G-Code Program Example

Turbo PMAC's capability for accepting and executing RS-274 (G-code) programs gives the user great power and flexibility in creating and running programs that describe path motion and its associated I/O. This is important not just for classic CNC machine tool applications, but for any application that uses CAD/CAM software for the automatic generation of these programs.

Since RS-274 is a loose standard, with hundreds of dialects and thousands of machine-specific implementation issues, the key to Turbo PMAC's strategy for these programs is that it treats the G, M, T, and D codes within the programs as special subroutine calls. The machine integrator writes these subroutines so as to implement the features of the specific dialect and machine. How these subroutines are generated can remain hidden from the person (or software package) that generates the part program, and from the machine operator, for whom the controller simply appears as a standard "G-code" machine.

Here we give a few examples of how this feature can be used in Turbo PMAC.

A Basic Example

This first case implements a bare minimum of the most standard G and M-codes. For the G04 dwell, it uses a P argument, expressed in seconds. For controlling the cutting tool, it simply uses a discrete digital output. The path is the tool-center path, so no cutter-radius compensation is used.

Setup and Definitions

```
#define BitsPassed  Q100        ; Var for checking passed args
#define Parg  Q116              ; Var for P argument
#define Pval  32768             ; Val for checking if P passed
#define CutterOn  M1            ; Discrete cutter output
CutterOn->Y:$078802,8,1         ; Machine Output 1
&1                              ; Address CS 1
#1->2000X
#2->2000Y
#3->2000Z
```

Motion Program 1000 Contains the G-code Subroutines

```
OPEN PROG 1000 CLEAR
RAPID RETURN                    ; G00: Rapid mode (N0 is implied)
N1000 LINEAR RETURN             ; G01: Linear interpolation mode
N2000 CIRCLE1 RETURN            ; G02: Clockwise circle mode
N3000 CIRCLE2 RETURN            ; G03: Counterclockwise circle mode
N4000 READ(P)                   ; G04: Dwell for P seconds
IF (BitsPassed&PVal > 0)        ; P parameter specified?
  DWELL(PArg*1000)              ; Dwell time in milliseconds
ENDIF
RETURN
N17000 NORMAL K-1 RETURN        ; G17: Specify XY plane
N18000 NORMAL J-1 RETURN        ; G18: Specify ZX plane
N19000 NORMAL I-1 RETURN        ; G19: Specify YZ plane
N90000 ABS RETURN               ; G90: Absolute mode
N91000 INC RETURN               ; G91: Incremental mode
CLOSE
```

Motion Program 1001 Contains the M-code Subroutines

```
OPEN PROG 1001 CLEAR
N3000 CutterOn=1 RETURN         ; Start cutting tool
N5000 CutterOn=0 RETURN         ; Stop cutting tool
N30000 DWELL0 RETURN            ; End (execute any pending outputs)
CLOSE
```

Sample Part Program that uses these Subroutines

```
OPEN PROG 5 CLEAR
G17 G90                          ; XY plane, absolute move spec
F500                             ; Cutting speed 500 mm/min
G00 X10.00 Y5.00                 ; Rapid move to (10,5)
M03                              ; Start spindle
G04 P2.0                         ; Wait 2 seconds
G01 Z0                           ; Lower cutter
X30.25 Y5.00                     ; Linear XY move
G03 X35.25 Y10.00 J5             ; CCW arc move
G01 X35.25 Y50.10                ; Linear move
G03 X30.25 Y55.10 I-5            ; CCW arc move
G01 X10.00 Y55.10                ; Linear move
G03 X5.00 Y50.10 J-5             ; CCW arc move
G01 X5.00 Y10.00                 ; Linear move
G03 X10.00 Y5.00 I5              ; CCW arc move
G01 Z5                           ; Cutter up
M05                              ; Stop cutter
G00 X0 Y0                        ; Rapid move back to home
M30                              ; End of program (not actually needed)
CLOSE
```

A More Elaborate Example

This next example provides several elaborations. First, it adds cutter-radius compensation with the G40, G41, and G42 codes. The radius is determined by the tool-select codes T01, T02, T03, and T04, implemented in program 1002. These T-codes also select a power level for each "tool", to be used as an analog voltage output.

Second, there are two feedrate-override sources, one for rapid moves, and one for cutting (linear and circle) moves. When the program switches between these modes, the time-base source switches. Here it uses two results from the encoder conversion table. This example does not specify the ultimate source of these values, which could be potentiometers or switches.

Finally, it permits exact stop, modally and one-shot, disabling blending – particularly useful for sharp corners.

Setup and Definitions

```
#define BitsPassed  Q100         ; Var for checking passed args
#define Parg  Q116               ; Var for P argument
#define Pval  32768              ; Val for checking if P passed
#define CuttingMode  Q130        ; Flag for cutting/rapid
#define CS1TimeBaseAdr  I5193    ; Source of override
#define CS1TimeBaseSlew  I5194   ; Override slew rate
#define MaxSlew  8388607         ; Max slew rate
#define NormSlew  1644           ; Normal slew rate
#define CutOverride  $3504       ; 4th entry in conversion table
#define RapidOverride  $3505     ; 5th entry in conversion table
#define CutterOn  M1             ; Discrete cutter output
#define CS1InPos  M5187          ; In-position status bit
#define LaserControl  M402       ; Analog laser control
CutterOn->Y:$078802,8,1          ; Machine Output 1
CS1InPos->Y:$00203F,17,1         ; CS1 in-position status
LaserControl->Y:$07800A,8,16,S   ; DAC4 output (PMAC1)
```

Motion Program 1000 Contains the G-code Subroutines

```
OPEN PROG 1000 CLEAR
RAPID                          ; G00: Rapid mode (N0 is implied)
IF (CuttingMode=1)             ; Have been in G01,G02,G03?
  DWELL0                       ; Make sure cutting moves finish
  CS1TimeBaseSlew=MaxSlew      ; For instant change
  CS1TimeBaseAdr=RapidOverride ; Select override source
  DWELL0                       ; Ensure change occurs
  CS1TimeBaseSlew=NormSlew     ; Restore normal slew rate
ENDIF
CuttingMode=0                  ; Set flag
CS1TimeBaseAdr=RapidOverride   ; For first time called
RETURN
N1000 LINEAR                   ; G01: Linear interpolation mode
GOSUB 3500 RETURN              ;
N2000 CIRCLE1                  ; G02: Clockwise circle mode
GOSUB 3500 RETURN
N3000 CIRCLE2                  ; G03: Counterclockwise circle mode
GOSUB 3500 RETURN              ;
N3500                          ; Common subroutine for G01,G02,G03
IF (CuttingMode=0)             ; Have been in G00?
  CS1TimeBaseSlew=MaxSlew      ; For instant change
  CS1TimeBaseAdr=CutOverride   ; Select override source
  DWELL0                       ; Ensure change occurs
  CS1TimeBaseSlew=NormSlew     ; Restore normal slew rate
ENDIF
CuttingMode=1                  ; Set flag
CS1TimeBaseAdr=CutOverride     ; For first time called
RETURN
N4000 READ(P)                  ; G04: Dwell for P seconds
IF (BitsPassed&PVal>0)         ; P parameter specified?
  DWELL(PArg*1000)             ; Dwell time in milliseconds
ENDIF
RETURN
N9000 ExactStopOneShot=1       ; G09: Exact stop (single shot)
Postpone=1                     ; Don't do before next move
PRELUDE1 G61.2
RETURN
N17000 NORMAL K-1 RETURN       ; G17: Specify XY plane
N18000 NORMAL J-1 RETURN       ; G18: Specify ZX plane
N19000 NORMAL I-1 RETURN       ; G19: Specify YZ plane
N40000 CC0 RETURN              ; G40: Cutter comp off
N41000 CC1 RETURN              ; G41: Cutter comp left
N42000 CC2 RETURN              ; G42: Cutter comp right
N61000 ExactStopOneShot=0      ; G61: Exact-stop modal
PRELUDE1 G61.1                 ; Set up for each move
RETURN                         ;
N61100                         ; Exact-stop subroutine
IF (Postpone=1)                ; Need to wait for next move?
  Postpone=0                   ; So will do next move
ELSE
  DWELL 0                      ; Disable blending
  WHILE (CS1InPos=0) WAIT      ; Loop until in position
  IF (ExactStopOneShot=1)      ; Single shot
    PRELUDE0                   ; So will not do any more
  ENDIF
ENDIF
```

```
RETURN
N64000 ExactStopOneShot=1       ; G64: Cancel exact stop
RETURN                          ; Note delayed until after move
N90000 ABS RETURN               ; G90: Absolute mode
N91000 INC RETURN               ; G91: Incremental mode
RETURN
CLOSE
```

Motion Program 1001 contains the M-code Subroutines

```
OPEN PROG 1001 CLEAR
```

Motion Program 1000 contains the G-code Subroutines

```
N3000                           ; Start laser
LaserControl=LaserPower         ; Set power level
CutterOn=1                      ; Enable laser
RETURN
N5000                           ; Stop laser
CutterOn=0                      ; Disable laser
LaserControl=0                  ; Clear power level
RETURN
N30000 DWELL0 RETURN            ; End (execute any pending outputs)
CLOSE
```

Motion Program 1002 contains the T-code (Tool-Select) Routines

```
OPEN PROG 1002 CLEAR
N1000 ToolNum=1                 ; T1
LaserPower=5000                 ; Set power level to be used
CCR0.2                          ; Set radius for cutter comp
RETURN
N2000 ToolNum=2                 ; T2
LaserPower=10000                ; Set power level to be used
CCR0.4                          ; Set radius for cutter comp
RETURN
N3000 ToolNum=3                 ; T3
LaserPower=15000                ; Set power level to be used
CCR0.6                          ; Set radius for cutter comp
RETURN
N4000 ToolNum=4                 ; T4
LaserPower=20000                ; Set power level to be used
CCR0.8                          ; Set radius for cutter comp
RETURN
```

Sample Part Program that uses these Subroutines

```
OPEN PROG 6 CLEAR
G17 G90                         ; XY plane, absolute move spec
T03                             ; Select tool 3
G00 Z5.00                       ; Raise tool axis to rapid height
X10.00 Y2.00                    ; Rapid move to (10,2)
M03                             ; Start spindle
G04 P2.0                        ; Wait 2 seconds
F500                            ; Cutting speed 500 mm/min
G01 Z0.00                       ; Lower cutter
G42 X10.00 Y5.00                ; Turn on comp, lead-in move
G61 X35.25 Y5.00                ; Linear XY move, exact-stop mode
X35.25 Y55.10                   ; Linear move
G64 X10.00 Y55.10               ; Linear move, blended mode
G03 X5.00 Y50.10 J-5            ; CCW arc move
```

```
G01 X5.00 Y10.00                ; Linear move
G03 X10.00 Y5.00 I5             ; CCW arc move
G40 X10.00 Y2.00                ; Turn off comp, lead-out move
G01 Z5.00                       ; Cutter up
M05                             ; Stop cutter
G00 X0.00 Y0.00                 ; Rapid move back to home
M30                             ; End of program (not actually needed)
CLOSE
```