Flexible Fixturing Setup

For PC-DMIS 3.2 nd above

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Introduction

This document outlines the procedure for setting up Flexible Fixturing for use with PC-DMIS 3.2 and higher. The document is broken into two parts, DCC Setup (System 5) and Manual.

Some procedures of the setup process may require you to modify or view the Pcdlrn.ini file. You can find this file in the directory where you installed PC-DMIS (the default location is C:\Pcdmisw). You can access this file by using a simple text editor such as NotePad. Remember to always close down PC-DMIS before modifying the INI file and double check all changes before saving them.

System Five (DCC) Setup

Before proceeding with any of the System 5 setup steps, make sure that you have already completed the Master/Slave setup for the system. For further information, see the MasterSlave.doc file on WAI's ftp site: ftp://wilcoxassoc.com/docs/masterslave.zip.

All System 5 settings are entered either in the fixture property sheets accessed by selecting the **Utilities | Fixture** menu or by changing INI settings in the Pcdlrn.ini file.

Note: If the **Utilities | Fixture** menu is not on your menu, make sure that the portlock for your computer system has the **SystemV** option available.

System Definition

After completing the Master/Slave setup, you will define the System 5 configuration for each arm individually. This *cannot* be done while in Master/Slave mode. System definition includes the following steps:

1.) Define the System Type

2.) Define the Arm Approach Direction

3.) Define the Safe Angle

4.) Configure the Rack

5.) Define the Column

Use the **System Setup** tab to complete the five steps described below:

Step 1: Define the System Type

On the **Setup** tab, select the **System Five (DCC)** option and the **C500 System Five** option.

The C500 System refers to the column type present on the system. The C500 system also includes the C200 column types. The C250 system is an older system. The system is identified by a removable gripper that is exchanged with a PH10. The C250 system is currently not supported.

Step 2: Define the Arm Approach Direction

Define the arm approach direction. This is the direction the arm moves when engaging a column. For Master arms (arm 1) this will generally be YPLUS and Slave arms (arm 2) will be YMINUS.

Step 3: Define the Safe Angle

1. Define the safe angle. This is the wrist angle used each time a column is loaded onto the arm. The angles are specified individually.
2. Type each angle value in the **Angle A** and **Angle B** boxes.

Note: The tip at the safe angle *does not* need to be calibrated since you won't use that angle for measuring.

Step 4: Configure the Rack

1. In the **Number of Slots in Rack** box type the number of slots in the rack that can be used by this arm (this will be an integer value between 8 and 26). Note that this arm can only reach the columns in one half of the rack, thus the number used in the **Number of Slots in Rack** box is half of the total slots in the rack. This is *not* the number of columns in the rack. After you have entered the number of slots in the rack and move the cursor to another area, you will see that the list is updated and should display the appropriate number of slots.
2. Define the rack type using the **Rack Configuration** area. There are two different rack types described here:
   1.) The first type of rack, and most common, has a short slot as its first slot. This slot is actually slot number 2 but it is the first *physical slot* in the rack. PC-DMIS defaults to this type of rack.
   2.) The second type of rack has a long slot as its first type and its slot number is 1. If you have this type of rack configuration, you must change the rack configuration. To do this, select the first element in the list and change the slot number in the **Slot Number** box from **2** to **1**. Click the **Apply** button. This will change the rack layout to match the one that you have.

Step 5: Define the Column

Associate the appropriate type of column with each of the slots in the rack. To do this:

1. Select the appropriate slot from the list.
2. From the **Column Type** list , select the correct column type for this slot. If there is no column in a slot, make sure it's set to **Empty**. The column ID will default to the slot number.

3. If needed, change the ID for a column in the **ID** box.
4. Repeat steps 1 through 3 until *all* of the columns have been assigned to a slot.
5. When you are finished, click the **Apply** button to update the configuration file.

System I/O Bit configuration

In the Pcdlrn.ini file, in the `[SystemFiveDCC]` section, you will need to specify the correct bit configuration (input / output settings) for the system.

Note: The I/O (input / output) bits control the air injectors used to move the columns into position on the machine. Unfortunately, the bits can differ from one machine to another depending on the way the physical system was installed.

To specify the correct bit configuration:

1. Close PC-DMIS.
2. Using NotePad (or some other text editor), open the Pcdlrn.ini file.
3. Go to the `[SystemFiveDCC]` section.
4. Verify the INI settings.

The INI settings are listed below with their default settings.

```
FirstIOBitColumnPresent=19
LastIOBitColumnPresent=31
TestForGripperBit=1
TurnOnAirBitZAxis=3
TurnOnAirBitXYAxis=5
TurnOffAirBitZAxis=2
TurnOffAirBitXYAxis=4
TestAirBitXYAxis=2
TestAirBitZAxis=3
```

CAUTION: Neglecting to verify these settings could cause serious damage to your fixturing system. You may need to update these values in your Pcdlrn.ini file so that they correctly match your system's configuration.

System Move Distances

These values control the distance that PC-DMIS moves when loading and unloading a column. These values are found in the `[SystemFiveDCC]` section and are shown below with their default values. The defaults should work well; however, they are changeable if necessary.

```
ApproachOffsetInY=43.0
ApproachAfterAirInY=2.0
ApproachAfterAirInZ=3.0
```

```
ParkedOffsetInZ=18.0
ApproachSpeed=66.0
ApproachAccel=50.0
```

This table contains the descriptions of the settings:

Setting	Description
`ApproachOffsetInY`	The distance away from the column that PC-DMIS starts its load cycle.
`ApproachAfterAirInY`	The distance along the Y axis that the arm continues to move after turning on the Z air injector. **Example:** For the default case, the air will be turned on after the arm has moved 41 mm in the Y direction. After successfully turning on the Z air injector, the arm will move another 2 mm along the Y axis before moving down the Z axis.
`ApproachAfterAirInZ`	The distance along the Z axis that the arm continues to move after tunring on the XY air injector. **Example:** For the default case, the arm will move the column down 15 mm before turning on the XY injector. At this point the gripper should be just resting on the conical portion of the injector. After the air is turned on successfully, the arm will move down the Z axes the additional 3 mm before completing the load cycle.
`ParkedOffsetInZ`	The total distance down the Z axis that the arm must move to safely engage the column on the XY injector pins. It should also be the height of the column *gauging shim.
`ApproachSpeed`	The approach speed during the load/unload cycle.
`ApproachAccel`	The approach acceleration during the load/unload cyle.

***** The gauging shim is a semicircular piece of metal of a specific height. This fits around the column shaft. In order to correctly calibrate the column, the shaft must be placed at a specific height. The shim is placed on the column and the shaft is moved all the way down until it rests on the top of the shim. This position defines the lowest position of the shaft.

Initial Calibration

Before beginning the initial calibration, make sure that you completely back the proximity switch off. After entering the above information in the Pcdlrn.ini file, you can do the initial calibration.

On the **Calibrate Columns** tab, select the **Manual** and **Initial** options.

From the **Probe Information** area select the probe file and tip that you will be using to calibrate the columns.

To start the initial calibration, click the **Calibrate** button.

The initial calibration will walk you through the following steps:

1. Load column 1 onto the gripper.
2. Manually position the column in front of the first physical slot in the rack. This is the slot closest to the arm.
3. Press the **Done** button on the jog box after locating the column. PC-DMIS will immediately calculate the locations of all of the other columns in the rack.
4. Calibrate the gripper. Under DCC control, PC-DMIS will move the column out of the rack, disengage the column, raise the arm up and change tips. It will then prompt you to take one hit on the sphere. After measuring the column sphere, the gripper will be calibrated.
5. Load the rack. PC-DMIS will now prompt you to manually load each of the columns onto the gripper so that it can place them into the rack. Be aware that this is done in reverse order. When all of the columns have been loaded, the system is initially calibrated.
6. Adjust the proximity switches so that there is approximately a 1-2 mm gap between the column and the *proximity switch.

***** The proximity switch is a small screw at the end of the rack that extends from the slot. This screw has a magnetic field around it and is used to determine if a column currently resides in the slot. In order for the proximity switch to register a column's presence in the slot, the column must be within approx. 2mm of the screw.

Limit Definition

This section requires that you place PC-DMIS in Master/Slave mode. You must now define the limits of the useful fixture volume. These values are placed in the `[SystemFiveDCC]` section of the pcdlrn.ini file. The default INI settings for fixture volume limits follow:

```
FreeXMoveFromRack= 100.0
MasterPlateBoundsYMin=-999999.0
MasterPlateBoundsYMax=-999999.0

SlavePlateBoundsYMin=-999999.0

SlavePlateBoundsYMax=-999999.0

MasterSlavePlateBoundsXMax=-999999.0
```

If the entries that have a default of –999999.0 remain at that value, PC-DMIS will use the machine limits returned from the controller. In order to determine what the extents (or volume limits) are, follow the following procedure:

1. Make sure that your part program is in Manual mode.
2. Open the Edit window and place it in Command mode.
3. Type "`COLUMN/LOAD`" into the Edit window and press TAB. The entire command appears.
4. Make sure the first field is set to LOAD. The remainder of the fields can be left in their default states.
5. Execute the part program. PC-DMIS will prompt you to load a column on the arm. It will then turn the air on, load the column, and return control of the machine to you.
6. Place your cursor in the header section of the part program so that you can read the counters without any probe offsets being applied to them.
7. Using the jog box move the column to the passing lane in front of the rack. The “X” coordinate is the value that you enter for `FreeXMoveFromRack.`
8. Now move the column as close to the edge of the plate as possible since you want to be able to place a column as part of a fixture. The “Y” coordinate is the value used for `MasterPlateBoundsYMin.`

Note: If you place a column too close to the edge of the plate, it may not be able to measure the column sphere during placement iterations because the head will need to retract even further to measure the column.

9. Now move the column out to the center of the volume to the end of travel of the arm. The “Y” coordinate is the value placed in the `MasterPlateBoundsYMax.`
10. Now move the column to the furthest extent of the plate in X. The “X” coordinate is the value used for `MasterSlavePlateBoundsXMax.`
11. To unload the column, change the first field in the `COLUMN/LOAD` command to `UNLOAD` and execute the part program. This will unload the column in its current location.
12. Change to slave mode and repeat steps 2-5, 7-8 and 10. Read the counters and fill in the correct INI entries.

Note: The `SlavePlateBoundsYMin` value is in the middle of the machine volume not at the extreme net to the edge of the plate like on the master side. Remember that the coordinate system is continuous across both arms.

Mount Points

Mount points are safe locations where the arms will move each time that the system is used. Common situations when you would use mount points include:

- After calibration
- Pulling a fixture out
- Recovering a column.
- Calibrating the system

The values are entered in the `[SystemFiveDCC]` section of the Pcdlrn.ini file. The settings are:

```
MountX=0.0
MountY=0.0
MountZ=0.0
SlaveMountX=0.0
SlaveMountY=0.0
SlaveMountZ=0.0
```

These values are the XYZ location of the end of the ram in machine coordinates. Move the ram to the position that you want to use as the mount point for each arm and enter the XYZ values into the ini file.

Note: On the slave machine, you need to enter the same value into the `MountX`, `MountY`, `MountZ`, that you put into the `SlaveMountX`, `SlaveMountY`, and `SlaveMountZ`, entries in the Master arm's Pcdlrn.ini file.

Collision Detection Parameters

These values are entered into the `[SystemFiveDCC]` section of the Pcdlrn.ini file. The INI settings with their default values follow.

```
HeadCollisionCheckDistance=270.000000
ColumnCollisionCheckDistance=110.000000
```

These variables are defined as:

Setting	Description
`HeadCollisionCheckDistance`	The overhang in Y axis of the probe head as measured from the center of the gripper pins to the end of the probe head.
`ColumnCollisionCheckDistance`	The width of the ram.

These values will vary with machine type and wrist configuration. You will need to manually measure (probably with a tape measure) these distances on the machine. They do not need to be exact and if you are going to err, do it larger.

Recovering the column

Now that you have finished defining the limits of the machine, you should have two columns still hooked to the end of the rams.

To free the columns from the gripper:

1. In the Edit window, place your cursor over the `COLUMN/LOAD` command.
2. Press F8 to change it to `COLUMN/UNLOAD`.
3. Execute the part program.

Next, you will tell PC-DMIS to recover the colum(s):

1. In Master mode, select **Utilities | Column Recovery.** The **Column Recovery** dialog box appears asking which column you want to recover.
2. Choose the column from the list and click the **Recover** button.
3. Follow the prompts and PC-DMIS will recover the column for you.
4. Change to Slave mode and follow the same procedure for the slave side.

CAUTION: If you are not recovering the first column in the rack, make sure that all of the columns before the one that you are recovering are removed from the rack. If they are not, the arm will smash the columns that are still in the rack. The column recovery procedure will need to be completed for each moved column as well.

Full Calibration

Now that you have finished the setup process, you only need to calibrate the columns.

1. Exit Master/Slave mode. Calibration must be done on each computer individually. It will also save you time.
2. From the **Calibrate Columns** tab, select the **Full** and **DCC** options on the dialog box.
3. Make sure that your probe file and tip are correct.
4. Click the **Calibrate** button. PC-DMIS will do the following in order:
   - Bring all of the columns out and line them up along the X-axis.
   - Measure all of the column spheres at their lowest position.
   - Measure the pin vectors
   - Raise the column shaft to its fully extended height
   - Measure the sphere again.

Note: The two sphere measurements give us the shaft vector and are used during column placement.

After all measurements are complete, PC-DMIS will load all of the columns back into the rack and display the results of the calibration.

Five Unique (Manual) Setup

If you are using the manual system on a dual arm machine, make sure that you have already completed the Master/Slave setup for the system before proceeding with any of the System 5 setup steps. For further information, see the MasterSlave.doc file on WAI's ftp site: ftp://wilcoxassoc.com/docs/masterslave.zip. All System 5 settings are entered either in the fixture property sheets accessed by selecting the **Utilities | Fixture** menu or by changing INI settings in the Pcdlrn.ini file.

Note: If the **Utilities | Fixture** menu is not on your menu, make sure that the portlock for your computer system has the **SystemV** option available.

System Definition

After completing the Master/Slave setup, you will define the System 5 configuration for each arm individually. This *cannot* be done while in Master/Slave mode. System definition includes the following steps:

1.) Define the System Type

2.) Define the Safe Angle

Use the **System Setup** tab to complete the two steps described below:

Step 1: Define the System Type

On the **System Setup** tab in the **System Type** area, select the **Five Unique (Manual)** option. This will disable most of the options on the setup tab.

Step 2: Define the Safe Angle

1. In the **System Settings** area, define the safe angle. This is the wrist angle used when positioning columns during fixture deployment. The angles are specified individually. The angles specified must allow the *gripper to be fixed onto the arm.
2. Type each angle value in the **Angle A** and **Angle B** boxes.

* The gripper is a device placed on the end of the ram. It "grips" (or holds) columns in order to accurately position the columns in the usable fixturing volume.

Gripper Calibration

Before using the system, you must define the gripper offsets and calibrate each gripper. For the manual version, the default values correspond to the theoretical values for the gripper for bridge machines. If you are using a horizontal arm with a different type of gripper, you can modify the default values before calibration so that you don't have to take any manual measurements. The INI entries to change are in the [Options] section. They are:

5UniqueGripperOffsetX=0.0

5UniqueGripperOffsetY=0.0

5UniqueGripperOffsetZ=149.0

To Calibrate the Gripper:

1. Select the **Calibrate Columns** tab.
2. In the **Probe Information** section, select the correct probe file from the **Probe** list and the tip to use for calibration from the **Tip** list.
3. Select the **Calibrate** button. The probe rotates to the safe angle.
4. Connect the gripper at PC-DMIS's prompt.
5. Move the gripper to any location where a column is easily accessible.
6. Load the column into the gripper.
7. Remove the gripper.
8. Measure the column sphere.

Limit Definition

If using a dual arm system, you must place PC-DMIS in Master/Slave mode. You must now define the limits of the useful fixture volume. These values are placed in the `[SystemFiveDCC]` section of the pcdlrn.ini file.

Note: The term "`[SystemFiveDCC]`" is not a typo. Even though we are defining a manual system, the items contained in this section of the Pcdlrn.ini file are common to both DCC and Manual systems.

The default INI settings for fixture volume limits follow:

```
FreeXMoveFromRack= 100.0
MasterPlateBoundsYMin=-999999.0
MasterPlateBoundsYMax=-999999.0
SlavePlateBoundsYMin=-999999.0
SlavePlateBoundsYMax=-999999.0
MasterSlavePlateBoundsXMax=-999999.0
```

If settings with a default of –999999.0 remain at that value, PC-DMIS will use the machine limits returned from the controller. If the machine controller does not support machine limit queries, you can enter them in the INI file in [Option] section. An example follows:

```
MachineXPLUS=2829.0
MachineXMINUS=-59.0
MachineYPLUS=720.0
MachineYMINUS=-78.0
MachineZPLUS=70.0
MachineZMINUS=-2328.0
```

To Determine Volume Limits:

In order to determine what the extents (or volume limits) are, follow the following procedure:

1. Open an existing or new part program, open the Edit window, and place the cursor in the header section of the part program.
2. Place a column at the corner of the machine with the smallest X and Y values.
3. Place a second column in the corner of the machine with the largest X and Y values.
4. Manually jog the machine to the first column and load the column into the gripper.
5. Read the X value and enter it into the `FreeXMoveFromRack` Pcdlrn.ini entry.
6. Read the Y value and enter it into the `MasterPlateBoundsYMin` Pcdlrn.ini entry.
7. Manually jog the machine to the second column and load the column into the gripper.
8. Read the X value and enter it into the `MasterSlavePlateBoundsXMax` Pcdlrn.ini entry.
9. Read the Y value and enter it into the `MasterPlateBoundsYMax` Pcdlrn.ini entry.
10. If you are using a dual arm machine, repeat steps 1-8 for the slave machine. You will only need the Y values for the slave machine since the X values are shared by both machines. Enter the minimum Y value in the `SlavePlateBoundsYMin` Pcdlrn.ini entry and the maximum Y value in the `SlavePlateBoundsYMax` Pcdlrn.ini entry.

Note: Many dual arm systems have overlap in Y. This means that both arms can reach areas in the middle of the machine volume. It is recommended that when defining the usable fixturing volume that you limit this overlap to one column diameter. This will not affect the

measuring capability of the system but will aide in creating balanced fixtures.

Mount Points

Mount points are safe locations where the arms will move each time that the system is used. Common situations when you would use mount points include:

- After calibration
- After fixture placement.

The values are entered in the `[SystemFiveDCC]` section of the Pcdlrn.ini file. The settings are:

```
MountX=0.0
MountY=0.0
MountZ=0.0
```

For dual arm systems, place the values are the XYZ location of the end of the ram in machine coordinates into these Pcdlrn.ini entries:

```
SlaveMountX=0.0
SlaveMountY=0.0
SlaveMountZ=0.0
```

To obtain the XYZ values:

1. Move the ram to the position that you want to use as the mount point for each arm.
2. Type the XYZ values into the appropriate entries.

Note: On the slave machine, you need to enter the same value into the `MountX`, `MountY`, `MountZ` entries that you put into the `SlaveMountX`, `SlaveMountY`, and `SlaveMountZ`, entries in the Master arm's Pcdlrn.ini file.

Collision Detection Parameters

These values are entered into the `[SystemFiveDCC]` section of the Pcdlrn.ini file. The INI settings with their default values are.

```
HeadCollisionCheckDistance=270.000000
ColumnCollisionCheckDistance=110.000000
```

These settings are defined as:

Setting	Description
`HeadCollisionCheckDistance`	The overhang in Y axis of the probe head as measured from the center of the gripper pins to the end of the probe head.
`ColumnCollisionCheckDistance`	The width of the ram.

These values will vary with machine type and wrist configuration. You will need to manually measure (probably with a tape measure) these distances on the machine. They do not need to be exact and if you are going to err, do it larger.

Gripper Mount Points

For manual systems, you can define a mount point. This is a position that the machine will move to when it is time to mount the gripper onto the end of the ram. To define this point:

1. Place the cursor in the header section of the part program's Edit window.
2. Move the machine to the desired location. This should be a position where probe is easy to reach.
3. Read the X, Y, and Z values and place them in the Pcdlrn.ini file under the following entries:

   `X Value - GripperMountX`

   `Y Value - GripperMountY`

   `Z Value – GripperMountZ`

4. For dual arm systems, repeat steps 1-3 with the slave arm and place the XYZ value under the following entries:

   `X Value - GripperMountSlaveX`

   `Y Value - GripperMountSlaveY`

   `Z Value - GripperMountSlaveZ`