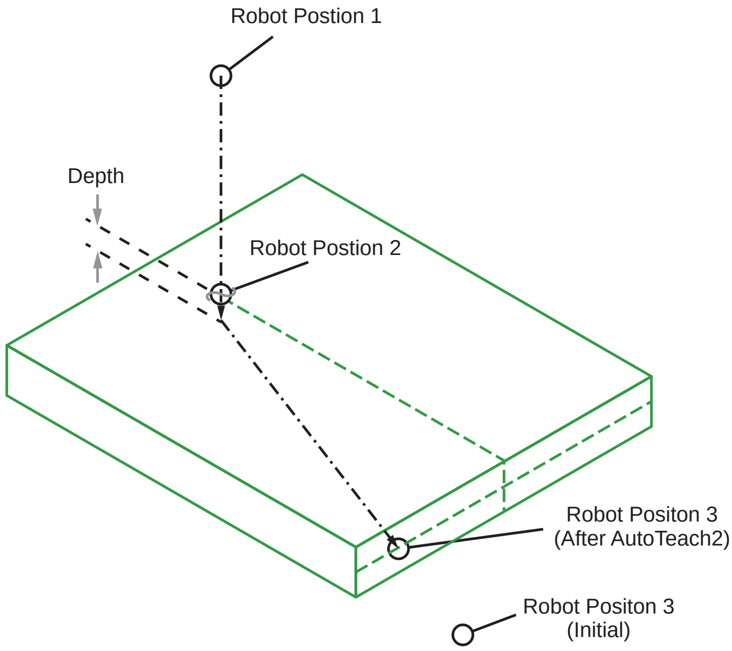
Fig. 8-21: Pattern Type 5, AutoTeach 1



8.2.6.2 AutoTeach 2, Step Offset 0

AutoTeach 2 is used to redefine Robot Position 3.

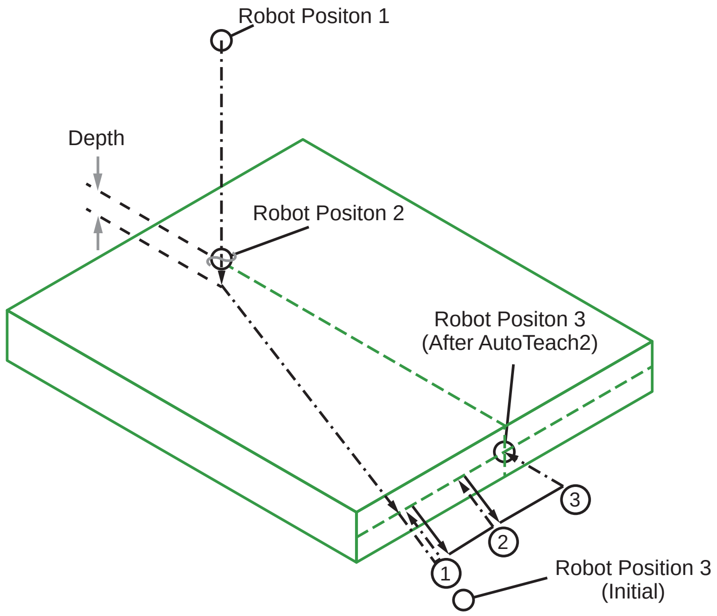
Fig. 8-22: Pattern Type 5, AutoTeach 2, Step Offset = 0



8.2.6.3 AutoTeach 2, Step Offset > 0

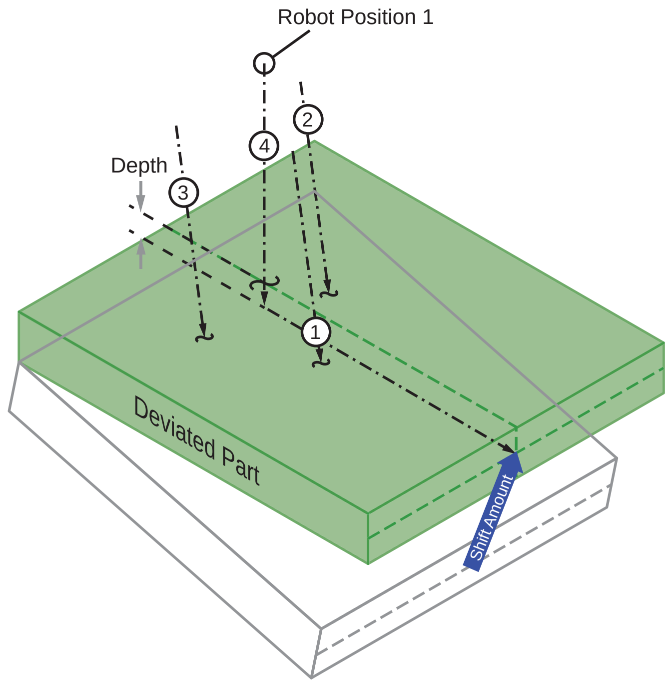
AutoTeach 2 is used to redefine Robot Position 3.

Fig. 8-23: Pattern Type 5, AutoTeach 2, Step Offset > 0



8.2.6.4 AutoTeach 0

Fig. 8-24: Pattern Type 5, AutoTeach = 0 (Playback)



9 Target for TCP Update for AccuFast

9.1 Requirements

It is under the assumption that the user has knowledge of Yaskawa Motoman “Touch Sense and AccuFast Macro Jobs” function; mostly the R1-EDGE macro instructions including its uses, programming procedure, and association parameter settings.

User is required to have knowledge on how to program an accurate User Frame onto the supplied detection block.

9.2 Objective of Function

Macro Manager function enables batch modification of macro instructions of the existing jobs in a DX controller. The Macro Manager develops Tool data for updating macro instructions for Seam Finding Macros when using AccuFast. When it is necessary to relocate AccuFast relative to the T-Flange of the robot, and to avoid manually re-teaching the seam finding macro instructions, Macro Manager develops two Tool files. One file contains information before the sensor is re-mounted and the second file contains information after the sensor is re-mounted. Macro Manager uses Relative Job function in the DX controller to update any relevant jobs automatically. This results in not having to re-teach the seam finding macros manual or only minimal re-teaching required.

9.3 Overview

In the event that AccuFast needs to be re-mounted or replaced, (it is impossible to get the exact location of the original sensor), measurements using the sensor would have an error in shift measurements due to the sensor not being in the expected location.

One of the following would have to take place to correct the above issue.

- **Manual**
  Manually reprogram all of the seam finding macro instructions the controller after AccuFast has been remounted. Robot positions before the ARCON/ARCOF instruction would probably need to be touched up also.

- **Semi-Automatic**
  User needs to create a TCP (i.e Tool#1) for AccuFast while it is mounted in its original location. This could be done using the traditional 5 point method. The sensor would then be replaced. The user would then be required to create a second TCP (i.e. Tool#2) for the sensor in its new location. Lastly, Macro Manager would need to be ran and the two Tool Files would be referenced for updating the robot jobs containing seam finding macro instructions.

- **Automatic**
  A target is used with AccuFast where a TCP is calculated and stored into a Tool File. This is done twice - once before the sensor is taken off and once after the sensor is remounted. The tool files are then updated (i.e. Tool #1 and Tool #2... the exact Tool File numbers are user defined). The macro manager is then ran and the two Tool Files are referenced for updating of the robot jobs' seam finding macro instructions.

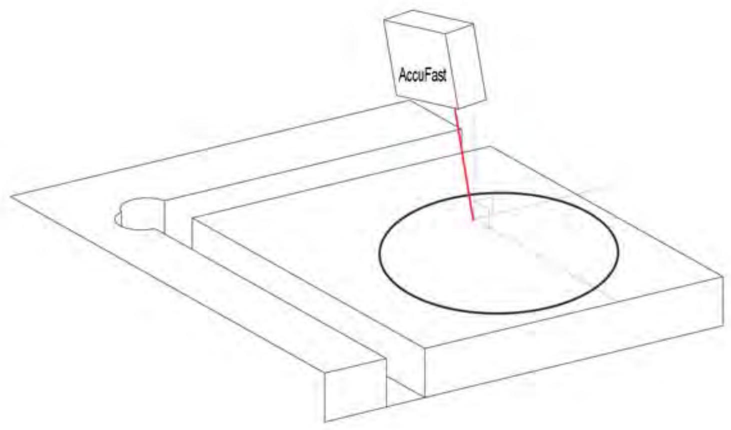
9.4 Breakdown of Procedure

1. Mount target securely within range of the robot arm.
2. Program a user frame to target.
3. Robot job (ACCUFAST - TCP - UPDATER) programmed to the target and parameters are set.
4. Run ACCUFAST - TCP - UPDATER in “TRAIN” mode with original laser mounting condition.
5. Replace / Remount AccuFast box.
6. Run ACCUFAST - TCP - UPDATER in “CALC” mode.
7. Run macro manager. The job data will automatically be updated.

9.5 Detailed Usage

- Mount target on a secure surface.
- Mount the target securely on a surface that is easily reachable by the robot.
- Mount the target so that the sensor can be programmed above the target.
- Sensor beam should be roughly perpendicular to the large, flat surface of the target.

Fig. 9-1: Mounting Target



9.6 Adjust Settings of ACCUFAST - TCP - UPDATER robot job

"Adjust setting values at the top of the robot job as needed for the application that AccuFast is being used for.

```
'-------------------------------
'
'LI003=Pvar# for Saved Tool
SET LI003 5
'
'LI016=Pvar# for DetPosInitial
SET LI016 9
'
'LI001=Detected Tool File #
SET LI001 1
'
'LI002=OriginalPos Tool File #
SET LI002 2
'
'LI005=ZeroData Tool File #
SET LI005 4
'
'LD014=Fine Point Scaling, mm
' Factory setting: 8
SET LD014 8
'
'LI007=fine tuning depth; mm
' Factory setting: 2
SET LI007 2
'
'LI004=RIN# for Search Motion
SET LI004 4
'
'LI006=Search Speed, cm/min
SET LI006 50
'
'LI0=User Frame # of block
SET LI000 1
'
'--- Setup Complete
'-------------------------------
```

Table 9-1: Parameters

Variable	Parameter Name	Default Value	Description
LI003	P variable #; saved tool	5	
LI016	P variable #; initial detected position	9	
LI001	Tool File #; detected tool	1	
LI002	Tool File #; original tool	2	
LI005	Tool File #; zero data	4	
LD014	Fine point scaling, mm	8	
LI007	Fine point tuning; depth used	2	
LI004	Rapid Input #; used for search motion	4	Set this based on the Rapid Input # that the AccuFast sensor is using for the 'detect' signal
LI006	Search Speed	50	Speed used during fine point turning while searching for the edge of the block.
LI000	User Frame #; used during initial teaching		

WARNING

The P variable set by the parameters LI001, LI002, LI003, and LI006 will be overwritten during successful execution of this robot job. Any data that was in these P variables will be lost. It is important to note which P variables these parameters are referencing as other jobs are being programmed into the robot controller.

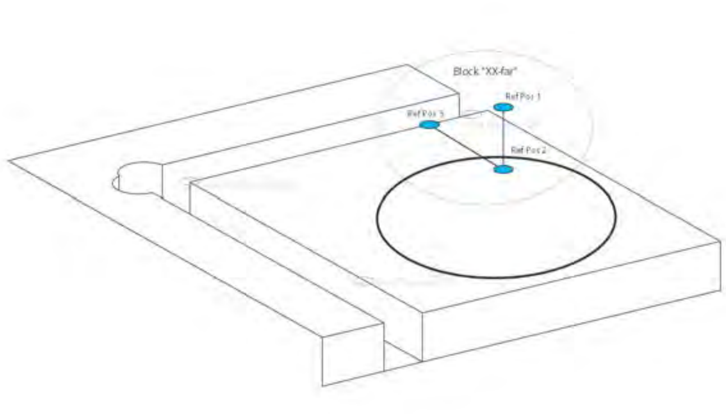
9.6.1 Program the user Frame to be used by the Macro Manager Function's Robot Job

To program an accurate User Frame, a tool is required (i.e Welding wire of a welding torch) with a good accurate Tool Center Point (TCP). If TCP is bad, (doesn't stay in same spot when moved in the round about motions in World Coordinates), program a new TCP using the 5 point method.

1. Program the ORG of the User Frame at the corner of the block (as shown in figure below). This corner of the detection block should be smooth and flat, with adjacent surfaces that are as close to 90 degrees from each other as possible.

2. Program the XX and XY of the User Frame as shown *Fig.9-2 Programing the XX and XY of the User Frame*.

Fig. 9-2: Programing the XX and XY of the User Frame



9.6.2 Set and Program the AccuFast - TCP - UPDATER Robot Job

1. Open the Robot Job named ACCUFAST - TCP - UPDATER.
2. Cursor to the variable setting section at the top of the job and confirm the set values.

Table 9-2: AccuFast Variable Settings

Variable	Description	Setting Range	Default Value
LI003	P variable # to save original, unmodified tool to	0 - max number of P vars	5
LI016	P variable # used for calculations	0 - max number of P vars	9
LI001	Tool File # for new sensor location	1 - 24	1
LI002	Tool File # for original sensor location	1 - 24	2
LI005	Tool File # used for calculations	1 - 24	4
LD014	Offset for corner detection	3 - 20	8
LI007	Depth used during corner detection	2 - 10	2
LI004	Rapid Input used for Laser Sensor searching	1 - 5	3
LI006	TCP speed used during Search motion, cm/min	10 - 100	50
LI000	User Frame number of detection block	1 - 24	1

3. Cursor to the top section of the robot job. The bottom of this section is noted by the comment “---Setup Complete”.

4. Change the necessary value for the application.
   - LI003
     - Pvar# for Saved Tool
     - When Executing the robot job in “TRAIN” mode, the current Tool data is saved to the P variable number. In case there is a need to recover the previous Tool's value. The to-be-changed Tool number is set by the parameter “LI002 = Pvar# / OriginalPos Tool #”.
   - LI001
     - Detected Tool Number
     - This is the value to be used in the Macro Manager Programming pendant application when it prompts the user for the “Updated Tool Number”.
   - LI002
     - Original Tool Number
     - This is the value that will be used in the Macro Manager Programming pendant application when it prompts the user for the “Original Tool Number”.
   - Zero Tool #
     - The value of the Tool that contains 0,0,0,0,0,0 data. If a Tool doesn't contain this data, there will need to be one to be set.
     - Set a Tool File to a value of
       - X:0
       - Y:0
       - Z:0
       - RX:0
       - RY:0
       - RZ:0
     - Set the variable LI005 to the Tool number used above.
   - Fine Point Scaling
     - A value of 8 mm is recommended.
     - This sets the distance that the final edge search routines will be performed from the corner of the block.
     - This value will need to be increased to larger values if AccuFast cannot be programmed to project the laser beam at an angle roughly perpendicular to the surface of the block.
   - LI004
     - Set the Rapid Input # used for AccuFast.
   - LI000
     - Set for user frame.

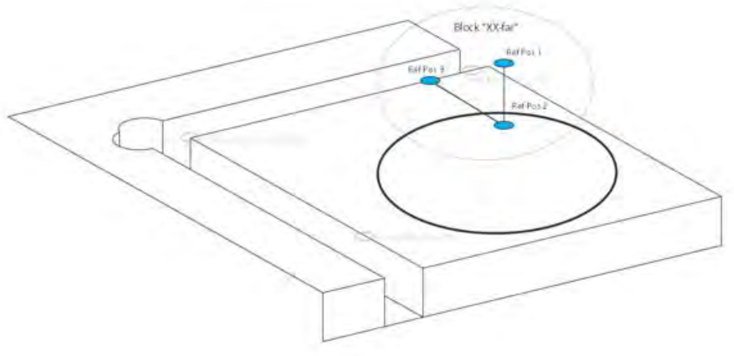
5. Set the User Frame number used above in the first section of the instructions.
6. Program the three areas where the search motion will take place on the block. User will program an approach point and the three Robot Positions of the R1-EDGE macro instruction for each of the three areas.

NOTE

- Use the same orientation of the laser sensor to the robot Base Frame for all three R1-EDGE macro instruction instances. DO NOT CHANGE R_X, R_Y, OR R_Z while jogging robot to the 9 positions inside the three R1-EDGE macro instructions.
- Take care when Robot Position 2 is programmed for each of the three R1-EDGE macro instructions. Make sure the Robot Position 2 are programmed far enough from the edge of the block so that after the sensor is remounted that the sensor is still pointing at the horizontal surface of the block when it moves towards Robot Position 2.
- Recommended settings for the R1-EDGE macro instructions include:
  - Set the Rapid Input # used for AccuFast
  - Search Speed - 100 cm/min
    - Keep this search speed slow for optimum accuracy.
  - Depth - 25 mm
    - Smaller values are better for calculated accuracy, but too small of a value may lead to variability in detection.
  - Search Distance - 25 mm
    - This should be set to a value greater than the expected deviation between the old and new AccuFast locations.
- For optimum accuracy, the AccuFast laser beam should be programmed as close to perpendicular to the surface of the part as possible. If perpendicular is not possible, the value of the 'Fine Point Scaling' parameter (located in the SETUP section of the Robot Job) may need to be increased from the factory default setting.

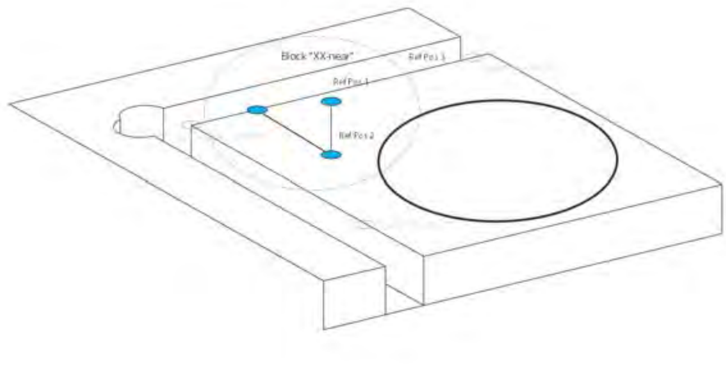
7. Program the MOVJ positions labeled Program Position and the first R1-EDGE macro instruction labeled “Block, UF XX - Far.” It is recommended to program the MOVJ position in the same area that the Robot Position 1 or the R1-EDGE macro is programmed.

Fig. 9-3: Location of Robot Position 2, Block UF XX - Far



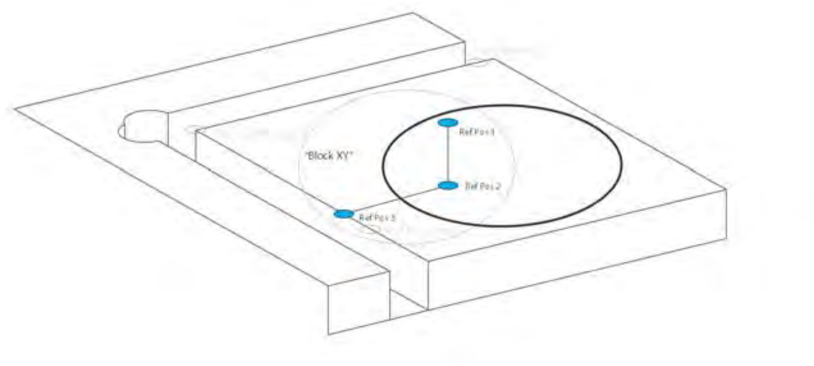
8. Program the second R1-EDGE macro instruction labeled “Block, UF XX - Close.” It's recommended to program to program MOVJ position in the same area that the Robot Position 1 of the R1-EDGE macro is programmed.

Fig. 9-4: Location of Robot Position 2, Block UF XX - close.



9. Program the third R1-EDGE macro instruction labeled “Block, UF XY.” It is recommended to program the MOVJ position in the same area that the Robot Position 1 of the R1-EDGE macro is programmed.

Fig. 9-5: Location of Robot Position 2, Block UF XY



9.7 Run the Robot Job in Train Mode

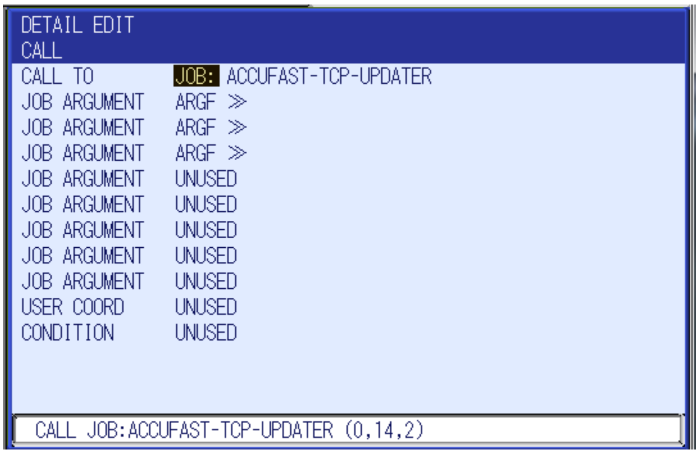
1. Open the job named ACCUFAST - TCP - UPDATER - MASTER.
2. Cursor to the CALLJOB:ACCUFAST - TCP - UPDATER instruction

```
JOB CONTENT
J:ACCUF-TCP-UPDATE-MASTER            S:0000
CONTROL GROUP: R1                    TOOL: **
0000 NOP
0001 CALL JOB:ACCUFAST-TCP-UPDATER (0,14,2)
0002 PAUSE IF B014<>1
0003 PAUSE
0004 END
```

3. Set the ACCUFAST - TCP - UPDATER jobs ARGUMENT #1 to a value of 0, for Train mode.

NOTE

- A parent robot job can cause ARGUMENTS to pass data into the child job that is being called. The ACCUFAST - TCP - UPDATER job has been programmed with two arguments. The value of these arguments can be seen by opening the CALL JOB:ACCUFAST - TCP - UPDATER - MASTER.
  – To open the CALL instruction, move the cursor to the CALL instruction line.
  – Cursor to the instruction side and them press [SELECT] twice. The Argument List now appears.
  – Select the argument to change the value.
- Cursor to the '>>' and press [SELECT] to modify the data, or change the data in the in - line instruction (0, 14, 2).
- The descriptions of the JOB ARGUMENTs for the ACCUFAST - TCP - UPDATER job are listed in Appendix B. These arguments can be viewed by:
  – Selecting the job called ACCUFAST - TCP - UPDATER - MASTER.
  – These arguments can be viewed by selecting the job called ACCUFAST - TCP - UPDATER - MASTER.
  – Cursor to the instruction CALL JOB:ACCUFAST - TCP - UPDATER.
  – Cursor to the instruction side and press [SELECT] > [SELECT].
  – Argument 1: 0 = train mode, 1 = calc mode.
  – Argument 2: B variable number for status bit (value of B variable... 0 = successful train, 1 = successful calc, 2 = search failed).
  – Argument 3: Amount of TCP deviation. Value = microns (ie Dvar = 1204 = 1.204 mm).



4. Set the ACCUFAST - TCP - UPDATER jobs ARGUMENT #2 to the B variable number desired to save the success / fail result to. Example: ARGUMENT #2 set to a value of 4, thus B004 is set to provide the success / fail status of the robot job.
5. From the top of the ACCUFAST - TCP- UPDATER - MASTER job, run the job. The routine should located the edge of the block 5 times and then move the laser beam to the exact edge of the block. The routine, if successful, should set the status B variable (default B014 to a value of 0).

Fig. 9-6: Setting the AccuFast -TCP-Updater

9.8 Run the Robot Job in Calc Mode

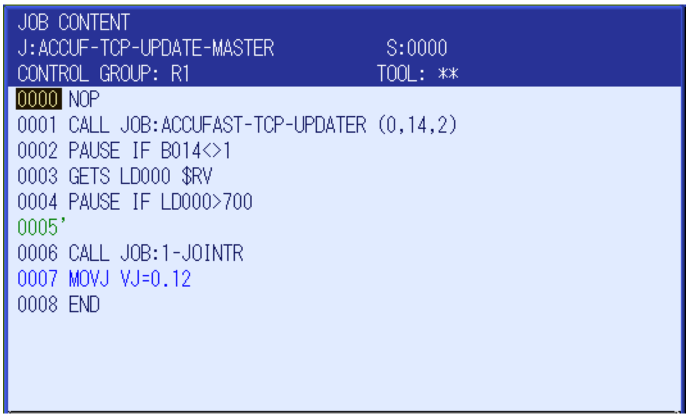
1. Set the ACCUFAST - TCP - UPDATER job's ARGUMENT #1 to a value of 0, for the Calculate Offset Mode.
2. The routine should have located the edge of the block 5 times and then move to the exact edge of the block. The routine, if successful, should set the status B variable (default is B014) to a value of 1.
3. Upon completion of this mode the user should have two Tool Files set the value of LI002 and the value of LI001 determine which Tool Files were set.

9.9 Update Robot Positions in AccuFast Macro Instructions

1. Follow instructions of the Macro Manager Function. See manual 162160-1CD for details.
2. The jobs containing seam finding macro instructions should now be updated.
3. To verify accuracy, observe that the detected shift offsets of the macro jobs that use the AccuFast sensor are providing the same offsets after the AccuFast sensor was moved as they were before the AccuFast sensor was remounted.

9.10 TCP Detection Mode (Optional)

1. Open the job named ACCUFAST - TCP - UPDATER - MASTER.
2. Cursor to the CALL JOB:ACCUFAST - TCP - UPDATER instruction.
3. Set the ACCUFAST - TCP - UPDATER jobs argument #1 to a value of 2, for Detection Only Mode.
4. From the ACCUFAST - TCP - UPDATER - MASTER job, adjust the allowable TCP deviation to what is acceptable for the application, typically ½ the diameter of the welding wire. If 1.2 mm (0.045 inches) welding wire is being used, a value of 0.6 mm could be used as the allowable TCP deviation (if the value of deviation is greater than this value, the robot job will pause after Detection Only routine was performed).



NOTE In the inform job, a PAUSE IF LD000>700 is shown in the example. With this PAUSE command, the robot controller is suing units of micros, so a value of 700 is actually 0.7 mm.

The first Argument (JOB ARGUMENT > ARG. 1) of the robot job ACCUFAST - TCP - UPDATER sets the operating mode of this function. The various modes are listed in the table below.

Appendix A ARG Target Values

Table A-1: ARG Values

Value of ARG.1	Description	Comment
0	Calculate Offset	The routines measures the calculated TCP offset and writes the “before” and “after” data into the Tool Files.
1	Train	For initial teaching. This mode is to be used BEFORE any dimensional changes to the AccuFast sensor.
2	Detection Only	This mode can be used at any time AFTER the initial “Train” mode has been ran. This mode can be used to verify that the TCP of the AccuFast sensor has not changed since the initial teaching, or “Train” step. The calculated change in location of the TCP is available via the “GETS xDyyy$RV” Inform instructions.

Appendix B Value B Variables

The second argument (JOB ARGUMENT > ARG 2) of the robot job ACCUFAST - TCP - UPDATER sets the address of a B Variable. This B variable is given a value on the success / failure state of the robot job. The possible values for this B variable are listed in the table below.

Value B Variable	**Description**	**Recommended Countermeasure**
0	‘Training’ successful	Ok. Next, switch to ‘Calculate’ mode.
1	“Calculate” successful	Ok.
2	Unsuccessful search	Check search path. Check the laser sensor is programmed correctly. Check that Rapid Input # for laser sensor is set correctly is SETUP section of Robot Job.
3	“Detection Only” successful	Check return value (GETS Dxxx SRV) to collect detected TCP deviation amount.
4	Robot Job was halted	Re-Run Robot Job.

Appendix C AccuFast Verify Routine (Optional Function)

C.1 Overview

This a robot job that was written for the user to be able to see AccuFast is experiencing a “drift” in measurement accuracy. Daily temperature changes can make the sensor drift up to 8 mm. The robot moves the laser sensor toward a pre - programmed distance - the “focal length” - and checks to see that the sensor is turning off/on at the expected distance. If the sensor is not turning off/on at the expected distance, the routine will stop and prompts the user to: Check that sensor lens is clean. Once the user clears the alarm and presses start, the routine will automatically reprogram AccuFast to compensate for the drift amount in the sensor measurement. This will occur for a total of five times. After five recalibrations, the next attempt to update will cause the robot to stop and an alarm will be displayed telling the user to: “Clean sensor lens, press START” before recalibration will continue.

The number of times that AccuFast is automatically recalibrated is able to be changed in the SETUP section at the top of the job. Setting this value to a higher number is not recommended.

1. Place the ACCUFAST-VERIFY-Z-R* job into a robot job. The ACCUFAST-VERIFY-Z-R* job can be placed anywhere in the robot programs. Ideally it would be used immediately before or after a routine torch cleaning routine.
2. Direct open the job (using the [DIRECT OPEN] key).
3. Move the robot over a known, fixed object (i.e. the target used in the routine in the previous section and move the sensor so that it is roughly perpendicular to the surface).
4. Cursor to “Step 1" section of the ACCUFAST-VERIFY-Z-R* job and program the TCH-* macro instruction in “1TCH” routine. Use of the Auto Teach mode is recommended for this step.
5. Next, cursor to “Step 2" section and re-program the MOV step at the same position as what was detected as Robot Position 2 in the TCH-* macro instruction above.
6. Adjust the LD000 parameter to adjust for the allowable detection amount that the robot will ignore. If the detected deviation is equal or greater than the value of LD000, the sensor will be recalibrated.
7. Adjust LI000 as the Universal Output use for “Laser On/Off” recalibration.
8. The job is now ready to be ran in PLAY mode.

TOUCHSENSE AND ACCUFAST WITH MACRO JOBS INSTRUCTIONS

HEAD OFFICE
2-1 Kurosakishiroishi, Yahatanishi-ku, Kitakyushu 806-0004, Japan
Phone +81-93-645-7745 Fax +81-93-645-7746

YASKAWA America Inc. M Robotics Division
100 Automation Way, Miamisburg, OH 45342, U.S.A.
Phone +1-937-847-6200 Fax +1-937-847-6277

YASKAWA Nordic AB
Box 504 Verkstadsgatan 2, PO Box 504 SE-385 25 Torsås, Sweden
Phone +46-480-417-800 Fax +46-486-414-10

YASKAWA Europe GmbH Robotics Div.
Yaskawastrasse 1, 85391 Allershausen, Germany
Phone +49-8166-90-0 Fax +49-8166-90-103

YASKAWA Electric Korea Co., Ltd
9F, KYOBO Securities Bldg., 26-4, Yeoido-Dong Yeoungeungpo-ku, Seoul, Korea
Phone +82-2-784-7844 Fax +82-2-784-8495

YASKAWA Electric (Singapore) PTE Ltd.
151 Lorong Chuan, #04-02A, New Tech Park, Singapore 556741
Phone +65-6282-3003 Fax +65-6289-3003

YASKAWA Electric (Thailand) Co., Ltd.
252/246, 4th Floor. Muang Thai-Phatra Office Tower II Rachadaphisek Road,
Huaykwang Bangkok, 10320, Thailand
Phone +66-2-693-2200 Fax +66-2-693-4200

YASKAWA Shougang Robot Co. Ltd.
1015. Boxuenan Rd. Maluzhen, Jiading District, Shanghai, China
Phone +86-21-5950-3521 Fax +86-20-3878-0651

YASKAWA ELECTRIC CHINA Co., Ltd.
12F Carlton Building, No. 21-42 Huanghe Road, Shanghai 200003, China
Phone +86-21-5385-2200 Fax +86-21-5385-3299

YASKAWA Robotics India Ltd.
#426, Udyog Vihar, Phase- IV, Gurgaon, Haryana, India
Phone +91-124-475-8500 Fax +91-124-475-8542

YASKAWA
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