Motoman NX100 Controller

ToolSight User's Manual

Part Number: 150008-1CD
Revision 0

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Chapter 1
Introduction

ToolSight was designed specifically for use with Motoman arc welding robots. It is a fiber-optic detection system designed to automatically detect worn contact tips, excessive wire cast, or torch alignment problems during production. Inadvertent torch collisions with a part, fixture, or positioner can cause the robot to appear to "wander" during welding, when in actuality, it is the tool center point (TCP) that is "wandering." ToolSight checks the robot's tool center point (TCP) on-line, verifies its with in acceptable limits, and calculates the offset required to correct the TCP.

ToolSight consists of a fiber-optic gauge, a torch alignment tool (see Figure 1-1), and two realignment software functions. Fiber-optic lenses, which are mounted in each quadrant of the ToolSight gauge, project two intersecting photo beams at 90 degrees. During a quick inspection, the robot will move the wire to a "center of beams" position, and verify that both beams are still blocked.

1.1 About This Document

This manual is intended as an introduction and overview for personnel who have received operator training from Motoman, and who are familiar with the operation of their Motoman robot model. For more detailed information, refer to the manuals listed in Section 1.3. This manual contains the following sections:

SECTION 1 - INTRODUCTION
This section provides general information about ToolSight and its components, a list of reference documents, and customer service information.

SECTION 2 - SAFETY
This section provides information regarding the safe use and operation of ToolSight.

SECTION 3 - INSTALLATION
This section provides instructions for the installation of ToolSight.

SECTION 4 - SETUP AND OPERATION
This section provides instructions for basic operation of ToolSight. This section also provides procedures for set up.

SECTION 5 - VARIABLES AND JOBS

This section contains descriptive tables of the ToolSight variable and jobs.

SECTION 6 - TROUBLESHOOTING AND MAINTENANCE

This section provides instructions for troubleshooting ToolSight, and calibration of the sensors.

APPENDIX A - TOOL CENTER POINT

Appendix A provides instructions for programming the tool center point (TCP).

APPENDIX B - FIBER OPTIC SENSOR

Appendix B provides a datasheet for the fiber optic sensor.

APPENDIX C - TOOLSIGHT JOBS

Appendix C provides sample jobs for ToolSight.

APPENDIX D - SETTOOL/GETTOOL INSTRUCTIONS

Appendix D provides information for the SETTOOL/GETTOOL instructions.

1.2 Components

ToolSight package configurations:

- Standard ToolSight with 80 mm ID Ring (P/N 150013-1)
- Standard ToolSight with 80 mm ID Ring and accessory stand (P/N 150013-2)
- Magnum ToolSight with 205 mm ID Ring (P/N 150013-3)
- Magnum ToolSight with 205 mm ID Ring and accessory stand (P/N 150013-4)
- Magnum V ToolSight with 155 mm Beams (P/N 150013-5)
- Magnum V ToolSight with 155 mm Beams and accessory stand (P/N 150013-6)

Each ToolSight package includes the following items:

- ToolSight Gauge Assembly (P/N 143207-1)
- 8 meter cable (P/N 144631-6)
- Internal pigtail for NX100 controller (P/N 150014-1)
- ToolSight User's Manual (P/N 150008-1)
- ToolSight Jobs software (P/N 142195-1)
- Search Function Manual (P/N 150010-1)
- Relative Job software (P/N 142472-1)
- Relative Job Function Manual (P/N 149648-9)
- PMT manual (P/N 149648-8)

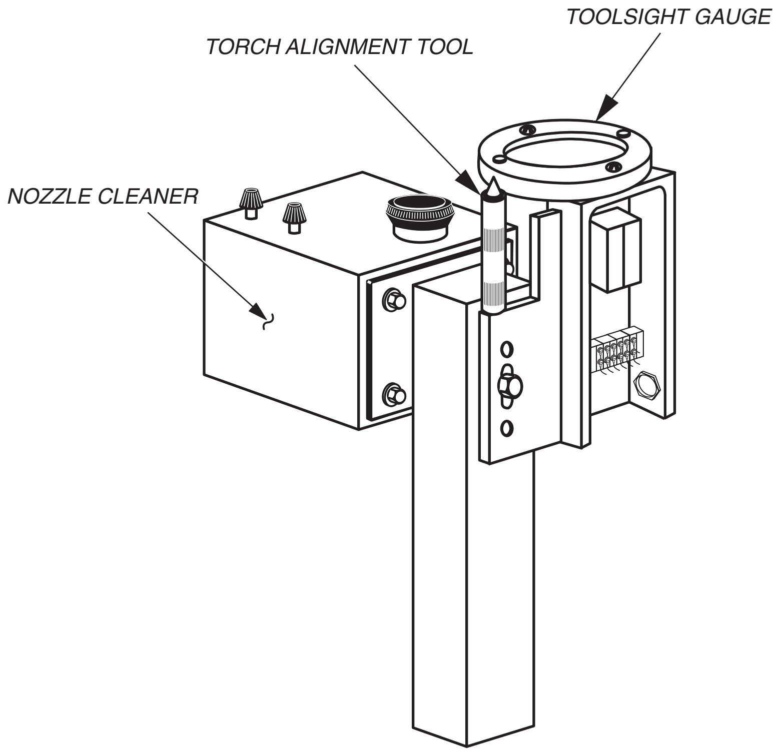


Figure 1 ToolSight

1.3 Reference to Other Documentation

For additional information refer to the following:

- Motoman Concurrent I/O Manual (P/N 149230-1)
- Operator's Manual for Arc Welding (P/N 149235-1)
- Vendor manuals for system components not manufactured by Motoman

1.4 Customer Service Information

If you are in need of technical assistance, contact the Motoman service staff at (937) 847-3200. Please have the following information ready before you call:

- Robot Type (HP20, EA1900N, UP50N, etc.)
- System Type (ToolSight)
- Software Version (access using MAIN MENU, SYSTEM INFO, VERSION on programming pendant)
- Robot Serial Number (located on back side of robot arm)
- Robot Sales Order Number (located on front door of NX100 controller)

Notes

Chapter 2
Safety

2.1 Introduction

It is the purchaser's responsibility to ensure that all local, county, state, and national codes, regulations, rules, or laws relating to safety and safe operating conditions for each installation are met and followed.

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems. This information can be obtained from the Robotic Industries Association by requesting ANSI/RIA R15.06-1999. The address is as follows:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338
INTERNET: www.roboticsonline.com

Ultimately, the best safeguard is trained personnel. The user is responsible for providing personnel who are adequately trained to operate, program, and maintain the robot cell. **The robot must not be operated by personnel who have not been trained!**

We recommend that all personnel who intend to operate, program, repair, or use the robot system be trained in an approved Motoman training course and become familiar with the proper operation of the system.

This safety section addresses the following:

- Standard Conventions (Section 2.2)
- General Safeguarding Tips (Section 2.3)
- Mechanical Safety Devices (Section 2.4)
- Installation Safety (Section 2.5)
- Programming, Operation, and Maintenance Safety (Section 2.6)

2.2 Standard Conventions

This manual includes the following alerts – in descending order of severity – that are essential to the safety of personnel and equipment. As you read this manual, pay close attention to these alerts to insure safety when installing, operating, programming, and maintaining this equipment.

DANGER!
Information appearing in a DANGER concerns the protection of personnel from the immediate and imminent hazards that, if not avoided, will result in immediate, serious personal injury or loss of life in addition to equipment damage.

WARNING!
Information appearing in a WARNING concerns the protection of personnel and equipment from potential hazards that can result in personal injury or loss of life in addition to equipment damage.

CAUTION!
Information appearing in a CAUTION concerns the protection of personnel and equipment, software, and data from hazards that can result in minor personal injury or equipment damage.

Note: Information appearing in a Note provides additional information which is helpful in understanding the item being explained.

2.3 General Safeguarding Tips

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. General safeguarding tips are as follows:

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this robot system.
- Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the robot cell.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).
- The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- In accordance with ANSI/RIA R15.06-1999, section 4.2.5, Sources of Energy, use lockout/tagout procedures during equipment maintenance. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).

2.4 Mechanical Safety Devices

The safe operation of the robot, positioner, auxiliary equipment, and system is ultimately the user's responsibility. The conditions under which the equipment will be operated safely should be reviewed by the user. The user must be aware of the various national codes, ANSI/RIA R15.06-1999 safety standards, and other local codes that may pertain to the installation and use of industrial equipment. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety equipment is provided as standard:

- Safety fences and barriers
- Light curtains and/or safety mats
- Door interlocks
- Emergency stop palm buttons located on operator station, robot controller, and programming pendant

Check all safety equipment frequently for proper operation. Repair or replace any non-functioning safety equipment immediately.

2.5 Installation Safety

Safe installation is essential for protection of people and equipment. The following suggestions are intended to supplement, but not replace, existing federal, local, and state laws and regulations. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. Installation tips are as follows:

- Be sure that only qualified personnel familiar with national codes, local codes, and ANSI/RIA R15.06-1999 safety standards are permitted to install the equipment.
- Identify the work envelope of each robot with floor markings, signs, and barriers.
- Position all controllers outside the robot work envelope.
- Whenever possible, install safety fences to protect against unauthorized entry into the work envelope.
- Eliminate areas where personnel might get trapped between a moving robot and other equipment (pinch points).
- Provide sufficient room inside the workcell to permit safe teaching and maintenance procedures.

2.6 Programming, Operation, and Maintenance Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to program, operate, and maintain the system. All personnel involved with the operation of the equipment must understand potential dangers of operation.

- Inspect the robot and work envelope to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.
- Be sure that all safeguards are in place. Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.
- Do not enter the robot cell while it is in automatic operation. Be sure that only the person holding the programming pendant enters the workcell.
- Check the E-STOP button on the programming pendant for proper operation before programming. The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- Back up all programs and jobs onto suitable media before program changes are made. To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.

- Any modifications to PART 1, System Section, of the robot controller concurrent I/O program can cause severe personal injury or death, as well as damage to the robot! Do not make any modifications to PART 1, System Section. Making any changes without the written permission of Motoman will VOID YOUR WARRANTY!
- Some operations require standard passwords and some require special passwords. Special passwords are for Motoman use only. YOUR WARRANTY WILL BE VOID if you use these special passwords.
- The robot controller allows modifications of PART 2, User Section, of the concurrent I/O program and modifications to controller parameters for maximum robot performance. Great care must be taken when making these modifications. All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot and other parts of the system. Double-check all modifications under every mode of robot operation to ensure that you have not created hazards or dangerous situations.
- Check and test any new or modified program at low speed for at least one full cycle.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.
- Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.
- Use proper replacement parts.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).

NOTES

Chapter 3

Installation

3.1 Installation of ToolSight Guage

Note: The ToolSight system includes the Relative Job software option. If the Relative Job software is not pre-installed, contact the Motoman service staff at (937) 847-3200 for installation.

WARNING!
If ToolSight is used with TouchSense, be sure the gauge is grounded in the weld circuit. TouchSense voltage is live during searching and may short against the gauge.

Depending on your configuration, ToolSight comes mounted on an accessory stand, or will need to be mounted within the robot's work area. In either case, mount the gauge or stand so that the sensor beams are roughly aligned with the robot's X and Y coordinates (world coordinates). See Figure 2.

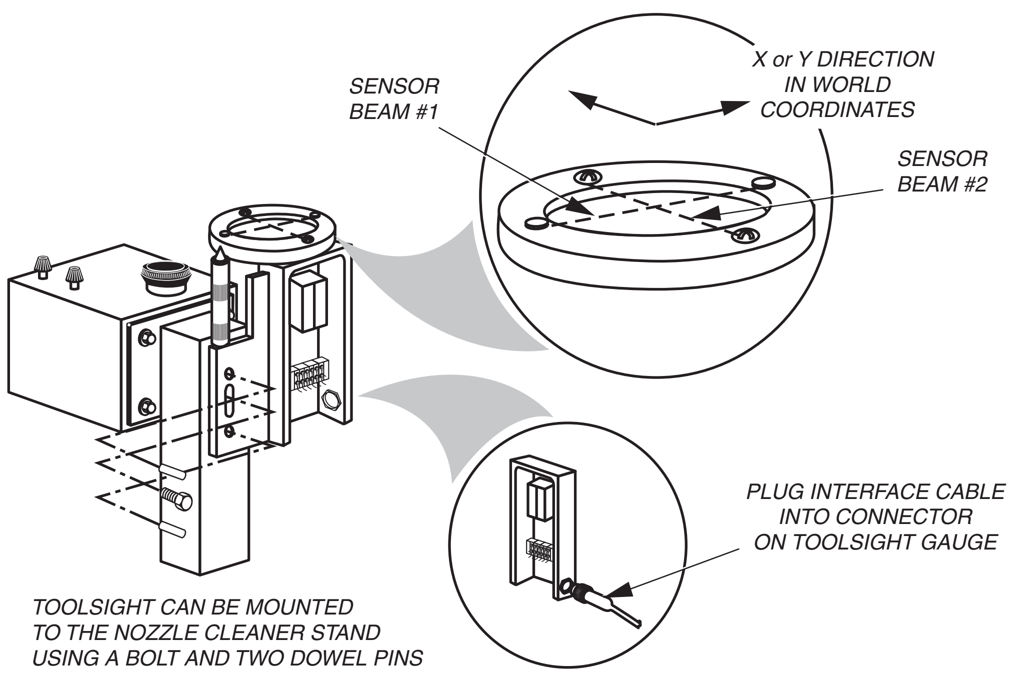


Figure 2 Installing ToolSight

3.2 Wiring Connections

DANGER!
Wiring should be completed only by a qualified technician familiar with the operation of this sytem. Follow all lockout/tagout procedures and national electrical code and/or local electrical codes.

CAUTION!
Improper connections can damage the robot.

1. Remove a gland plate from side of controller and install the pigtail cable assembly (P/N 150014-1).
1. Wire pigtail to JZNC-NRK01/JANCD-NBB01 board inside the NX100 cabinet according to electrical prints shipped with your system.
2. Connect yellow cable (P/N 144631-6) between controller and ToolSight.

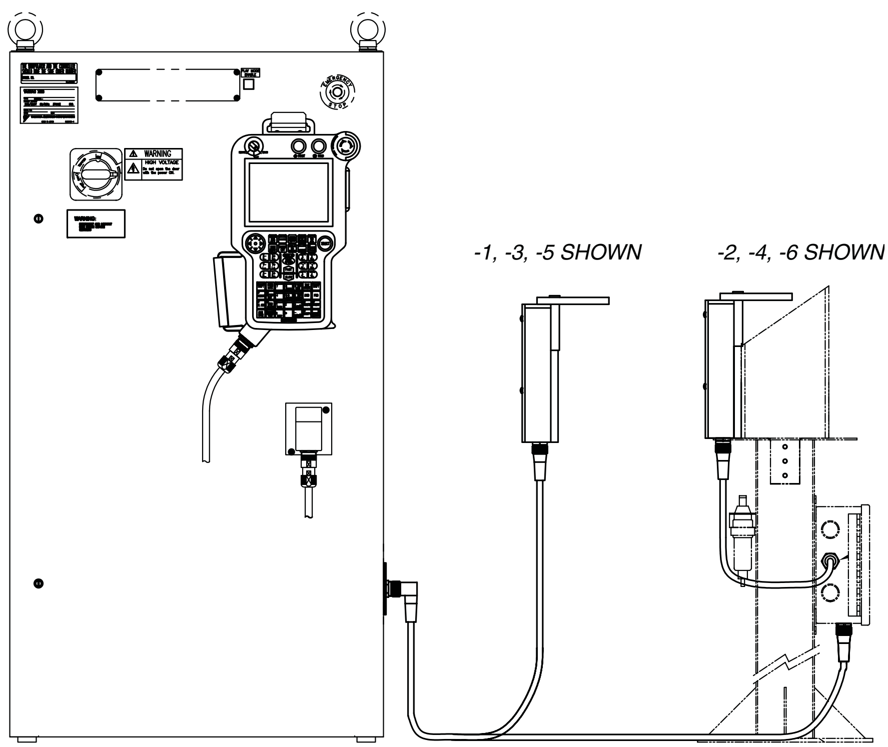


Figure 3 ToolSight Connections

Chapter 4

Setup and Operation

Your robotic system is shipped with the initial system parameters and a tool center point (TCP) already defined. ToolSight is most commonly used as a way to check the accuracy of the TCP. You can program the robot to execute the TCP–CHK job immediately following nozzle cleaning or periodically during production. If the TCP is not accurate, the TCP–CHK job executes the TS_SRCH routine, which automatically measures the amount of offset needed to correct the torch alignment and return it to the original TCP position.

Even though ToolSight can automatically adjust tool dimensions to compensate for an inaccurate TCP (which causes bad welds), worn contact tips or changing wire cast, which are often not visually apparent, can also cause problems. Worn contact tips are the most common cause of TCP variation. Regularly checking and replacing worn contact tips is an effective way to keep TCP accurate and avoid problem welds. Also, robot torches have replaceable necks. Torch manufacturers typically supply jigs to check torch alignment. Changing a deformed neck is a quick and effective way to maintain a mechanically consistent TCP.

ToolSight is also a diagnostic tool and can be used to rule out the possibility of a bad TCP. This allows you to focus debugging efforts on tooling misalignments or out-of-tolerance parts.

4.1 Setting Up ToolSight

CAUTION!
The default jobs and parameters are only functional on a floor mounted robot. If your robot is either wall or ceiling-mounted, do not run these jobs, because the orientation will be incorrect. Call Motoman Service for further instructions.

Note: The instructions in this manual were written for a system with a single robot. For dual robot systems, refer to the Tables 5-1 and 5-2 in Section 5 to determine which variables and jobs are used for Robot 2.
Before running the ToolSight programs, write down the existing Tool #0 data into a permanent record.

4.1.1 Verify the TCP

Before setting up ToolSight, verify the tool center point (TCP). Jog the robot to a position where the TCP is next to the alignment pointer. In World coordinates, use the rotate buttons of each axis to move the torch. If the torch rotates about a single reference point, without wandering, the TCP is acceptable.

If you need to reteach the TCP, refer to Appendix A for the TCP procedure. You will get more accurate results if you use a standard length teaching tip, instead of wire. Most contact tips have 5/16-inch threads, so the teaching tip can screw into the gas diffuser of the torch. The length of the teaching tip needs to match your preferred wire stick out length (WSO).

4.1.2 Set the Cup to TCP Distance

Measure from the bottom edge of the nozzle to the point where the TCP was taught. Convert this value to microns. (For example, 15mm would equal 15000 microns.) Select the SETUP job, and cursor down to the "INITIALIZE PARAMETERS" section. Set the D022 variable to this length.

4.1.3 Determine the X and Y Beam Rapid Inputs

Display the rapid inputs on the pendant as follows:

Select TOP MENU > IN/OUT > RIN.

1. With the wire extended, move the torch in the world X direction, until it breaks the beam which is perpendicular to its movement. When the beam is blocked, the sensor's yellow light will turn off. Set I022 at the top of the SETUP job to the same number as the rapid input that just turned on.
2. Move the torch in the world Y direction, until it breaks the beam which is perpendicular to its movement. Set I023 at the top of the SETUP job to the same number as the rapid input that just turned on.

4.1.4 Run the SETUP Job

1. Extend the wire approximately 1 inch below the nozzle.
2. It is very important that the bottom of the torch nozzle is parallel to the plane of the beams. To verify this, place a thin ruler on top of the gauge and jog the robot down until it almost touches the ruler. Set the speed to INCH, and press the rotate buttons in world coordinates until the nozzle is parallel to the ruler on all sides.
3. Jog the robot until the wire is in the center of both beams (see Figure 4-1). The exact center is not necessary. A rough starting point that blocks both beams is sufficient. When a beam is blocked, the yellow light of its sensor will turn off.

Note: If the 7th LED starts to flash, ignore it. This alarm indicates that a marginal sensing condition is detected, which could be expected when the edge of the wire is sensed. This "center of beams" position must be re-taught each time before running the setup job.

4. In TEACH mode select the SETUP job. Cursor down to the second MOVJ command. MODIFY this instruction for this new "center of beams" position. The first MOVJ command needs to be taught as an approach point above the gauge.
5. Execute the SETUP job.

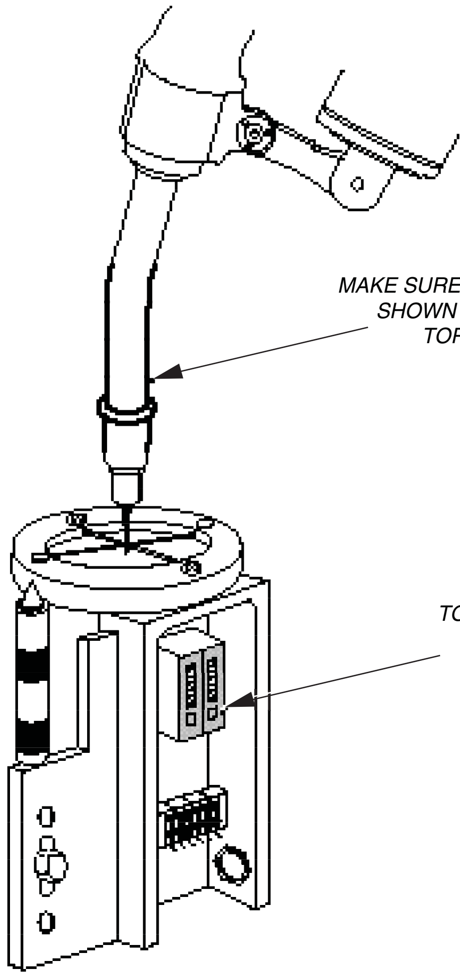


Figure 4 Torch Tip Intersecting Beam

The SETUP job will automatically define the User Frame #10 (Gauge Frame), the User Frame #11 (Flange Frame), the reference point for the original tool, and the PVariables used during the incremental moves of the ToolSight routines. User Frame #10 is taught with Tool 0, and is defined so that the origin is the intersection of the beams, and the X and Y-axes are the actual beam lines. User Frame #11 is defined with Tool 23, which has a value of 0 in the tool dimension file. This creates a user frame, which is exactly aligned with the tool frame.

4.1.5 Teach the Move Positions

1. In TEACH mode, select the R1SAFE job. Modify the MOVJ in this job at the safe or home position.
2. Select the TCP-CHK job. A total of 3 MOVJ and MOVL positions need to be modified for this new installation. Refer to Table 4-1 for the locations of the move instructions in the TCP-CHK job that need to be modified. On the left side of the table, look for a triangle with a number to determine which positions need to be taught. The list below defines where to teach each of these positions.
   - Operator Inspection Position where the contact tip can be examined ❶
   - Position above Torch Alignment Pointer ❷
   - Check Position at Torch Alignment Pointer ❸

Table 4-1 TCP—CHK Job

```
/JOB
//NAME TCP-CHK
//POS
///NPOS 3,0,0,7,0,0
///TOOL 0
///POSTYPE PULSE
///PULSE
C00000=-153024,9957,53125,-63063,-1786,19333
C00001=-142008,20205,60902,-42052,-5033,19165
C00002=-141944,14462,48442,-41794,-2032,20305
///USER 10
///POSTYPE USER
///RECTAN
///RCONF 0,0,0,0,0,0,0,0
P0078=0.000,0.000,0.000,0.00,0.00,0.00
P0079=31.383,79.105,-58.734,0.31,46.91,19.76
///USER 11
P0090=-97.456,-1.054,389.403,-0.02,-0.01,0.01
P0091=-96.587,-3.063,390.328,-0.02,-0.01,0.01
P0092=0.869,-2.009,0.925,0.00,0.00,0.00
///POSTYPE BASE
P0095=-96.653,-2.615,390.235,0.00,0.00,0.00
///USER 10
///POSTYPE USER
P0097=-0.232,0.072,-89.990,-0.04,44.84,31.15
//INST
///DATE 2005/02/01 15:56
///ATTR SC,RW
///GROUP1 RB1
NOP
'Software 142196-1, V1.3
'Installation Notes:
'1. Teach 3 MOV positions
'2. Adjust wire pulse timers (3)
'   so pulse wire out = retract.
'Note: Look for....to indicate
```

```
' which lines need modification.
'
CALL JOB:R1SAFE
SET B021 0
*RETEST
' Move above ToolSight.
MOVJ P097 VJ=100.00
'
'....Pulse wire (191=XRC,127=MRC)
'....Pulse wire (1023=NX)
① PULSE OT#(1023) T=0.07
'
'....This command is only
' required on 2 robot systems.
' Set relay for operation on R1.
'''DOUT OT#(5) OFF
'
'================================
'   CHECK FOR CENTER OF BEAMS
'================================
'
' Code for center check.
SET B020 59
CALL JOB:TS_SRCH
'
' Search error
JUMP *DONE IF B020>50
' Less than min limit - TCP is OK
JUMP *DONE IF B020=1
' Was there 2 attempts to correct
JUMP *REINSTLL IF B021>1
'
*FIX_TCP
' Between min & max limits
' - Automatically update TCP.
JUMP *UPDATE IF B020=21
'
' Greater than max limit
' - Perform Operator Inspection.
'
'================================
'   PERFORM OPERATOR INSPECTION
'================================
'
' Move above ToolSight
MOVJ P097 VJ=100.00
'
'....Move to inspect tip position
❶ MOVJ C00000 VJ=100.00
PAUSE
' Check contact tip.
' Display P089 for offset amount
'   (gauge point difference).
'
```

```
        '....Retract wire(192=XRC,128=MRC
        '....RETRACT WIRE(1024=NX)
②       PULSE OT#(1024) T=0.10
        '
        '....Move above alignment pointer
❷       MOVJ C00001 VJ=100.00
        GETS PX075 $PX000
        CNVRT PX079 PX075 UF#(10)
        '
❸       '....Move to torch alignment ptr
        MOVL C00002 V=83.3 PL=0
        PAUSE
        ' Check torch alignment.
        '
        ' Move up from torch alignment.
        MOVJ P079 VJ=100.00
        PAUSE
        ' Does the TCP need correction?
        ' If not, press TEST-START.
        ' To automatically correct the
        ' TCP, cursor down to *UPDATE.
        '
        JUMP *SKIP
        '
        '================================
        '   UPDATE TOOL DATA (TS_UPDAT)
        '================================
        '
        *UPDATE
        ' Is this the first attempt?
        JUMP *NOT_1ST IF B021>0
        ' Save Previous Tool data as P095
        GETTOOL P095 TL#(I021)
        *NOT_1ST
        ' Original Flange Point
        CNVRT PX090 PX087 UF#(11)
        ' Current Flange Point
        CNVRT PX091 PX088 UF#(11)
        SET P092 P091
        ' Difference of Flange Points
        SUB P092 P090
        ' Modify Tool Data.
        SETTOOL TL#(I021) - P092
        ADD B021 1
        JUMP *RETEST
        '
        '================================
        '  RE-INSTALL PREVIOUS TOOL DATA
        '================================
        '
        *REINSTLL
        PAUSE
        ' There have been 2 attempts to
        ' correct the TCP.  Investigate
        ' the problem.
```

```
'
' Press TEST-START to try again.
' To re-install the previous Tool
' cursor to *PREVTOOL.
'
JUMP *FIX_TCP
'--------------------------------
*PREVTOOL
' Current tool data
GETTOOL P078 TL#(I021)
' Previous tool data
SET P079 P095
' Difference
SUB P078 P079
' Modify tool data for prev tool.
SETTOOL TL#(I021) - P078
'
'================================
'   COMPLETE JOB
'================================
'
*DONE
' Move up from ToolSight.
MOVJ P097 VJ=100.00
'
'....Retract wire(192=XRC,128=MRC
'....RETRACT WIRE(1024=NX)
③ PULSE OT#(1024) T=0.10
*SKIP
CALL JOB:R1SAFE
'--------------------------------
'
' IMPORTANT PARAMETERS
'  P087=Original Gauge Point
'  P088=Current Gauge Point
'  P089=Diff Gauge = Current-Org
'  P094=Original Tool after SETUP
'  P095=Previous Tool data
'  TL#(I021)=Current Tool
END
```

4.1.6 Verify Wirefeed Output

The timer settings on the wirefeed pulse outputs may need to be modified to match the welders wirefeed drive mechanism. The amount of wire fed out (Table 4-1, Line ①) should be equal to the amount retracted (Lines ② and ③). The default times for both TCP-CHK and TCPCKR2 are T=0.30 to feed wire and T=0.40 to retract wire. Measure the wire before and after the job is executed. If the measurements are not equal, adjust the times accordingly.

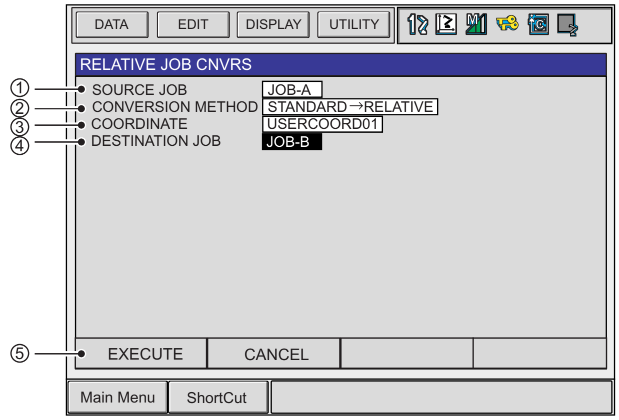
4.1.7 Convert Jobs to Relative Jobs

The TCP-CHK job and any job that needs automatic TCP correction has to be converted to a relative job format. Typically, Motoman adds an "R" to the end of the job name to indicate it's a relative job, i.e. TCP-CHKR.

The relative job software provided with ToolSight allows you to convert programs from the standard encoder pulse format to X, Y, and Z values based on a user frame. When the TCP is modified, all the relative jobs that use that tool are updated automatically. For additional information, refer to the Relative Job Function manual (P/N 149648-9).

To Convert a job to a Relative Job, proceed as follows:

	Operation	Explanation
1	Select {JOB} under the main menu.	
2	Select {JOB CONTENT}.	

	Operation	Explanation
3	Select {UTILITY} under the menu.	Relative job conversion window appears.  ①SOURCE JOB Selects the job to be converted. Select {SOURCE JOB} and the job list display is shown. Select the job to be converted. ②CONVERSION METHOD Displays the conversion method. STANDARD→RELATIVE : Converts a standard job into a relative job RELATIVE→STANDARD : Converts a relative job into a standard job
4	Select {RELATIVE JOB}.	③COORDINATE Selects a coordinate system where a standard job is converted into a relative job. Select {COORDINATE}, and the selection dialog is disSets a job name for the conversion destination. Select {DESTINATION}. Enter a job name for the conversion destination. When a job name for the conversion destination has been set, a new job is created when converting. When a job name has not been set, the job at the conversion source itself is used. ⑤EXECUTE Executes job conversion. Select {EXEC} to execute the conversion. *Note: During conversion, all key operations are unavailable.* *Any alarm during the conversion interrupts the operation.* *When the conversion is completed, the job contents window appears.*

4.1.8 Using the TCP-CHK Job

Insert the relative job version of the TCP-CHK job at the point in your job where you want to automatically check the accuracy of the torch alignment. The TCPCHKR job moves the tip of the weld wire into the intersection of ToolSight's light beams. If the tip of the weld wire breaks both beams, the TCP passes the verification and the robot resumes normal production.

The TCP-CHKR job verifies that both sensor lenses are clean before an inspection begins. The robot will pulse out the wire to make sure there is enough wire to cross the beams and to avoid any bad measurements from a weld ball at the end of the wire. The wire will be retracted after the test.

The robot will move the wire to the TCP check position. If the wire blocks both light beams, the TCP is okay, and the robot will return to a safe position to complete the job.

If one of the beams is not broken, the program executes the TS_SRCH job to determine the current "center of beam" position and calculate offsets from the previous position. This job compares the difference between the current and previous position against minimum and maximum limits.

If the difference is less than the minimum limit, the previous TCP is still acceptable. If the difference is between the minimum and maximum limits, the TCP will be updated automatically. If the difference is greater than the maximum, the robot will perform an operator inspection sequence that will allow you to decide whether an automatic TCP correction is necessary.

Note: Systems are shipped with the minimum limit equal to the maximum limit (0.6mm). It is highly recommended that you inspect the torch for worn tips and wire cast variations before choosing to change the TCP automatically. In the rare case that you would choose to automatically correct the TCP without an inspection, the maximum limit can be changed in the SETUP job.

During the operator inspection sequence, the robot moves the torch to a position where you can remove the nozzle and inspect the contact tip for possible replacement. Switch the system to TEACH, and press TEST START to move the robot to the torch alignment pointer. At this station, the wire cast and the torch alignment are examined. A sleeve can be raised up and over the tip to check the alignment. The actual offset distances in the Gauge Frame (UF#10) can be observed by viewing the P089 variable.

Pressing TEST START moves the robot up and the programming pendant displays a question, asking if the TCP needs to be corrected. If you can fix the problem without changing the TCP data, press START (in PLAY mode) to skip the correction and finish the job. If you decide that an automatic correction (shift) of the TCP is necessary, there will be comments in the program instructing you to cursor down to the *UPDATE label. Press TEST START to perform the TCP update.

If you choose to change the TCP data, this job will convert the offset from the Gauge Frame (UF#10) to the Flange (tool) Frame (UF#11) of reference. Then it will execute the SETTOOL command to modify the tool data for this difference.

Whenever the tool data is changed, the program will check the TCP again to verify that the correction was successful.

Note: The old tool data can always be retrieved at the end of the SETUP job, the original tool data is stored in Pvariable P094. And each time before the TCP is changed, the previous tool data is stored in P095. If for some reason, there are two *unsuccessful attempts to correct the TCP, the job will pause and give the operator the option to automatically re-install the previous tool, which was used on the last production run.*

4.1.9 Verifying ToolSight Corrects the TCP

1. Write down the Tool #0 data.
2. Turn off the power to the wirefeeder so that the bent wire will not be pulsed out any farther.
3. Run the relative job TCP-CHKR. The robot should move the wire to the center of the beams, pass the test, and return to the safe or home position.
4. Slightly bend the wire at the contact tip. It is very important that you don't bend the wire more than 5mm away from the original TCP. ToolSight is designed to correct TCP deviations of up to ± 5mm in any direction.
5. Run the relative job TCP-CHKR. This time the check position will fail, and the robot will perform a search routine to determine the offset to the center of the beams.
6. During the torch inspection sequence, press the START button (in PLAY) twice. Press TEACH mode and cursor to the Update label. Switch back to PLAY mode and press START to automatically correct the TCP. The robot moves the bent wire to the center of the beams to verify the new TCP and returns to home position.
7. Compare the updated Tool #0 data with the original tool data that was written down in step 1, or view the P089 variable to observe the actual offset amount in the Gauge Frame (UF#10).
8. Turn on the power to the wirefeeder. Feed the wire out and cut off the bent section.
9. Run the relative job TCP-CHKR. The check position will fail again, and the robot will perform a search routine to determine the offset.
10. During the torch inspection sequence, press the START button (in PLAY) twice. Press TEACH mode and cursor to the Update label. Switch back to PLAY mode and press START to automatically correct the TCP. The robot moves the bent wire to the center of the beams to verify the new TCP and returns to home position.
11. Compare the updated Tool #0 data with the original tool data that was recorded in step 1. This data should be very close to the original data.

ToolSight is now set up properly and is fully functional.

✍ *Note: Any time you change a tool, you must teach a new TCP and run the SETUP procedure again.*

Notes

Chapter 5

Variables and Jobs

5.1 Variables and User Frames

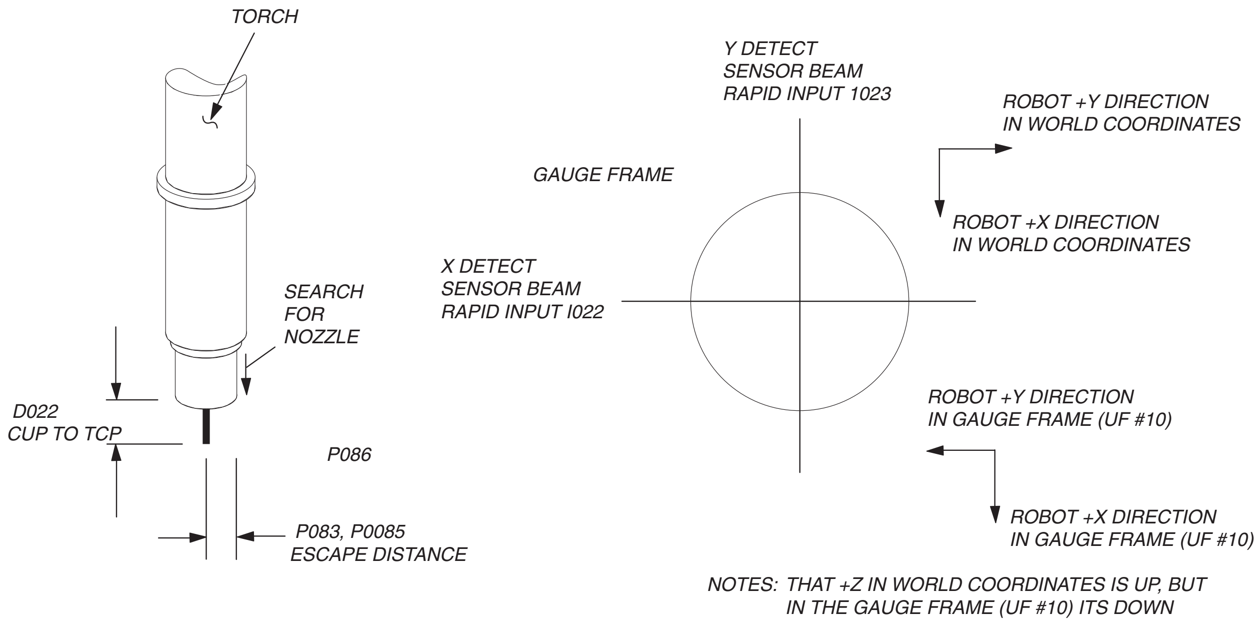
ToolSight uses the variables, user frames (UF), and tool #'s shown in Table 5-1. Avoid using these variables in other programs. ToolSight parameters are shown in Figure 5-1.

Table 1 ToolSight Variables

R1 Variables	Description	R2 Variables (Dual)
B020	ToolSight Search Status Code	B030
B021	Number of TCP correction attempts	B031
B022 - B023	Used for miscellaneous storage	B032-B033
1020 = 350	Search Speed (cm/min)	I030=350
1021 = 0	Tool Number (0..21) (Tools 22 and 23 are reserved)	I031=1
1022 = 2	Rapid Input Number for X beam (1..3)	I032=2
1023 = 3	Rapid Input Number for Y and Z beams (1..3)	I033=3
D021	Z addition of center of cup	D031
D022 = 15000	Measurement of Cup to TCP distance (0.001mm)	D032 = 15000
D023 = 600	Minimum Limit XYZ (0.001 mm)	D033 = 600
D024 = 600	Maximum Limit XY (0.001 mm)	D034 = 600
D025 = 600	Maximum Limit Z (0.001 mm)	D035 = 600
D036 - D039	Used for miscellaneous storage	D036-D039
P079 - P079	Used for miscellaneous storage	P105-P109
P080	Base Position (Origin of gauge frame)	P110
P081	Search Start Position	P111

Table 1 ToolSight Variables

R1 Variables	Description	R2 Variables (Dual)
P082	X search distance	P112
P083	X escape distance	P113
P084	Y search distance	P114
P085	Y escape distance	P115
P086	Z search distance	P116
P087	Original Gauge Point	P117
P088	Current Gauge Point	P118
P089	Difference Gauge	P119
P090	Original Robot Flange Point	P120
P091	Current Robot Flange Point	P121
P092	Different Flange	P122
P093	Z escape distance	P123
P094	Original tool data saved after SETUP job ran	P124
P095	Previous tool data saved before last change	P125
P096	Position at center of beams (check point)	P126
P097	Position above ToolSight	P127
Uframe #10	User Frame for Gauge	UFrame #20
Uframe #11	User Frame for Robot Flange	UFrame #21
TOOL #23	Tool that has values of 0 for dimensions	Tool #22
REFF 1	Reference Point with 0 Dimension Tool	REFF 2



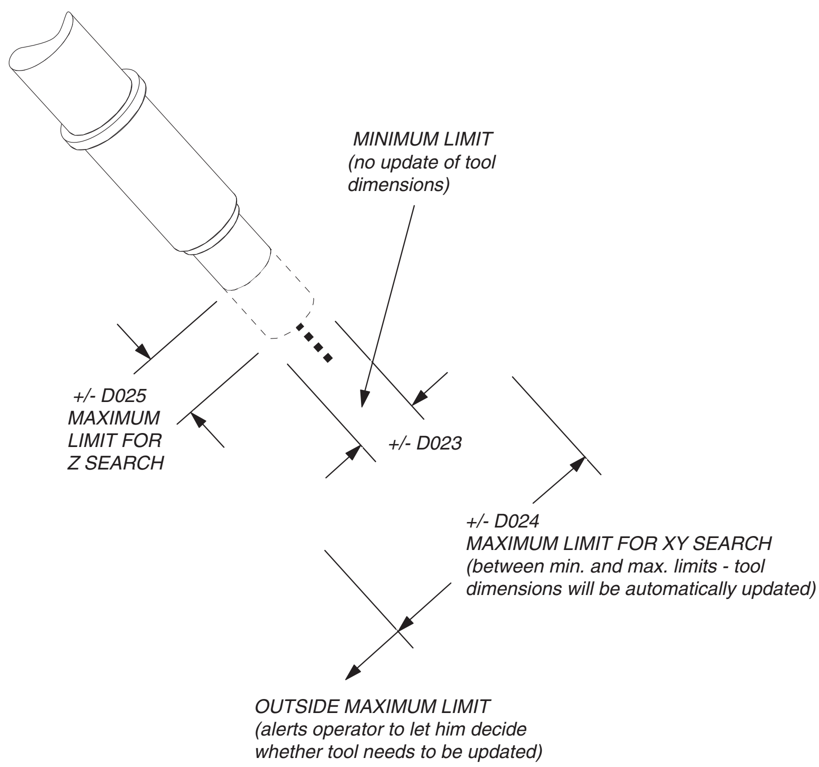


Figure 5 ToolSight Parameters

5.2 Standard Jobs

Table 5-2 lists the standard jobs that are included with the ToolSight package which are used to set up and define various ToolSight parameters and variables. The TCPCHK job was listed in Table 4-1, and the TS_SRCH and SETUP jobs are listed in Appendix C.

Table 2 ToolSight Jobs

Robot1 Jobs	Robot2 Jobs	Robot3 Jobs	Description
TCP_CHK	TCPCHK2	TCPCHK3	This job is a quick go/no-go check for TCP. If the TCP is unacceptable, an operator inspection sequence will be performed. With the operator's approval, the tool data can be automatically updated.
TS_SRCH	SRCH_R2	SRCH_R3	This job searches for the differences between current and previous center of beams position. Then it will compare this difference against the minimum and maximum limits.
SETUP	SETUP_R2	SETUP_R3	This job sets up user frames #10 and #11, sets the initial parameters and default values for the user variables, and defines the Pvariables for incremental moves.
R1SAFE	R2SAFE	R3SAFE	This job moves the robot to a safe or home position.

Chapter 6

Troubleshooting and Maintenance

6.1 Troubleshooting

Table 6-1 identifies problems you might encounter while using ToolSight. Refer to the Relative Job Function Manual for an explanation of error and alarm messages related to the relative job function. Appendix D contains additional information related to the parameters and alarms that may be associated with the settool/gettool function.

Table 3 ToolSight Troubleshooting

Problem	Probable Cause	Solution
After the tool center point is shifted with the ToolSight routine, the job points appear to have shifted correctly, yet all points are consistently off by the same amount in the same direction.	The robot's absolute data is in error. The absolute data can be affected by motor maintenance or by a severe crash that affects the relationship of the encoder to the axis position.	Calibrate the robot with Motoman's MotoCal software. This PC-based software improves the robot's accuracy by refining the absolute data.
You have received an Illegal Position Variable error message.	In the ToolSight job, the format of a position variable does not match the instruction being executed.	Make sure that the position variables used in the ToolSight job are not used in other jobs. Refer to the ToolSight variables in Section 5.
Robot will not stop in the ToolSight gauge when the light beams are broken.	There is a set up or programming error.	Verify X beam and Y beam are set up for the correct Rapid Input numbers. Refer to section 4.1.3. Search Speed is too fast. The limit is 350 cm/min.

Table 3 ToolSight Troubleshooting

Problem	Probable Cause	Solution
Tool data changed, but jobs did not shift.	Jobs have not been converted to relative jobs.	Refer to Section 4.1.7 for instructions on converting standard pulse jobs into relative jobs in base frame. Run these relative jobs so the new tool data can take effect. Save the pulse jobs as backup for your original taught program.
Very large shift results occur.	Check to make sure the TCP is correctly set up.	Follow instructions in Appendix A to teach a new TCP and then perform the SETUP procedure again.
The setup program pauses and displays the message, "Adjust torch angle so cup is level with gauge."	The bottom of the torch's nozzle needs to be somewhat parallel to the gauge.	Level the nozzle, by referring to section 4.1.4.2, and execute SETUP again.
The final check after a TCP correction keeps failing.	ToolSight was designed to correct the TCP for deviations of up to +/- 5mm in the gauge frame. If the deviation is greater, the side of the nozzle could be sensed for a Z measurement, which will cause a bad correction.	Investigate the problem, reteach the TCP, and run SETUP again.

6.2 Maintenance

ToolSight requires occasional cleaning, and the sensors may require occasional calibration. There is an inspection for a dirty sensor lens each time the TCP-CHK job is executed. If the signal strength is unacceptable, the program will pause with a comment stating that the sensor lens needs to be cleaned.

You can also detect a dirty sensor lens by looking at the sensor's red illuminated 7- segment scale, which indicates the signal strength. When nothing is blocking the beam and the fourth red LED from the bottom does not turn, the sensor lens needs to be cleaned.

6.2.1 Cleaning the Sensor Lens

Using mild soap and water, clean each plastic sensor lens, located on the four sides of the ToolSight gauge. Do not use a solvent or alcohol, because this could damage the lens. If the cleaning process does not increase the strength to at least the #4 red LED, you need to re-calibrate the sensor.

6.2.2 Calibrating the Sensor

Locate the signal strength potentiometer on the front of the sensor. Make sure there is nothing blocking the beams and turn the potentiometer clockwise until the #7 red LED just turns on. Then continue to turn the potentiometer one additional full turn clockwise.

Appendix A

Programming Tool Center Point

The tool center point (TCP) is the position that the robot references for interpolated motion (linear and circular) and positioning for relative jobs. The TCP is calculated by software based on 5 points taught about a fixed point. The alignment pointer is used as a reference for these 5 points. The torch should have proper wire stick out or a pointer of the correct length.

It is recommended that the first point be taught with the torch perpendicular and the two tips aligned (see Figure A-1). The other four points should be taught at angles 45 - 90 degrees from perpendicular. These four points should be at 90-degree angles, matching the directions of the compass on the x - y plane.

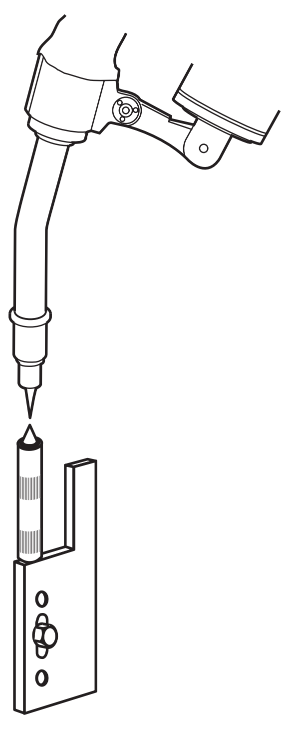
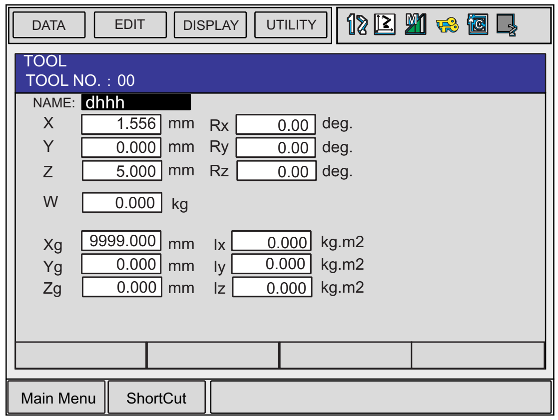


Figure 6 Defining Tool Center Point - First Taught Position

1. Select TEACH on the playback box.
2. Press MAIN MENU, cursor to the ROBOT icon and press SELECT.

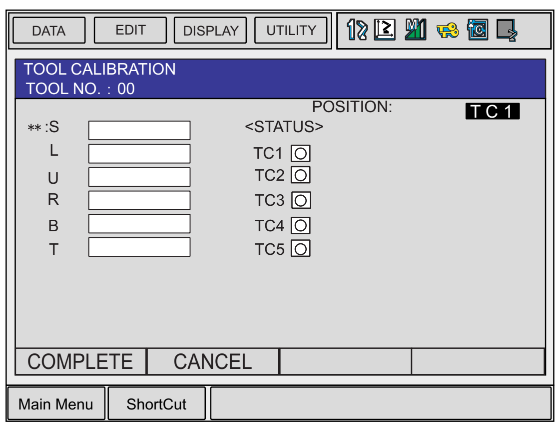
3. Cursor to TOOL and press SELECT.



4. Select desired tool number.

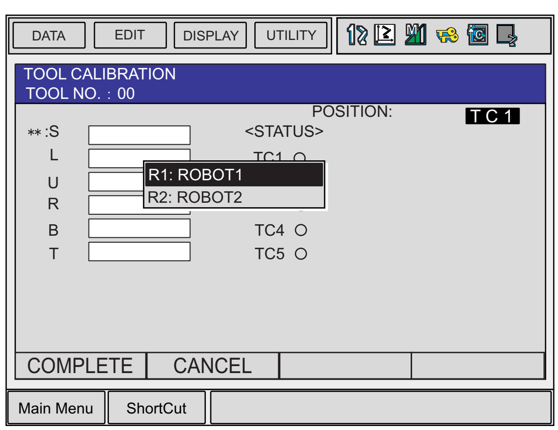
5. Press the AREA key, cursor to UTILITY and press SELECT.

6. Cursor to CALBRATION and press SELECT. The Tool Calibration window appears.

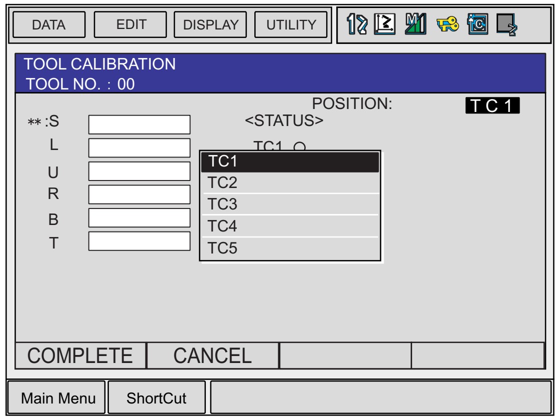


Note: To clear existing data, press the AREA key to highlight DATA and press SELECT. Cursor to CLEAR DATA and press SELECT. Cursor to YES on the "Clear Data?" screen and press SELECT.

7. Select the Robot.



8. Press TEACH LOCK and enable Servos On. Choose any COORD except TOOL.
9. If TC1 is not highlighted, cursor to TC1 and SELECT it.



10. Jog the robot to the pointer until the tip of the torch pointer almost touches the alignment pointer. See Figure A-1.
11. Press MODIFY and ENTER. The first TC point (TC1) has been programmed. Cursor to TC2 and SELECT it. The Taught position is registered.
12. Jog the robot to a 45 – 90 degree angle, as shown in Figure A-2, making sure tip of torch pointer contacts the alignment pointer.

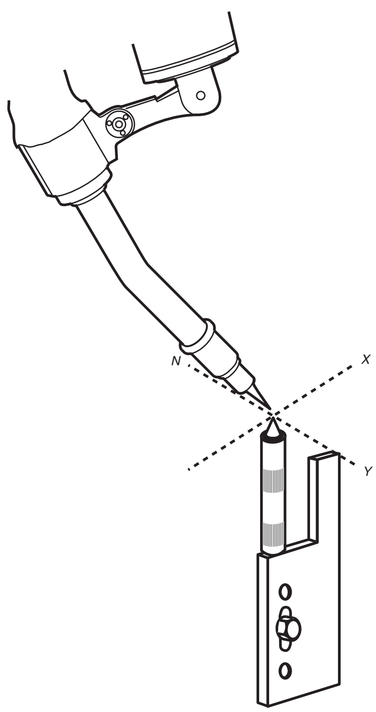
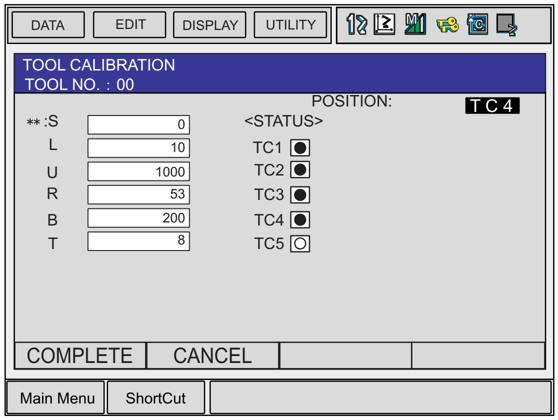


Figure 7 Figure A-2 Defining Tool Center Point - Second Taught Position

13. Press MODIFY and ENTER. The second TC point (TC2) has been programmed.
14. Cursor to TC3 and SELECT it.

Note: For each of the five TC points, change the robot's orientation to obtain as much variance as possible between points.

● indicates that teaching is completed and ○ indicates that it is not completed.

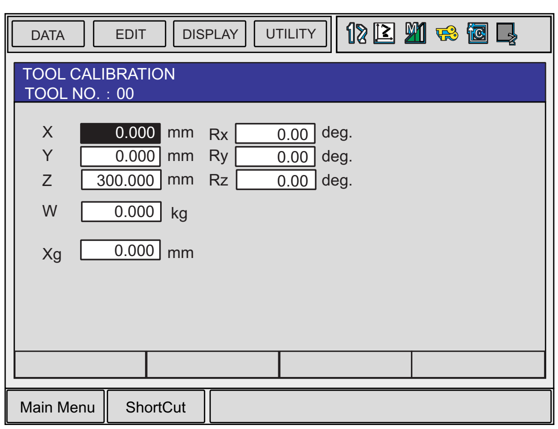


15. Repeat steps 12 and 13 for points TC3 through TC5, moving the robot to a different orientation each time.

Note: If you need to view the position where the TC point was set, press the FWD key to move to the desired TC point. When the highlighted TC point stops flashing, the robot is at that TC point's set location.

16. After all five TC points have been entered, cursor down to COMPLETE and press SELECT. If there is a difference between the current position of the manipulator and the shown position data, "TC☐" next to "POSITION" in the window flashes.
17. The Tool Calibration screen appears with the new TCP data. Highlight RY, press EDIT, SELECT, –45, and ENTER.

Calibration data is registered in the tool file. Once calibration is completed, the coordinate window is shown.



The new tool center point is now defined.

Appendix B
Jobs

B.1 Setup Job

```
/JOB
//NAME SETUP
//POS
///NPOS 3,0,0,16,0,0
///TOOL 0
///POSTYPE PULSE
///PULSE
C00000=38599,-6475,-10297,3119,40989,-111
C00001=38599,-7465,-21468,3757,47094,-477
///TOOL 23
C00002=-161384,20375,-29475,-36577,12679,50599
///USER 10
///TOOL 0
///POSTYPE USER
///RECTAN
///RCONF 0,0,0,0,0,0,0,0
P0076=0.100,0.000,0.000,0.00,0.00,0.00
P0077=0.424,5.305,0.122,-5.55,2.11,-24.56
P0078=0.000,0.000,0.000,0.00,0.00,0.00
P0079=-31.908,-82.836,-81.094,-5.56,1.97,-24.57
P0080=0.002,-0.001,0.001,-5.56,2.11,-24.57
P0081=-14.998,-0.001,-14.999,-5.56,2.11,-24.57
P0082=30.000,0.000,0.000,0.00,0.00,0.00
P0083=0.000,-15.000,0.000,0.00,0.00,0.00
P0084=0.000,30.000,0.000,0.00,0.00,0.00
P0085=0.000,-5.000,0.000,0.00,0.00,0.00
P0086=0.000,0.000,30.000,0.00,0.00,0.00
P0087=-0.472,-0.921,0.011,-5.56,2.11,-24.57
P0088=0.426,0.298,0.095,-5.56,2.11,-24.57
P0089=0.898,1.219,0.084,0.00,0.00,0.00
P0093=0.000,10.000,-15.000,0.00,0.00,0.00
///POSTYPE BASE
P0094=1.061,1.041,321.089,0.00,-45.00,0.00
//INST
///DATE 2001/02/22 18:03
///ATTR SC,RW
///GROUP1 RB1
NOP
```

```
'Software 142196-1, V1.3
'Installation Notes:
'1. Teach 2 MOVJ positions.
'2. Verify parameters below.
'3. It is very important to set
'    D022 to the proper length.
'
'....Move above ToolSight.
MOVJ C00000 VJ=50.00
'....Move to center of beams.
'Always re-teach before running.
MOVJ C00001 VJ=50.00
'
'Note that before teaching this
'position, verify that the
'bottom of the cup is parallel
'to plane of the beams, or gauge
'
'================================
'INITIALIZE PARAMETERS (TS_INIT)
'================================
'
'....Set D022 to distance from
'Nozzle to TCP (0.001mm).
SET D022 15000
'Tool number (0-22)
SET I021 0
'See note below on X beam def.
'Rapid input # for X beam (1-3).
SET I022 2
'Rapid input # for YZ beam (1-3)
SET I023 3
'MIN limit XYZ (0.001mm)
SET D023 600
'MAX limit XY (0.001mm)
SET D024 600
'MAX limit Z (0.001mm)
SET D025 600
'Search speed (cm/min,350max).
SET I020 350
'
'Note that the X Beam is
'defined as the beam that the
'robot crosses when it is
'moving in the X direction.
'The X Beam should be roughly
'parallel to the robot Y axis.
'
'....This command is only
'required on 2 robot systems.
'Set relay for operation on R1.
''DOUT OT#(5) OFF
'
'*******************************
'*******************************
'  No modifications required
'      below this line.
```

```
'********************************
'********************************
'
'
'================================
'  DETERMINE CENTER OF BEAMS
'================================
'
'Find Wire Edge & Stickout
' at Center.
'
GETS PX076 $PX001
SUB P076 P076
SETE P076 (2) 7000
IMOV P076 V=I020 BF
SETE P076 (2) -7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed wire
SETE P076 (2) 7000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -30000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed cup
SETE P076 (3) D022
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (2) -7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed wire
'--------------------------------
'
'  Find Z of Beam Intersection.
'
SETE P076 (2) 7000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -25000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed cup-side1
GETS PX075 $PX002
SETE P076 (2) -14000
SETE P076 (3) 15000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -15000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
```

```
GETS B022 $B002
PAUSE IF B022=0
'Missed cup-side2
CNVRT PX076 PX075 BF
GETS PX075 $PX002
CNVRT PX077 PX075 BF
GETE D036 P076 (3)
GETE D021 P077 (3)
SUB D021 D036
DIV D021 2
'D021 = Z Offset for cup center
'       from +Y side.
PAUSE IF D021>450
PAUSE IF D021<-450
'Adjust torch angle so cup is
'level with gauge, & start over.
'
'Z for wire stickout
SET D038 D022
'Z Offset for cup center
SUB D038 D021
SUB P076 P076
SETE P076 (3) D038
IMOV P076 V=I020 BF
'--------------------------------
'
'  Find Y Beam.
'
SUB P076 P076
SETE P076 (2) 7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed - side of Y beam.
GETS PX075 $PX002
IMOV P076 V=I020 BF
SETE P076 (2) -7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed + side of Y beam.
CNVRT PX076 PX075 BF
GETS PX075 $PX002
CNVRT PX077 PX075 BF
GETE D036 P076 (2)
GETE D037 P077 (2)
SUB D037 D036
DIV D037 2
ADD D036 D037
SETE P076 (2) D036
'Center of Y beam
MOVL P076 V=I020
'--------------------------------
'
```

```
'  Find X Beam
'
SUB P076 P076
SETE P076 (1) 7000
IMOV P076 V=I020 BF
SETE P076 (1) -7000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed + side of X beam.
GETS PX075 $PX002
IMOV P076 V=I020 BF
SETE P076 (1) 7000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed - side of X beam.
CNVRT PX076 PX075 BF
GETS PX075 $PX002
CNVRT PX077 PX075 BF
GETE D036 P076 (1)
GETE D037 P077 (1)
SUB D037 D036
DIV D037 2
ADD D036 D037
SETE P076 (1) D036
SET P079 P076
MOVL P079 V=I020
'
'P079=XY Center of beams at WSO
'
'================================
'  DETERMINE UF#10 FOR GAUGE
'================================
'
'  Find Wire Edge & Stickout
'   at XX.
'
SUB P076 P076
SETE P076 (1) 20000
SETE P076 (2) 20000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (2) -30000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed wire
SETE P076 (2) 7000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -25000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
```

```
PAUSE IF B022=0
'Missed cup
SET D038 D022
ADD D038 D021
'Raise for WSO + Z offset
SETE P076 (3) D038
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (2) -7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed wire
'--------------------------------
'
'  Find XX for UF#10.
'
SETE P076 (2) 7000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -25000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed cup
'
'Raise for WSO + Z offset.
SETE P076 (3) D038
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (2) -7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed + side of Y beam.
GETS PX075 $PX002
IMOV P076 V=I020 BF
SETE P076 (2) 7000
IMOV P076 V=I020 BF SRCH RIN#(I023)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed - side of Y beam.
CNVRT PX076 PX075 BF
GETS PX075 $PX002
CNVRT PX077 PX075 BF
GETE D036 P076 (2)
GETE D037 P077 (2)
SUB D037 D036
DIV D037 2
ADD D036 D037
'Center of Y beam
SETE P076 (2) D036
GETE D039 P076 (3)
'Subtract WSO to get position.
```

```
SUB D039 D022
SETE P076 (3) D039
SET P078 P076
'
'P078=XX of UF#10
'--------------------------------
'
'  Find Wire Edge & Stickout
'   at XY.
'
SUB P076 P076
SETE P076 (2) -20000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (1) -30000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed wire
SETE P076 (1) 7000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -25000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed cup
SETE P076 (3) D022
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (1) -7000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed wire
'--------------------------------
'
'  Find Z of XY for UF#10.
'
SETE P076 (1) 7000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -25000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed cup-side1
GETS PX075 $PX002
SETE P076 (1) -14000
SETE P076 (3) 15000
IMOV P076 V=I020 BF
SUB P076 P076
SETE P076 (3) -15000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
```

```
GETS B022 $B002
PAUSE IF B022=0
'Missed cup-side2
CNVRT PX076 PX075 BF
GETS PX075 $PX002
CNVRT PX077 PX075 BF
GETE D036 P076 (3)
GETE D037 P077 (3)
SUB D037 D036
DIV D037 2
'D037 = Z Offset for cup center
'       from +X side.
PAUSE IF D037>450
PAUSE IF D037<-450
'Adjust torch angle so cup is
'level with gauge, & start over.
'
'Z for wire stickout
SET D038 D022
'Z Offset for cup center
SUB D038 D037
SUB P076 P076
SETE P076 (3) D038
IMOV P076 V=I020 BF
'--------------------------------
'
'  Find XY for UF#10.
'
SUB P076 P076
SETE P076 (1) 7000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed - side of X beam.
GETS PX075 $PX002
IMOV P076 V=I020 BF
SETE P076 (1) -7000
IMOV P076 V=I020 BF SRCH RIN#(I022)=ON DIS=10.0
GETS B022 $B002
PAUSE IF B022=0
'Missed + side of X beam.
CNVRT PX076 PX075 BF
GETS PX075 $PX002
CNVRT PX077 PX075 BF
GETE D036 P076 (1)
GETE D037 P077 (1)
SUB D037 D036
DIV D037 2
ADD D036 D037
'Center of X beam
SETE P076 (1) D036
SET P077 P076
GETE D039 P077 (3)
'Subtract WSO to get position.
```

```
SUB D039 D022
SETE P077 (3) D039
'
'P077=XY of UF10
'--------------------------------
'
'Find Org for UF#10 & make Frame
'
SET P076 P079
GETE D039 P076 (3)
'Subtract WSO to get position
SUB D039 D022
SETE P076 (3) D039
'
'P076=Origin of UF#10
'
MFRAME UF#(10) PX076 PX078 PX077
'
MOVL P076 V=I020 PL=0
GETS PX075 $PX000
CNVRT PX080 PX075 UF#(10)
'P080=Base Position
'
'================================
'   DETERMINE UF#11 FOR FLANGE
'================================
'
REFP 1 C00002
GETS PX075 $PX011
CNVRT PX076 PX075 TF
SUB P076 P076
SET P077 P076
SET P078 P076
SETE P077 (1) 20000
SETE P078 (2) 20000
IMOV P076 V=I020 TF
GETS PX076 $PX000
'P076=Origin of UF11
IMOV P077 V=I020 TF
GETS PX077 $PX000
'P077=XX of UF11
MOVL P076 V=I020
IMOV P078 V=I020 TF
GETS PX078 $PX000
'P078=XY of UF11
'
MFRAME UF#(11) PX076 PX077 PX078
'Move to center of beams.
MOVL P079 V=I020
'
'================================
'   DEFINE PVariables (TS_PREP)
'================================
'
```

```
'Search start position
SET P078 P080
SUB P078 P078
SET P081 P078
SETE P081 (1) -15000
SETE P081 (3) D022
GETE D039 P081 (3)
MUL D039 -1
SETE P081 (3) D039
ADD P081 P080
'X search distance
SET P082 P078
SETE P082 (1) 30000
'X escape distance
SET P083 P078
SETE P083 (2) -15000
'Y search distance
SET P084 P078
SETE P084 (2) 30000
'Y escape distance
SET P085 P078
SETE P085 (2) -5000
'Z search distance
SET P086 P078
SETE P086 (3) 30000
'Z escape distance
SET P093 P078
SETE P093 (2) 10000
SETE P093 (3) D039
'
'Original gauge point
SET P087 P080
'Current gauge point
SET P088 P080
SET P089 P080
'Difference gauge
SUB P089 P089
'
'================================
'  MEASURE OFFSETS
'================================
'
'Adjust Z Offset for 5mm from
'center instead of 7mm.
MUL D021 5
DIV D021 7
'Code to skip center check.
SET B020 99
CALL JOB:TS_SRCH
'Original gauge point
ADD P087 P089
'Difference gauge
SUB P089 P089
'
```

```
'Move to TCP Check position.
MOVL P079 V=I020 PL=0
GETS PX075 $PX000
'Save check position.
CNVRT PX096 PX075 UF#(10)
'Move above ToolSight.
SUB P079 P079
SETE P079 (3) -75000
IMOV P079 V=700.0 UF#(10)
GETS PX075 $PX000
'Save position above ToolSight.
CNVRT PX097 PX075 UF#(10)
'
'Save Original Tool as P094.
GETTOOL P094 TL#(I021)
END
```

B.2 TS_SRCH Job

```
/JOB
//NAME TS_SRCH
//POS
///NPOS 0,0,0,14,0,0
///USER 10
///TOOL 0
///POSTYPE USER
///RECTAN
///RCONF 0,0,0,0,0,0,0,0
P0076=0.100,0.000,0.000,0.00,0.00,0.00
P0077=0.424,5.305,0.122,-5.55,2.11,-24.56
P0080=0.002,-0.001,0.001,-5.56,2.11,-24.57
P0081=-14.998,-0.001,-14.999,-5.56,2.11,-24.57
P0082=30.000,0.000,0.000,0.00,0.00,0.00
P0083=0.000,-15.000,0.000,0.00,0.00,0.00
P0084=0.000,30.000,0.000,0.00,0.00,0.00
P0085=0.000,-5.000,0.000,0.00,0.00,0.00
P0086=0.000,0.000,30.000,0.00,0.00,0.00
P0087=-0.472,-0.921,0.011,-5.56,2.11,-24.57
P0088=0.426,0.298,0.095,-5.56,2.11,-24.57
P0089=0.898,1.219,0.084,0.00,0.00,0.00
P0093=0.000,10.000,-15.000,0.00,0.00,0.00
P0096=-0.063,-0.619,-14.994,-5.56,2.11,-24.57
//INST
///DATE 2000/12/13 16:12
///ATTR SC,RW
///GROUP1 RB1
NOP
'Software 142196-1, V1.3
'
'Skip Center Check for SETUP.
JUMP *SEARCH IF B020=99
'
```

```
'=================================
' Verify Clean Sensors (TS_CLEAN)
'=================================
'
TIMER T=0.20
SET P076 P080
SUB P076 P076
SETE P076 (1) 100
IMOV P076 V=I020 UF#(10) SRCH RIN#(I022)=OFF DIS=0.0
GETS B022 $B002
PAUSE IF B022=0
' Clean X Beam Sensor.
IMOV P076 V=I020 UF#(10) SRCH RIN#(I023)=OFF DIS=0.0
GETS B022 $B002
PAUSE IF B022=0
' Clean Y Beam Sensor.
'
'=================================
'  Check Center of Beams
'=================================
'
' Move to center of beams.
MOVL P096 V=750.0 PL=0
IMOV P076 V=I020 UF#(10) SRCH RIN#(I022)=ON DIS=0.0
GETS B022 $B002
MOVL P096 V=80.0 PL=0
IMOV P076 V=I020 UF#(10) SRCH RIN#(I023)=ON DIS=0.0
GETS B023 $B002
ADD B023 B022
JUMP *SEARCH IF B023<>2
' TCP is Okay
SET B020 1
JUMP *DONE
'
'=================================
'  Search for New Center
'=================================
'
*SEARCH
' Search for X.
MOVL P081 V=I020
IMOV P082 V=I020 UF#(10) SRCH RIN#(I022)=ON T=0.10 DIS=0.1
GETS B022 $B002
JUMP *MISSED_X IF B022=0
GETS PX075 $PX002
CNVRT PX076 PX075 UF#(10)
GETE D039 P076 (1)
' Current gauge X
SETE P088 (1) D039
IMOV P083 V=I020 UF#(10)
' Search for Y
IMOV P084 V=I020 UF#(10) SRCH RIN#(I023)=ON T=0.10 DIS=0.1
GETS B022 $B002
JUMP *MISSED_Y IF B022=0
```

```
GETS PX075 $PX002
CNVRT PX076 PX075 UF#(10)
GETE D039 P076 (2)
'Current gauge Y
SETE P088 (2) D039
IMOV P085 V=I020 UF#(10)
'1ST Search for Z.
IMOV P086 V=I020 UF#(10) SRCH RIN#(I023)=ON T=0.10 DIS=0.1
GETS B022 $B002
JUMP *MISSED_Z IF B022=0
GETS PX075 $PX002
IMOV P093 V=I020 UF#(10)
'2ND Search for Z.
IMOV P086 V=I020 UF#(10) SRCH RIN#(I023)=ON T=0.10 DIS=0.1
GETS B022 $B002
JUMP *MISSED_Z IF B022=0
CNVRT PX076 PX075 UF#(10)
GETS PX075 $PX002
CNVRT PX077 PX075 UF#(10)
GETE D036 P076 (3)
GETE D037 P077 (3)
'Note that +Z for UF#10 is down.
'Z Offset for center of cup.
SUB D036 D021
ADD D037 D021
'Compare to Previous Z
GETE D038 P087 (3)
SET D039 D038
SUB D038 D036
SUB D039 D037
'Use smallest, because contact
'tip could cause a bad read.
JUMP *POS1 IF D038>=0
MUL D038 -1
*POS1
JUMP *POS2 IF D039>=0
MUL D039 -1
*POS2
SUB D038 D039
JUMP *2ND_Z IF D038>=0
SETE P088 (3) D036
JUMP *1ST_Z
*2ND_Z
SETE P088 (3) D037
*1ST_Z
'P088 = Current Gauge Point
JUMP *JUDGE
'
*MISSED_X
SET B020 55
PAUSE
'X search error
JUMP *DONE
*MISSED_Y
```

```
SET B020 53
PAUSE
'Y search error
JUMP *DONE
*MISSED_Z
SET B020 51
PAUSE
'Z search error
JUMP *DONE
'
'===============================
'Compare with Original Point
'===============================
'
*JUDGE
'Diff gauge=current-original
SET P089 P088
SUB P089 P087
JUMP *DONE IF B020=99
'
GETE D037 P089 (1)
JUMP *30 IF D037>=0
MUL D037 -1
*30
GETE D038 P089 (2)
JUMP *31 IF D038>=0
MUL D038 -1
*31
GETE D039 P089 (3)
JUMP *32 IF D039>=0
MUL D039 -1
*32
JUMP *40 IF D037>D023
JUMP *40 IF D038>D023
JUMP *40 IF D039>D023
'Less than min.
'TCP is Acceptable.
SET B020 1
JUMP *DONE
*40
JUMP *41 IF D037>=D024
JUMP *41 IF D038>=D024
JUMP *41 IF D039>=D025
'Between min & max.
SET B020 21
JUMP *DONE
*41
'Greater than max.
SET B020 23
*DONE
END
```

Appendix C
D12 HighPower Sensor Vendor Information

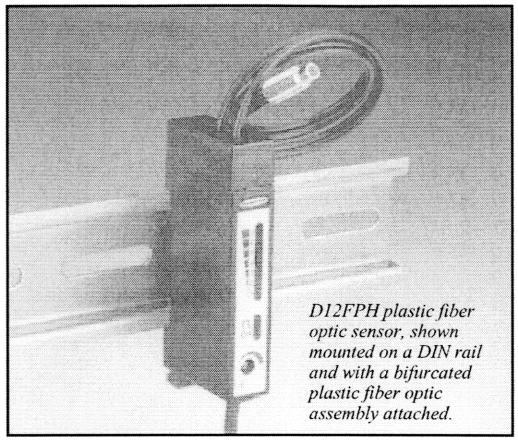
Vendor P/N for the D12 HighPower Sensor is D12SN6FPH.

D12FPH Series DIN Rail High Power Fiber Optic Sensors

Very high power sensors for use with plastic fiber optic assemblies

BANNER® the photoelectric specialist

- **Plastic fiber optic sensors for DIN rail mounting**
- **Highest optical power available in a plastic fiber optic sensor**
- **Visible red light source; for use with Banner cut-to-length plastic fiber optic assemblies**
- **Choice of either NPN (current sinking) or PNP (current sourcing) complementary output models; 150 mA maximum (continuous) load**
- **Normally closed output may be wired as a diagnostic alarm output, depending upon hookup to power supply*; 10-30V dc operation.**
- **LED indicators for POWER ON and N.O. OUTPUT CONDUCTING**
- **Patented 7-segment moving-dot LED bargraph† shows received signal strength, OUTPUT OVERLOAD, MARGINAL EXCESS GAIN**



D12FPH plastic fiber optic sensor, shown mounted on a DIN rail and with a bifurcated plastic fiber optic assembly attached.

Description

D12FPH Series sensors are compact, totally self-contained visible-red fiber optic sensors for DIN rail mounting. D12FPH Series sensors are designed for use with Banner cut-to-length plastic fiber optic assemblies. They may be used in the opposed and diffuse fiber optic sensing modes. D12FPH Series sensors have the highest optical power available in a plastic fiber optic sensor.

D12s operate from 10-30V dc and draw 45 mA maximum, exclusive of load current. Models are available with a choice of NPN or PNP complementary outputs (one output normally open, one output normally closed). The normally closed output of all models may be used as a diagnostic alarm output, depending upon the hookup of the sensor to the power supply*. All models are available with either an attached cable or a 6" pigtail with a pico-style quick disconnect connector. A complete listing of models is given on page 2.

Each output is capable of 150 mA continuous load. The choice of NPN (sinking) or PNP (sourcing) models enables D12 sensors to interface to a wide variety of loads.

Two top-mounted LED indicators (see drawing, right) light to indicate POWER ON and NORMALLY OPEN OUTPUT CONDUCTING conditions.

A highly-visible red 7-segment moving-dot LED bargraph† (right) lights to indicate the relative strength of the received light signal. This feature can greatly simplify sensitivity adjustment and the task of fiber optic alignment, as well as provide a constant reference over time for overall sensing system performance. Also, segment #1 of the bargraph flashes to indicate an output overload, and segment #7 flashes to indicate marginal excess gain. A flashing LED corresponds to the "on" state of the D12's alarm output.

WARNING D12FPH Series sensors do NOT include the self-checking redundant circuitry necessary to allow their use in personnel safety applications. A sensor failure or malfunction can result in *either* an energized or a de-energized sensor output condition.

Never use these products as sensing devices for personnel protection. Their use as safety devices may create an unsafe condition which could lead to serious injury or death.

Only MINI-SCREEN®, MULTI-SCREEN®, MICRO-SCREEN™, MACHINE-GUARD™ and PERIMETER-GUARD™ Systems, and other systems so designated, are designed to meet OSHA and ANSI machine safety standards for point-of-operation guarding devices. No other Banner sensors or controls are designed to meet these standards, and they must NOT be used as sensing devices for personnel protection.

D12s have a 15-turn SENSITIVITY control, with a slotted brass screw clutched at both ends of travel.

D12FPH Series sensors may be used with either the small diameter (.020") or large diameter (.040") Banner cut-to-length plastic fibers.

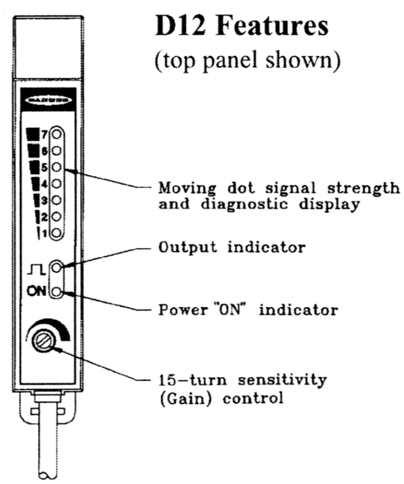
See page 4 for sensor dimension drawings. D12 Sensors mount directly to a standard DIN rail. They may also be through-hole mounted to a surface using the supplied bracket (see page 4) and stainless steel M3 x 0,5 mounting hardware.

D12s are constructed of rugged black ABS (Cycolac® KJB). The transparent housing cover is acrylic. D12FPH Series sensors are rated NEMA 4.

*U.S. Patent #5087838 †U.S. Patent #4965548

D12 Features

(top panel shown)



D12FPH Series DIN RAIL Fiber Optic Sensors

Specifications, D12FPH Series sensors

Sensing range: see individual excess gain curves, page 3.

Sensing beam: visible red, 660 nanometers.

Supply voltage: 10 to 30V dc at 45 mA max, exclusive of load. Protected against reverse polarity and inductive load transients.

Sensor model listing and output configurations:

Solid-state dc outputs:

D12SN6FPH NPN sinking complementary outputs, attached cable.
D12SN6FPHQ NPN sinking complementary outputs, 6-inch pigtail with pico-style QD.
D12SP6FPH PNP sourcing complementary outputs, attached cable.
D12SP6FPHQ PNP sourcing complementary outputs, 6-inch pigtail with pico-style QD.

The N.C. (normally closed) output may be used as an alarm output, depending upon the hookup to the power supply.

Output rating: 150 mA maximum each output. No false pulse on power-up. (False pulse protection circuit causes a 20 millisecond delay on power-up.) Short-circuit protected.
Off-state leakage current <10 microamps at 30V dc.
On-state saturation voltage <1V at 10 mA dc; <1.5V at 150 mA dc.
The* total load *may not exceed 150 mA.

Response time: .5 millisecond "on"; .5 millisecond "off".
Repeatability is 130 microseconds.
Response time and repeatability are independent of signal strength.

Indicators: Two top-mounted LED indicators, one yellow and one green, and one 7-segment red LED moving-dot bargraph.
GREEN LED lights to indicate DC POWER ON.

YELLOW LED lights to indicate NORMALLY OPEN OUTPUT CONDUCTING.

7-segment moving dot red LED bargraph lights to indicate relative received light signal strength. In addition, segment #1 flashes to indicate OUTPUT OVERLOAD, and segment #7 flashes to indicate MARGINAL EXCESS GAIN (a "dark" signal that lights LED #2 for at least one second, or a "light" signal that lights LED #3 for at least one second). A flashing LED corresponds to the "on" state of the alarm output. See page 1 for further description.

Adjustments: SENSITIVITY control on top of module (15-turn slotted brass screw, clutched at both ends of adjustment).

Construction: Black ABS (Cycolac® KJB) housing with acrylic cover. Rated NEMA 4. The fiber clamping element is Delrin®.

Cable: 6-1/2-foot long (2 meter) attached PVC-covered cable* or 6-inch pigtail with pico-style 4-pin QD connector. Use mating cable model PKG4-2 (straight connector) or PKW4-2 (right angled); 6-1/2 feet (2 m) long. *Models also available with 30 ft (9 m) attached cable.

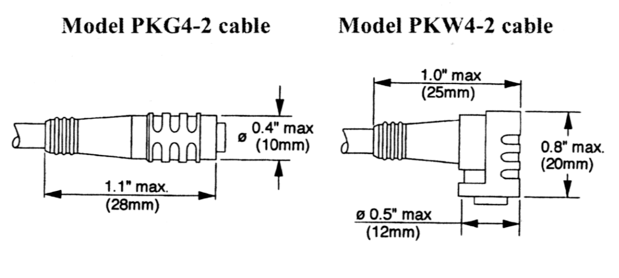
Mounting bracket: D12 Series sensors mount directly to a standard DIN rail, or may be through-hole mounted using the supplied mounting bracket and M3 x 0,5 stainless steel hardware. Bracket material is black VALOX®.

Operating temperature range: -20° to +70°C (-5° to +158°F).
Maximum relative humidity 90% at 50°C (non-condensing).

Application caution...

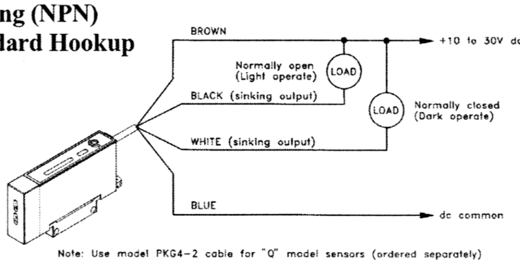
D12 Series sensors are designed to deliver very high optical energy (excess gain). They should **not** be used for applications which offer low optical contrast (i.e. only a small difference in received light levels between the light and dark sensing conditions). Examples include diffuse mode sensing of objects in front of a reflective background and opposed mode sensing of non-opaque materials.

D12 sensors excel in applications requiring high excess gain (e.g. for long-range sensing, sensing with long fiber lengths, diffuse sensing of materials with low reflectivity, etc.)

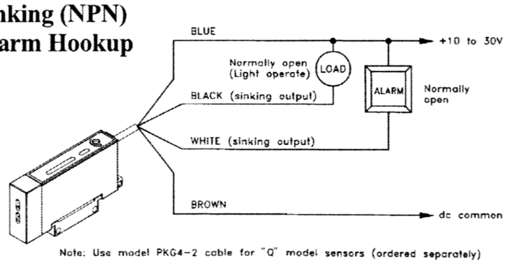


Hookup Diagrams, D12FPH Series Sensors

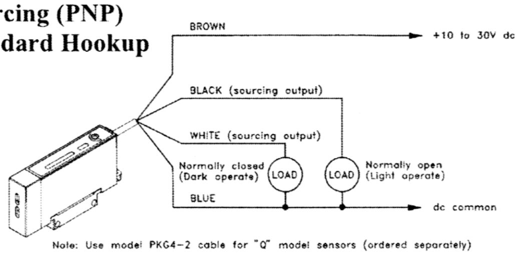
Sinking (NPN) Standard Hookup



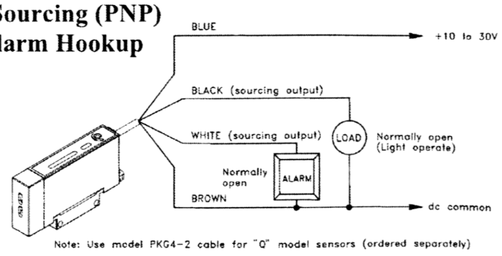
Sinking (NPN) Alarm Hookup



Sourcing (PNP) Standard Hookup



Sourcing (PNP) Alarm Hookup



D12FPH Series DIN RAIL Fiber Optic Sensors

Model range and gain information for D12FPH Series sensors

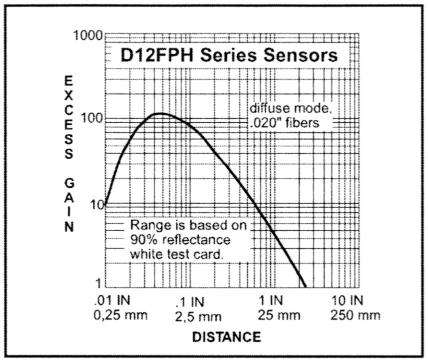
The following D12 models are available for use with plastic fiber optics:*

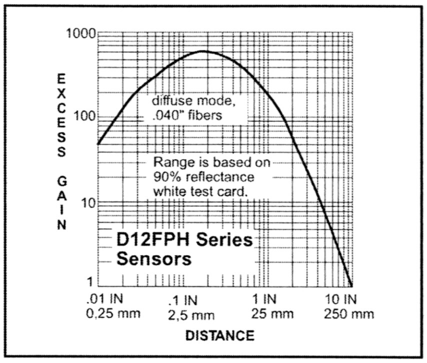
D12SN6FPH	p/n 34464	NPN sinking complementary outputs, 6-1/2 foot attached cable.
D12SN6FPHQ	p/n 34973	NPN sinking complementary outputs, 6-inch pigtail with pico-style QD.
D12SP6FPH	p/n 34972	PNP sourcing complementary outputs, 6-1/2 foot attached cable.
D12SP6FPHQ	p/n 34974	PNP sourcing complementary outputs, 6-inch pigtail with pico-style QD.

*Models with 30-foot attached cable are also available.

Diffuse Sensing Mode

Excess gain curves for bifurcated plastic fibers in the diffuse sensing mode are given at the right. Fiber sizes are noted on the curves.



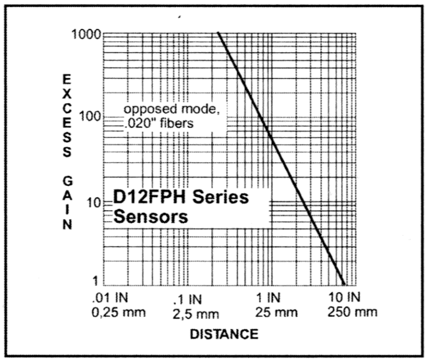


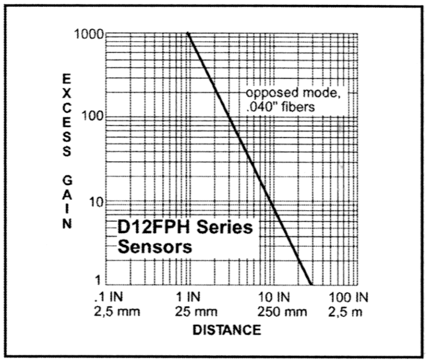
Opposed Sensing Mode

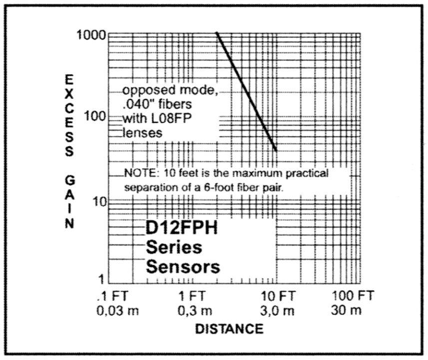
Excess gain curves for individual plastic fibers in the opposed sensing mode (without lenses) are given at the right. Fiber sizes are noted on the curves.

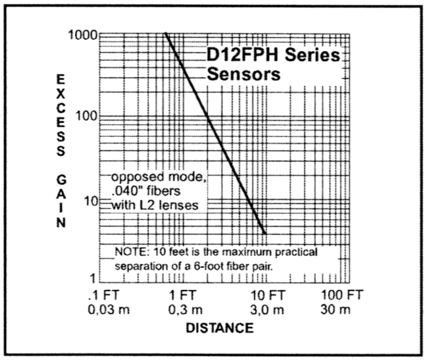
The curve at the lower near right shows the performance of two individual unterminated .040" dia. plastic fibers, each fitted with a model L08FP lens (shown below, sold separately). The curve at the lower far right shows the performance of two individual threaded .040" dia. plastic fibers (PIT4 Series), each fitted with a model L2 lens (below, sold separately). Note that, in both lensed situations, the curves stop at 10 feet separation (the maximum practical separation of the sensing ends for a pair of 6-foot single fibers).

A pair of 6-foot cut-to-length individual plastic fibers with factory-installed L08FP lenses is also available. Order plastic fiber assembly model PIL46U.

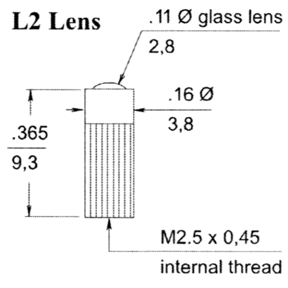


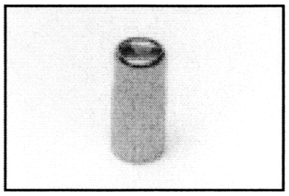




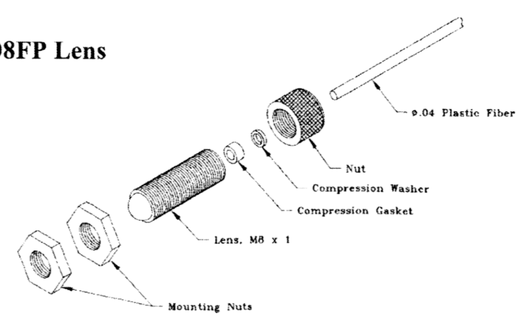


L2 Lens



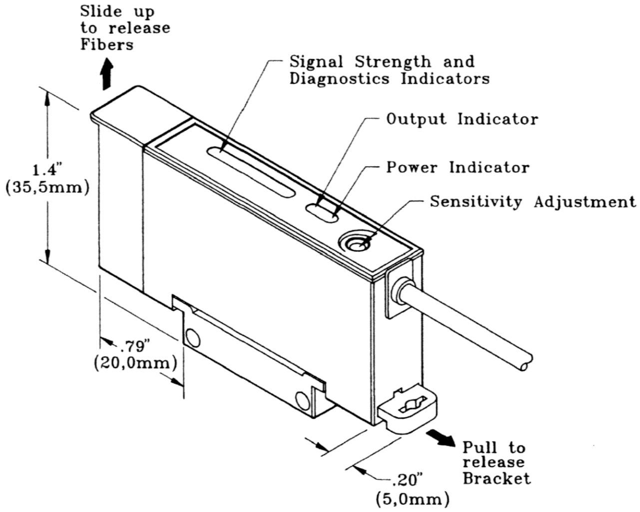


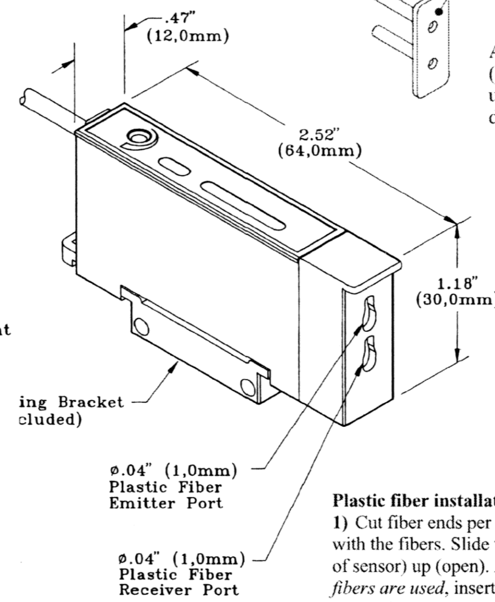
L08FP Lens

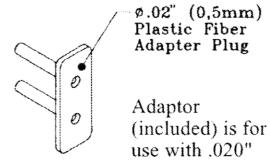


D12FPH Series DIN RAIL Fiber Optic Sensors

D12FPH Dimensions and Features







Adaptor (included) is for use with .020" diameter fibers.

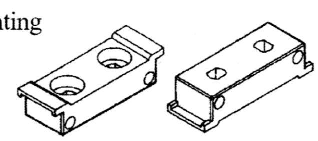
Plastic fiber installation:

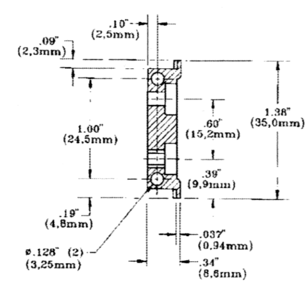
1) Cut fiber ends per instructions included with the fibers. Slide the fiber gripper (front of sensor) up (open). *If .020" or .010" dia. fibers are used,* insert the adaptor (drawing above) into the ports as far as it will go.

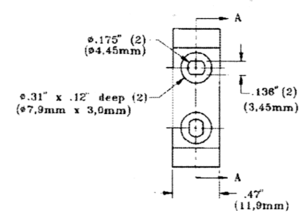
2) All fibers: Insert the prepared plastic fiber sensor ends gently into the ports as far as they will go. Slide the fiber gripper back down to lock.

D12 Bracket Dimensions

For through-hole mounting of all models; stainless steel hardware included.







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