FANUC Robot series

R-30*i*B/R-30B Mate/R-30*i*B Plus/R-30*i*B Mate Plus/
R-30*i*B Compact Plus/R-30*i*B Mini Plus CONTROLLER

Dynamic Path Modification

OPERATOR'S MANUAL

B-84474EN/01

ORIGINAL INSTRUCTIONS

Thank you very much for purchasing a FANUC robot.

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

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

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

SAFETY PRECAUTIONS

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

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

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

PERSONNEL

Personnel can be classified as follows:

Operator:

- Turns the robot controller power ON/OFF
- Starts the robot program from the operator panel

Programmer or Teaching operator:

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

Maintenance technician:

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

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

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

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

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

Table s-1 Work Performed Outside the Safeguarded Space

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

	Operator	Programmer or Teaching Operator	Maintenance Technician
Start robot program with teach pendant		o	o
Reset alarm with operator's panel		o	o
Reset alarm with teach pendant		o	o
Set data on teach pendant		o	o
Teaching with teach pendant		o	o
Emergency stop with operator's panel	o	o	o
Emergency stop with teach pendant	o	o	o
Operator panel maintenance			o
Teach pendant maintenance			o

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

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

DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with **"WARNING"** or **"CAUTION"** according to its severity. Supplementary information is indicated by **"NOTE"**. Read the contents of each **"WARNING"**, **"CAUTION"** and **"NOTE"** before using the robot.

Symbol	Definitions
WARNING	Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.
CAUTION	Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.
NOTE	Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

TABLE OF CONTENTS

1 DYNAMIC PATH MODIFICATION OVERVIEW

Dynamic Path Modification (DPM) provides dynamic path modification with a flexible third party sensor interface. It supports both Modal DPM instructions and Inline DPM instructions. Inline is used for real time destination offset. Modal is used for real-time path offset. To use DPM, the Dynamic Path Modification option (R739) must be installed.

1.1 MODAL DPM

Modal DPM is designed for applications that require real time path modification based on sensor information along the entire motion path.

- Real-time path modification
- Modal Track DPM instruction
- Continuous path modification
- Real time sensor offset (x,y,z,w,p,r)
- Flexible sensor interface (Digital I/O, Analog I/O, Group I/O and system variables)
- Path update rate at 8ms
- Quick path correction response (offset after JBF)

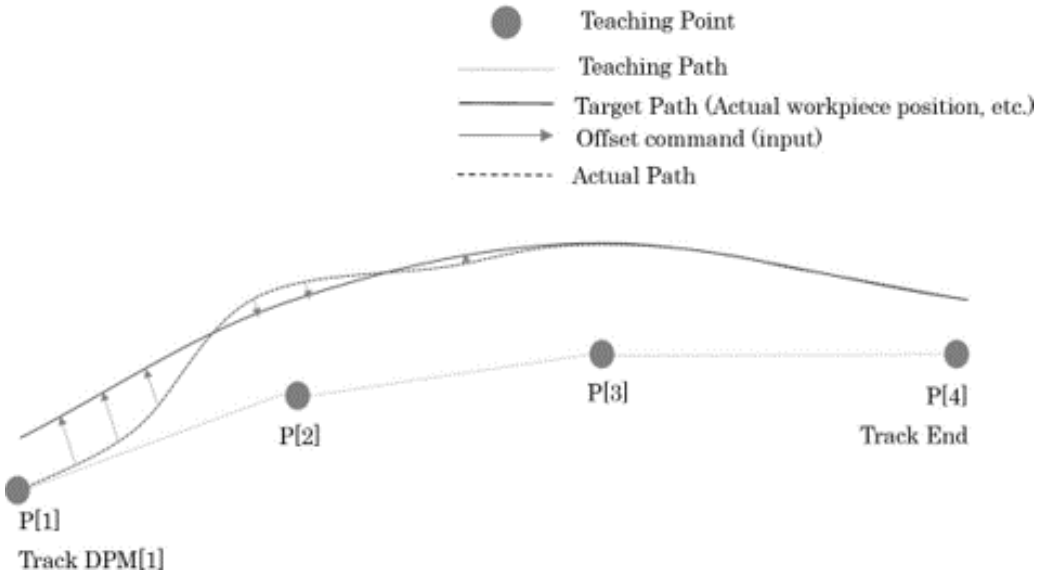


Figure 1.1 Real-time path modification

1.2 INLINE DPM

The inline DPM is designed for applications that require real time modification on the destination position for each motion segment.

- Real-time path destination modification
- Inline DPM instruction for any motion line

- Third party sensor for path segment destination offset (x,y,z,w,p,r) during run time
- Smooth Segment Path Transition
- Single Step and constant path at different speed override

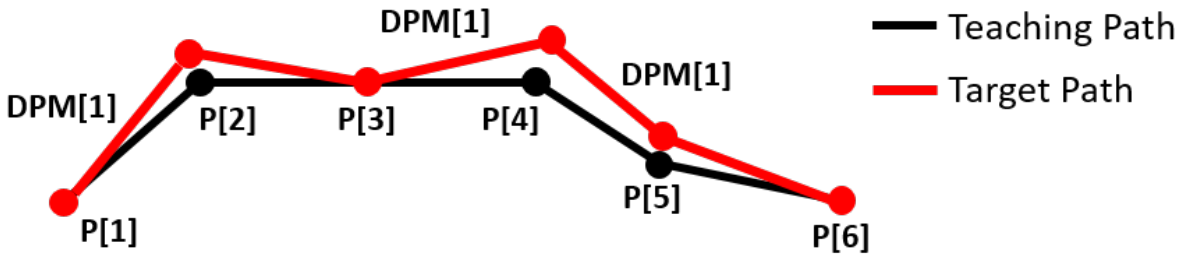


Figure 1.2 Real-time destination modification

2 ASSUMPTIONS AND LIMITATIONS

- DPM supports multi-group motion but limits to two DPM control groups per controller
- DPM supports weave operation for modal DPM motion
- DPM is independent of the PROCESS and can be applied to ALL applications
- DPM supports extended axis (integral rail configuration) and Toploaд
- DPM can co-exist but cannot work simultaneously with the Remote TCP (RTCP) option
- DPM can co-exist but cannot work simultaneously with any tracking related operation such as
  - TAST/AVC
  - Servo-Robot Tracking
  - Line Tracking
- DPM can support orientation control but it is limited to UFRAME and UTOOL
- DPM supports Linear and Circular motion types. Circular Arc is not supported.
- Only one, either **INLINE** (Destination Modifier) or **MODAL** (Path Modifier), can be used at a time. Cycle power is required when the DPM mode is changed
- DPM requires that the Constant Path Option (R663) is installed

3 DPM SETUP

Setup of DPM via the UIF is described in this chapter.

The following block diagram shows the hierarchy of the DPM setup.

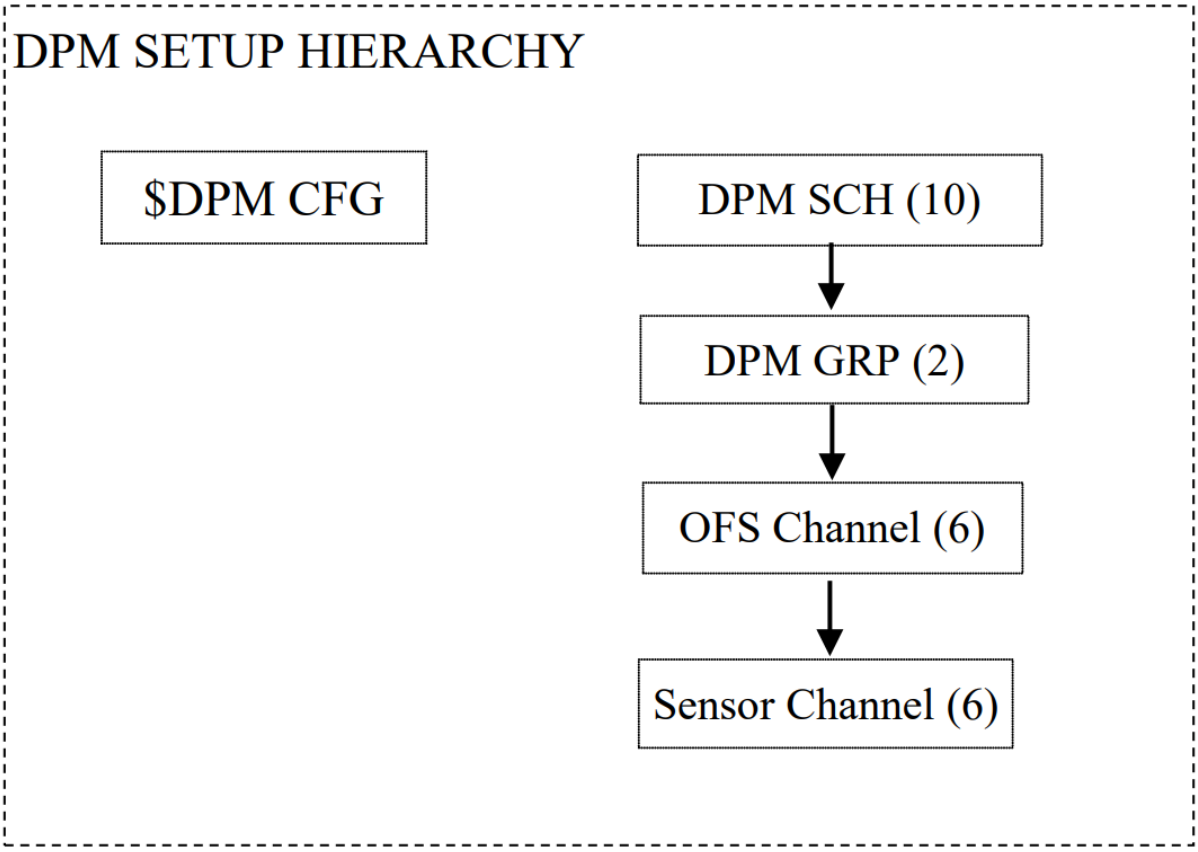


Figure 3 DPM Setup Hierarchy

3.1 DPM CONFIGURATION SETUP

About this task

Use this procedure to get to the DPM Configuration setup menu.

Procedure

1. Press **MENU**.
2. Select **SETUP**.
3. Press **F1, [TYPE]**.
4. Select **DPM SETUP**.
5. Press **F3, CONFIG**.

You will see a CONFIG SETUP screen similar to the following.

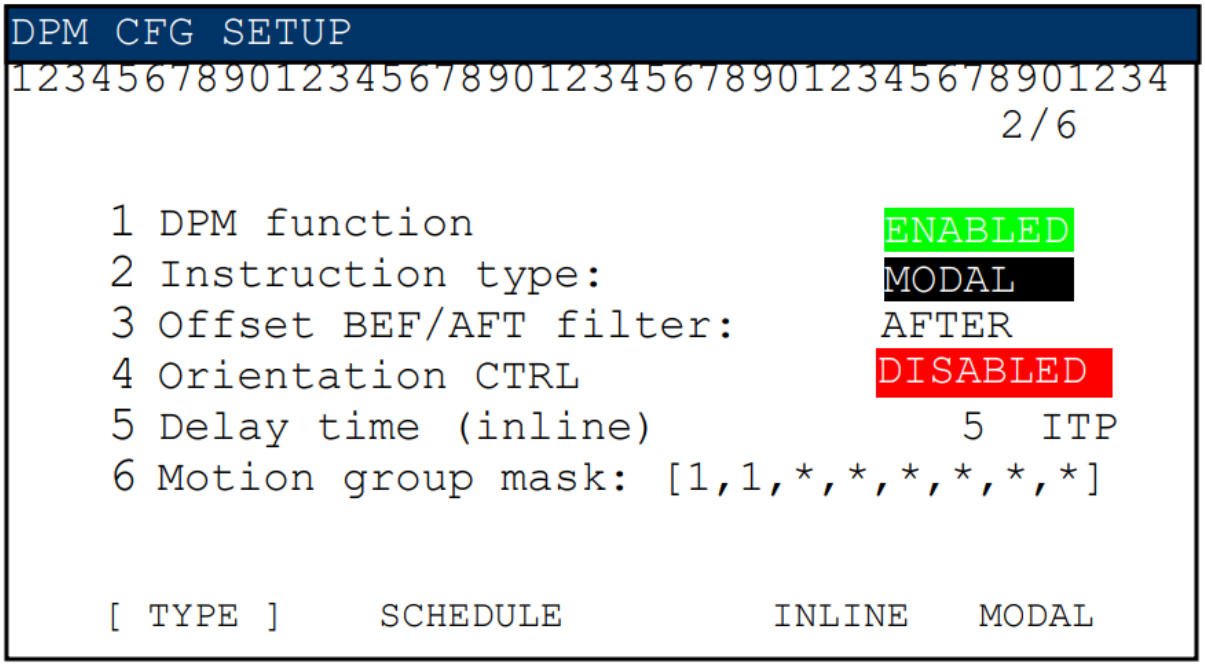


Figure 3.1 DPM CFG SETUP

> **NOTE**
>
> Cycling power is required after changing the CONFIG items.

3.1.1 DPM Configuration Descriptions

Table 3.1.1 DPM Configuration Descriptions

Item	Item Descriptions
DPM function	Allows you to enable or disable the DPM function.
Instruction type	DPM supports **MODAL** and **INLINE** DPM instructions. Make this the same setting as the **DPM type** in the Schedule DETAIL Setup Screen (described in Section 3.2.2, Schedule Detail) Re-power is required for the change to be effective.
Offset BEF/AFT filter	**AFT**: The offset command is smoothed by the filtering process dedicated to this function. **BEFORE**: Not smoothed by the process above. Instead, the smoothing process for the motion itself is used. If responsiveness is important, set this item to **AFT**. However, when the Constant path function is disabled, even if this item is **AFT**, the smoothing process will be the same as **BEF**. Re-power is required for the change to be effective.
Orientation CTRL	**ENABLED**: Enable orientation control, **DISABLED**: Disable orientation control

Item	Item Descriptions
Delay time (inline DPM)	Specifies window time (ITP delay) for Inline DPM to accept offset after a new segment starts.
Motion group mask: [1,1,*,*,*,*,*,*]	DPM supports two DPM motion groups per controller and you can map a robot motion group to a DPM motion group. The first **1** of the motion group maps to DPM group 1 and the second **1** maps to DPM group 2. Re-power of the controller is required for the change to be effective.

3.2 DPM SCHEDULE SETUP

3.2.1 DPM List Schedule Setup

About this task

Use this procedure to display the DPM list schedule menu.

NOTE

DPM can support up to 50 schedules and each schedule can support up to two DPM groups. Use the variable *$DPM_CFG.$MAX_SCH* to change the number of schedules, and cycle power for the change to take effect.

Procedure

1. Press **MENU**.
2. Select **SETUP**.
3. Press **F1, [TYPE]**.
4. Select **DPM SETUP**.
   You will see a screen similar to the following:

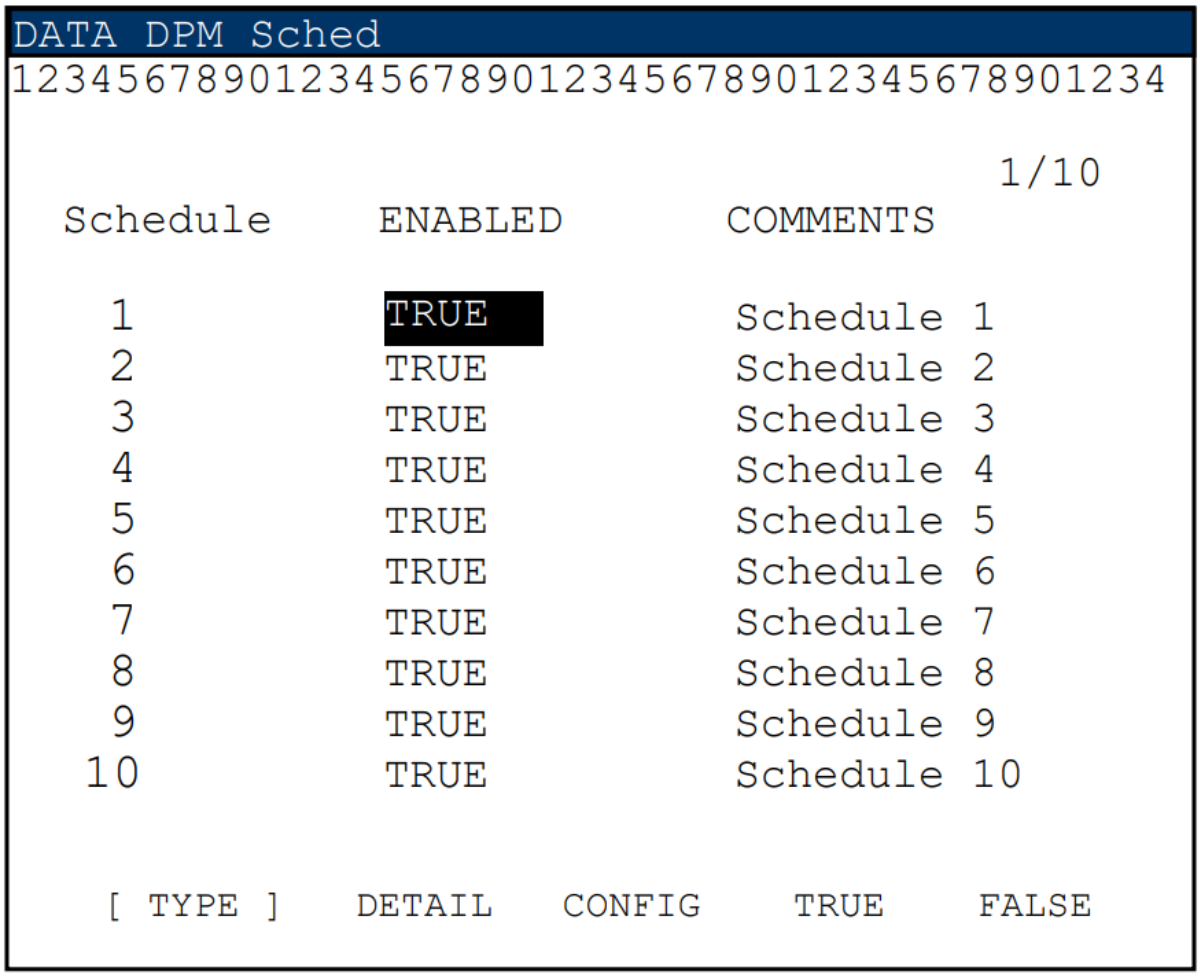


Figure 3.2.1 DATA DPM Sched

5. Press **TRUE** or **FALSE** to enable/disable this schedule.

3.2.2 Schedule Detail

> **NOTE**
>
> You can specify **INLINE** or **MODAL DPM type** for any DPM group in the schedule. However, you can only execute DPM motion when the **DPM type** is the same as the **Instruction type** in the DPM configuration setup. Otherwise, you will get a `DPMO-027 Mismatch DPM type` alarm.

Pressing **F2, DETAIL** from the list schedule menu, will reveal the detail schedule menu. The detail schedule menu consists of DPM group and DPM channel setup. The group and channel display items are further dependent on the **DPM type** (**MODAL** or **INLINE**) and channel input type.

3.2.2.1 Modal Detail Schedule

The Modal Detail Schedule screen will look similar the following:

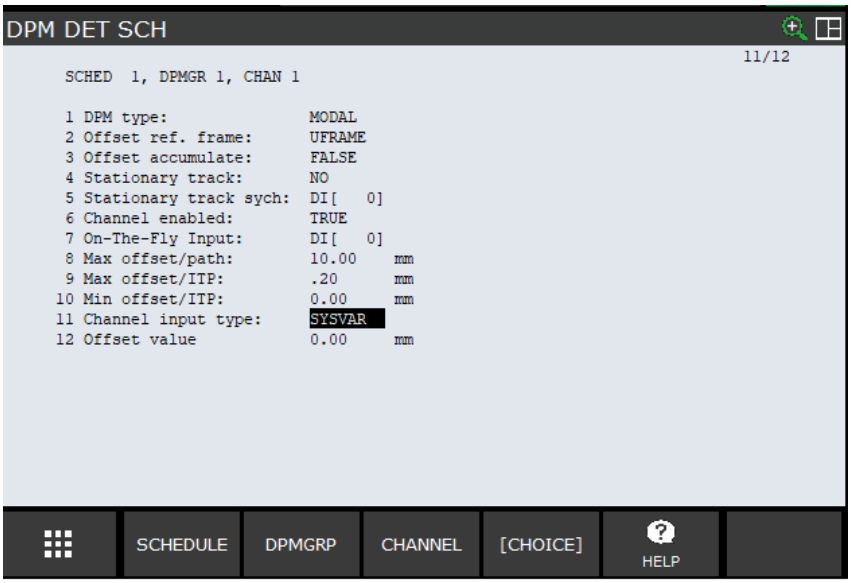


Figure 3.2.2.1 (a) MODAL Detail Schedule Screen for SYSVAR Input Type

The display will change dynamically depending on the **Offset input type** as shown in the screens below:

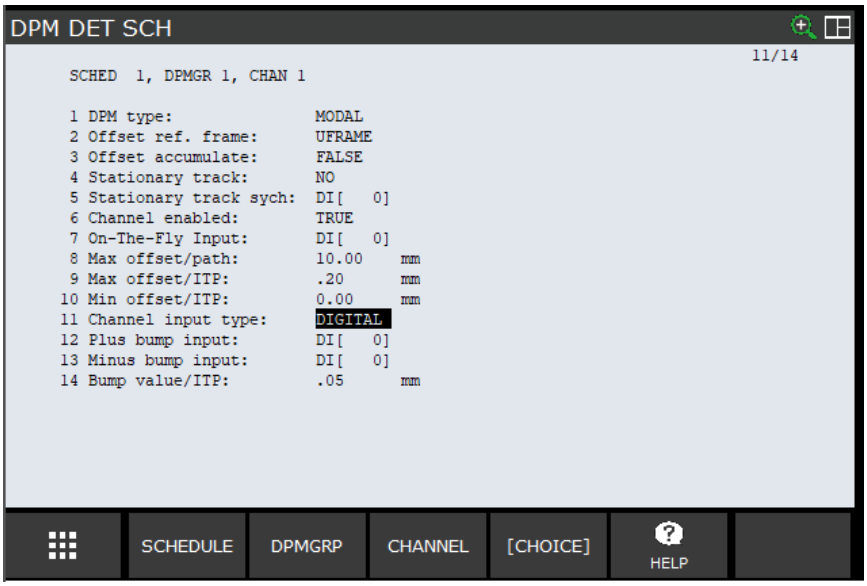


Figure 3.2.2.1 (b) MODAL Detail Schedule Screen for Digital Input Type

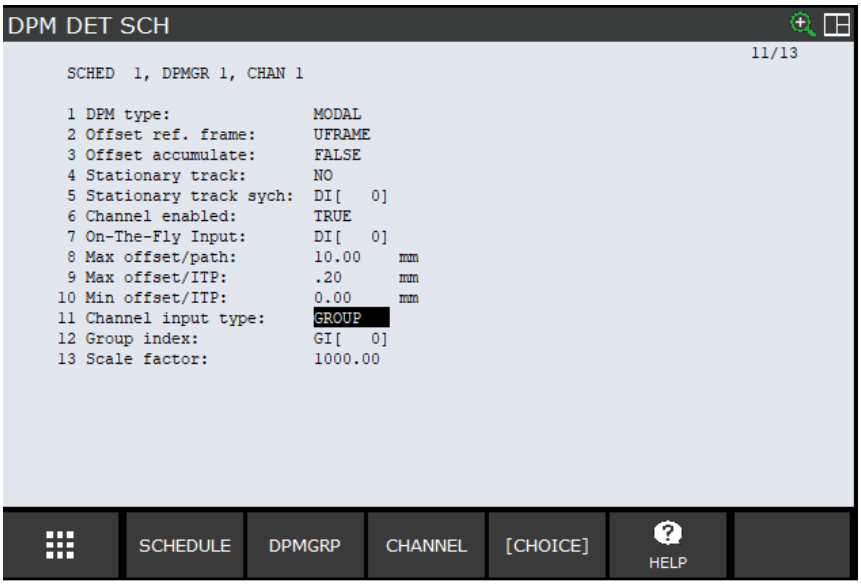


Figure 3.2.2.1 (c) MODAL Detail Schedule Screen for Group Input Type

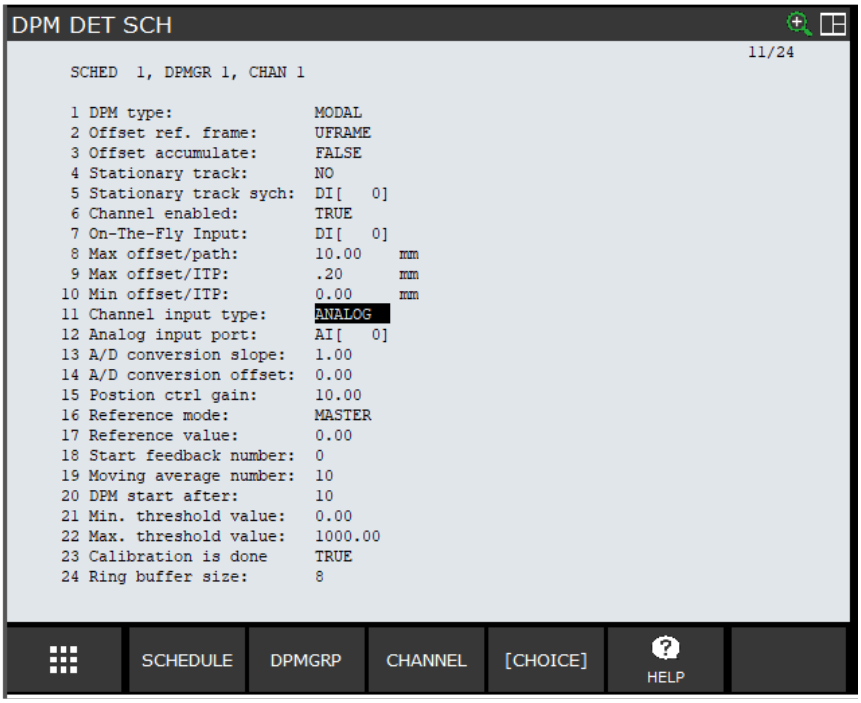
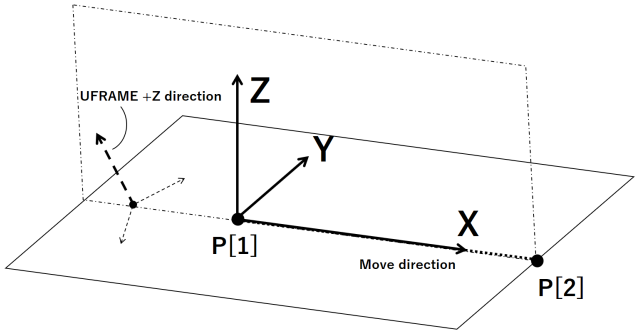
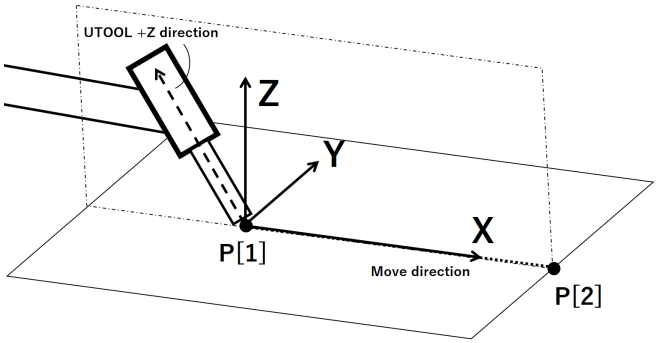


Figure 3.2.2.1 (d) MODAL Detail Screen for Analog Input Type

Each item that could show up in the Modal Detail Schedule screen is described in Table 3.2.2.1

Table 3.2.2.1 Modal Detail Schedule Descriptions

	Item	Description
Group	**DPM type**	Set **MODAL** for this DPM Group. Ensure that the instruction type is also set to MODAL in the DPM CFG setup screen (described in Section 3.1.1, DPM Configuration Descriptions).
	Offset ref. frame	DPM supports following four offset reference frames: ● 1: PATH. The x direction is the path direction, the y direction is perpendicular to both x and UFRAME z and the z direction is perpendicular to both x and y. Path relative is limited to positional offset only, offset channels 1, 2 and 3 corresponding to x, y and z w/r PATH.  **Figure 3.2.2.1 (e) PATH offset reference frame** ● 2: TOOL-PATH: The x direction is the path direction, the y direction is perpendicular to both x and TOOL z and the z direction is perpendicular to both x and y. TOOL-Path relative is limited to positional offset only, offset channels 1, 2 and 3 corresponding to x, y and z w/r TOOL-PATH.  **Figure 3.2.2.1 (f) TOOL-PATH offset reference frame** ● 3: UFRAME: The offset is relative to the current user frame. Offset channels 1, 2, 3, 4, 5 and 6 correspond to x, y, z, w, p, r w/r UFRAME. ● 4: UTOOL: The offset is relative to current tool frame. Offset channels 1, 2, 3, 4, 5 and 6 correspond to x, y, z, w, p, r w/r UTOOL.
	Offset accumulate	● True for Accumulated: If a new offset is commanded while old offset is in progress the new offset would be added to the old offset to establish a new total offset ● FALSE for Non-Accumulated: If a new offset is commanded while the old offset is in progress the new offset would become the new total offset and the unconsumed old offset will be flushed.

	Item	Description
Group	**Stationary Track**	● DPM supports stationary track motion for modal DPM with FINE term motion. In the stationary track motion, the robot will move to a taught position with or without any offset and to continue to follow the offset input (via joystick command or other sensors input in six channels) in Cartesian move relative to UTOOL or USER frame. The stationary track for this motion will not end until a specified synchronization digital input is set to TRUE. Then, robot will continue to move to next motion segment. ● Yes to enable stationary track. ● No for regular track mode. **NOTE** Stationary Track only supports AFTER Filter. If BEFORE Filter, offsets cannot be applied.
	Stationary track sych DI[idx]	Stationary track digital index used to terminate the stationary tracking: ● DI[sync_di] = OFF, DPM will perform stationary track. ● DI[sych_di] = ON will terminate stationary track for this motion line and continues to next motion line. If next motion line is also a stationary track, you should reset DI[sync_di] = OFF prior to the motion end. **NOTE** If Stationary Tracking is enabled, the Stationary Track Synch DI must be set to a valid input otherwise the program will not be able to continue. If the input is not valid at run-time, you will need to abort the program to recover.
Offset Channel	**Channel enabled**	Enable or disable this channel.
	On-The-Fly input	Input I/O index for feedback.
	Max offset/ path	Allowed total path deviation in mm
	Max offset/ITP	Allowed max absolute path change in mm per ITP
	Min offset/ITP	Minimum offset per ITP before control take effect in mm
	Channel input type	1. **ANALOG**: The offset is derived from an analog signal. 2. **GROUP**: The offset is derived from group input. 3. **DIGITAL**: The offset is derived from Bump Digital Input. 4. **SYSVAR** : User set offset via sysvars. 5. **SENSOR**: Only applies to specific options (R900 or R901).

	Item	Description
Analog Input Channel (See Section 3.2.2.2, Analog Input Channel Details)	**Analog input port** AI[idx]	Analog port number
	A/D conversion slope	Analog A/D calibration parameter
	A/D conversion offset	Analog A/D calibration parameter.
	Position ctrl gain	Positional control gain for the PID control. (*p_gain* in Analog Proportional Control in Section 3.2.2.2, Analog Input Channel Details)
	Reference mode	• **MASTER**: User set reference value. • **FEEDBK**: Regular feedback mode. • **FEEDBK1**: Special feedback mode.
	Reference value	Reference value used to generate offset. This item is used when **Reference mode** is **Master**. Offset command = Position ctrl gain x (Distance - Reference value)
	Start feedback number	Specify first no. of samples to skip before calculating reference value. Only used when **Reference mode** is in **FEEDBK1** mode.
	Moving average number	Average feedback number. This item is used when **Reference mode** is **FEEDBK** or **FEEDBK1**
	DPM start after	Specifies the number of ITP before DPM control.
	Min. threshold value	Minimum calibrated feedback value. Data will be marked as invalid when data is less than this value.
	Max. threshold value	Maximum calibrated feedback value. Data will be marked as invalid when data is greater than this value.
	Calibration is done	Set **TRUE** when calibration is done.
	Ring buffer size	Ring buffer size. MUST be larger than moving average number.

	Item	Description
Group Input Channel	**Group index** GI[idx]	Index for the group input. It is necessary to assign 16 bits of signals to the selected GI[].
	Scale factor	Scale factor for the group input. *Offset = Group input value / Scale factor* The input range of group input (16-bit) is between -32768 and 32767. Negative values (-32768 to -1) are expressed as two's complement. Therefore, if the value is greater than or equal to the decimal number 32768 (2^(16-1)) as displayed on the I/O screen, it will be actually a negative number (example below) by subtracting 65536 (2^16). On the I/O screen :0, 1,..., 32767, 32768, 32769,..,65535 Software internal :0, 1,..., 32767,-32768, -32767,.., -1
Digital Input Channel	**Plus bump input** DI[idx1]	Index for bump DIN for plus direction.
	Minus bump input DI[idx2]	Index for bump DIN for minus direction.
	Bump value/ITP	Bump offset per ITP when bump DIN is on.
Sysvar Input Channel	**Offset value**	Channel offset value. (Except SENSOR input type.) The offset value can be input by the following System Variable. *$DPM_SCH[schedule No.].$GRP[group].$OFS[axis].$INI_OFS*
SENSOR Input Channel	**SENSOR ID**	Select SENSOR ID for the current channel. Only available when SENSOR is selected in channel input type with specific option (R900 or R901)

3.2.2.2 Analog Input Channel Details

Analog Port Calibration

You must determine the intercept and slope based on an A/D conversion and sensor analog signal range. Set the slope as **A/D conversion slope** and the intercept as **A/D conversion offset** in the UIF. Then set **Calibration is done** to TRUE.

Reference Modes

Analog channel control supports three reference modes.

- **MASTER**: The user sets the **Reference value** in the UIF.
- **FEEDBK**: **Reference value** is set by the system based on the first *i* samples where *i* = **Moving average number** in the UIF. The formula used to calculate the reference value is:

  ref _val = {ave (fbk_val) – intercept}/slope
- **FEEDBK1**: This mode allows you to apply additional constrains to calculate the reference value.

1. You can specify a non-zero value to **Start feedback number** to skip that many samples at the start of tracking.
2. The consecutive number of samples is **Moving average number**. Each of these samples must be between **Min. threshold value** and **Max threshold value**.
3. Once the above constrains are satisfied the reference value will be calculated as

   ref _val = {ave (fbk_val) – intercept}/slope

Variable *$DPM_SCH[sch].$GRP[g].$AI_CH[chn].$MST_DONE* will be set to true automatically when **Reference value** is set and DPM tracking starts.

Analog Proportional Control

In analog proportional control, each channel offset is derived from the analog signal relative to a reference signal every ITP based on following equation:

offset = p_gain(cal_fbk – ref_val)*

The port_value is the moving average of the feedback data and the calibrated feedback value after A/D conversion is calculated as below:

cal_fbk = (port_value - intercept)/slope

Analog Adaptive Stage Control

The adaptive stage control dynamically adjusts ITP incremental offset threshold (*$MAX_INC*) based on the deviation of the analog value from the reference value. It can effectively affect the tracking speed. The adaptive stage control uses three parameters.

$CTL_STAGE	Stage threshold. Set value > 0 will enable this control.
$PARM1_F	Stage control rate
$PARM2_F	Upper bound of max offset per ITP

```
delta = ABS {cal_fbk – ref_val}
if (delta > $ctl_stage) {
   stage =  floor (delta / $ctl_stage)
   $max_inc = stage * $parm1_f
   If ($max_inc > $parm2_f)
      $max_inc = $parm2_f
   If ($max_inc < -$parm2_f)
      $max_inc = -$parm2_f
}
```

3.2.2.3 Inline Detail Schedule

For Inline DPM, the offset is applied to the destination position. The offset is normally provided at one time for each motion segment. Therefore, the sensor channel setup is not displayed.

The Inline Detail Schedule screen will look similar the following:

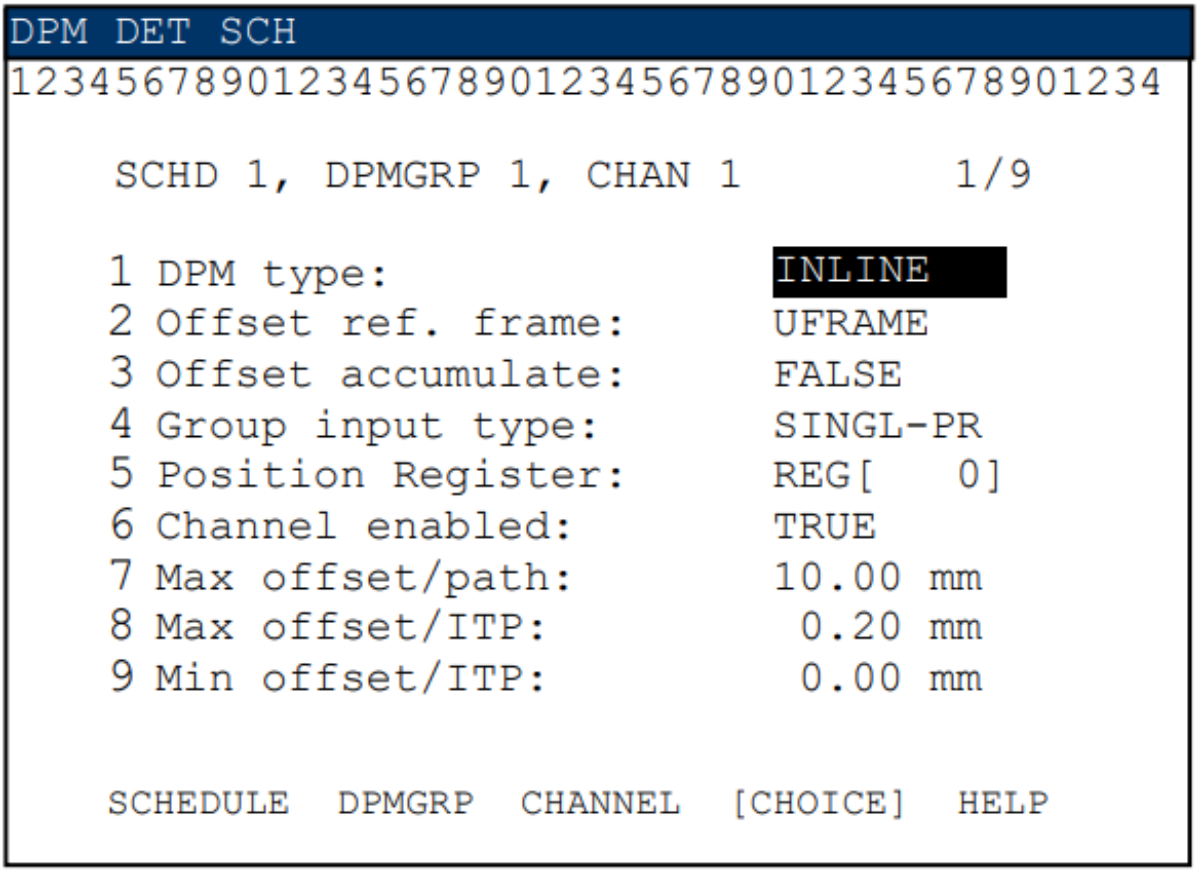


Figure 3.2.2.3 Inline Detail Shedule Screen

Each item that could show up in the Modal Detail Schedule screen is described in Table 3.2.2.3.

Table 3.2.2.3 Inline Detail Schedule Descriptions

	Items	Description
Group	**DPM type**	Set **INLINE** for this DPM Group Ensure that the **instruction type** is also set to **INLINE** in the DPM CFG setup screen (described in Section 3.1.1, DPM Configuration Descriptions).
	Offset ref. frame	Same as MODAL DPM case
	Offset accumulate	• True for Accumulated: The offset stored in position register will not be flushed after being used. • FALSE for Non-Accumulated: The offset stored in position register will be flushed after being used.
	Group input type	• USER-DEF: User defined offset. In this input type, you will provide the offset and a handshake flag through the following two system variables: **1.** *$DPM_SCH[schedule].$GRP[group].$OFS[axis].$INI_OFS* **2.** *$DPM_SCH[schedule].$GRP[group].$DAT_RDY* Frist initialize the offset through system variable (1), and then set (2) to 1 to inform the motion system that the offset value is ready. After implementing the offset, the motion system will reset the system variables to 0. • SINGLE-PR: The offset is stored at a specified position register for all DPM moves. You must set the position register index. The offset stored in the register will not be flushed after being used for accumulated offset mode and will be flushed after being used for non-accumulated mode. • MULTI-PR: The offset is stored at different position registers where the register index must match the DPM move line number.
	Position Register REG[idx]	Specify the position register for SINGLE-PR input type
Offset Channel	**Channel enabled**	Same as MODAL DPM
	Max offset/path	Same as MODAL DPM
	Max offset/ITP	Same as MODAL DPM
	Min offset/ITP	Same as MODAL DPM

4 DPM PROGRAMMING

DPM supports modal and inline program instructions. Modal DPM is designed for the application that requires real time path modification based on sensor information along the entire motion path. The inline DPM is designed for the application that requires real time modification on destination position for each motion segment.

4.1 MODAL DPM PROGRAMMING

Modal DPM is for continuous path modification based on the sensor's input. It provides following two instructions

- Track DPM(sch)
- Track End

Using Modal DPM Example 1

```
1: J P[1] 100% CNT100
2: Track DPM[1]
3: L P[3] 100mm/sec CNT100
4: L P[4] 100mm/sec CNT100
5: L P[5] 100mm/sec CNT100
6: L P[6] 100mm/sec CNT100
7: Track End
8: J P[7] 100% CNT100
```

On lines 3-6 the offset is generated based on the sensor and added to the total offset and appled to the path. Offsets will not be applied on line 1 and 8.

4.1.1 DPM Stationary Tracking Example

DPM Stationary Tracking Example 2

Stationary tracking must be enabled for the schedule.

```
1: J P[1] 100% CNT100
2: Track DPM[2]
3: L P[3] 100mm/sec CNT100
4: L P[4] 100mm/sec FINE
5: L P[5] 100mm/sec CNT100
6: L P[6] 100mm/sec FINE
7: Track End
8: J P[7] 100% FINE
```

Line 4

- Initial Setting: DI[sync_di] = OFF
- DPM will do stationary tracking at P[4] until DI[sync_di] = ON
- After DI[sync_di] = ON, program will continue to Line 5

Line 6

- Initial Setting: DI[sync_di] = OFF
- DPM will do stationary tracking at P[6] until DI[sync_di] = ON
- After DI[sync_di] = ON, program will continue to Line 7

4.1.2 DPM Track to Track Changing Track Schedules Before Track End

In this case, the DPM track schedule changes before Track End. This allows user to change control parameters to different motion segments.

Using Modal DPM Example 3

```
1: J P[1] 100% CNT100
2: Track DPM[1]
3: L P[3] 100mm/sec CNT100
4: L P[4] 100mm/sec CNT100
5: Track DPM[2]
6: L P[5] 100mm/sec CNT100
7: L P[6] 100mm/sec FINE
8: Track End
9: J P[7] 100% CNT100
```

Line 2

Use Schedule 1

Line 5

Use Schedule 2

4.1.3 DPM Track to Track Changing Schedules After Track End

In this case, the DPM track schedule changes after Track End. There is no non-track motion point between Track End and Track DPM[2]. This also allows user to change control parameters to different motion segments.

Using Modal DPM Example 4

```
1: J P[1] 100% CNT100
2: Track DPM[1]
3: L P[3] 100mm/sec CNT100
4: L P[4] 100mm/sec CNT100
5: Track End
6: Track DPM[2]
7: L P[5] 100mm/sec CNT100
8: L P[6] 100mm/sec FINE
9: Track End
10: J P[7] 100% CNT100
```

4.1.4 Modal DPM Programming (Multiple Tasking and Stationary Track)

Figure 4.1.4 illustrates two arc welding robots welding a round tank. The two welding robots perform the independent stationary DPM track to a rotation tank.

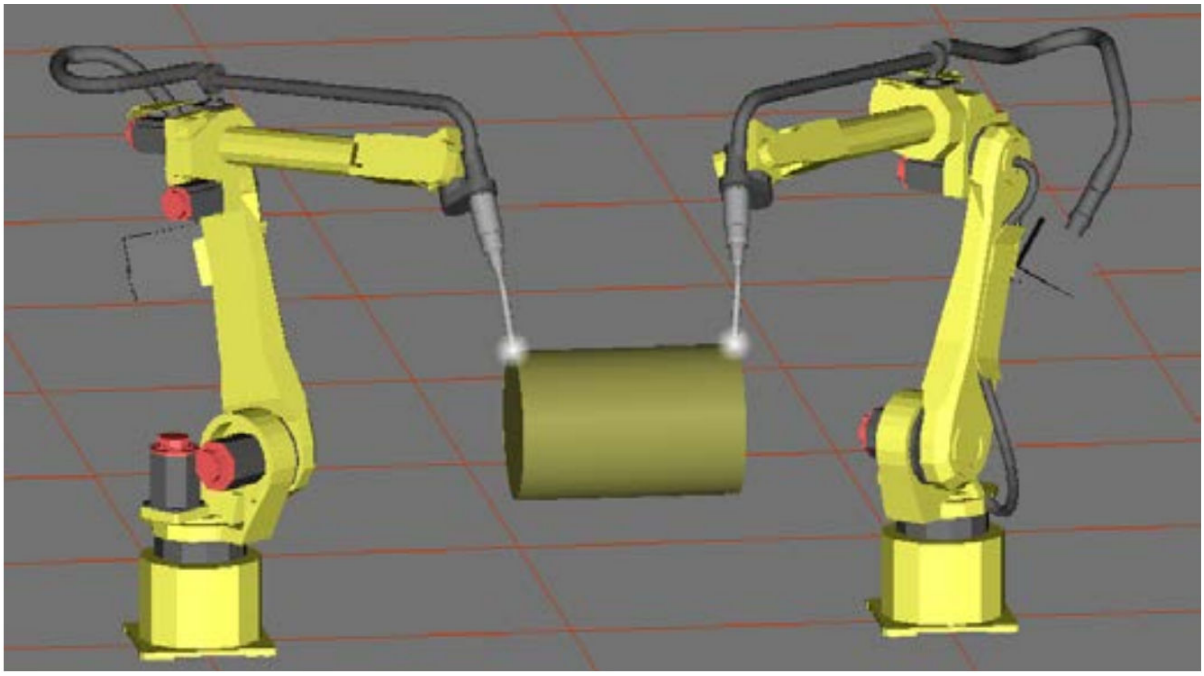


Figure 4.1.4 Arc Welding Robots Welding a Round Tank

Set stationary track for group 1 & 2 in the DPM schedule.

Main Program

DEFAULT_GROUP = *,*,*,*,*,*,*,*;

```
1: DO[11]=OFF ;
2: DO[12]=OFF ;
3: DO[10]=OFF ;
4: DO[13]=OFF ;
5: RUN GET_OFS ;
6: RUN G3_SUB ;
7: RUN DPM_TRC_G2 ;
8: RUN DPM_TRC_G1 ;
```

Line 6 runs program G3_SUB

Line 7 runs program DPM_TRC_G2

Line 8 Runs program DPM_TRC_G1

G3_SUB

DEFAULT_GROUP = *,*,**1**,*,*,*,*,*;

```
1:J P[1] 100% FINE ;
2: WAIT DO[10]=ON ;
3: WAIT DO[11]=ON ;
4: DO[12]=ON ;
5:J P[2] 60.0sec FINE ;
6: DO[13]=ON ;
```

DPM_TRC_G2

DEFAULT_GROUP = *,**1**,*,*,*,*,*,*;

```
1:J P[1] 100% FINE ;
2: WAIT 2.00(sec) ;
3:J P[2] 100% FINE ;
4: DO[11]=ON ;
5: WAIT DO[12]=ON ;
6: Arc Start E2[1] ;
7: Track DPM[1] ;
8:L P[3] 100mm/sec FINE ;
9: Track End ;
10: Arc End E2[1] ;
```

$DPM_SCH[1].$GRP[2].$TRK_MODE = 1
Set to stationary DPM until *$DI[idx]* = ON
idx = *$DPM_SCH[1].$GRP[2].$SYNC_IDX*

DPM_TRC_G1

DEFAULT_GROUP = **1**,*,*,*,*,*,*,*;

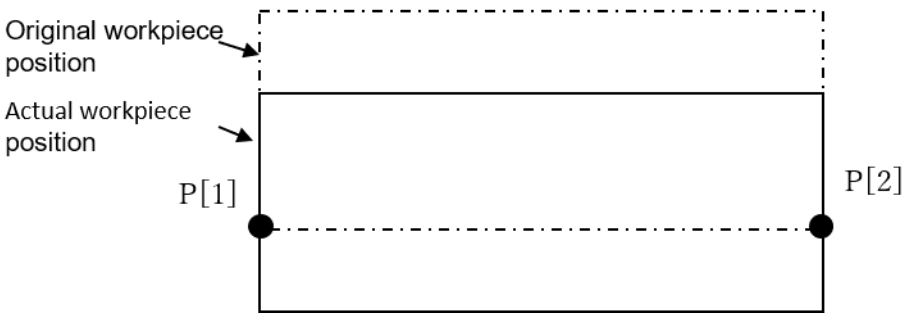
```
1:J P[1] 100% FINE ;
2: WAIT 2.00(sec) ;
3:J P[2] 100% FINE ;
4: DO[10]=ON ;
5: WAIT DO[12]=ON ;
6: Arc Start E1[1] ;
7: Track DPM[1] ;
8:L P[3] 100mm/sec FINE ;
9: Track End ;
10: Arc End E1[1] ;
```

$DPM_SCH[1].$GRP[1].$TRK_MODE = 1
Set to stationary DPM until *$DI[idx]* = ON
idx = *$DPM_SCH[1].$GRP[1].$SYNC_IDX*

4.1.5 Programming Technique: Use MODAL DPM with Tool Offset Instruction

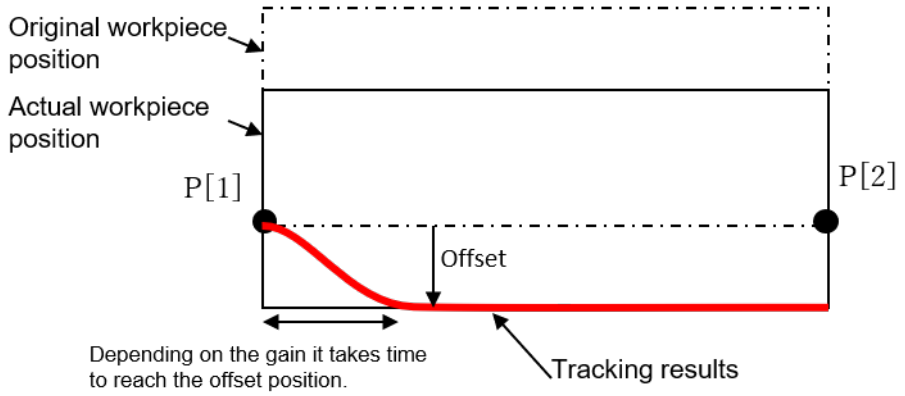
Assume the situation shown in the following figure.

- Linear motion from P[1] to P[2] along the workpiece.
- The actual workpiece is not in the same position as when it was taught.



If you teach a simple MODAL DPM program, the robot cannot move along the actual workpiece in the beginning of tracking because it takes time to reach the compensated position as shown in the figure below.

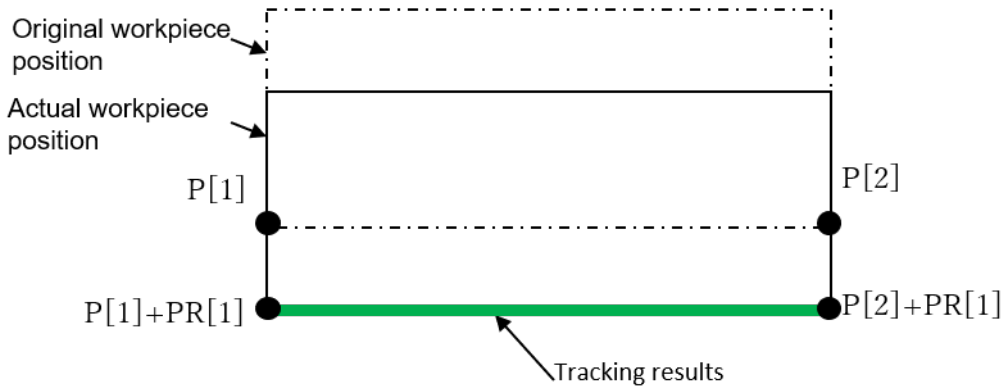
```
L  P[1] 1000mm/s FINE
Track DPM[1]
L P[2] 20mm/s FINE
Track End
```



Tool offset instruction is effective to offset the amount of misalignment from the start of tracking.

- Store the detected amount of misalignment near the start of tracking in PR.
- Add Tool offset instruction to each motion line. Use the PR in which the misalignment value is stored.

```
L  P[1] 1000mm/s FINE
PR[1,y] = AI[1(Sensor input)] * Conversion
PR[1,z] = AI[2(Sensor input)] * Conversion
L  P[1] 1000mm/s FINE Tool_Offset, PR[1]
Track DPM[1]
L P[2] 20mm/s FINE Tool_Offset, PR[1]
Track End
```



Large deviation near the start of tracking are compensated by the Tool offset instruction.
Small deviations are compensated by the MODAL DPM.

4.2 INLINE DPM PROGRAMMING

Inline DPM provides the following inline option to be attached to a motion instruction:

- DPM[(sch)]

4.2.1 Single Group Inline DPM Programming

Single Group DPM motion

[1,*,*,*,*,*,*,*]

$DPM_CFG.$GRP_MSK = 1

```
1: J P[1] 100% CNT100
2: L P[2] 100mm/sec CNT1 DPM[1]
3: L P[3] 100mm/sec CNT10 DPM[1]
4: L P[4] 100mm/sec CNT100 DPM[1]
5: J P[5] 100% CNT100
6: L P[6] 100mm/sec FINE DPM[1]
7: J P[7] 100% CNT100:
8: L P[8] 100mm/sec FINE DPM[1]
9: J P[9] 100% CNT100
```

4.2.2 Simultaneous Multiple Group Inline DPM Motion

DPM supports simultaneous group DPM motion. All the robot group motion starts and stops at the same time and each robot group modify its destination based on its own offset input.

Multiple Group DPM Motion

[1,1,*,*,*,*,*,*]

$DPM_CFG.$GRP_MSK = 3

```
1: J P[1] 100% CNT100
2: L P[2] 100mm/sec CNT5 DPM[1]
3: L P[3] 100mm/sec CNT100 DPM[1]
4: L P[4] 100mm/sec FINE DPM[1]
```

4.2.3 Multiple Independent Group Inline DPM

In this case, robot group motion is not synchronized and each robot group modifies its destination based on its own offset input.

Multiple Independent Group Inline DPM Motion Example

[*,*,*,*,*,*,*,*]

```
1: run DPM_G1
2: run DPM_G2
```

Line 1 runs program DPM_G1

Line 2 runs program DPM_G2

DPM_G1

[1,*,*,*,*,*,*,*]

$DPM_CFG.$GRP_MSK = 3

```
1: J P[1] 100% CNT100
2: L P[2] 100mm/sec CNT1 DPM[1]
3: L P[3] 100mm/sec CNT10 DPM[1]
4: L P[4] 100mm/sec FINE DPM[1]
```

DPM_G2

[*,1,*,*,*,*,*,*]

$DPM_CFG.$GRP_MSK = 3

```
1: J P[1] 100% CNT100
2: L P[2] 100mm/sec CNT1 DPM[2]
3: L P[3] 100mm/sec CNT10 DPM[2]
4: L P[4] 100mm/sec FINE DPM[2]
```

5 DPM/SPLINE ADD-ON OPTION (R916)

In general, Dynamic Path Modification (DPM), with order number R739, does not support Spline motion type. However, by loading **DPM/Spline Add-on Option** (R916), Spline motion type can be supported with limited configuration. This feature can allow the user to dynamic modify the robot nominal path while the robot is running spline motion.

5.1 PLATFORM

This option is applicable on the R-30*i*B Plus platform.

- V9.30 series: V9.30P/17 (7DF3/17) and newer.
- V9.40 series: V9.40P14 (7DF5/14) and newer.

5.2 DEPENDENCY/REQUIREMENT

DPM / Spline Add-on (R916) requires the following options

- Constant Path (R663)
- Spline Motion (R904)
- Dynamic Path Modification (R739)

5.3 SUPPORTED CONFIGURATION AND LIMITATIONS

5.3.1 Supported Configuration

DPM/Spline Add-on only supports a subset of the DPM configuration. The list of supported configurations are listed here:

- Modal DPM
- After Filter DPM
- Frame type: UTOOL and UFRAME
- Channel Input type: All except for SENSOR type
- Integrated Extended Axis
- High Accuracy Coordinated Motion
- Dynamic UFRAME

5.3.2 Limitations

DPM / Spline Add-on has the following global limitations. (All schedules)

- Modal DPM only
- After Filter DPM only
- No Orientation Control
- Turbo Move (cycle time priority) is not supported. (Path Priority only)
- Not compatible with Servo Robot PKG (R900) or Universal Sensor IF2 (R901)

DPM / Spline Add-on has the following schedule based limitations.

- Offset reference frame: UTOOL and UFRAME only
- No Stationary Track
- No DPM On-The-Fly Input Support
- Single Step FWD/BWD on nominal path only
- Channel input type: Not SENSOR type
- Complete Stop Tracking while switching DPM schedule (No live schedule change)
- Cannot run with
  - Weave
  - TAST(Through Arc Seam Tracking)
  - AVC (Automatic Voltage Control)
  - RPM (Root Path Memorization)
  - Line tracking
  - MPass (multi-pass)
- Maximum allowed program speed: 200 mm/sec
- Coordinated Motion related:
  - Only follower accepts offset
  - One follower only
  - One pair only
  - No COORD <=> Non COORD switching during DPM tracking

5.4 DPM/SPLINE ADD-ON SETUP

5.4.1 DPM/Spline Add-on Setup Overview

The setup/configuration of DPM/Spline Add-on is identical to the standard Dynamic Path Modification (R916) option. In addition, there are few more entries in setup page that allow user to configure.

5.4.2 Global Feature Enable

When R916 is loaded successfully, a new **SPLINE** entry in DPM Configuration Page will be presented. This entry can allow the user to enable/disable this feature globally. The default setting is ENABLED.

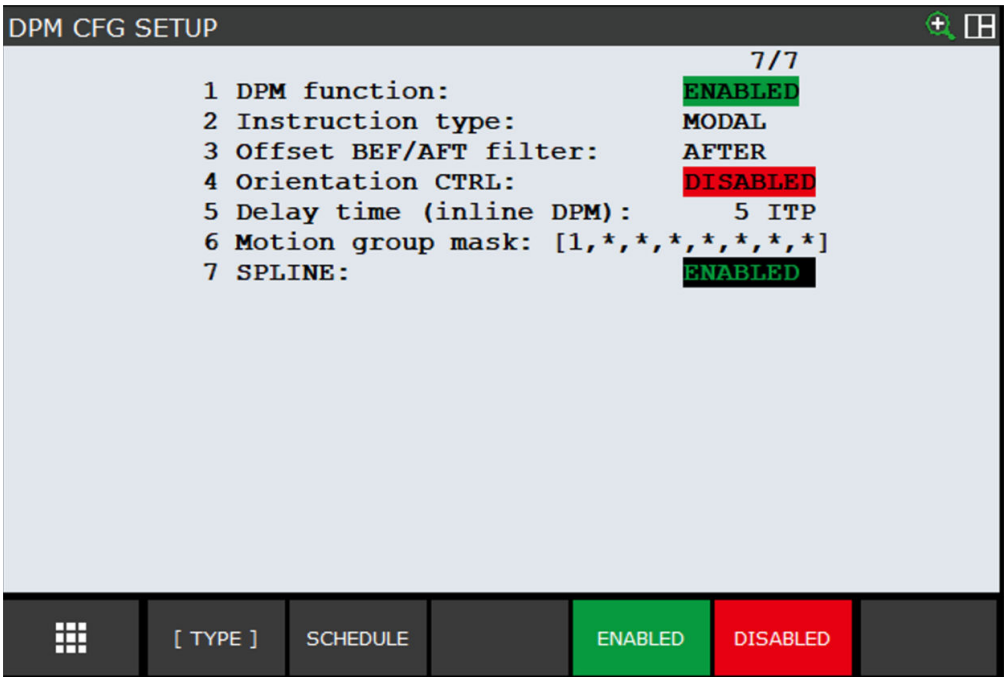


Figure 5.4.2 DPM CFG SETUP with SPLINE

5.4.3 Schedule Setup

In the DPM schedule setup page for each schedule, a new entry **SPLINE** will be displayed when R916 is successfully loaded. This entry allow you to enable/disable DPM with support for this schedule. You can configure schedules that enable SPLINE with the schedule-based limitations as mentioned above. Please note that you can configure other schedules that disable SPLINE while allowing full DPM functionality.

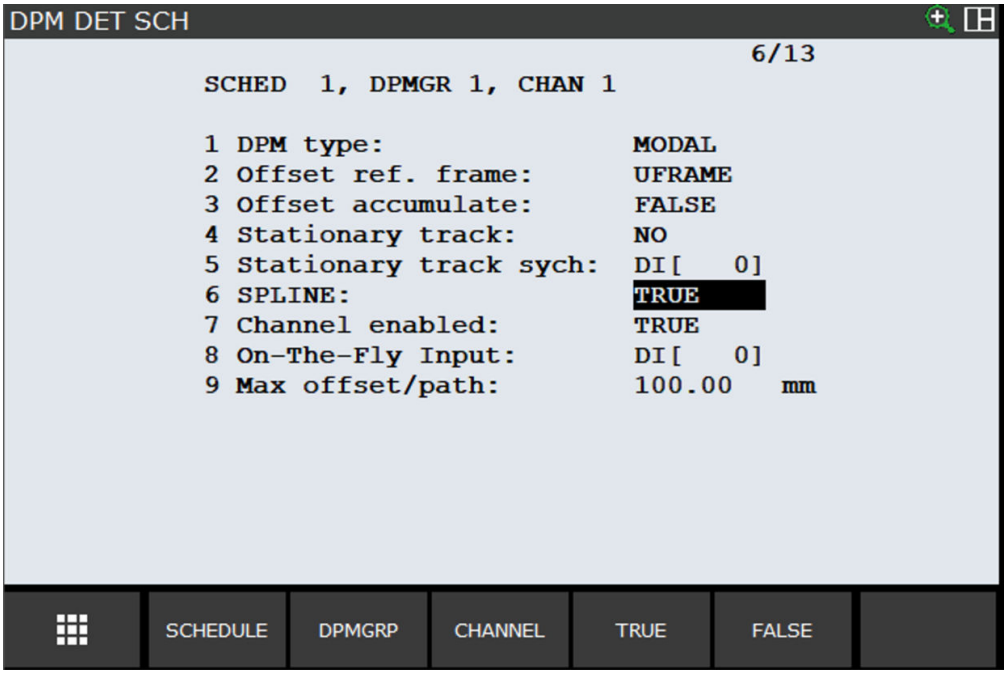


Figure 5.4.3 DPM DET SCH with SPLINE

5.5 PROGRAMMING EXAMPLE

The following is a typical program using DPM with the Spline motion type.

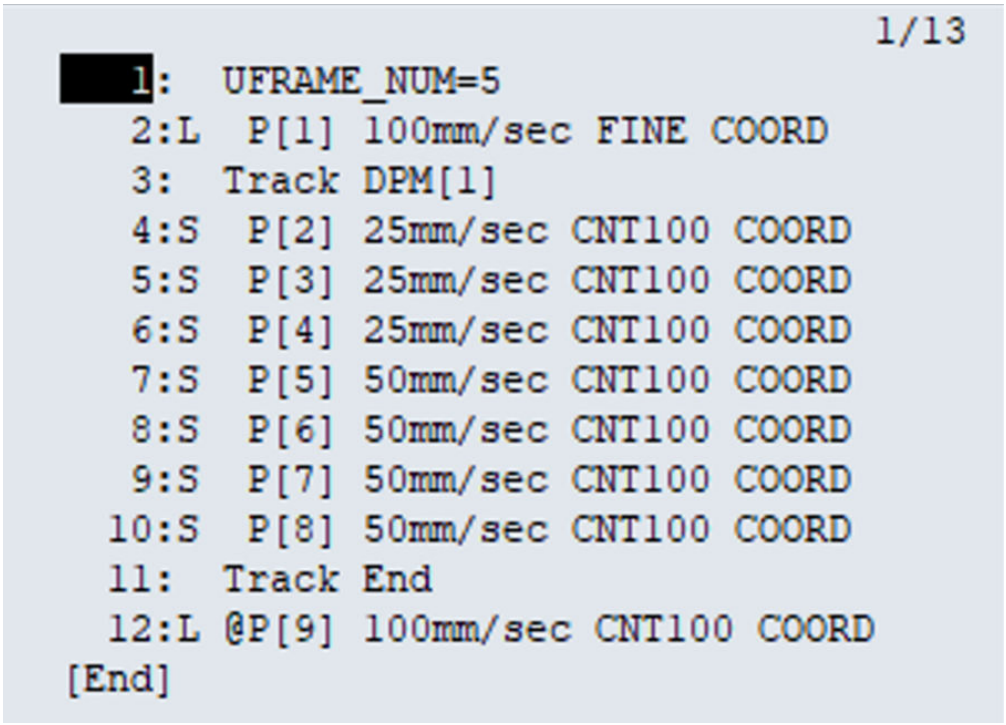


Figure 5.5 (a) Example of DPM program with spline motion

NOTE

1. Program one motion before TRACK DPM[x]
2. Program one motion after TRACK END

The following is a typical program when switching of the schedule is required.

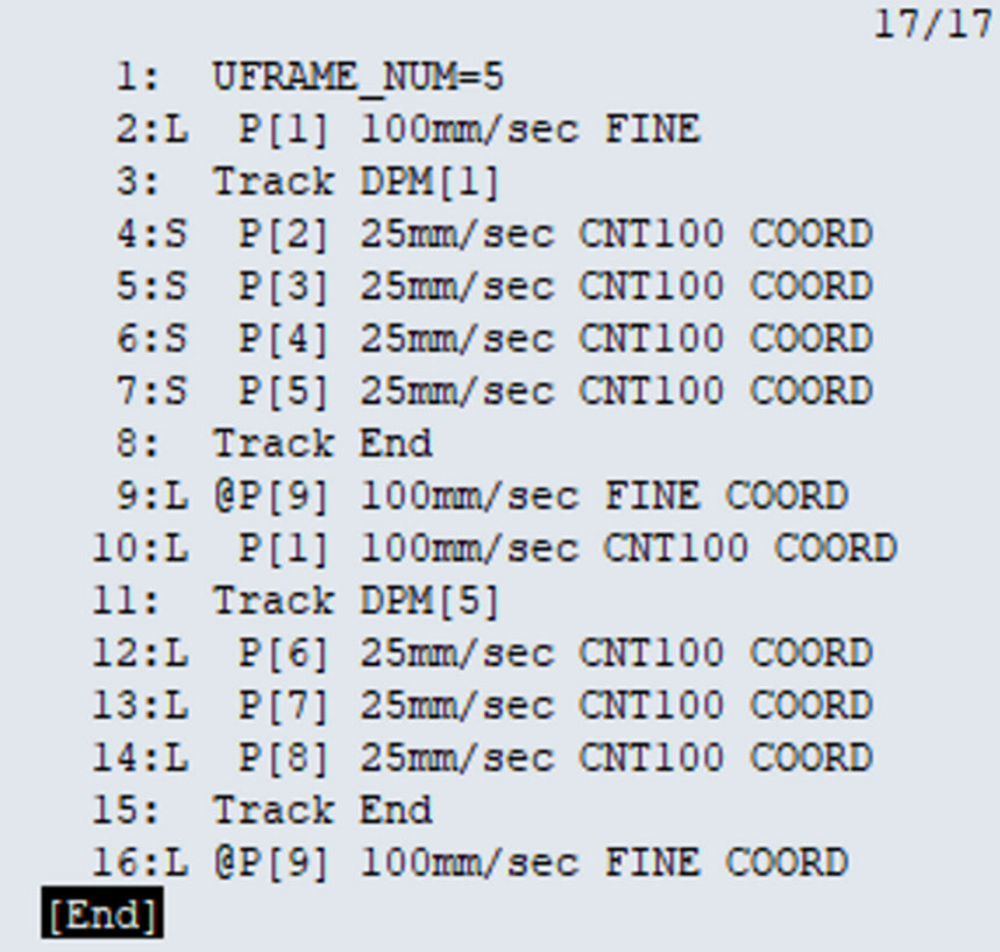


Figure 5.5 (b) Example of program when schedule switching is required

NOTE

Program motion is required between TRACK END and next TRACK DPM[y]

5.6 HOLD/RESUME BEHAVIOR

Hold/Resume behavior for DPM/ Spline Add-on enabled schedule would be the same as regular DPM hold/resume behavior in the following configuration.

- Modal DPM
- After Filter DPM

5.7 DPM/SPLINE ADD-ON ERROR MESSAGES

Alarm	Severity	Description
DPMO-033 `Adv DPM Invalid Config: %s`	Warning	Configuration is not supported
DPMO-034 `Adv DPM Invalid Config`	STOP	Configuration is not supported

DPMO-033 will have the following additional information:

Text	Description
AFT FLTR	Requires After Filter DPM.
INLINE	Inline DPM is not supported
FRAME	Frame selection is not supported.
SENSOR	Sensor input type is not supported.
ORNT CTRL	Orientation Control is not supported.
STAT TRCK	Stationary Tracking is not supported.
OnTheFly	On-The-Fly is not supported.
TBMOVE	Turbo move is not supported.
OVER SPD	Program speed is too large.
LDR OFST	Leader cannot accept offset
TooManyFlw	Only one follower is allowed.
CD TRANS	COORD <=> Non COORD transition inside TRACK DPM is not allowed.

6 ERROR MESSAGES

Table 6 Error Messages

Alarm	Severity	Description
DPMO-002 `Cyc Offset Limit Err`	Stop	interpolated offset exceeds the allowed bound (*$DPM_SCH[].GRP[].$MAX_CYC*)
DPMO-003 `Offset is ignored`	Warning	current segment is done interpolating
DPMO-004 `Offset is too late`	Warning	Offset is available after window time
DPMO-005 `No Zero Dist Move`	Stop	Zero distance DPM motion is not allowed
DPMO-006 `No Joint motion`	Stop	Attempt to offset a JOINT motion
DPMO-013 `NO Sysvar loaded`	Stop	DPM is not installed properly
DPMO-014 `Dest Offset Limit Error`	Stop	Destination offset exceeds the allowed bound (*$DPM_SCH[].GRP[].$MAX_LIM*)
DPMO-015 `Analog IN not set`	Stop	Analog input is not set properly
DPMO-016 `Group IN not set`	Stop	Group input is not set properly
DPMO-017 `Bump IN not set`	Stop	Bump digital input is not set properly
DPMO-018 `Analog IN not calibrated`	Stop	Analog input is not calibrated
DPMO-019 `Group IN not calibrated`	Stop	Need set none zero scale factor for group Input.
DPMO-020 `Inline DPM is not set`	Stop	Need set *$DPM_CFG.$ENABLE* = TRUE
DPMO-021 `WJNT is not supported`	Stop	Attempt to offset a Wrist Joint motion
DPMO-022 `UTOOL is changed`	Stop	Attempt to OTF changing an UTOOL
DPMO-023 `Wrong Schedule Number`	Stop	Wrong schedule number
DPMO-024 `Can't control orientation`	Stop	DPM orientation is prohibited at non mode3 resume. Set *$DPM_CFG.$ORI_CTL* = FALSE.
DPMO-025 `Can't enb ori_ctl for PATH`	Stop	DPM orientation is NOT supported for TPATH and PATH. Use UFRAME or UTOOL offset relative for orientation control.

Alarm	Severity	Description
DPMO-026 `Fail to create offset frame`	Warning	Invalid robot move direction. Use UFRAME or UTOOL offset frame reference.
DPMO-027 `Mismatch DPM type`	Stop	DPM type mismatch in configuration and schedule.
DPMO-028 `Buffer is too short`	Abort	Buffer size is short to hold the data for analog input. Increase the buffer size and repower the controller.
DPMO-029 `No learn path found`	Abort	For SENSOR input type, no learn path was found.
DPMO-030 `Path learn buffer short`	Abort	For SENSOR input type, the learn path was found but the buffer size is too short.
DPMO-031 `CD - non CD transition in tracking`	Stop	Coord to non-Coord motion is detected during tracking.
DPMO-032 `Path Offset Limit Error`	Stop	Offset limit is detected. Reduce the total path offset or increase the offset limit per ITP.

INDEX

REVISION RECORD

Edition	Date	Contents
01	Aug.,2022	

B-84474EN/01