CINCINNATI

FANUC

I.S.O. Programming

Dart 21*i* M
Arrow 18*i* M
Sabre 18*i* M
Lancer 18*i* M

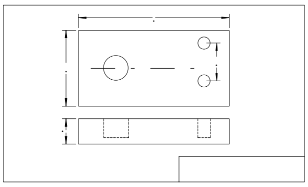
Index

1

Process from Drawing to Product completion

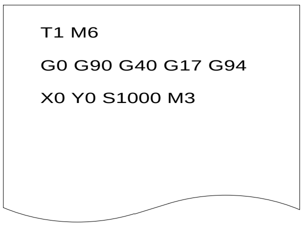
1. Drawing

Examine drawing to determine fixturing, machining origin, process and tooling.



2. Program preparation

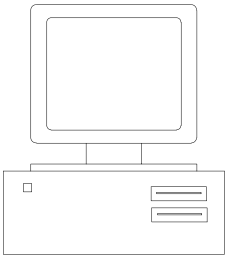
Prepare a program while considering cutting conditions as R.P.M., depth of cuts and feedrates.



```
T1 M6
G0 G90 G40 G17 G94
X0 Y0 S1000 M3
```

3. Program creation

Write the program in the control or another editing source (P.C.) as per the program preparation.



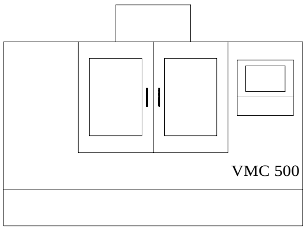
4. Test run

Test the mathematics of the program using the test run facilities i.e. Graphics (if available) & program run.

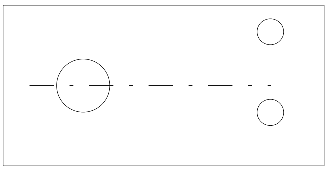
(G53 Z100)

5. Machining

Set tools, set offset values and then process a trial test workpiece.



6. Product completion and Inspection



Introduction to Programming

Programming of the C.N.C. control involves the sequential study of the operations required to produce a component part using established production engineering methods.

The priority of operations (determined by either the programmer or planning engineer) is then written into a format, which can be interpreted by the control. This is known as **“Word Address”** programming format.

Each “Word” is a complete command, and will instruct the control to perform one specific operation, i.e. S1000 M03 will set the spindle speed to 1000 R.P.M. (S1000) and start the spindle in clockwise rotation (M03).

A number of “Words” can be programmed on the same line, (as the above example) thus reducing the amount of program steps needed in any one program.

Each “Word” has it’s own “Letter Address” followed by its “Numerical Data” i.e. S1000.
The value must fall within its programming range. These “Words” written on one line will complete a block of information when the “End of Block” key (EOB) is used.

i.e.	**N100**	**S1000**	**M03**
	(Line number)	(Speed)	(Machine function)

The “Block’s” of information sequentially listed form the ***“Program”***

Cutting Condition Commands

Cutting conditions should be carefully examined when preparing a program, since these conditions greatly influence cutting efficiency and accuracy. The cutting conditions that determine the rate of metal removal are the “Cutting Speed”, the “Feedrate”, the “Depth of Cut” & the “Width of Cut”. These cutting conditions and the nature of the material to be cut determine the power required to take the cut. The cutting conditions must be adjusted to stay within the power available on the machine tool to be used. These conditions also effect the tool life, which would need consideration.

The following cutting conditions are required for all tooling used:

Spindle Speed – R.P.M. (Revolutions per Minute)

Designated with an S command.

400 rpm ⇒ S400

Formula

$$\text{R.P.M.} = \frac{\text{Constant Surface Speed (C.S.S.) x 1000}}{\pi \text{ x Diameter}}$$

C.S.S. can be found in all manufacturers tooling guides.

Feedrate – mm/min. , inch/min. , feed/tooth, feed/rev.

Designated with an F command.

400 mm/min. ⇒ F400

Formula

Feed = Number of teeth x feed/tooth (pitch) x R.P.M.

Feed/tooth can be found in all manufacturers tooling guides.

Programming Terms

Program Number:

O 1234

A four-digit number follows the letter O in program numbering.
The range of numbering can be as follows:

O0000 → O9999

The program numbers can be configured in a manner that allows "General Programs", "Custom Macro Programs" & "Machine Tool Macro Programs". The "Custom Macro Programs" & the "Machine Tool Macro Programs" can be created and "locked" by parameter settings to prevent accidental deletion or editing. Since this is a facility of the control the created programs can be split into 3 group numbers as follows:

Program Number	Program Type	Comments
O0000 – O7999	"General"	No protection by parameter
O8000 – O8999	"Custom Macro"	Parameter 3202 #0
O9000 – O9999	"Machine Macro"	Parameter 3202 #4

Sequence Number:

N 0002

A numerical number follows the letter "N" at the program line beginning. "N" numbers are used as a search facility to enable simple program editing and starting. "N" numbers have no effect on the program itself but does require memory. They can be switched on or off by parameter number 0000 #5. The sequence of numbers can be set by parameter 3216.
The sequence number can be allocated as the following examples:
Example 1: (sequence numbering at each toolchange line)

```
N001   T1 M6
(Program for Tool 1)
N002   T2 M6
(Program for Tool 2)
N003   T3 M6
(Program for Tool 3)
```

Example 2: (all line numbering)

```
N100   T1 M6
N101 (Program for Tool 1)
N200   T2 M6
N201 (Program for Tool 2)
N300   T3 M6
N301 (Program for Tool 3)
```

Programming Terms (cont.)

Block:

A block is the minimum amount of **“WORD”** commands necessary for the machine to perform their operations.
A block takes up one line when written on a program sheet. Each line is called a block.

O1111;	*The first “Block”*
N1 T1 M6;	*The second “Block”*
N2 G0 G90 G40 G21 G17 G94 G80;	*The third “Block”*
N3 G54 X? Y? S? M3;	*The fourth “Block”*
N4 G43 Z100 H?;	*The fifth “Block”*

Word:

A “WORD” is the minimum command to activate a function. It is composed of an “ADDRESS” and “NUMERICAL DATA” including a sign.

N1	G0	X0	Y0	Z0 ;
word	*word*	*word*	*word*	*word*

Address:

An “ADDRESS” is the alphabetical letter in a word.

N1 G0 X0 Y0 Z0 ;

Numerical Data:

“NUMERICAL DATA” refers to the number part of a word.

N1 G0 X0 Y0 Z0 ;

End Of Block (EOB):

Refers to the action created at the end of a “BLOCK” to allow a new “Block” to be created. The control recognizes this as the end of this sequence of events.

N1 G0 X0 Y0 Z0 ;

Table of preparatory Codes (G & M Functions)

a) All Codes are divided into group types.

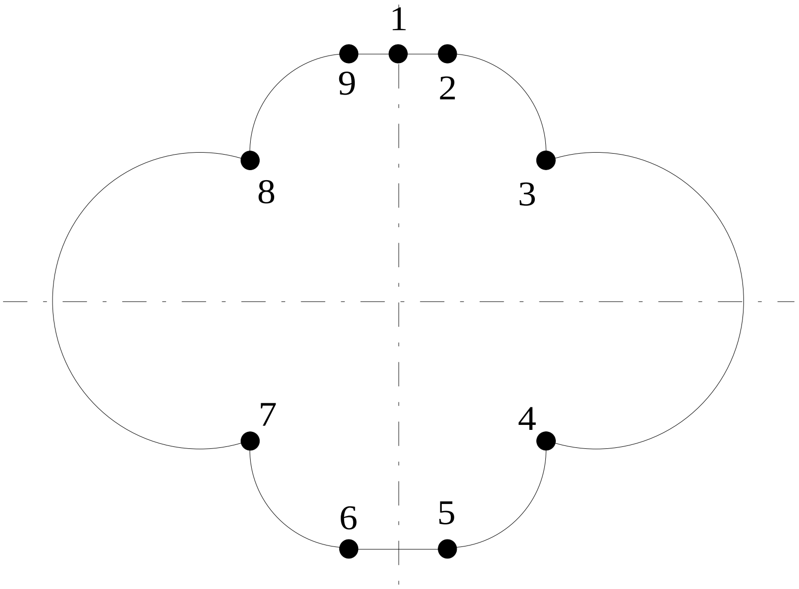
b) There are two types of “G” & “M” codes:

Non-Modal - The code is active only in the block in which it is specified & is self-canceling.

Modal - The code remains active when programmed on every line of program and does not require reprogramming on any following blocks until it is replaced by another action code of the same group number.

i.e. G01 and G00 are modal codes in group 01

```
G01 X?_____;    }
    Z?_____;    }- G01 is effective in this range.
    X?_____;    }
G00 Z?_____;
```



1 2 ______________________________

2 3 ______________________________

3 4 ______________________________

4 5 ______________________________

5 6 ______________________________

6 7 ______________________________

7 8 ______________________________

8 9 ______________________________

9 1 ______________________________

G & M Functions

1) "G" codes marked □ on the next page are initial (defaulted) "G" codes when the power is turned on. For G20/G21 (Inch/MM), the "G" code last programmed before the machine power is turned off remains the defaulted.

2) "G" codes of group 00 are "Non Modal". They are only effective in the block in which they are specified.

3) If a "G" code not listed or not purchased as an optional extra is commanded, an alarm (No. 010) will be displayed.

4) A number of "G" codes can be specified in the same block. When more than one "G" of the same group is specified, an alarm will be activated to inform the operator of this.

5) If any "G" code of group 01 is specified in a canned cycle mode, the canned cycle is automatically cancelled and the G80 condition entered.

Note:

Operators must note that programming G20/G21 will not convert information in offset registers, and therefore if several programs are stored in the library of either inch or metric format then the offsets must be manually changed to inch or metric units.

G Codes

G CODE	GROUP	FUNCTION (* Option)
□G00	01	Rapid Positioning
G01		Straight Line “Feed”
G02		Circular Clockwise “Feed”
G03		Circular Anti-Clockwise “Feed”
G04	00	Dwell
G05		High Speed Cycle Machining *
G07		Hypothetical Axis Interpolation *
G07.1		Cylindrical Interpolation *
G08		Look-Ahead Control *
G09		Exact Stop
G10		Programmable Data Input *
G11		Programmable Data Input Cancel *
G15	17	Polar Co-ordinates Command Cancel *
G16		Polar Co-ordinates Command *
□G17	02	XY Plane – Plan View (Z- Direction)
G18		XZ Plane – Front View (Y- Direction)
G19		YZ Plane – Side View (X- Direction)
G20	06	Imperial Dimensions
G21		Metric Dimensions
G27	00	Reference Position Return Check
G28		Return To Reference Position
G29		Return From Reference Position
G30		2nd, 3rd, & 4th Reference Position Return
□G40	07	Cutter Radius Compensation Cancel
G41		Cutter Radius Compensation Left
G42		Cutter Radius Compensation Right
G43	08	Tool Length Compensation +
G44		Tool Length Compensation -
G45	00	Tool Offset Increase
G46		Tool Offset Decrease
G47		Tool Offset Double Increase
G48		Tool Offset Double Decrease
□G49	08	Tool Length Compensation Cancel
□G50	11	Scaling Cancel *
G51		Scaling *
G50.1	22	Programmable Mirror Image Cancel *
G51.1		Programmable Mirror Image *
G52	00	Datum Shift
G53		Machine Co-ordinate Dimensioning

□G54	14	Workpiece Co-ordinate Selection 1
G55		Workpiece Co-ordinate Selection 2
G56		Workpiece Co-ordinate Selection 3
G57		Workpiece Co-ordinate Selection 4
G58		Workpiece Co-ordinate Selection 5
G59		Workpiece Co-ordinate Selection 6
G60	00	Single Direction Positioning
G61	15	Exact Stop Mode
G62		Automatic Corner Feed Override *
G63		Tapping Mode
□G64		Cutting Mode
G65	00	Macro Call
G66	12	Macro Modal Call
□G67		Macro Modal Call Cancel
G68	16	Rotation *
□G69		Rotation Cancel *
G73	09	High Speed Peck Drilling Cycle
G74		Left Hand Tapping Cycle
G76		Fine Boring Cycle
□G80		Canned Cycle Cancel
G81		Simple Drilling Cycle
G82		Drilling or Counterboring Cycle
G83		Peck Drilling Cycle
G84		Right Hand Tapping Cycle
G85		Boring Cycle
G86		Boring Cycle
G87		Back Boring Cycle
G88		Boring Cycle
G89		Boring Cycle
□G90	03	Absolute Dimensions
G91		Incremental Dimensions
G92	00	Work Co-ordinate System Setting
□G94	05	Feed Rate Per Minute
G95		Feed Rate Per Revolution
□G98	10	Return To Initial Point During Canned Cycle
G99		Return To “R” Point During Canned Cycle

G04 – Program Dwell:

A program dwell time can be created at any point within in a program. This is a non-modal code which can only be programmed on it’s own line of program. The dwell time is programmed in milli-seconds using a **P** word to a maximum of 999999 milliseconds (99.9999 seconds). Some cycles have their own dwell facilities within the cycle itself.

G04 P1000 (equals 1 second)

M codes

M Code	FUNCTION (** Option)*	START OF SPAN	END OF SPAN
M00	Program Stop		●
M01	Program Stop by switch		●
M02	End Of Program		●
M03	Spindle Clockwise	●	
M04	Spindle Anti-Clockwise	●	
M05	Spindle Stop		●
M06	Toolchange		●
M08	External Coolant On	●	
M09	Coolant Off		●
M10	4th Axis Unclamp *	●	
M11	4th Axis Clamp *		●
M13	Spindle Clockwise With External Coolant	●	
M14	Spindle Anti-Clockwise With External Coolant	●	
M15	Programmable Coolant Nozzle *	●	
M19	Spindle Orientates To Toolchange Position		●
M30	End Of Program	●	
M33	Spindle Clockwise With Thro’ Spindle Coolant *	●	
M34	Spindle Anti-clockwise with Thro’ Spindle Coolant *	●	
M38	Thro’ Spindle Coolant *	●	
M50	5th Axis Unclamp *	●	
M51	5th Axis Clamp *		●
M98	Sub-Program Call		●
M99	Sub-Program End		●

M00 – Program Stop:
After executing the block where the M00 is commanded, automatic operation stops the machine including the feed, spindle and coolant. Pressing the Cycle Start button resumes all operations.

M01 – Optional Program Stop:
M01 is identical to M00 but is actioned by a switch on the operators control panel. When this switch is “ON” then the code acts as M00, but when the switch is “OFF” the code is ignored and operation continues as programmed. Applications include : Checks on dimensions, Checks on tools and to remove chips during machining.

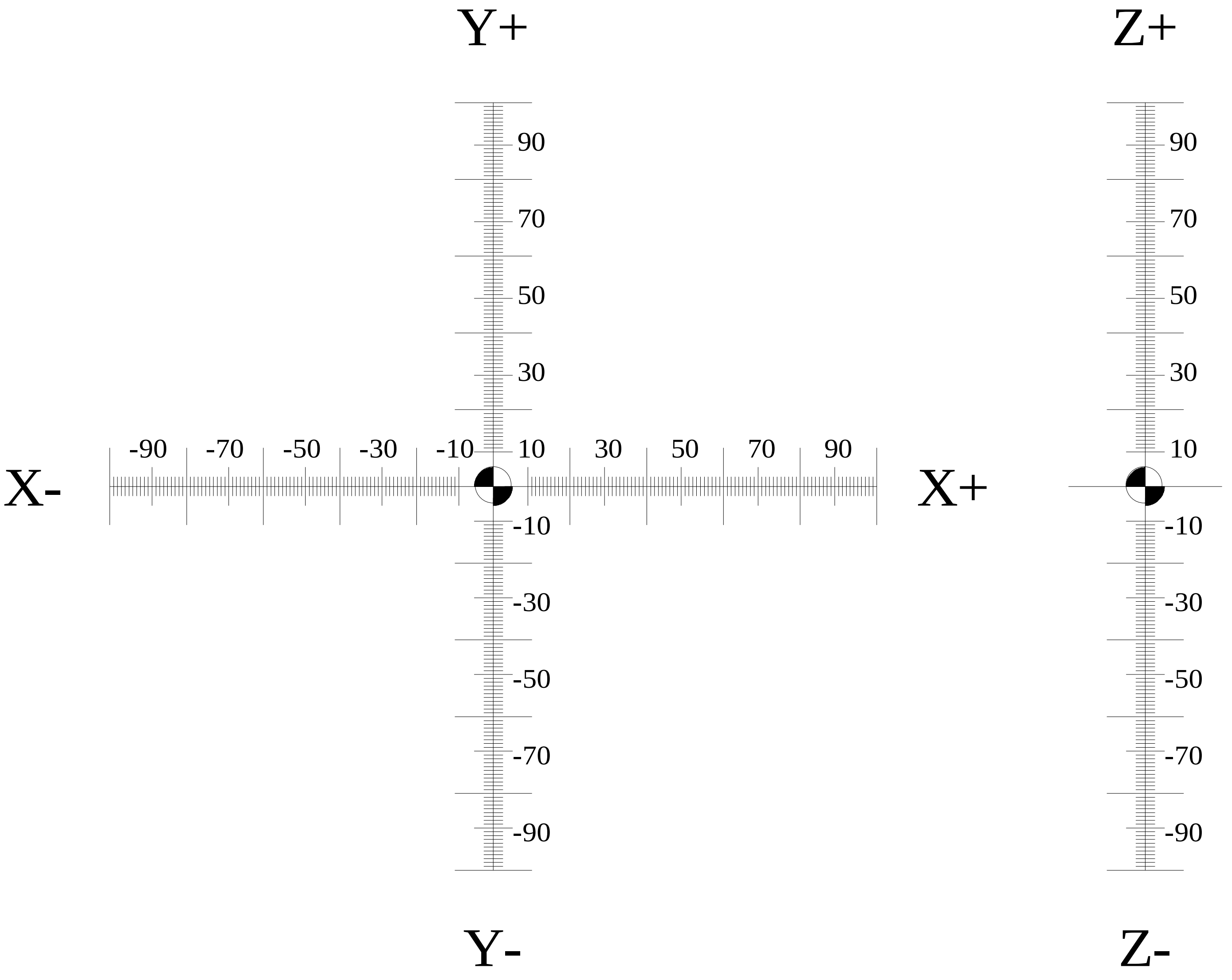
M02 – Program End:
This code informs the control that the program is at the end. Re-pressing the cycle start button will allow the program to be rewound before another cycle start press to run the program again. This is used in special applications, and all other applications should use M30.

M30 – Program End:
This code informs the control that the program is at the end and will automatically rewind the program for the next process start. The control screen will prompt the operator to “Open & Close the door” before starting the next operation.

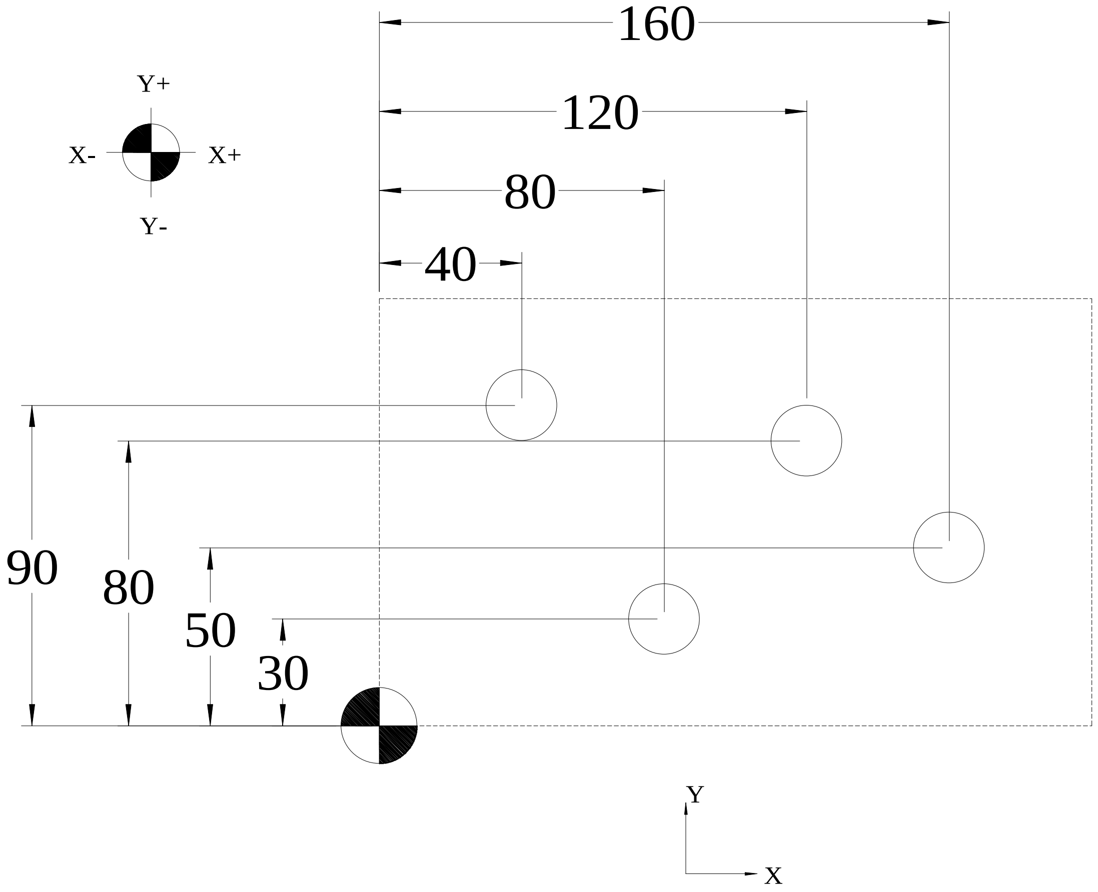
2

"Absolute (G90) Program Machine Movement"

Tool motion assumes now that the spindle moves and not the Table

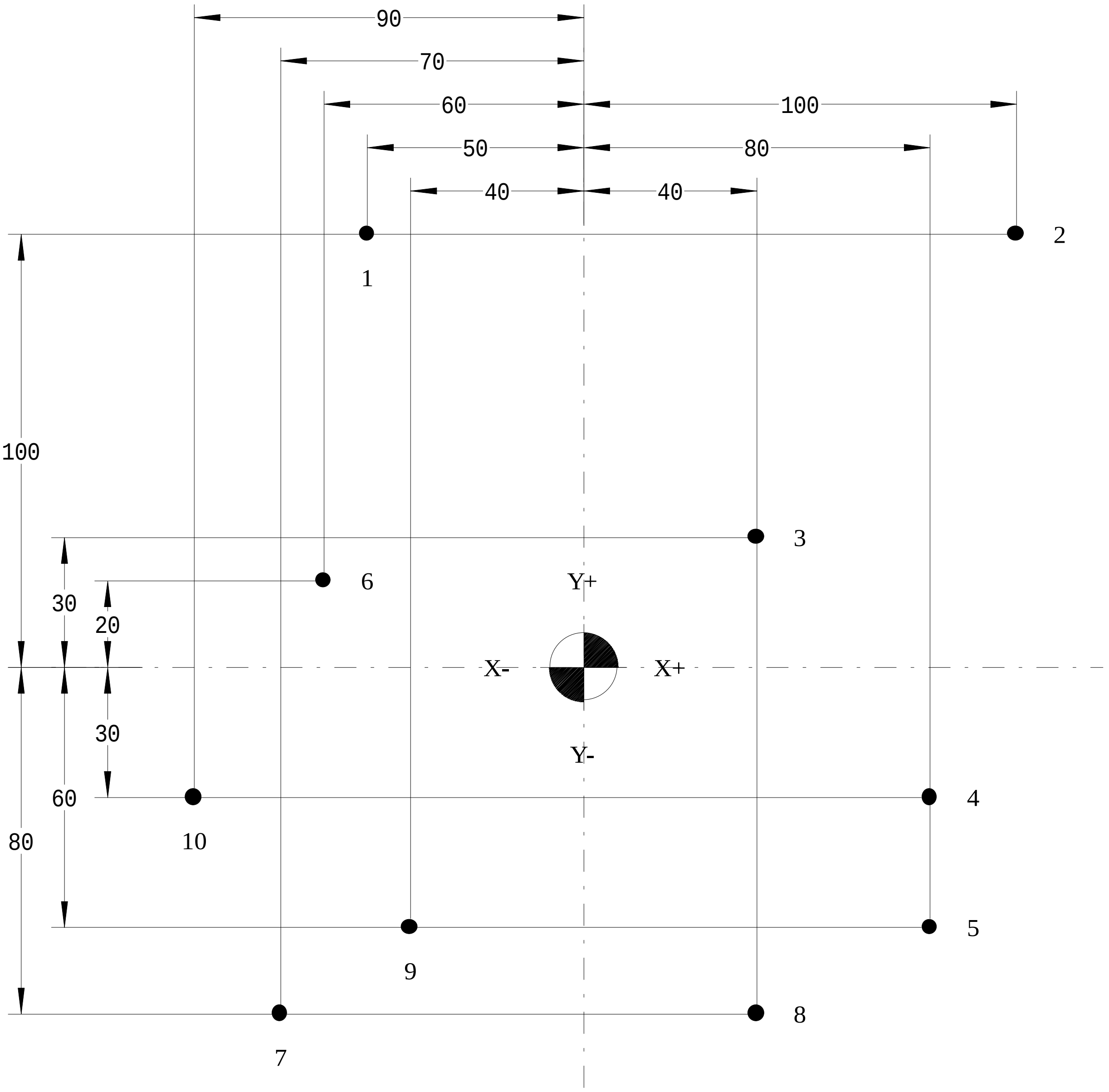


G90 Absolute Programming



```
G90 X40 Y90
X80 Y30
X120 Y80
X160 Y50
```

G90 Absolute Example Programming



N1 G90 X-50 Y100; Absolute Move to position 1

N2

N3

N4

N5

N6

N7

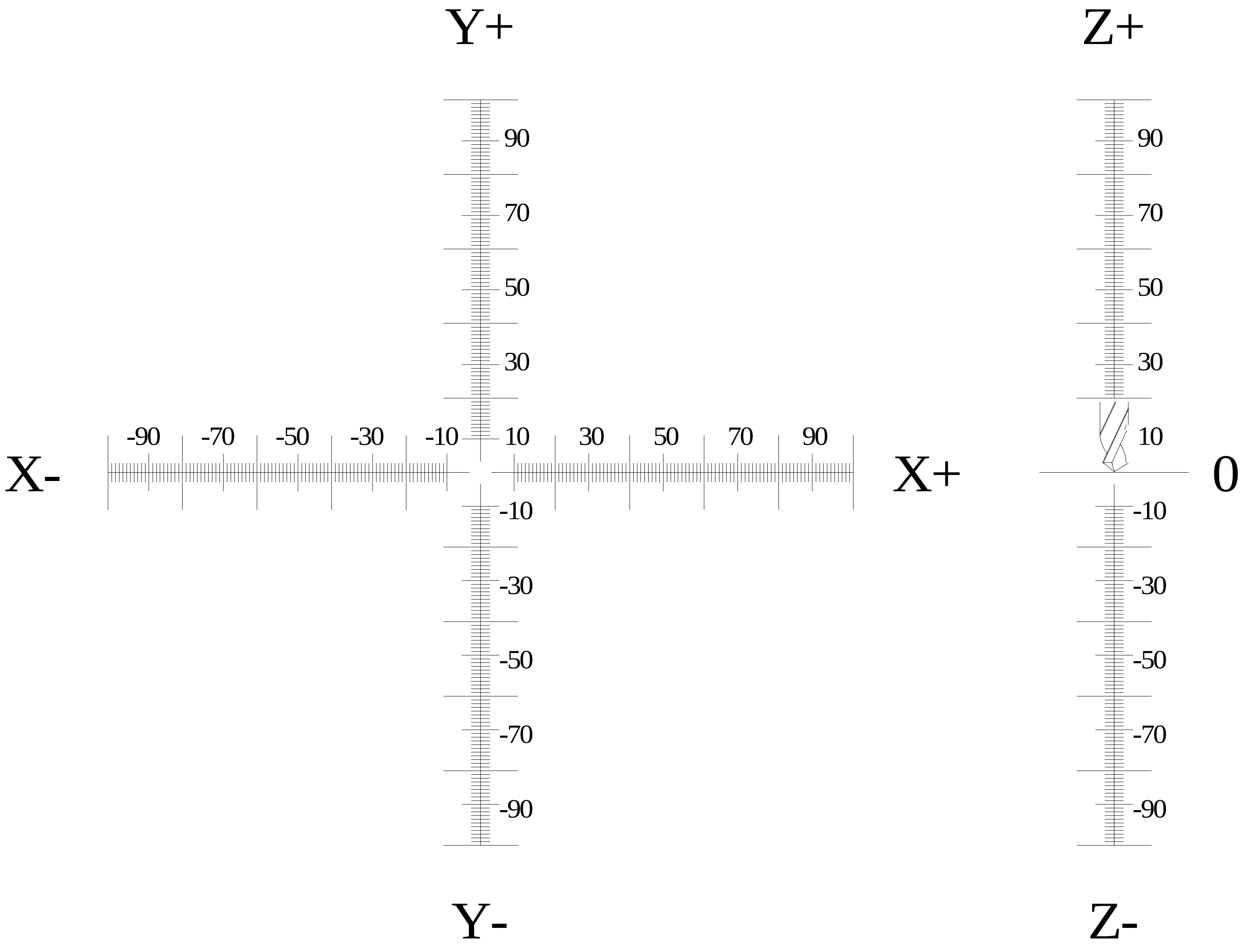
N8

N9

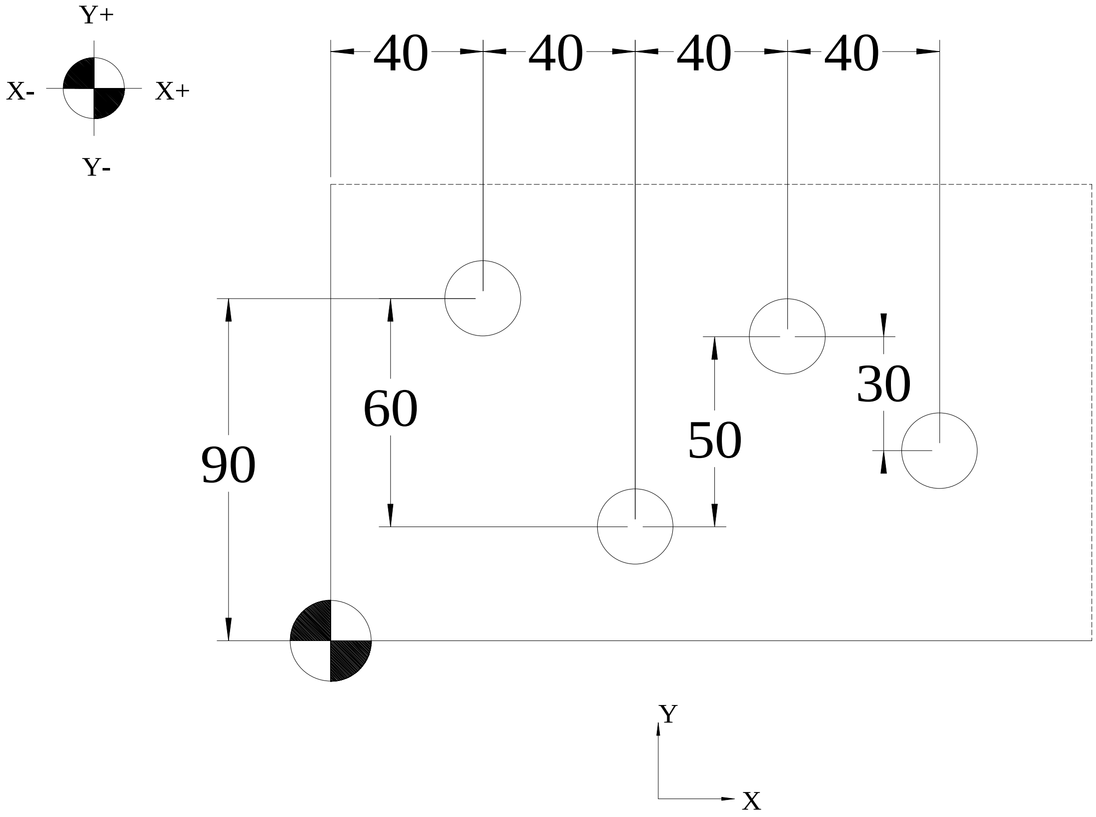
N10

"Incremental (G91) Program Tool Movement"

Tool motion assumes now that the spindle moves and not the Table

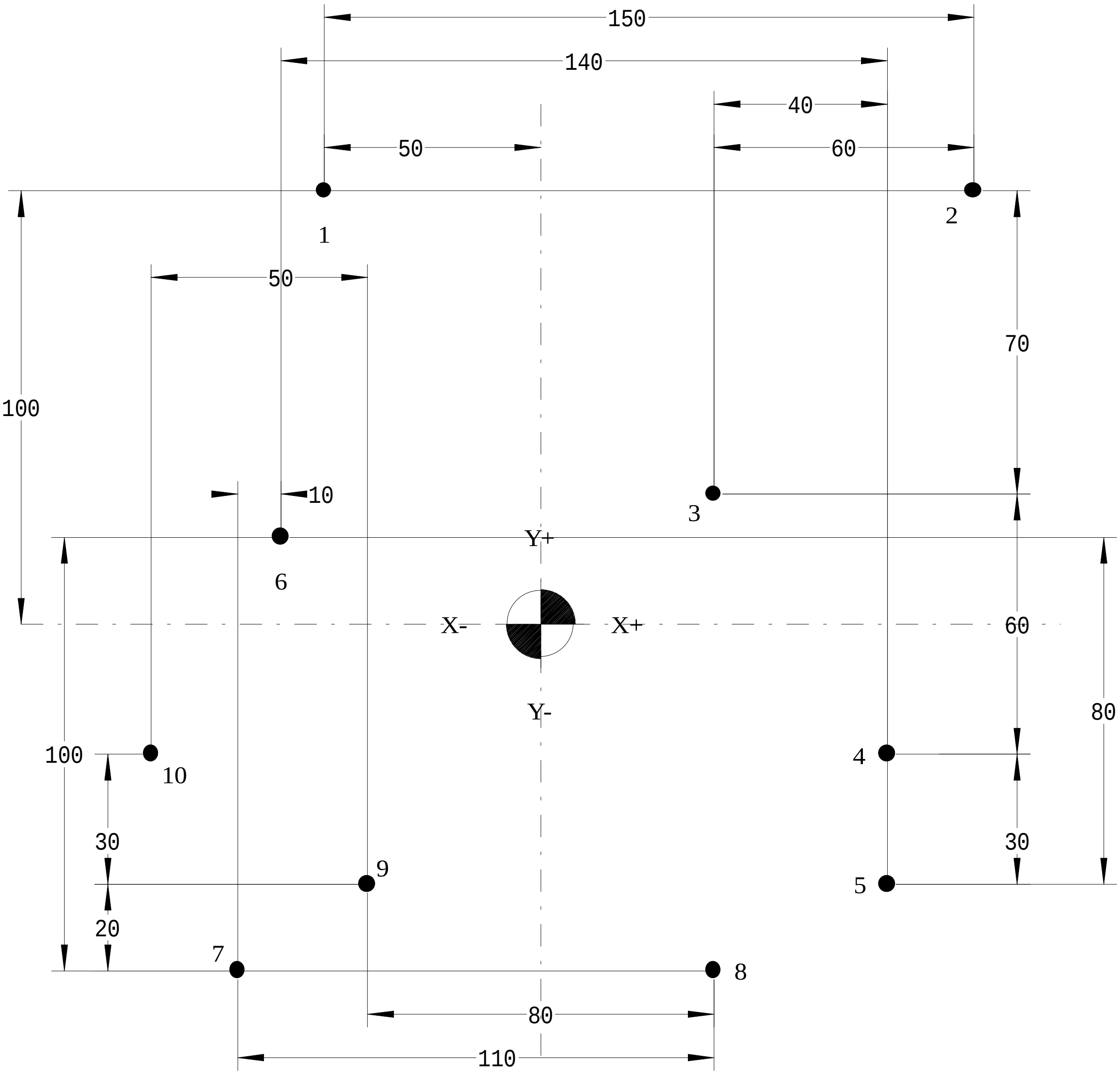


G91 Incremental Programming



```
G90 X40 Y90
G91 X40 Y-60
X40 Y50
X40 Y-30
```

G91 Incremental Example Programming



N1 G90 X-50 Y100; Absolute Move to position 1

N2

N3

N4

N5

N6

N7

N8

N9

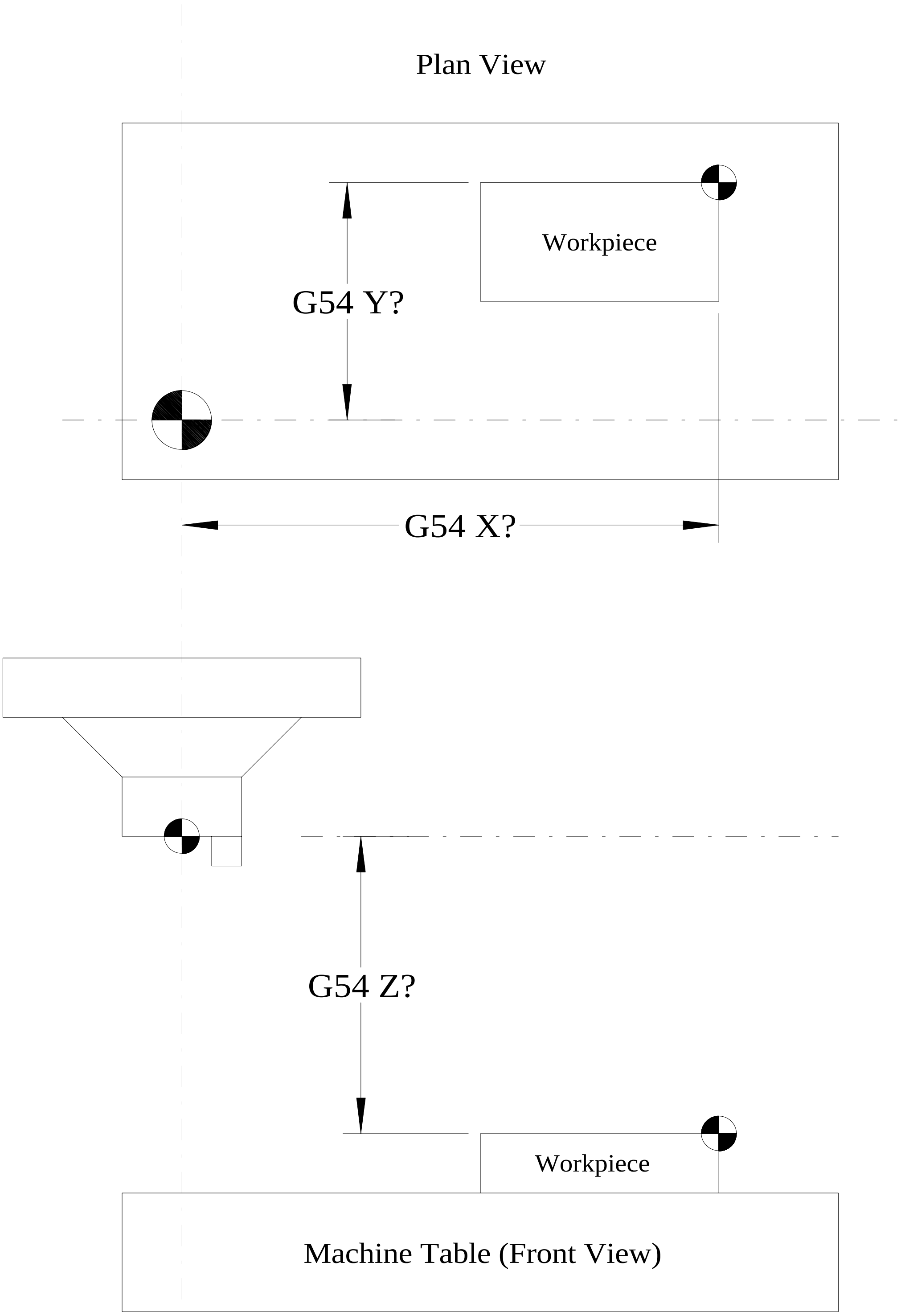
N10

3

Component Fixture Offsets

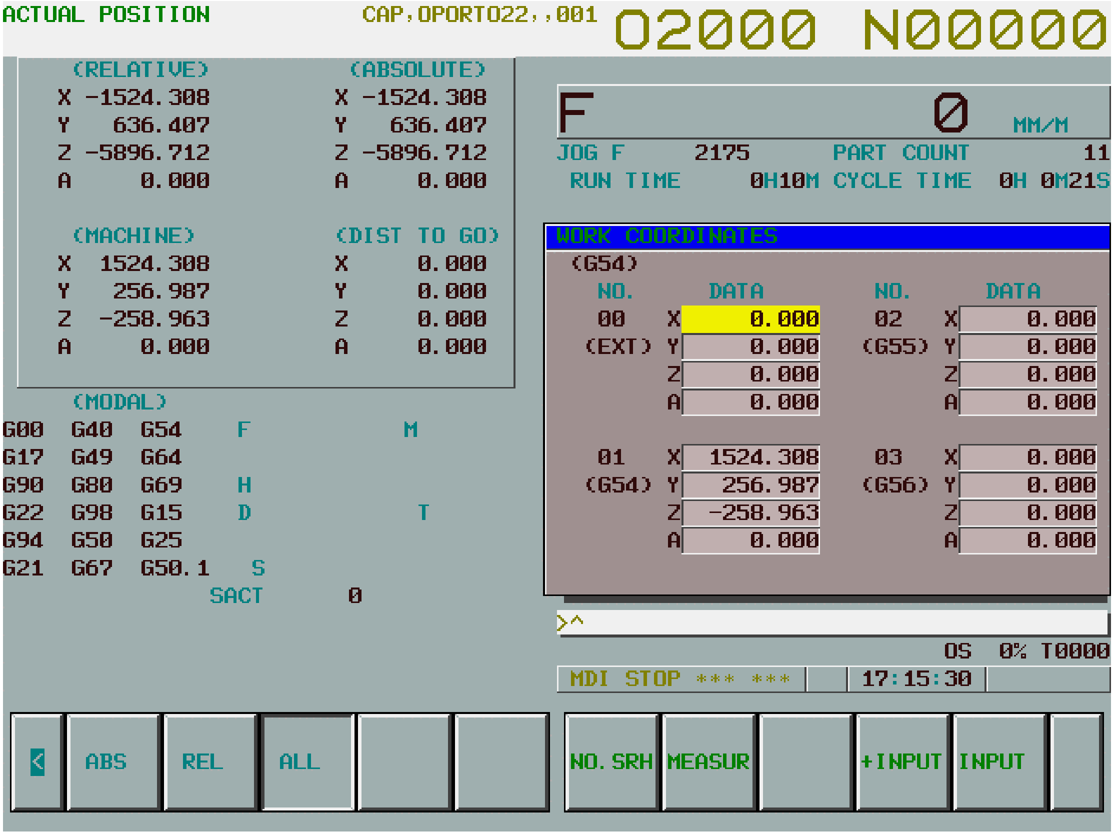
Work Coordinate System Programming (G54 - G59)

The work co-ordinate system allows for the setting of datum's relative to the machine reference co-ordinate system.



Component Fixture Offsets

Work Coordinate System Programming (G54 - G59)



```
ACTUAL POSITION                 CAP,OPORTO22,,001  O2000   N00000
     (RELATIVE)          (ABSOLUTE)
   X -1524.308         X -1524.308        F                        0    MM/M
   Y    636.407        Y    636.407       JOG F      2175     PART COUNT      11
   Z -5896.712         Z -5896.712         RUN TIME     0H10M CYCLE TIME   0H 0M21S
   A      0.000        A      0.000

     (MACHINE)           (DIST TO GO)      WORK COORDINATES
   X  1524.308         X      0.000         (G54)
   Y   256.987         Y      0.000           NO.      DATA         NO.      DATA
   Z  -258.963         Z      0.000           00    X     0.000     02    X     0.000
   A      0.000        A      0.000          (EXT)  Y     0.000    (G55)  Y     0.000
                                                    Z     0.000           Z     0.000
     (MODAL)                                        A     0.000           A     0.000
G00  G40  G54     F           M
G17  G49  G64                                    01 X  1524.308     03    X     0.000
G90  G80  G69     H                            (G54) Y   256.987    (G56)  Y     0.000
G22  G98  G15     D            T                    Z  -258.963           Z     0.000
G94  G50  G25                                       A     0.000           A     0.000
G21  G67  G50.1     S
               SACT        0
                                          >^
                                                                  OS    0% T0000
                                           MDI  STOP *** ***    17:15:30
```

Co-ordinates values (G54 – G59) are set using the axis data information values contained within the (*MACHINE*) axis position table to the required spindle centreline.

When the position of the component datum has been determined in all axis, it can be entered into the appropriate work offset register.

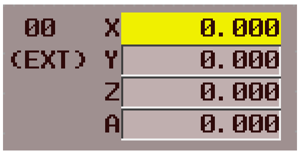
*<u>**Note:**</u>

Co-ordinates are specified using one of the following co-ordinates systems for each datum to be set:

Workpiece co-ordinate system - G54, G55, G56, G57, G58, G59

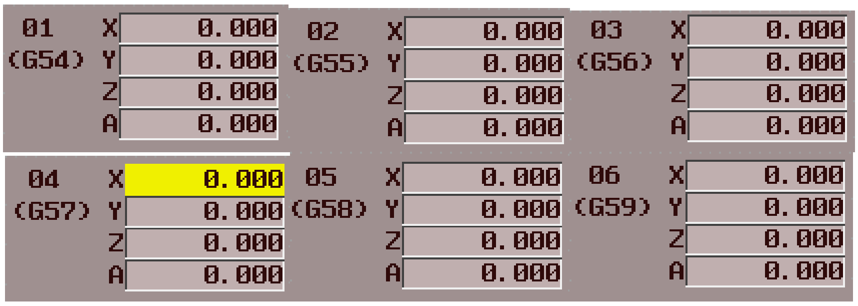
Fixture Offsets

1) Local Offset = Global offset which is relative to all offsets G54 – G59



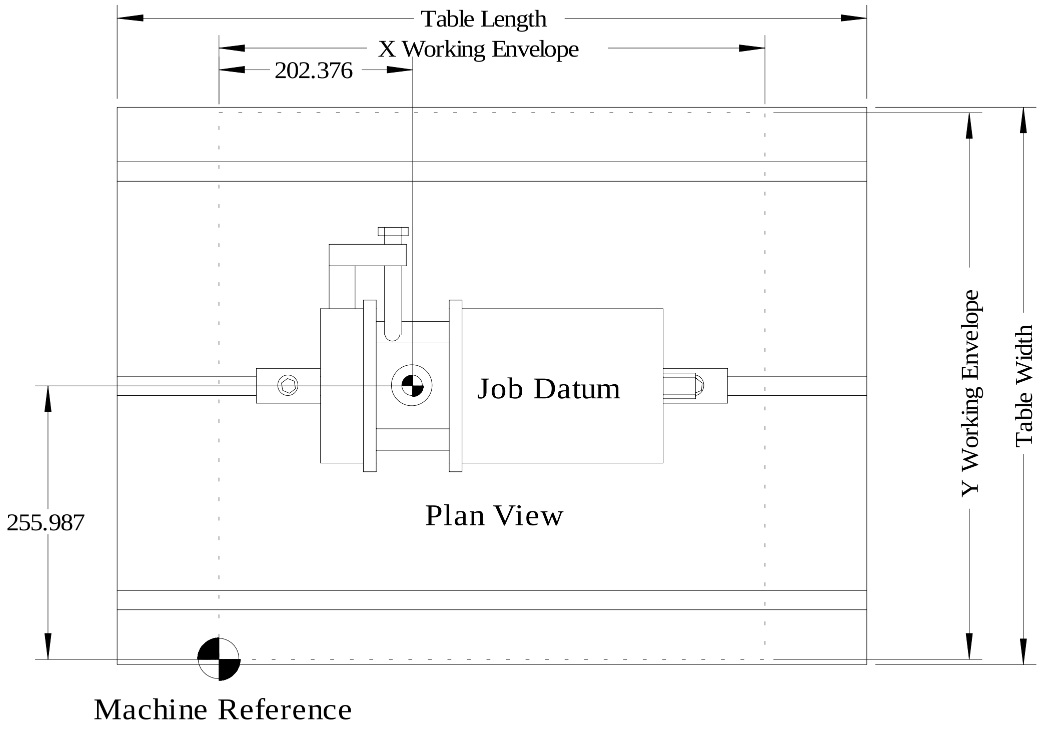
00	X	0.000
(EXT)	Y	0.000
	Z	0.000
	A	0.000

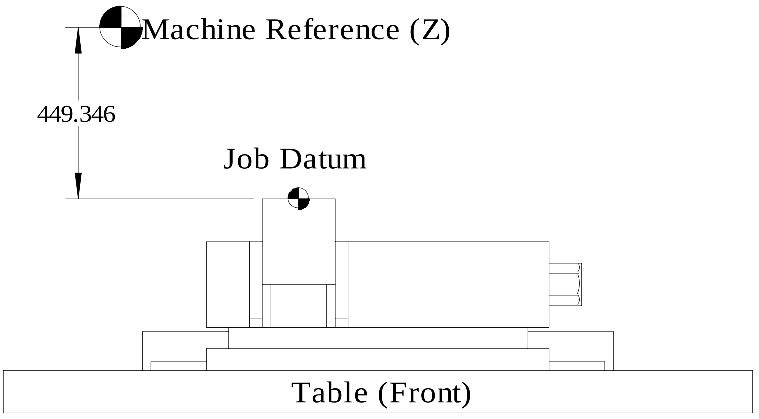
2) Work Co-ordinate Offsets = Individual offsets from either the Local Offset or Machine Offset if the Local Offset is all zero's.

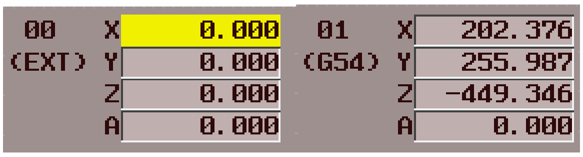


01	X	0.000	02	X	0.000	03	X	0.000
(G54)	Y	0.000	(G55)	Y	0.000	(G56)	Y	0.000
	Z	0.000		Z	0.000		Z	0.000
	A	0.000		A	0.000		A	0.000
04	X	0.000	05	X	0.000	06	X	0.000
(G57)	Y	0.000	(G58)	Y	0.000	(G59)	Y	0.000
	Z	0.000		Z	0.000		Z	0.000
	A	0.000		A	0.000		A	0.000

Part Offset

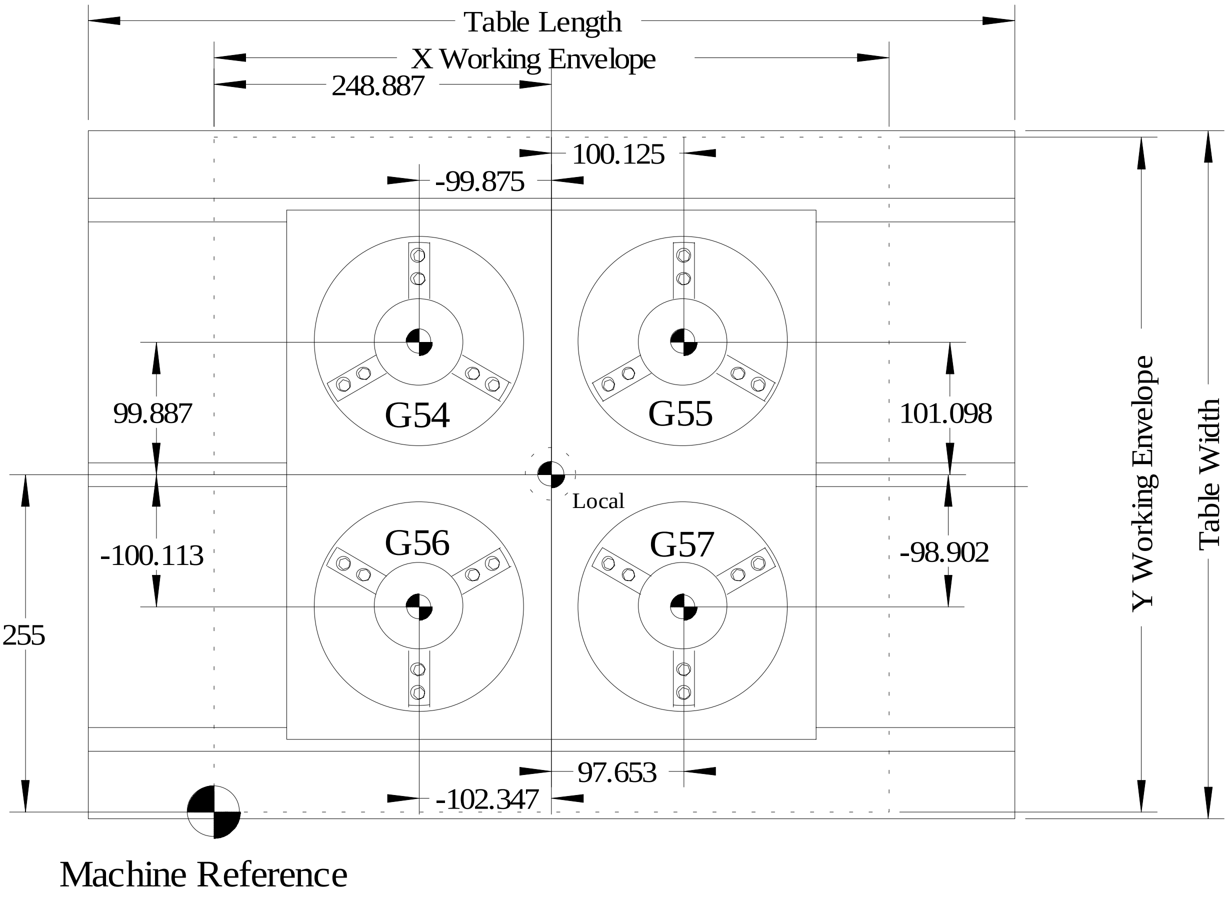


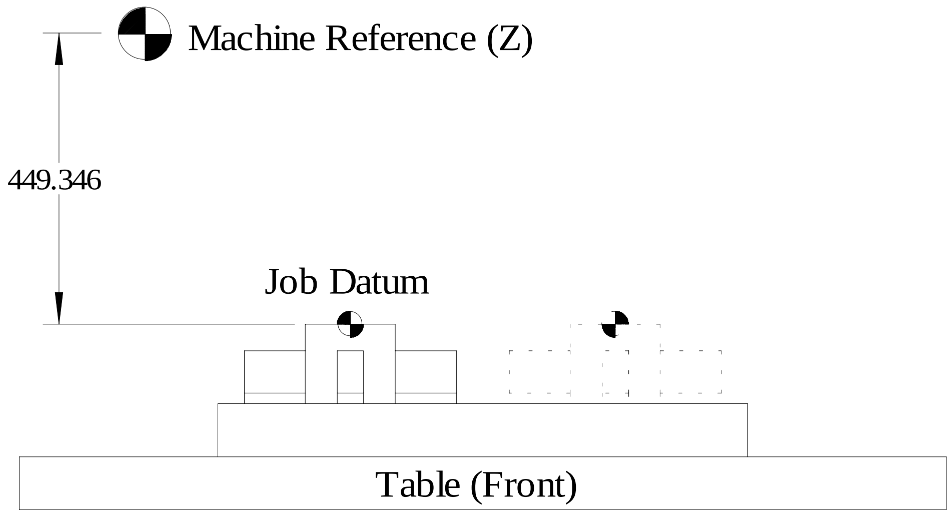




```
 00     X    0.000    01     X  202.376
(EXT)   Y    0.000   (G54)   Y  255.987
        Z    0.000           Z -449.346
        A    0.000           A    0.000
```

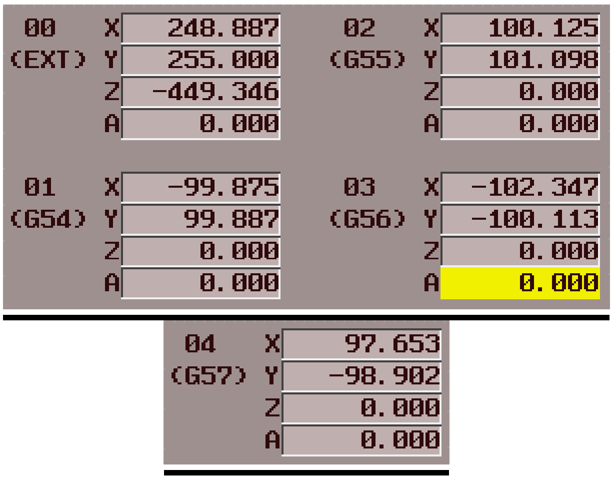
Fixture Offsets – Multiple Parts





Fixture Offsets – Multiple Parts (cont.)

The values contained in the “G54 – G59 Offsets” can be stored in the program using the G10 program data transfer system to save setting on the next batch resetting time (see Chapter 11 for more information on G10 – Programmable Data Entry).
The values are incremental from the “Local Offset” so will never change. The operator only has to set the main setting bore on the next batch set-up in External XY offsets.



00 (EXT)	X	248.887	02 (G55)	X	100.125
	Y	255.000		Y	101.098
	Z	-449.346		Z	0.000
	A	0.000		A	0.000
01 (G54)	X	-99.875	03 (G56)	X	-102.347
	Y	99.887		Y	-100.113
	Z	0.000		Z	0.000
	A	0.000		A	0.000

04 (G57)	X	97.653
	Y	-98.902
	Z	0.000
	A	0.000

Program example

```
O1000
G10 L2 P1 X-99.875 Y99.887
G10 L2 P2 X100.125 Y101.098
G10 L2 P3 X-102.347 Y-100.113
G10 L2 P4 X97.653 Y-98.902
T1 M6
Etc.
```

Any alterations to the part locations must be set in the program and not the actual offset page as the current values would be overwritten with the program values.

4

Program Start:

```
O1111 ;
T? M6 (Tool change line) ;
G0 G90 G40 G21 G17 G94 G80 (Safety default line) ;
G54 X? Y? S? M3 (First move setting Work co-ordinate system & Spindle R.P.M.) ;
```

Program Number Setting

O???? - 4 digit program number and starts with an O word.

Tool change information

T? – Tool/pocket number (any number above the available machine pocket numbers is recognised as a manual toolchange).
M6 - Tool change code.
; - EOB (End of block)

Text messages

( ) - Program message

Program Defaults (Set by the programmer as required)

G00 - Maximum Rapid Traverse of the machine
G90 - Absolute Co-ordinates taken from Datum set position
G40 - Cutter Compensation Cancel (Cutter follows program centreline path).
G21 - Metric Dimensions. (G20 = Imperial Dimensions).
G17 - X & Y Plane (Tool is in the Z axis - Spindle)
G94 - Programmed feed is Feed/min.(G95 = Feed/rotation)
G80 - Canned Cycle Cancel.

Initial Start

G54 - Work co-ordinate system.
X? - X axis start position.
Y? - Y axis start position.
S? - Spindle speed.
M3 - Spindle Clockwise rotation.

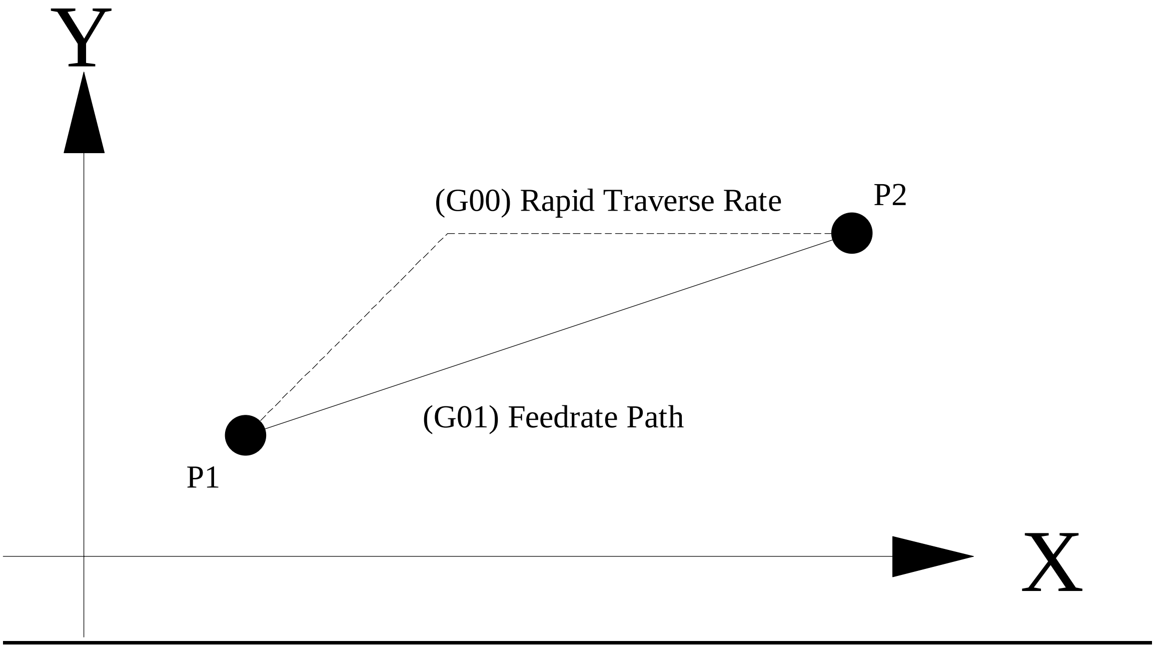
Linear Interpolation

The axis of the machine will move at either “Rapid” or “Feed” traverse rates. The rapid rates vary on all machine types.

When programming a straight line “Feed” (G01), with 2 axis (i.e X & Y), both axis will arrive at their programmed destination at the same time, irrespective of their length of motion, creating an angled motion. If one axis has to travel further than the other axis then this axis will move at an automatically calculated slower feed than that programmed to allow both axis to arrive together.

When programming a straight line “Rapid” (G00), with 2 axis (i.e X & Y), both axis will arrive at their programmed destination at different times as both will complete their motion at machine rapid. If one axis has to travel a shorter distance than the other axis then this axis will arrive at its programmed destination before the other axis creating a “Dogleg Effect” as per the example below.

A maximum of 3 axis can be programmed in one BLOCK



Parameter 1401.1 = 1 To remove Dog-leg effect (21i & 18i controls)

Tool Length Offset (G43)

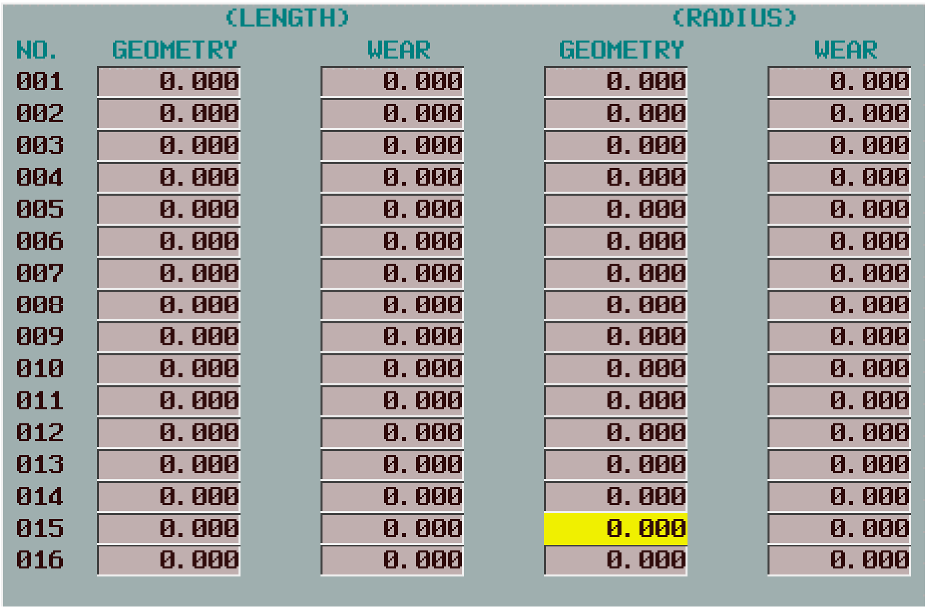
The tool length offset facility is used to set the new tool length & make adjustments in the programmed axis.

G43 - Applies tool length offset which is stored in the “Offset Setting” table, in the + direction and must be applied on a single axis motion.

An added “H” word (tool offset row number) adds the stored value from the length column + wear column to the single axis move to set tool length to the program.
e.g. G43 Z100 H?

Note:
There are 4 columns contained within the tool offset register type C.

LENGTH (H word) RADIUS (D word)

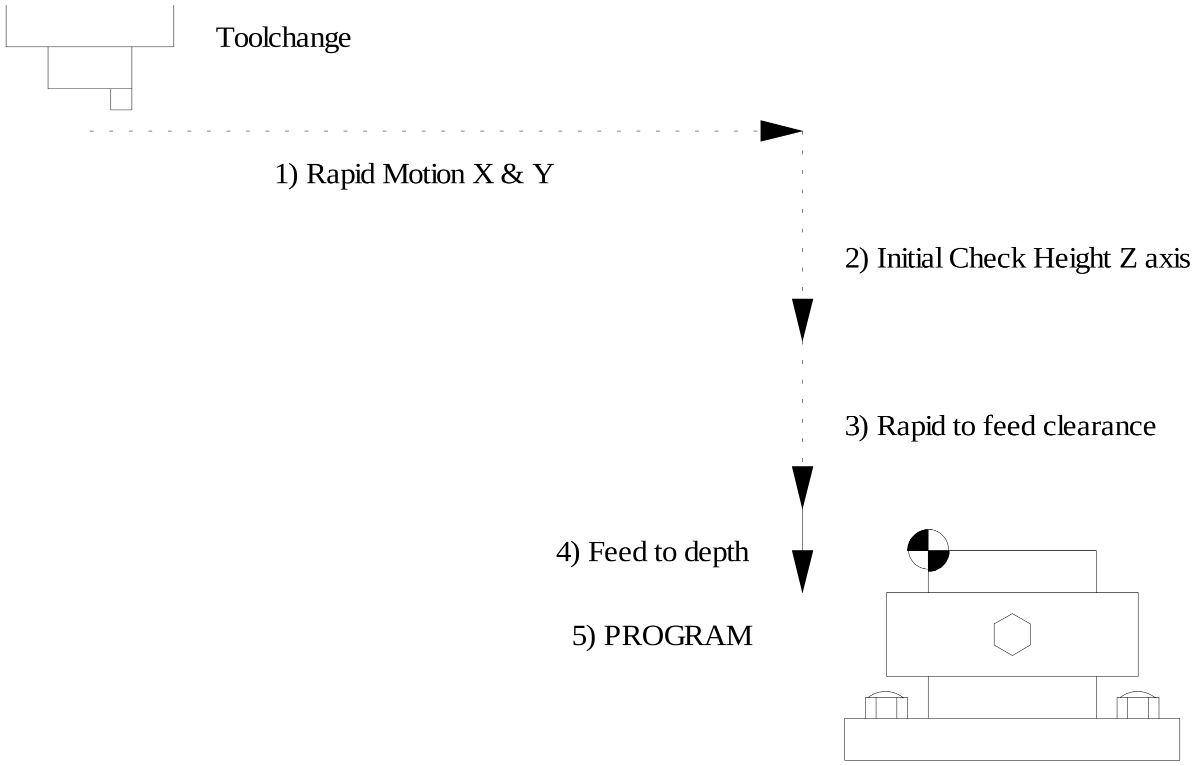


	(LENGTH)		(RADIUS)	
NO.	GEOMETRY	WEAR	GEOMETRY	WEAR
001	0.000	0.000	0.000	0.000
002	0.000	0.000	0.000	0.000
003	0.000	0.000	0.000	0.000
004	0.000	0.000	0.000	0.000
005	0.000	0.000	0.000	0.000
006	0.000	0.000	0.000	0.000
007	0.000	0.000	0.000	0.000
008	0.000	0.000	0.000	0.000
009	0.000	0.000	0.000	0.000
010	0.000	0.000	0.000	0.000
011	0.000	0.000	0.000	0.000
012	0.000	0.000	0.000	0.000
013	0.000	0.000	0.000	0.000
014	0.000	0.000	0.000	0.000
015	0.000	0.000	0.000	0.000
016	0.000	0.000	0.000	0.000

1 – 32 (99 – 200) Length storage rows
Geometry = Length of the tool
Wear = Trimming value

1 – 32 (99 – 200) Radius storage rows
Geometry = Radius of the tool
Wear = Trimming value

Initial Start of Program



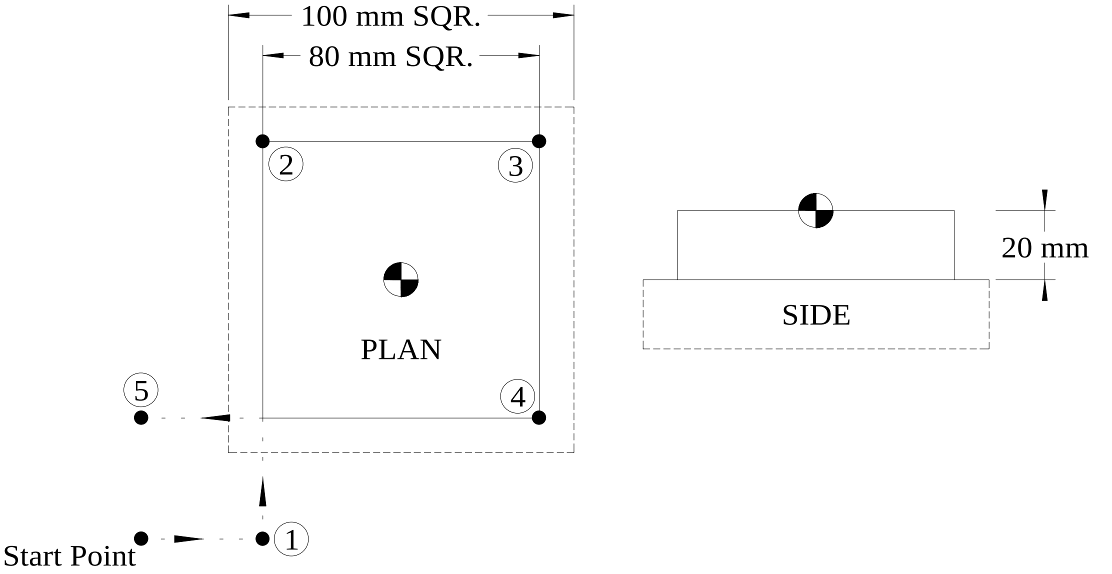
Note

1) The *“Rapid Motion”* towards the starting position of the workpiece will contain Absolute X & Y axis motion together with the required *“Workpiece Co-ordinate System”* G code, spindle speed (S?) and the required M code to start the spindle (M3, M4, M13, or M14)

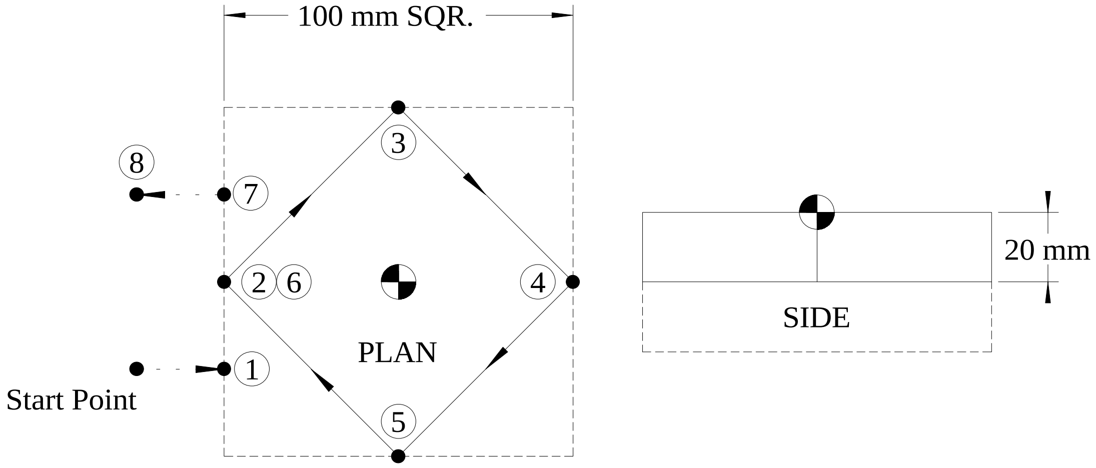
2) The *“Rapid Motion”* towards the *“Initial Check Height”* will contain a Z axis motion only together with the required *“Tool Length Set”* G code (G43) and the appropriate length offset storage number (H???).

```
O1111
T? M6 (Tool change line) ;
G0 G90 G40 G21 G17 G94 G80 (Safety default line) ;
G54 X? Y? S? M3 (First move setting Work co-ordinate system & Spindle R.P.M.) ;
G43 Z? H? (Set Tool Length) ;
```

Point to Point - example 1 (no compensation)



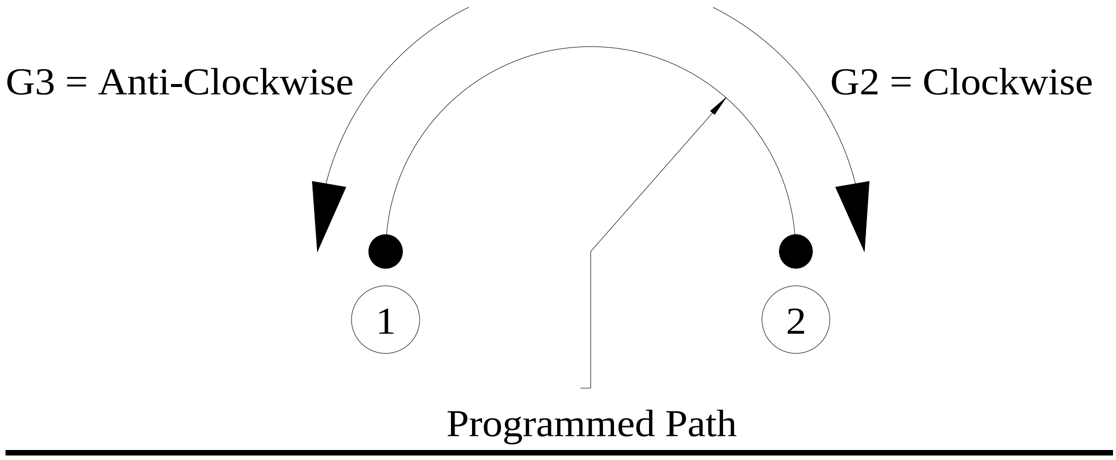
Point to Point - example 2 (no compensation)

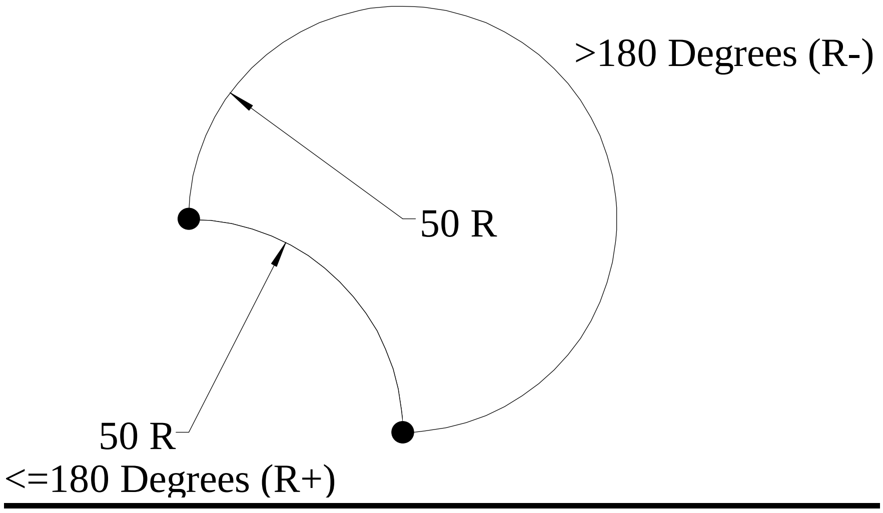


5

Circular Programmed Movements

1) ARCS WITH A KNOWN RADIUS





Note:

All arc movements where a radius of arc is specified in the line of program potentially have two arcs between the programmed endpoints. One arc will be greater than 180° and the other will be equal to or less than 180°

When programming arcs, the created line of program uses the designated motion code (G02 or G03) X & Y as the programmed endpoints and the letter ”R” to assign the radius value to the movement.

To specify the required arc, the following applies:

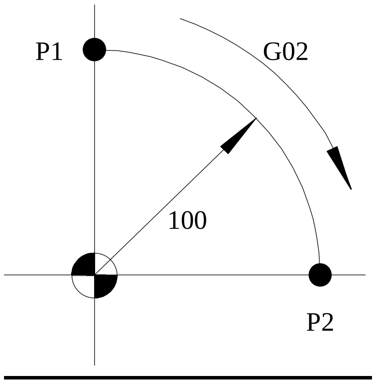
0.001° 180.000° = R+
180.001° 359.999° = R-

The “R” word can only be used with open Arcs up to 359.999°

Arc Interpolation (G02/G03 - R?)

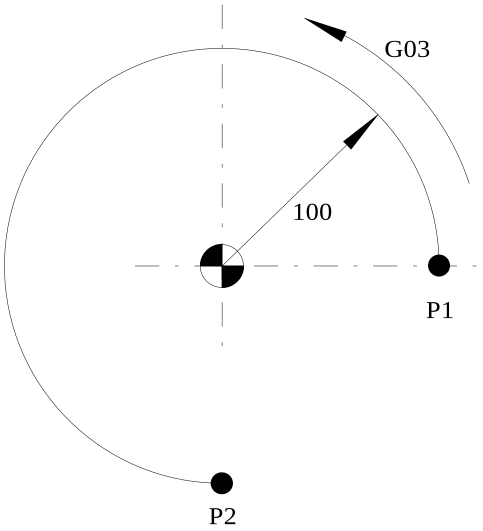
The information required to move in an arc involves the following “Word” addresses:

G17 Example:



G02 X100 Y0 R100

Where:
G02 = Modal Clockwise Feed Motion.
X100 = Radius end point in X axis.
Y0 = Radius end point in Y axis.
R100 = Radius of Arc (0.001° 180.000° arc motion = R+)

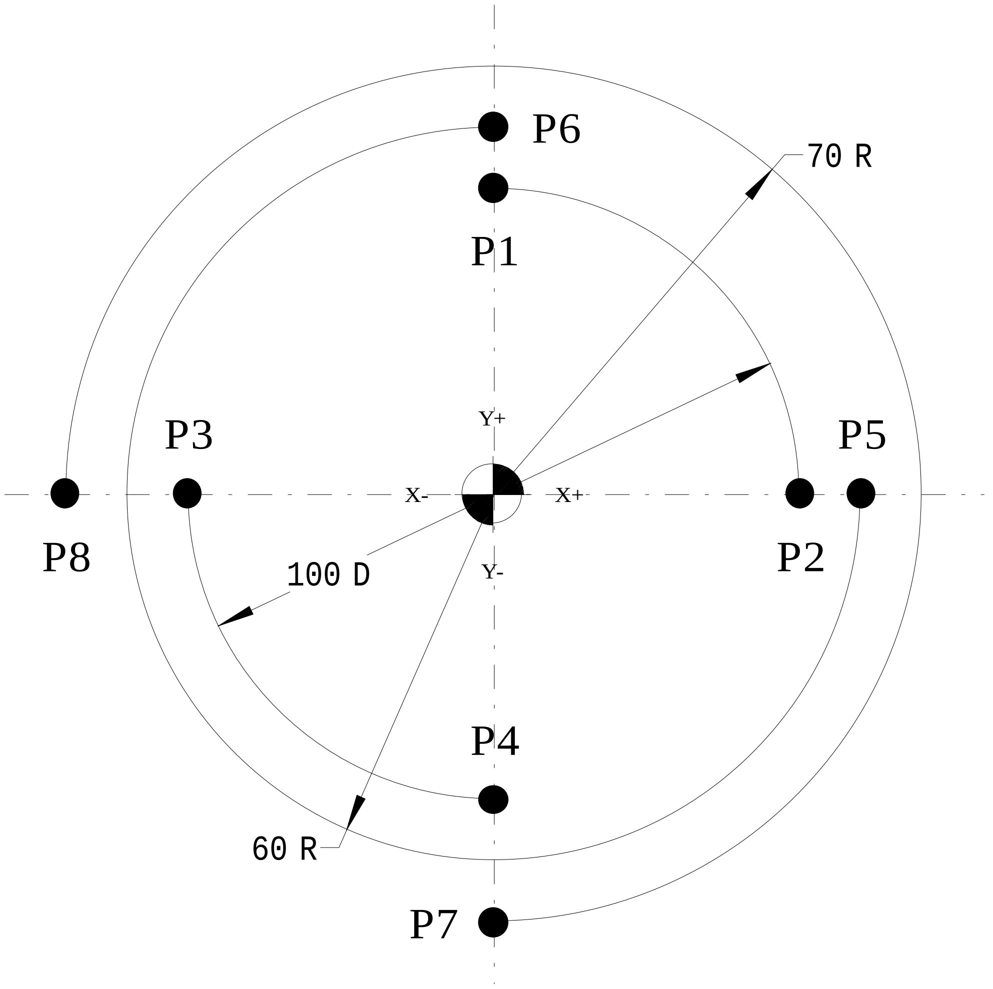


G03 X0 Y-100 R-100

Where:
G03 = Modal Counter Clockwise Feed Motion.
X0 = Radius end point in X axis.
Y-100 = Radius end point in Y axis.
R-100 = Radius of Arc (180.001° 359.999° arc motion = R-)

Circular Programmed Movements – e.g. 1

(Absolute)



1

(Absolute Rapid XY to point 1)

(Clockwise to point 2)

2

(Absolute Rapid XY to point 3)

(Anti-Clockwise to point 4)

3

(Absolute Rapid XY to point 5)

(Clockwise to point 6)

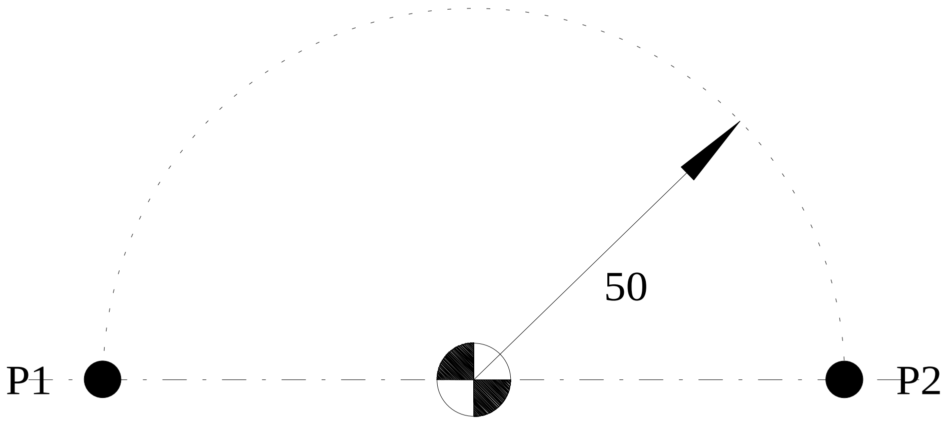
4

(Absolute Rapid XY to point 7)

(Anti-Clockwise to point 8)

Circular Programmed Movements – e.g. 2

(Absolute)



1

(Absolute Rapid XY to point 1)

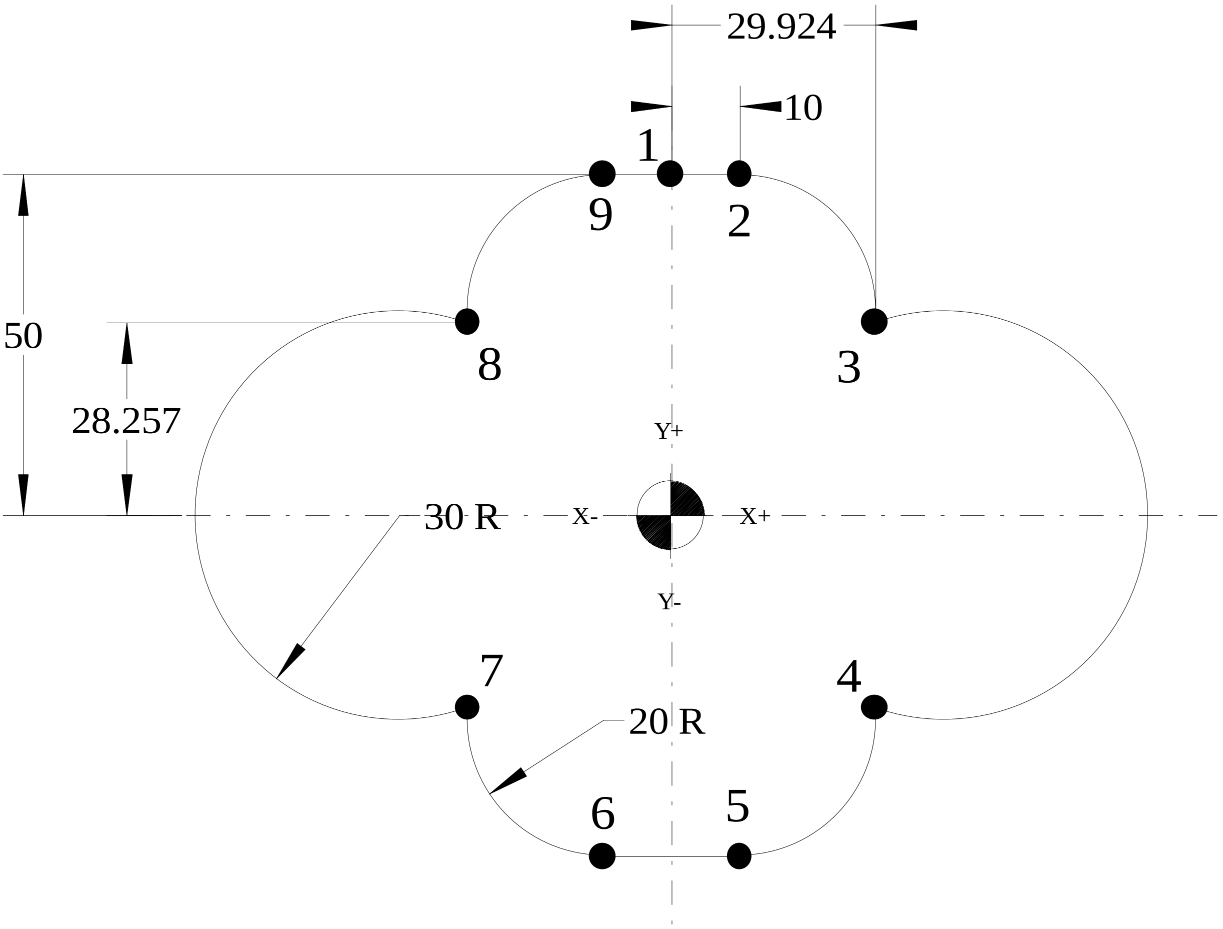
(Clockwise to point 2)

2

(Absolute Rapid XY to point 2)

(Anti-Clockwise to point 1)

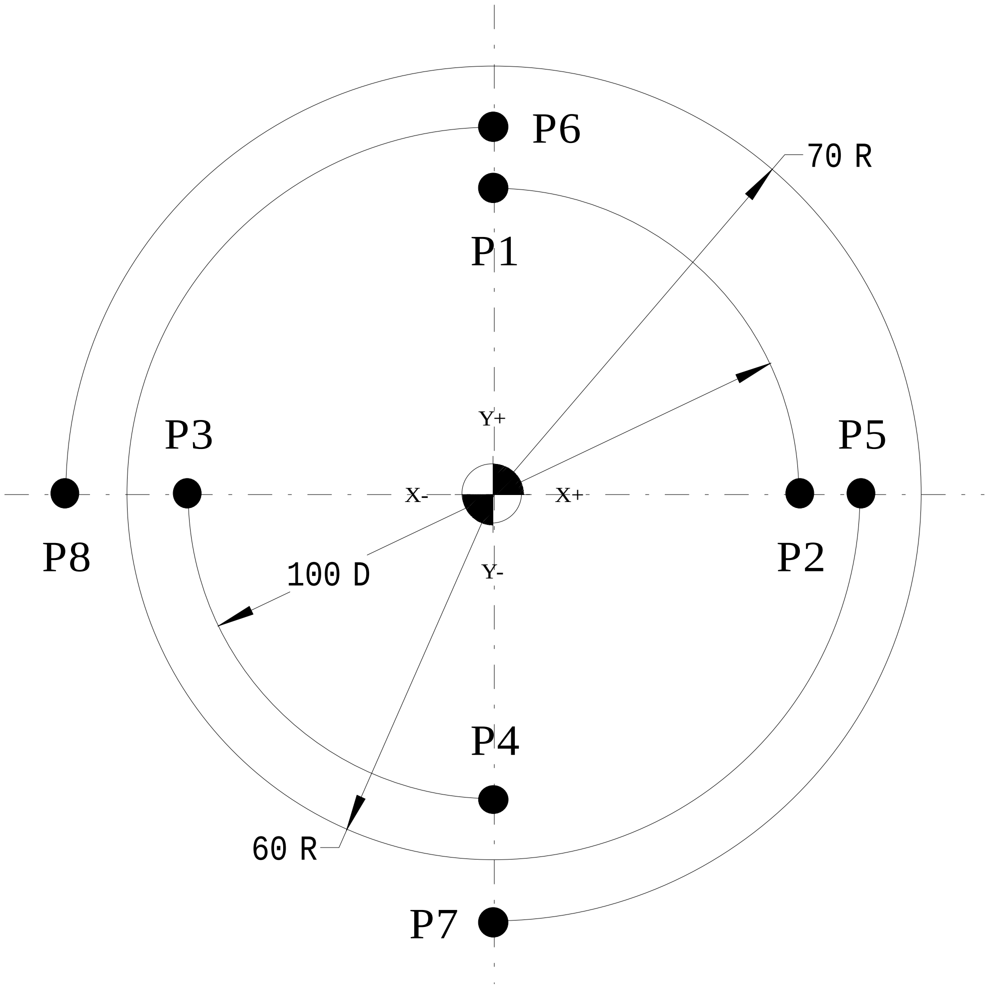
Circular Programmed Movements – e.g. 3



	1 G0 X0 Y50	
1	2	
2	3	
3	4	
4	5	
5	6	
6	7	
7	8	
8	9	
9	1	

Circular Programmed Movements – e.g. 4

(Incremental)



1

(Absolute Rapid XY to point 1)

(Incremental Clockwise to point 2)

2

(Absolute Rapid XY to point 3)

(Incremental Anti-Clockwise to point 4)

3

(Absolute Rapid XY to point 5)

(Incremental Clockwise to point 6)

4

(Absolute Rapid XY to point 7)

(Incremental Anti-Clockwise to point 8)

*__Note:__

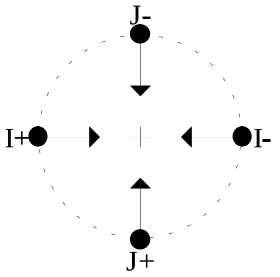
All Incremental values are taken “FROM” the programmed start point “TO” the programmed endpoint.

Circular Programmed Movements

2) ARCS/FULL CIRCLES USING THE CIRCLE CENTRE

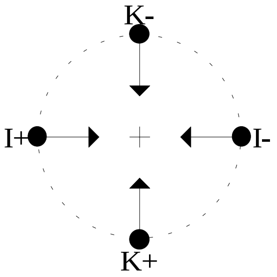
Circular Interpolation (G02/G03 - I?/J?/K?)

The control can also produce arcs or full circles in any of the 3 planes (G17 plan view, G18 front view and G19 side view). The program line contains the end points and the circle centre positions in all the relevant axis. Since the program line cannot contain duplicate information i.e. X? Y? for the endpoint and X? Y? for the circle centre, the control recognises other "Words" for the circle centre axis information. These are, in the relevant planes as follows:



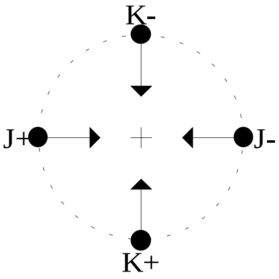
G17 Plan View

I = X axis circle centre
J = Y axis circle centre



G18 Front View

I = X axis circle centre
K = Z axis circle centre



G19 Side View

J = Y axis circle centre
K = Z axis circle centre

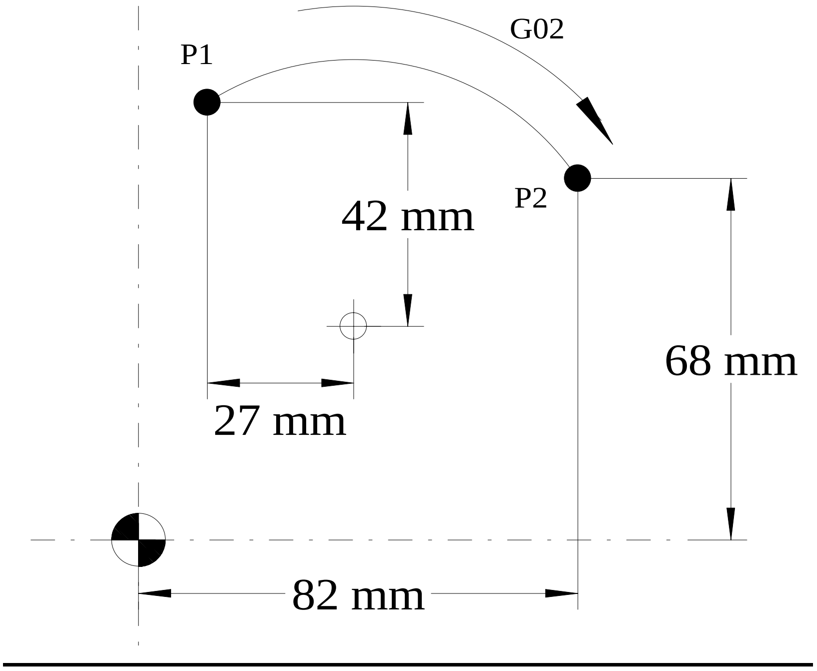
Note

The axis information I, J & K are incremental values taken *"FROM"* the arc/circle starting point *"TO"* the arc/circle centre position.

Circular Programmed Movements

Circular Interpolation (G02/G03 - I?/J?/K?)

The information required to move in an arc using the arc centre involves the following "Word" addresses:



G02 X82 Y68 I27 J-42 F?

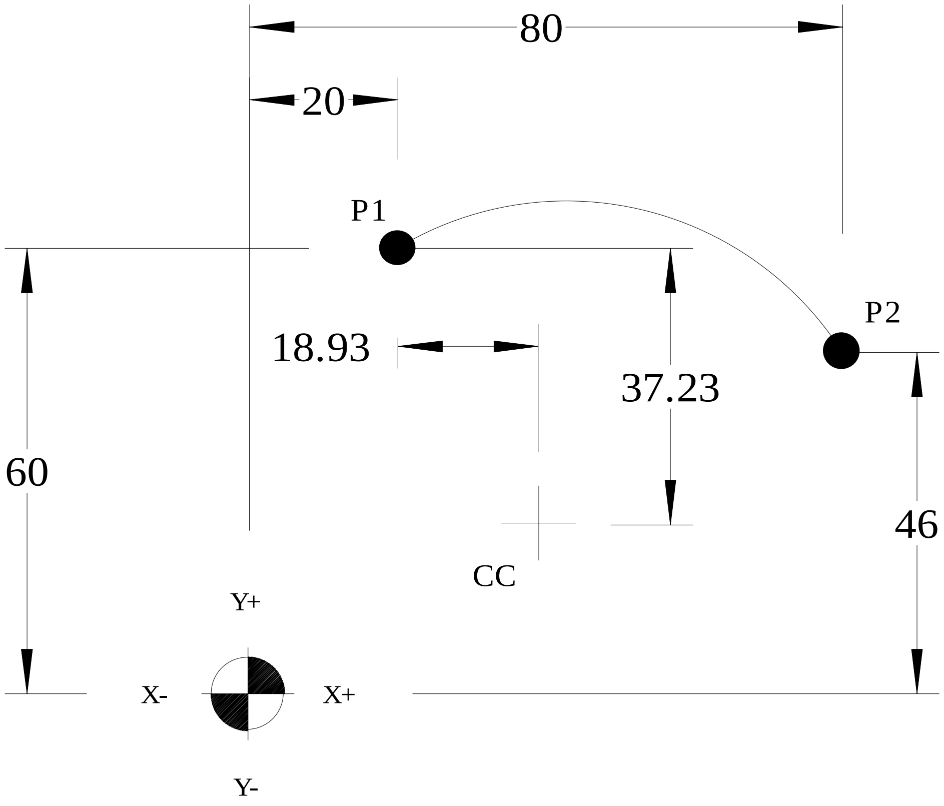
Where:
G02 = Modal Clockwise Feed Motion.
X82 = Arc end point in X axis.
Y68 = Arc end point in Y axis.
I27 = X axis Incremental distance from arc start point to Circle centre.
J-42 = Y axis Incremental distance from arc start point to Circle centre.
F? = Feedrate

Note:

The motions in any other machining plane (G18/G19) will require the Circle centre position for the Z axis. In this case the "Word" used to denote the Circle centre position for the Z axis is "K" and is again the incremental distance from the tool start point to the Circle centre.

Circular Programmed Movements – e.g. 6

X & Y (Absolute), I & J (Incremental)



(Absolute Rapid XY to point 1)

(Clockwise to point 2)

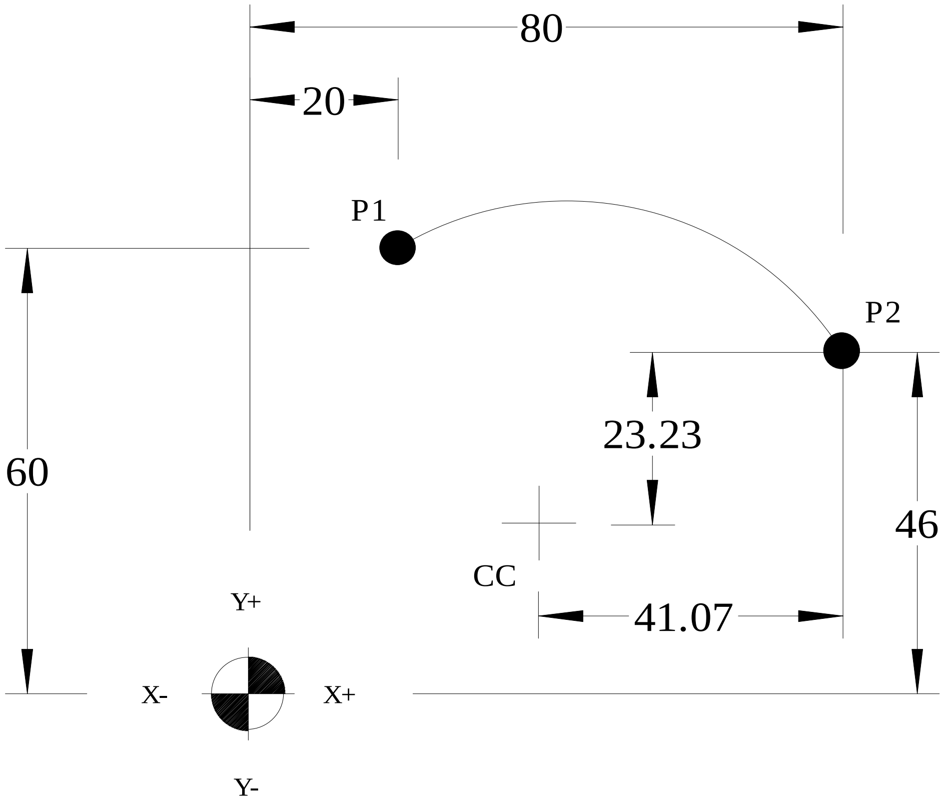
Note:

All Incremental Circle Centre values are taken “FROM” the programmed start point “TO” the Circle Centre.

“I” = X axis circle centre position
“J” = Y axis circle centre position

Circular Programmed Movements – e.g. 7

X & Y (Absolute), I & J (Incremental)



(Absolute Rapid XY to point 2)
(Anti-Clockwise to point 1)

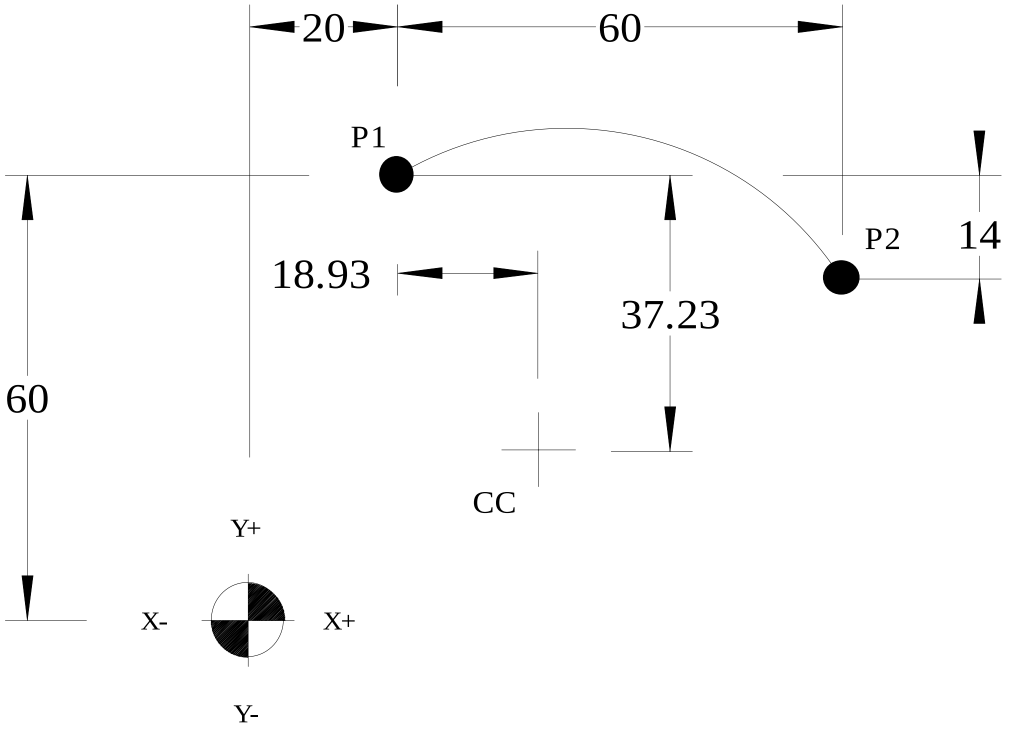
Note:

All Incremental Circle Centre values are taken “FROM” the programmed start point “TO” the Circle Centre.

“I” = X axis circle centre position
“J” = Y axis circle centre position

Circular Programmed Movements – e.g. 8

X & Y, I & J (Incremental)



(Absolute Rapid XY to point 1)
(Clockwise to point 2)

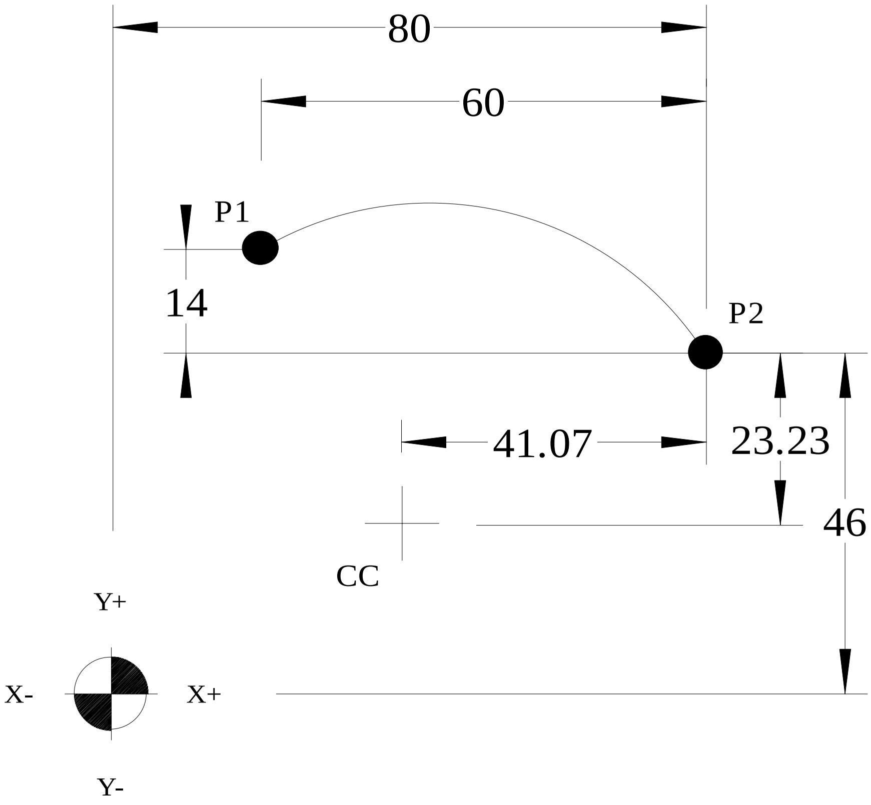
Note:

All Incremental Circle Centre values are taken “FROM” the programmed start point “TO” the Circle Centre.

“I” = X axis circle centre position
“J” = Y axis circle centre position

Circular Programmed Movements – e.g. 9

X & Y, I & J (Incremental)



(Absolute Rapid XY to point 2)

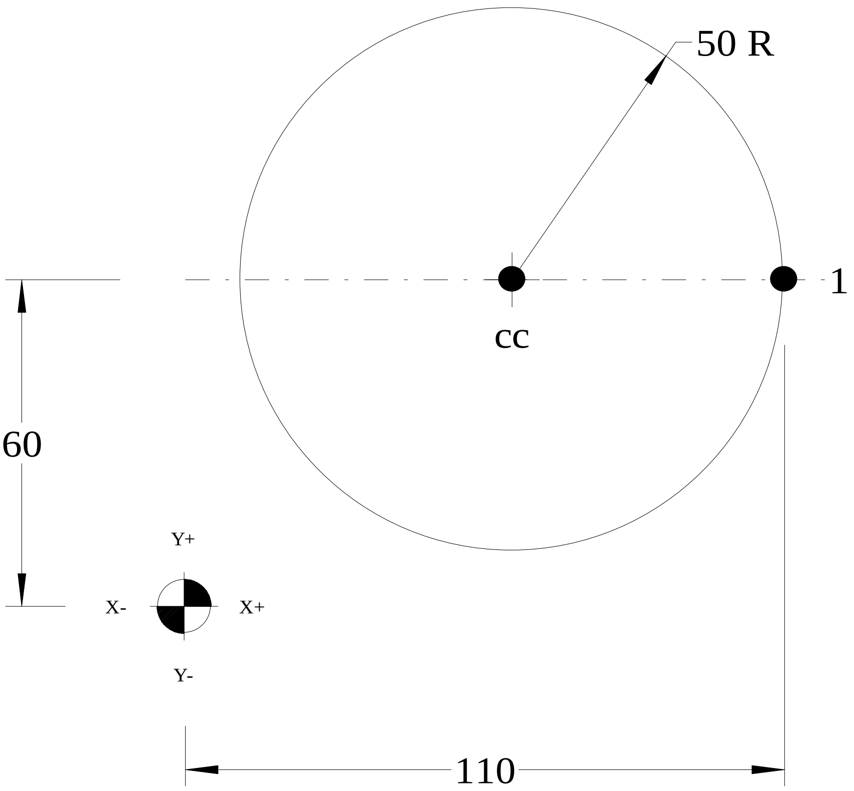
(Anti-Clockwise to point 1)

Note:
All Incremental Circle Centre values are taken “FROM” the programmed start point “TO” the Circle Centre.

“I” = X axis circle centre position
“J” = Y axis circle centre position

Full Circular Movements – e.g.10

I & J (Incremental)



(Absolute Rapid XY to point 1)

(Absolute Clockwise to point 1)

*<u>**Note:**</u>

The end points are taken from the job datum and the circle centre positions are "Incremental" from the start point 1.

(Absolute Rapid XY to point 1)

(Incremental Clockwise to point 1)

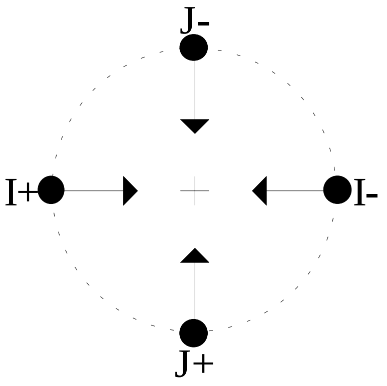
*<u>**Note:**</u>

The end points and circle centre positions are taken from the "Start point"

Full Circular Movements – e.g.11

By selecting a pole point of a circle (12, 3, 6 or 9 o'clock position) and using an "Incremental line of program" to create a full circle, all values on this line of program will have a zero value except for the I or J axis on the appropriate pole axis which will represent the radius to be produced:

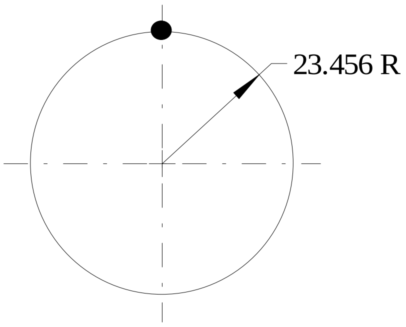
i.e. G91 G2 X0 Y0 I0 J-50

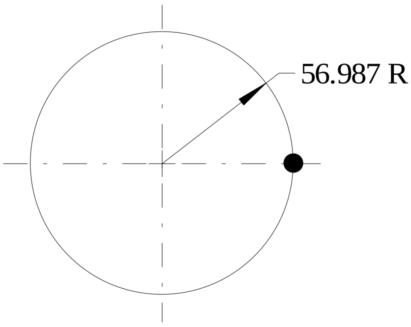


Since the I & J are already incremental the G91 is active on the X & Y values only. If starting from a pole axis, the only axis that needs programming is the pole axis that represents the radius.

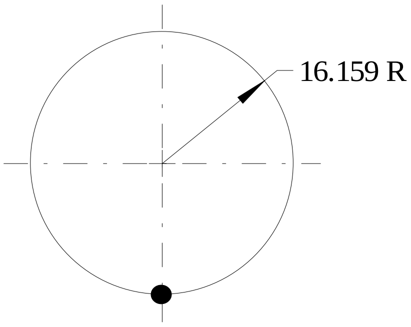
i.e. G2 J-50

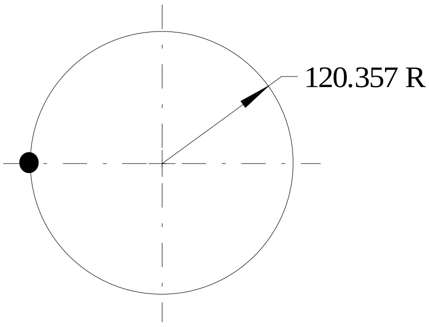
Create the line of circle program for each of the following quadrant points in the diagrams below using "Clockwise".





_________________________ _________________________





_________________________ _________________________

6

Programmable Cutter Radius Compensation

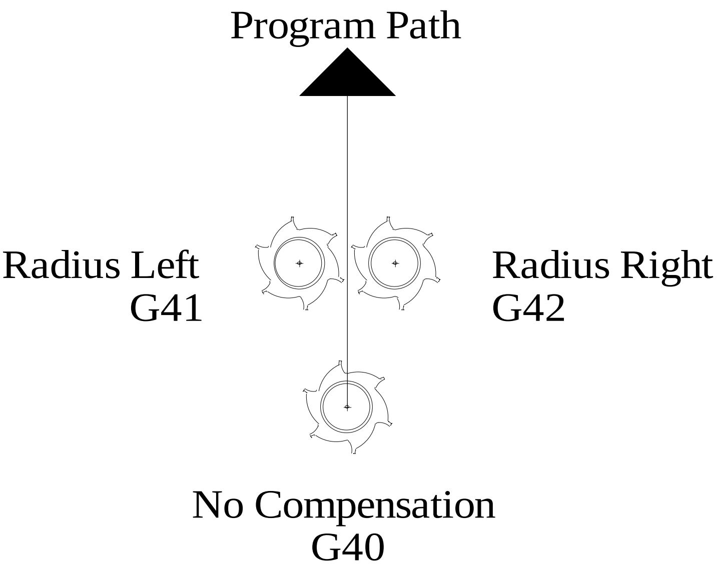
Programs can be created in a way that allows adjustments to be made to create a part within tolerance dimensions. Once the program has been created and the part machined, any adjustments can be made by adjusting the tool radius or tool length, which are stored in the offset tables.

Programs are created in two ways. **“Job Path”** where the programmer creates the program using exact dimensions used on the part drawing or **“Cutter Path”** where the programmer creates a program adding to each dimension the radius of the milling cutter to be used.

“Job Path” automatically adds the radius of the tool which is stored in the tool offset table, during program running and so makes programming very simple. “Cutter path” stills uses information taken from the tool offset table but this information is usually a trimming value of the original programmed radius to make adjustments to the finished part size since the radius is already added to the program dimensions. Adding or subtracting the tool radius to every dimension can make creating the program very long and difficult.

The program line of information contains a modal “G” code (G41 / G42) which determines the offset side of the program path, an axis motion and a modal “D” word with a numerical value to indicate the row number of the offset table where the **RADIUS** value is stored:

i.e. G41 X100 D5



Programmed Radius Compensation has 3 modes:

G40 – No compensation so the path is directly over the program path.

G41 – Compensation is to the left of the programmed path (Climb Milling) *Best method

G42 – Compensation is to the right of the programmed path (Conventional Milling)

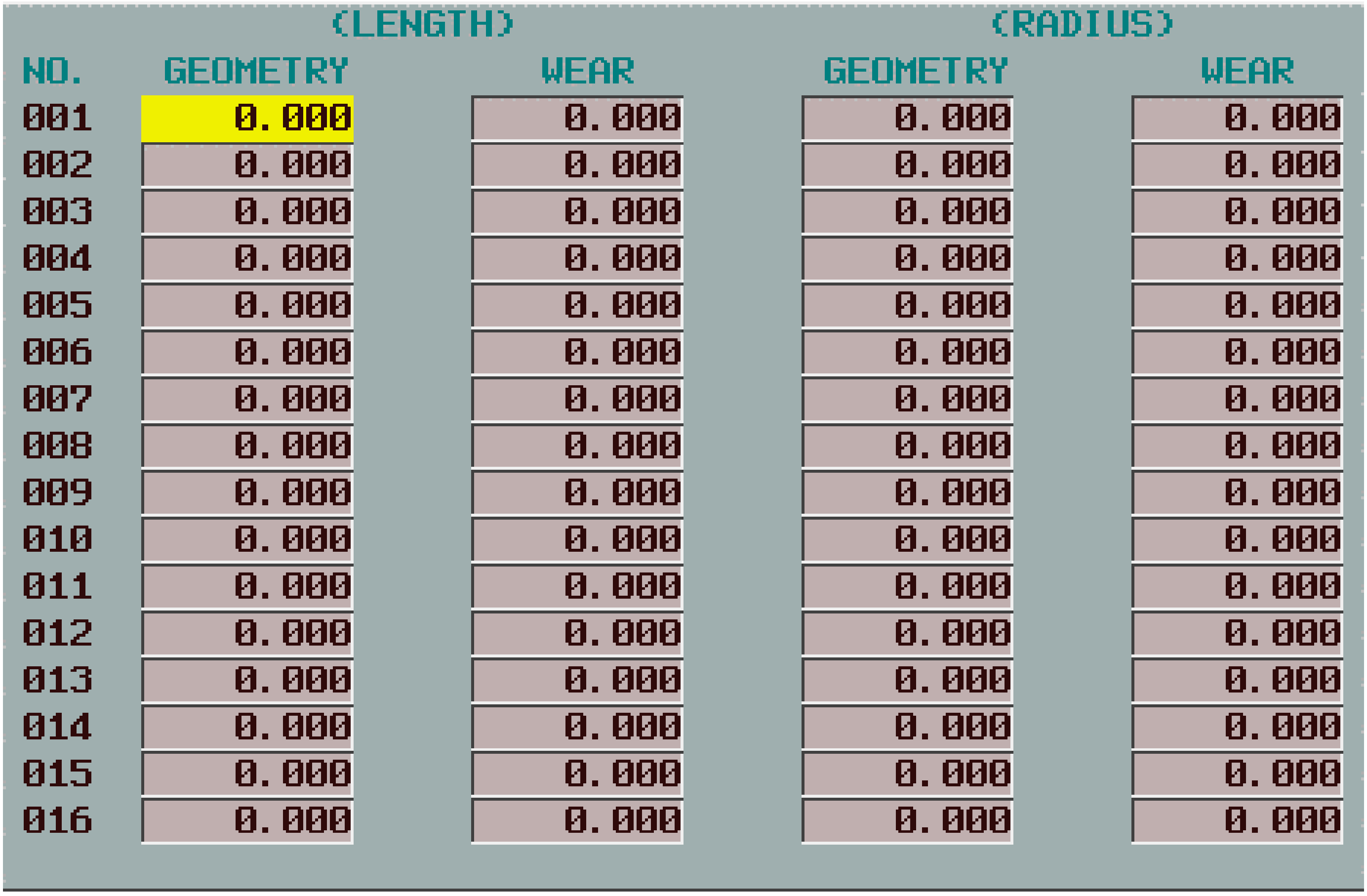
Making machining adjustments

To leave material on the contour or pocket “ADD” the offset value to the value in the radius offset “Wear” column.

To remove material on the contour or pocket “SUBTRACT” the offset value from the radius offset “Wear” column.

Tool Offset Page for Compensation

Tool information relative to the Length and Radius is stored in the "Offset Setting" menu as:



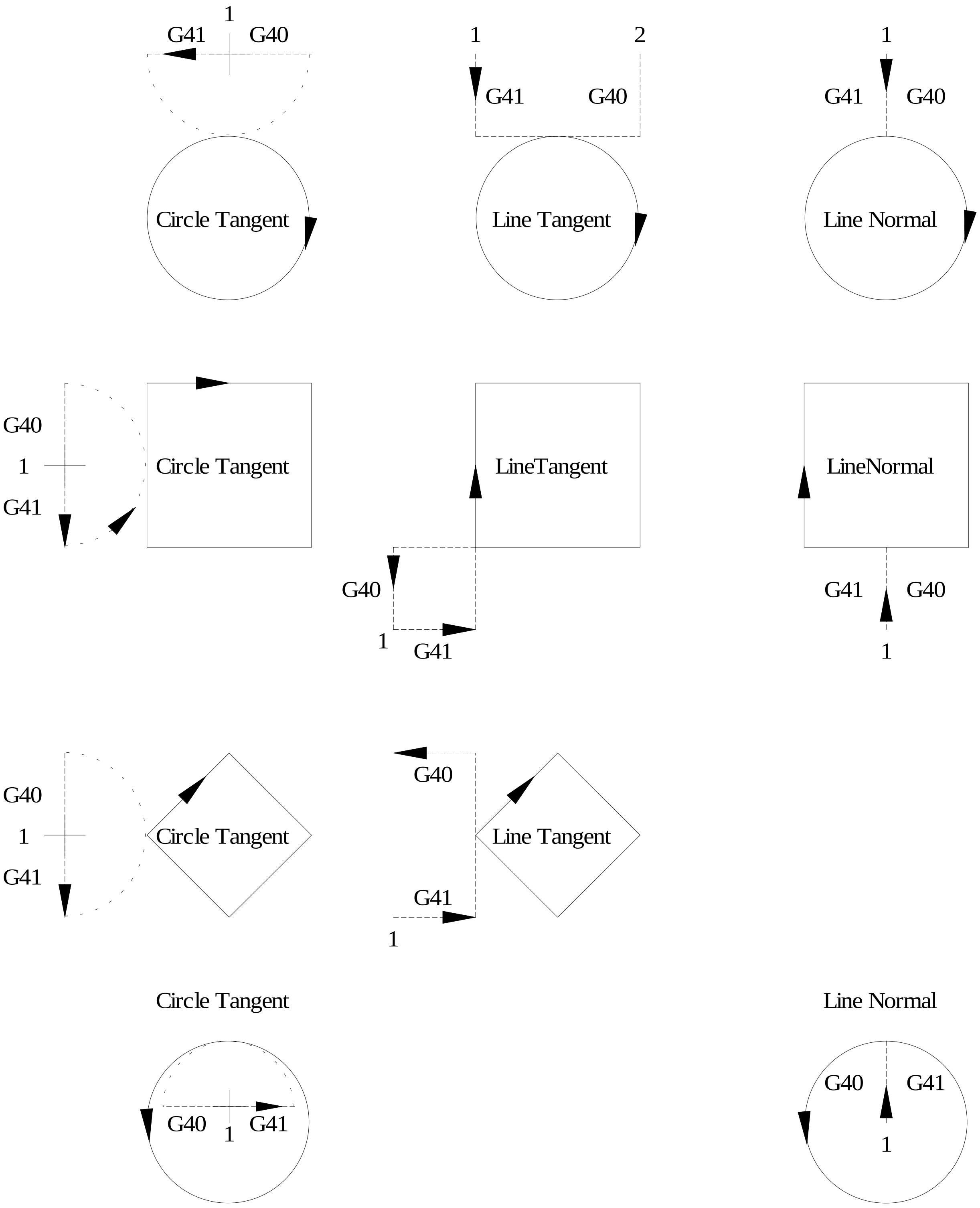
	(LENGTH)		(RADIUS)	
NO.	GEOMETRY	WEAR	GEOMETRY	WEAR
001	0.000	0.000	0.000	0.000
002	0.000	0.000	0.000	0.000
003	0.000	0.000	0.000	0.000
004	0.000	0.000	0.000	0.000
005	0.000	0.000	0.000	0.000
006	0.000	0.000	0.000	0.000
007	0.000	0.000	0.000	0.000
008	0.000	0.000	0.000	0.000
009	0.000	0.000	0.000	0.000
010	0.000	0.000	0.000	0.000
011	0.000	0.000	0.000	0.000
012	0.000	0.000	0.000	0.000
013	0.000	0.000	0.000	0.000
014	0.000	0.000	0.000	0.000
015	0.000	0.000	0.000	0.000
016	0.000	0.000	0.000	0.000

D/H	**Length**	Length Adj.	**Radius**	Radius Adj.

Compensation types

There are three main ways of applying compensation to a feature. Graphically described below, these are:

1) Circle Tangent – used in roughing/semi-roughing & finishing passes.
2) Line Tangent – used in roughing/semi-roughing & finishing passes.
3) Line Normal – used in roughing/semi-roughing passes.



Simple Compensation Rules

Applying compensation

1) Move “Z” to its programmed depth position before compensation is applied.

2) Compensation is best activated on a single axis motion towards the machining feature i.e. G41 X? and perpendicular (90°) to the next axis motion which should be the opposite single axis motion to the one used to apply compensation.

```
G0/G1 Z?
G41 X? D?
Y?
```

```
G0/G1 Z?
G41 Y? D?
X?
```

Cancelling compensation

1) **<u>“DO NOT MOVE”</u>** “Z” until compensation has been cancelled.

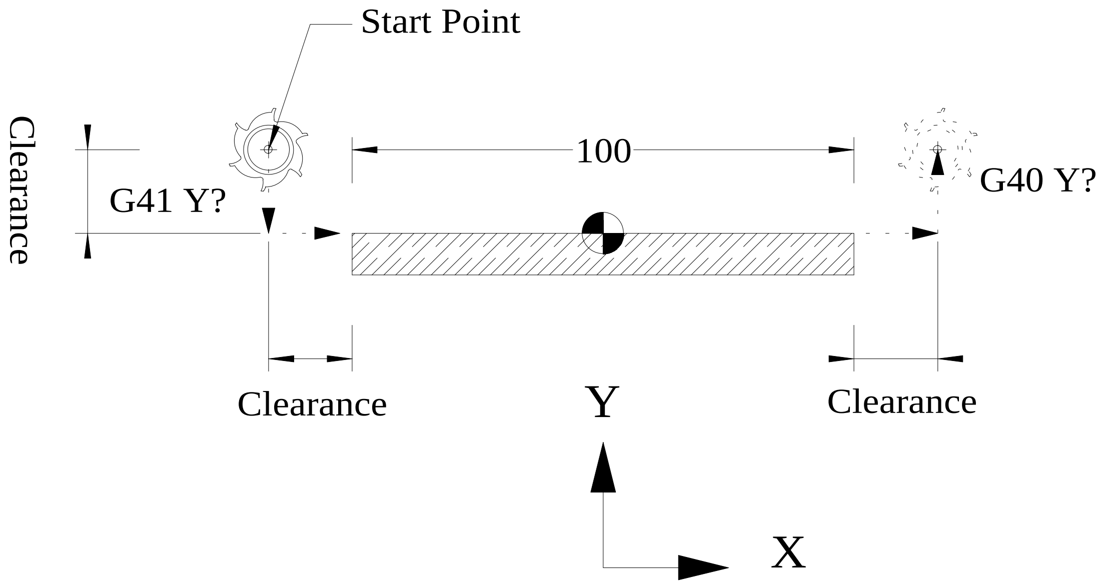
2) Compensation is best cancelled on a single axis motion away from the machining feature i.e. G40 X? and perpendicular (90°) to the last axis motion which should be the opposite single axis motion to the one used to cancel compensation.

```
X?
G40 Y?
G0/G1 Z?
```

```
Y?
G40 X?
G0/G1 Z?
```

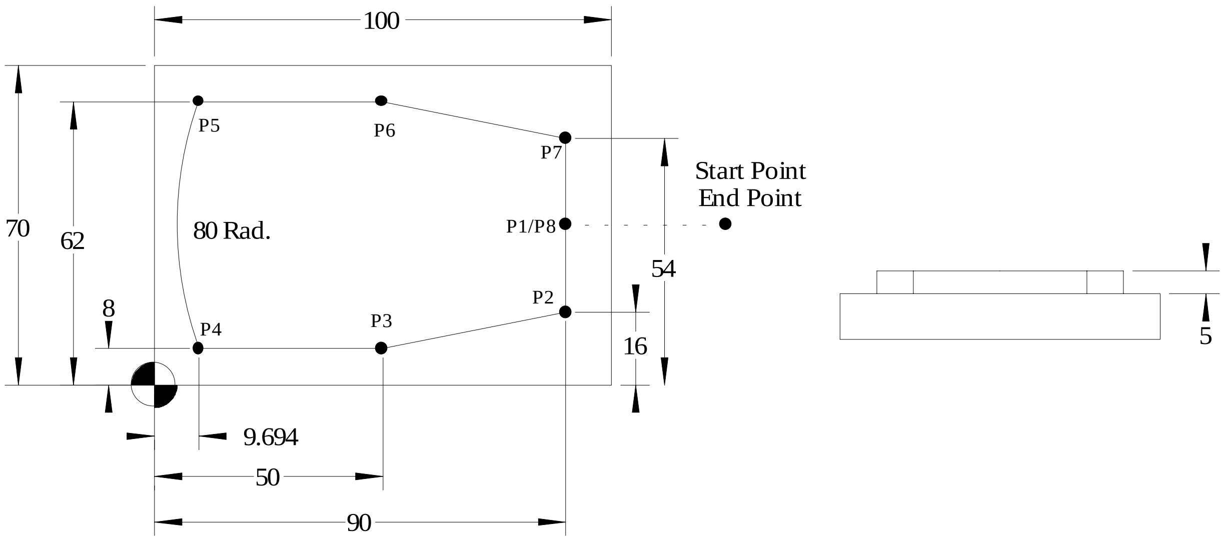
Programmable Cutter Radius Compensation

Dia. Offset = 25mm Depth = 25mm

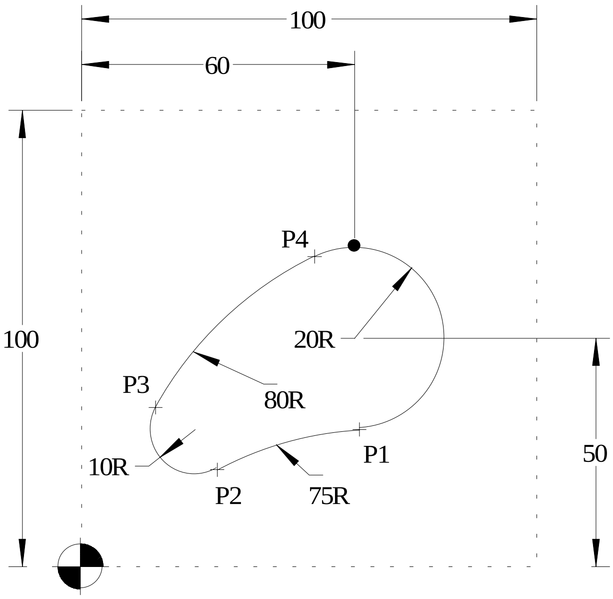


Program	***Absolute Position***
G54 X-75 Y25	X-75 Y25
G43 Z5 H?	X-75 Y25 Z5
G1 Z-25 F?	X-75 Y25 Z-25
G41 Y0 D?	X-75 *Y12.5* Z-25
X75	X75 *Y12.5* Z-25
G40 Y25	X75 *Y25* Z-25
G0 G90 Z100	X75 Y25 Z100

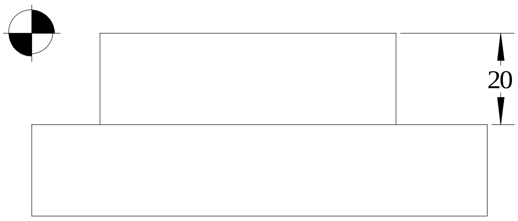
Compensation e.g. 1



Compensation e.g. 2



Plan



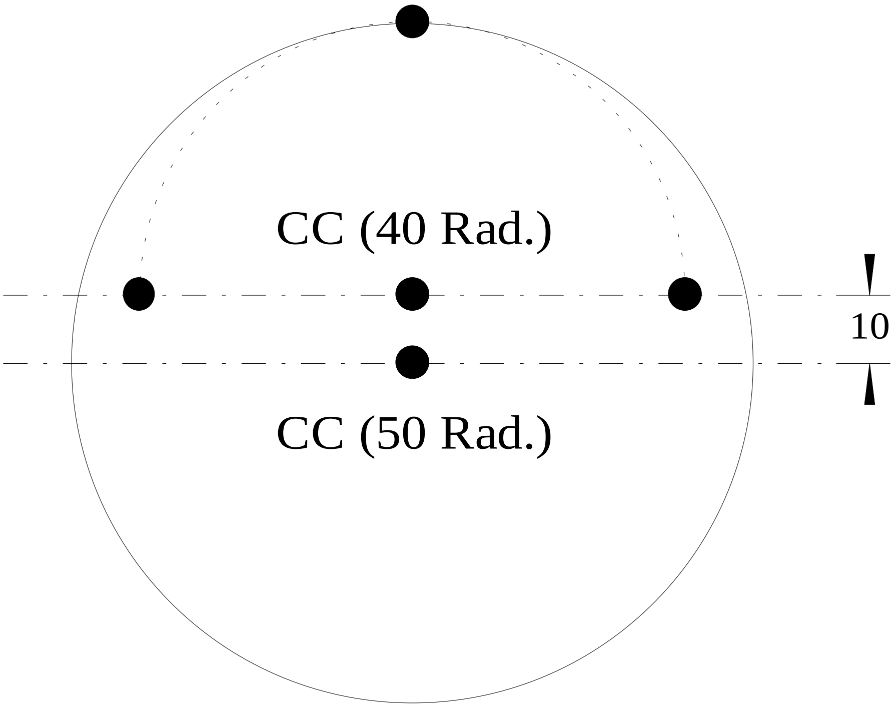
Front

	P1	**P2**	**P3**	**P4**
X	61.11	29.738	16.257	51.266
Y	30.031	21.194	34.854	67.992

Programmable Cutter Radius Compensation

Circle Tangent inside a full Circle

Main C/Bore = 50mm Radius



Main Radius = AR
Arc ON/OFF Radius = SR
CC Difference = YD

Note:

Make the **Approach & Departure Arc** a value less than the original radius to be produced, greater than the cutter radius being used, a radius value which can be subtracted from the original arc to leave a whole number for the "CC Difference" and attached to one of the pole points as the example above.

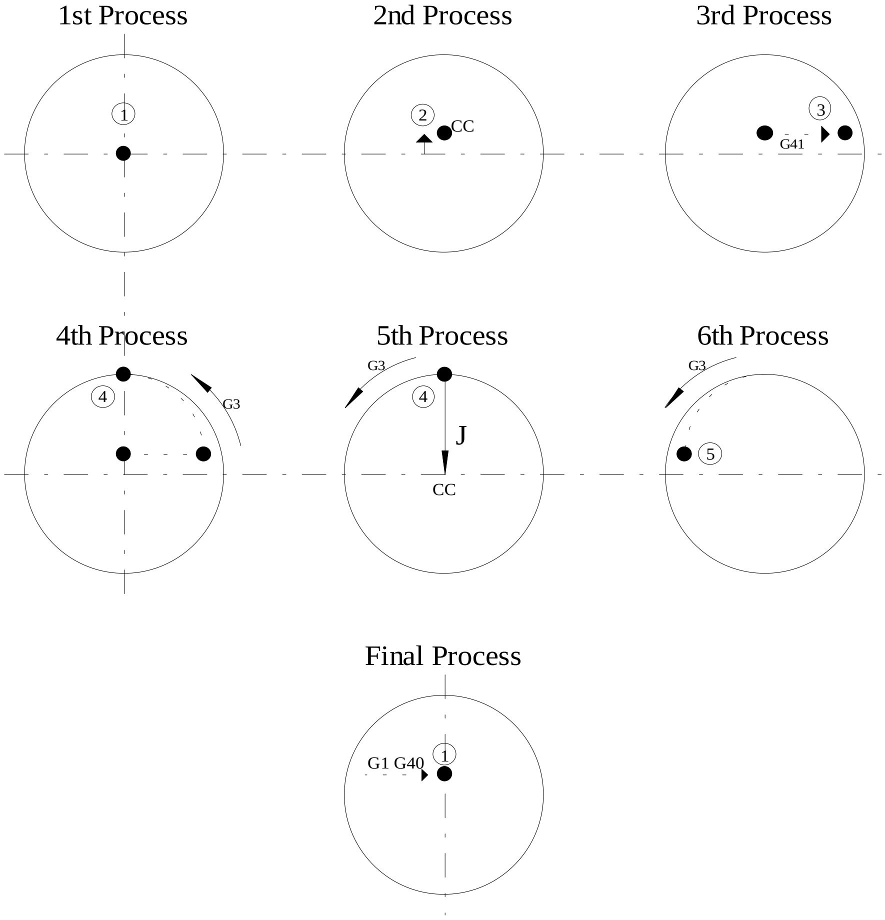
i.e.

SR = Radius less than AR
YD = AR – SR (i.e. 121.946 – 101.946 = 20)

As above graphical example
AR = 50
SR = 40
YD = 50 - 40 = 10

Programmable Cutter Radius Compensation

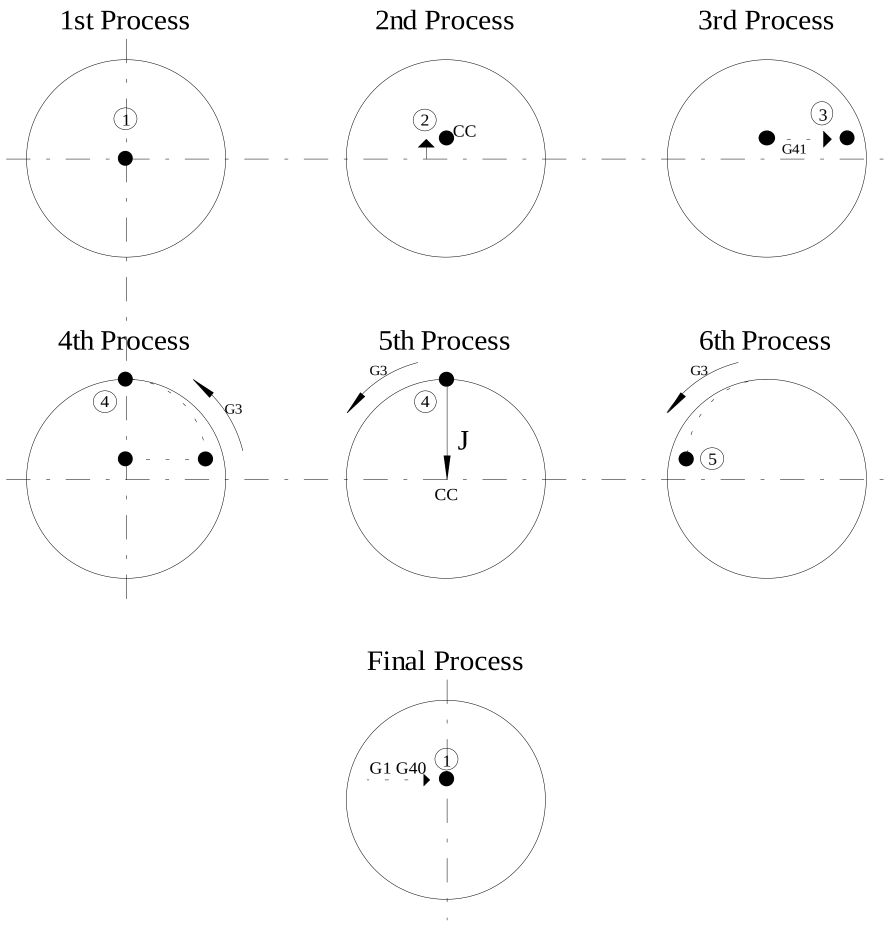
Circle Tangent



O1000;
T? M6 (Toolchange line - 25mm Endmill cutter);
G0 G90 G40 G21 G17 G94 G80 (Safety default line);
G54 X0 Y0 S? M3 (Absolute Start Point – Centre of Actual radius – position 1);
G43 Z5 H?? (Rapid to a position above material setting length offset);
G1 Z-? F? (Feed to required cut depth before compensation has been applied.);
G91 Y(YD) (Incremental move to centre of Arc on/off as calculated – position 2);
G41 X(SR) D?? M8 (Move to point 3 - Apply compensation incrementally);
G3 X-(SR) Y(SR) R(SR) (Move to position 4 - Arc On.as SR Rad.);
X0 Y0 I0 J-(AR) (Move 360 Degrees back to position 4 by Radius of AR);
X-(SR) Y-(SR) R(SR) (Move to position 5 - Arc Off as SR Rad.)
G1 G40 X(SR) (Move to start position cancelling compensation);
G0 G90 Z100 (Move to Absolute safe height above material after comp is cancelled);
M30 (End program);

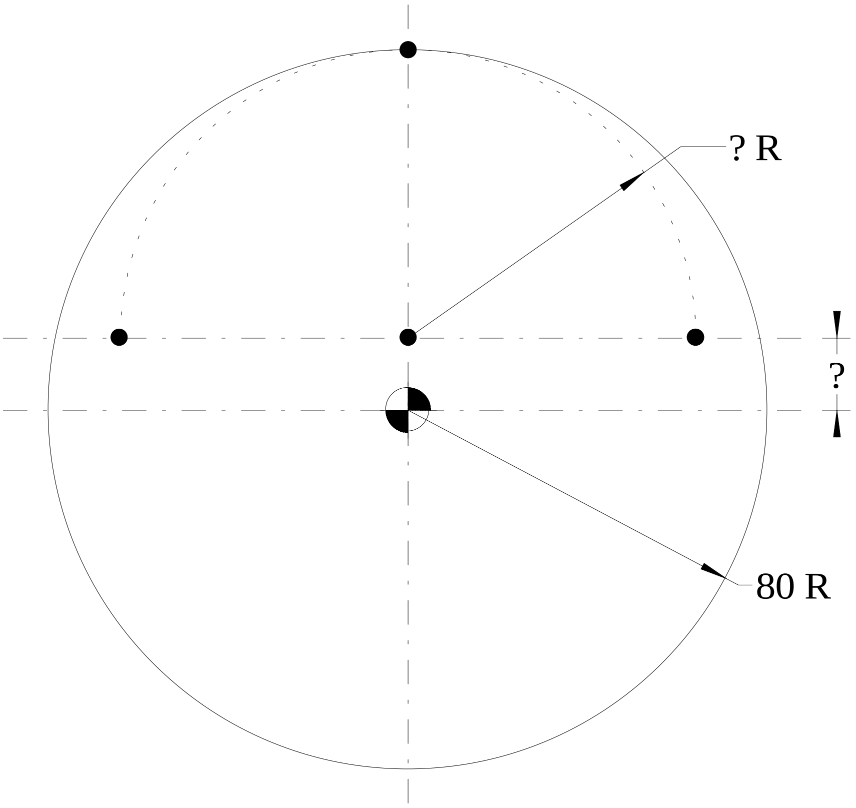
Programmable Cutter Radius Compensation

Circle Tangent



```
O1000;
T? M6  (Toolchange line - 25mm Endmill cutter);
(Internal circular contour - Arc on / Arc off);
G0 G90 G40 G21 G17 G94 G80 (Safety default line);
G54 X0 Y0 S? M3 (Absolute Start Point – Centre of Actual radius – position 1);
G43 Z5 H?? (Rapid to a position above material setting length offset);
G1 Z-? F? (Feed to required cut depth before compensation has been applied.);
G91 Y10 (Incremental move to centre of Arc on/off as calculated – position 2);
G41 G91 X40 D?? M8 (Move to point 3 - Apply compensation incrementally);
G3 X-40 Y40 R40 (Move to position 4 - Arc On.as SR Rad.);
X0 Y0 I0 J-50 (Move 360 Degrees back to position 4 by Radius of AR);
X-40 Y-40 R40 (Move to position 5 - Arc Off as SR Rad.)
G1 G40 X40 D0 (Move to start position cancelling compensation);
G0 G90 Z100 (Move to Absolute safe height above material after comp is cancelled);
M30 (End program);
```

Circle Tangent Compensation e.g. 1



7

Helical Milling

The pitch is programmed on the line of information requiring “X” , “Y” , and “Z” moves with circular programming.

i.e. If the Pitch = 2mm

One full circular movement = 360
1 FULL PITCH
Z incremental movement = 2

Half of a full circular movement = 180
½ FULL PITCH
Z incremental movement = 1mm

Quarter of a full circular movement = 90
¼ FULL PITCH
Z incremental movement = 0.5mm

If the Lead is 2mm and the arc is 90 then the Z move will be a ¼ of 2mm = 0.5mm.

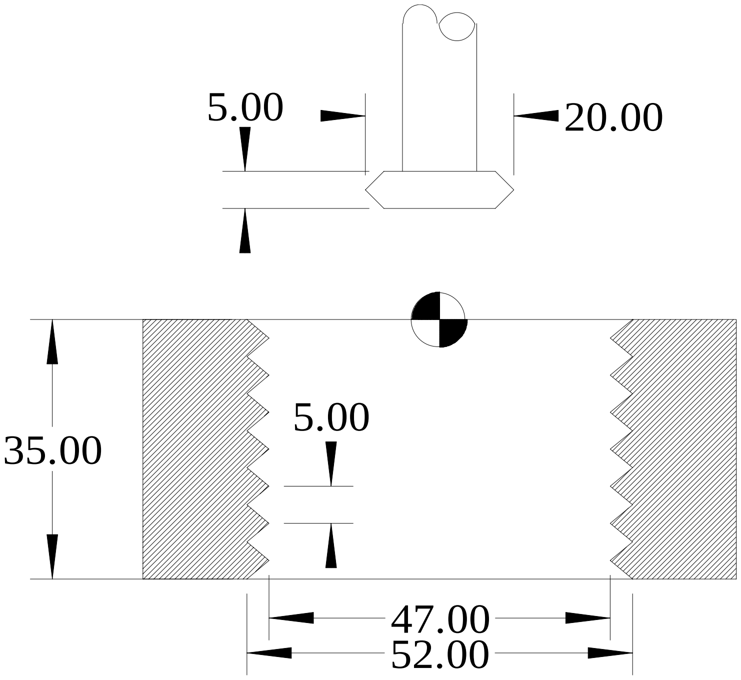
This value is then added or subtracted to the Z absolute positioning move at the lead on and the lead off the helix.

If incremental programming is used then the Z word would be the pitch relative to the angle of motion.

The line of program could look like this:

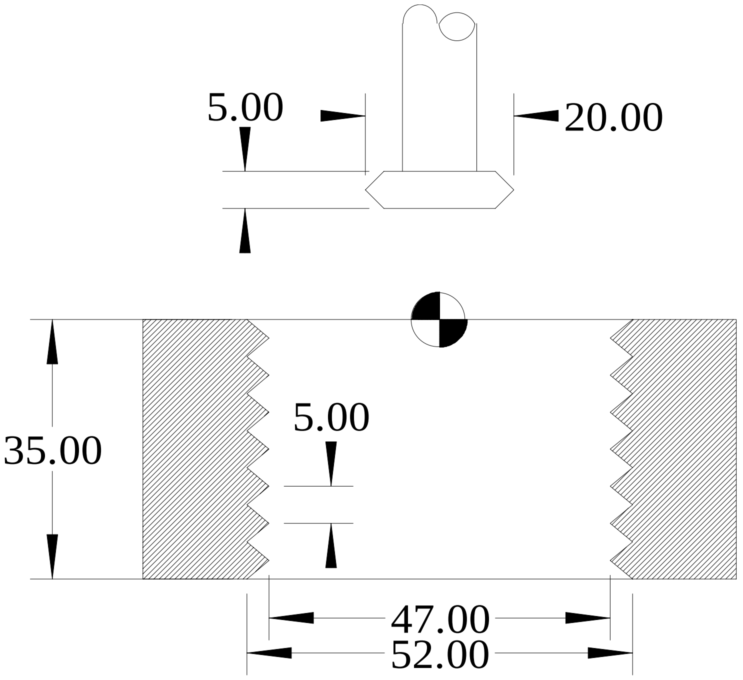
G2 X? Y? Z? I? J?
or
G2 X? Y? Z? R?

Helical Milling
“Single Point Tools”
Absolute Programming



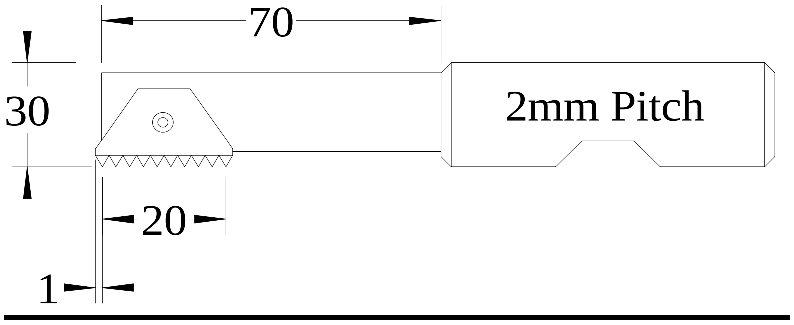
```
O1000 ;
T1 M6 (Tool change line.) ;
G0 G90 G40 G21 G17 G94 G80  (Safety Line.) ;
G54 X0 Y0 S? M3 (Move to centreline of bore) ;
G43 Z100 H? (Set tool length) ;
Z5 (Move to bore top) ;
G1 Z-38.75 F? (Feed to depth + ¼  of pitch for arcing ON + nose width/2.) ;
Y5 (Move to Arc On bore centre 26(AR) – 21(SR) = 5(YD)) ;
G41 X21 D?  (Apply compensation as a straight line.) ;
G3 X0 Y26 Z-37.5 R21 (This line creates a ¼  arc + Z movement of a ¼ of pitch) ;
X0 Y26 Z32.5 I0 J-26 (This line will create 1st pitch of 5mm.) ;
X0 Y26 Z27.5 I0 J-26 (This line will create 2nd pitch of 5mm.) ;
X0 Y26 Z22.5 I0 J-26 (This line will create 3rd pitch of 5mm.) ;
X0 Y26 Z17.5 I0 J-26 (This line will create 4th pitch of 5mm.) ;
X0 Y26 Z12.5 I0 J-26 (This line will create 5th pitch of 5mm.) ;
X0 Y26 Z7.5 I0 J-26 (This line will create 6th pitch of 5mm.) ;
X0 Y26 Z2.5 I0 J-26 (This line will create 7th pitch of 5mm.) ;
X-21 Y5 Z-2 R21 (This line creates a ¼  arc + Z movement of a ¼  of pitch) ;
G1 G40 X0 (Cancel Compensation as a straight line) ;
G0 G90 Z100 (Clear the workpiece) ;
M30 (End the Program) ;
```

Helical Milling
“Single Point Tools”
Absolute & Incremental Programming



```
O1000 ;
T1 M6 (Tool change line.) ;
G0 G90 G40 G21 G17 G94 G80  (Safety Line.) ;
G54 X0 Y0 S? M3 (Move to centreline of bore) ;
G43 Z100 H? (Set tool length) ;
Z5 (Move to bore top) ;
G1 Z-38.75 F? (Feed to depth + ¼  of pitch for arcing ON + nose width/2.) ;
G91 Y5 (Move to Arc On bore centre 26(AR) – 21(SR) = 5(YD) incrementally) ;
G41 X21 D?  (Apply compensation as a straight line.) ;
G3 X-21 Y21 Z1.25 R21 (This line creates a ¼  arc + Z movement of a ¼ of pitch) ;
• Z5 J-26 (This incremental line will create 1st  pitch of 5mm.) ;
• Z5 J-26 (This incremental line will create 2nd  pitch of 5mm.) ;
• Z5 J-26 (This incremental line will create 3rd  pitch of 5mm.) ;
• Z5 J-26 (This incremental line will create 4th  pitch of 5mm.) ;
• Z5 J-26 (This incremental line will create 5th  pitch of 5mm.) ;
• Z5 J-26 (This incremental line will create 6th pitch of 5mm.) ;
• Z5 J-26 (This incremental line will create 7th  pitch of 5mm.) ;
X-21 Y-21 Z1.25 R21 (This line creates a ¼  arc + Z movement of a ¼  of pitch) ;
G1 G40 X21 (Cancel Compensation as a straight line) ;
G0 G90 Z100 (Clear the workpiece) ;
M30 (End the Program) ;
```

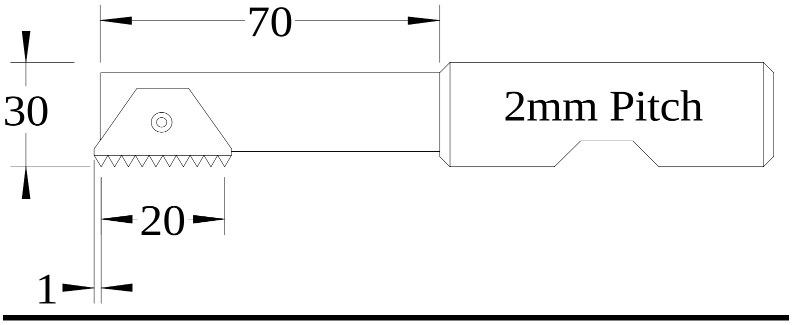
Helical Milling
“Multi toothed Tools”
Absolute Programming



***Produce a Thread M60 x 2mm pitch (60mm Deep)**

```
O1000 ;
T1 M6 (Tool change line.) ;
G0 G90 G40 G21 G17 G94 G80 (Safety Line.) ;
G54 X0 Y0 S? M3 (Move to centreline of bore) ;
G43 Z100 H? (Set tool length) ;
Z5 (Move to feed clearance) ;
G1 Z-61.5 F? (Feed to depth + ¼ of pitch for arcing ON + ½ tooth form width to tool end) ;
Y10 (Move to Arc On bore centre 30(AR) – 20(SR) = 10(YD)) ;
G41 X20 D? (Apply compensation as a straight line) ;
G3 X0 Y30 Z-61 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
Z-59 J-30 (This line will create 1 pitch.) ;
X-20 Y10 Z-58.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
G1 G40 X0 (Cancel Compensation as a straight line) ;
G0 Z-41.5 (Subtract edge length from 1st Z positioning move 61.5 – 20 = 41.5) ;
G1 G41 X20 D? (Apply compensation as a straight line) ;
G3 X0 Y30 Z-41 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
Z-39 J-30 (This line will create 1 pitch.) ;
X-20 Y10 Z-38.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
G1 G40 X0 (Cancel Compensation as a straight line) ;
G0 Z-21.5 (Subtract edge length from 2nd  Z positioning move 41.5 – 20 = 21.5) ;
G41 X20 D? (Apply compensation as a straight line) ;
G3 X0 Y30 Z-21 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
Z-19 J-30 (This line will create 1 pitch.) ;
X-20 Y10 Z-18.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
G1 G40 X0 (Cancel Compensation as a straight line) ;
G0 G90 Z100 (Clear the workpiece) ;
M30 (End the Program.) ;
```

Helical Milling
“Multi toothed Tools”
Absolute & Incremental Programming



***Produce a Thread M60 x 2mm pitch (60mm Deep)**

```
O1000 ;
T1 M6 (Tool change line.) ;
G0 G90 G40 G21 G17 G94 G80 (Safety Line.) ;
G54 X0 Y0 S? M3 (Move to centreline of bore) ;
G43 Z100 H? (Set tool length) ;
Z5 (Move to feed clearance) ;
G1 Z-61.5 F? (Feed to depth + ¼ of pitch for arcing ON + ½ tooth form width to tool end) ;
G91 Y10 (Move to Arc On bore centre 30(AR) – 20(SR) = 10(YD)) ;
• G1 G41 X20 D? (Apply compensation as a straight line) ;
• G3 X-20 Y20 Z0.5 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
• Z2 J-30 (This line will create 1 pitch.) ;
• X-20 Y-20 Z0.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
• G1 G40 X20 (Cancel Compensation as a straight line) ;
G0 G90 Z-41.5 (Subtract edge length from 1st Z positioning move 61.5 – 20 = 41.5) ;
• G1 G41 X20 D? (Apply compensation as a straight line) ;
• G3 X-20 Y20 Z0.5 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
• Z2 J-30 (This line will create 1 pitch.) ;
• X-20 Y-20 Z0.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
• G1 G40 X20 (Cancel Compensation as a straight line) ;
G0 G90 Z-21.5 (Subtract edge length from 2nd  Z positioning move 41.5 – 20 = 21.5) ;
• G41 X20 D? (Apply compensation as a straight line) ;
• G3 X-20 Y20 Z0.5 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
• Z2 J-30 (This line will create 1 pitch.) ;
• X-20 Y-20 Z0.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
• G1 G40 X20 (Cancel Compensation as a straight line) ;
G0 G90 Z100 (Clear the workpiece) ;
M30 (End the Program.) ;
```

8

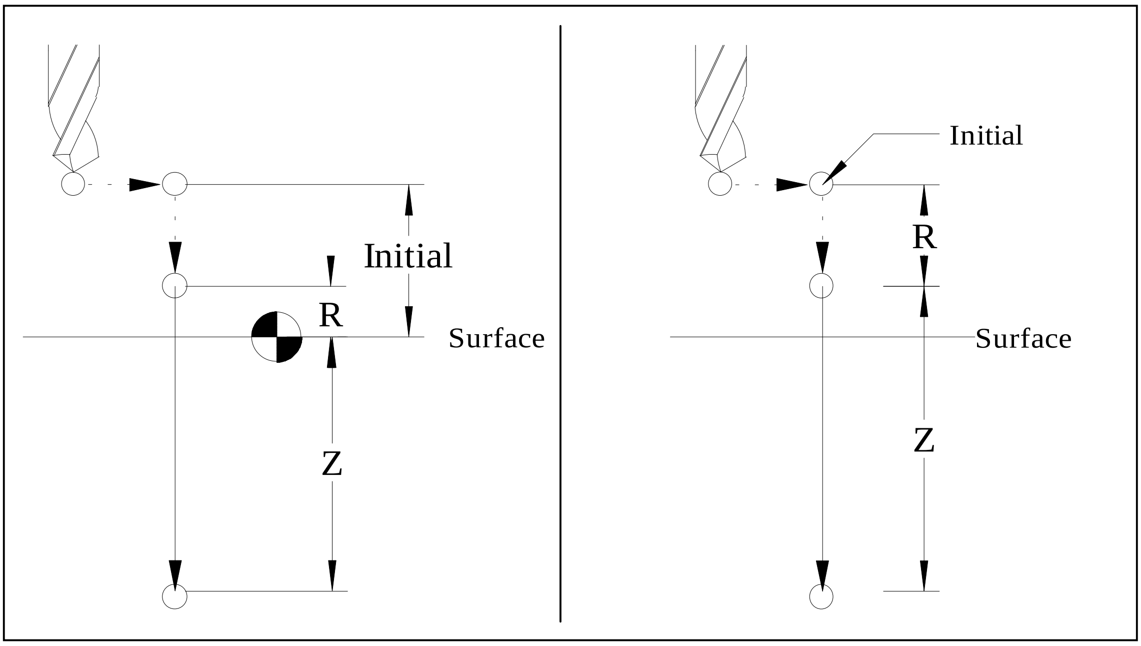
Canned Cycles

The control has the ability to machine holes using a series of "G" codes for different cycles. These are simple drilling, peck drilling, tapping and boring cycles.
A basic line of program consists of modal words all containing numerical values as:

G? G? X? Y? Z? R? F?

Where:
G? = Cycle machining code.
G? = Code to determine action at end of cycle (see G98 / G99 next page)
X & Y = Absolute hole centre position.
Z? = Absolute Z position at bottom of hole.
R? = Z axis starting position above surface.
F? = Feedrate.
M? = Coolant M8 or M38.

Absolute	Incremental



Incremental Mode

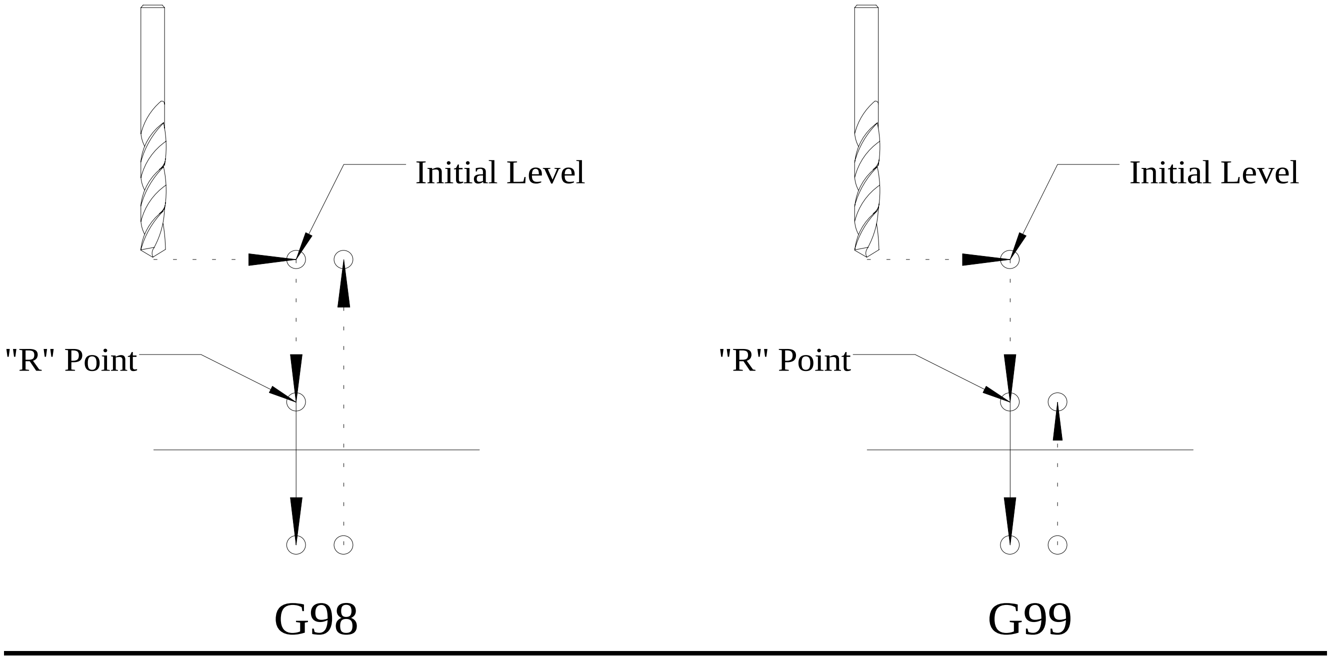
When using G91 on any Hole Canned Cycle the "R" value is the incremental distance from the "Initial Height" and the "Z" is the incremental distance from the "R" word.

Cancel Canned Cycle
G80

Group 01 Codes

The following G codes also are effective in cancelling any Hole Canned Cycle:
G0, G01, G02, G03

"G98" & "G99"



The G98 / G99 action code determines the final Z axis position after hole completion.

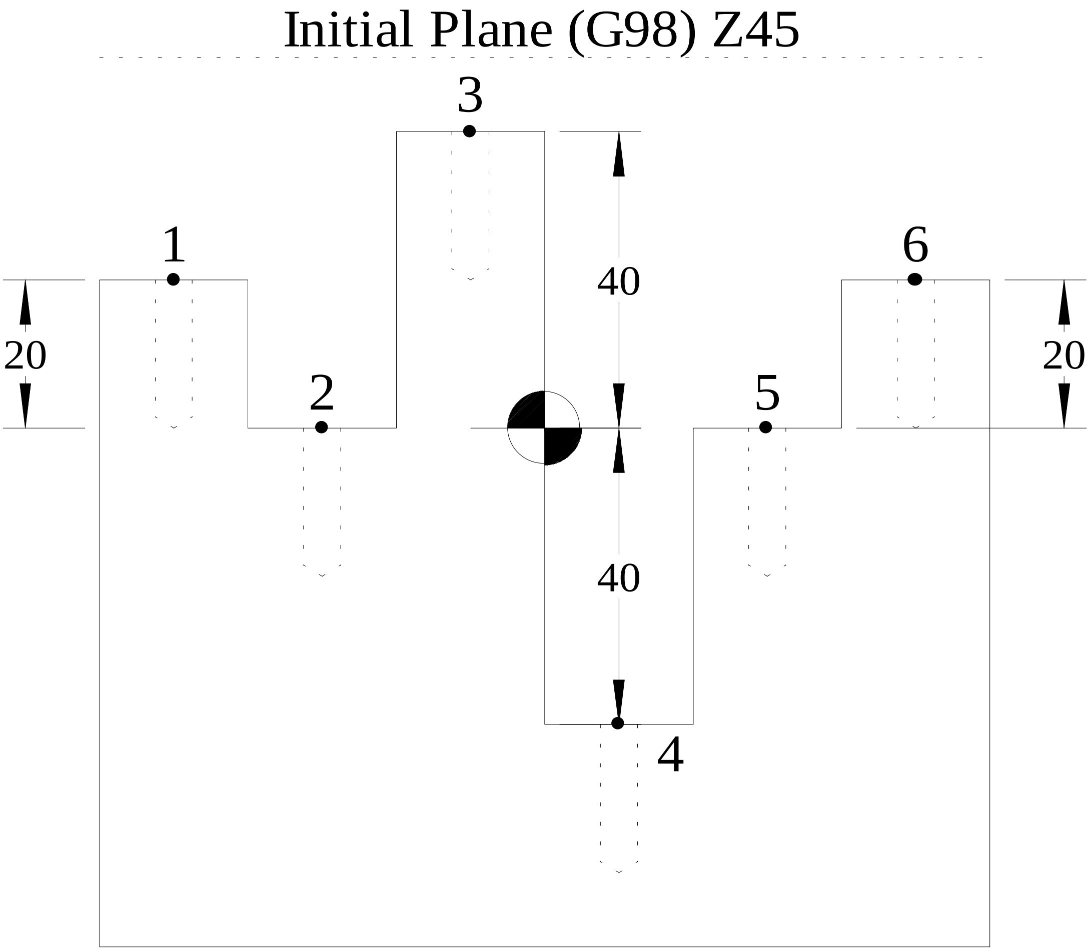
The actions are:
G98 = Return the tool to the last Z axis program position before the cycle line.
G99 = Return the tool point to the programmed "R" position on the cycle line.

*** The machine default for G98/G99 is set to G98 ***

A basic canned cycle always follows a sequence of four operations:
1) Rapid traverse X & Y axis to hole centre position.
2) Rapid traverse down to "R" position.
3) Feed to Z absolute depth.
4) Rapid to "R" position or Initial level.

Hole Canned Cycles

"G98/G99" & "R" Positions



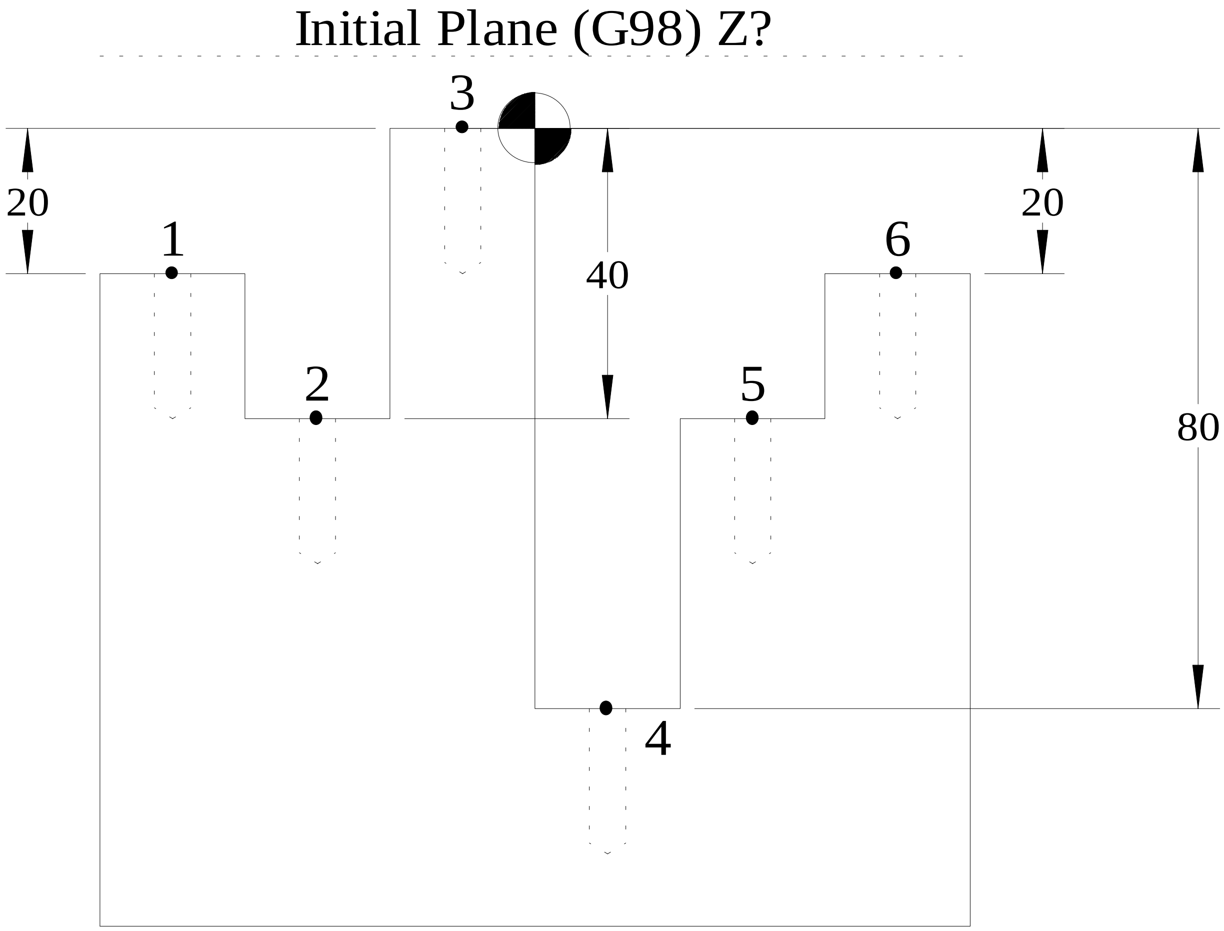
Section View YZ plane

All holes 20mm Deep

(Set Initial point) Z45	
(Point 1)	G99 G? X? Y? R23 Z0 F?
(Point 2)	G98 X? Y? R3 Z-20
(Point 3)	G99 X? Y? R43 Z20
(Point 4)	G98 X? Y? R-37 Z-60
(Point 5)	(G98) X? Y? R3 Z-20
(Point 6)	(G98 or G99) X? Y? R20 Z0

Hole Canned Cycles

“G98/G99” & “R” Positions



Section View YZ plane

All holes 20mm Deep

(Set Initial point)

(Point 1)

(Point 2)

(Point 3)

(Point 4)

(Point 5)

(Point 6)

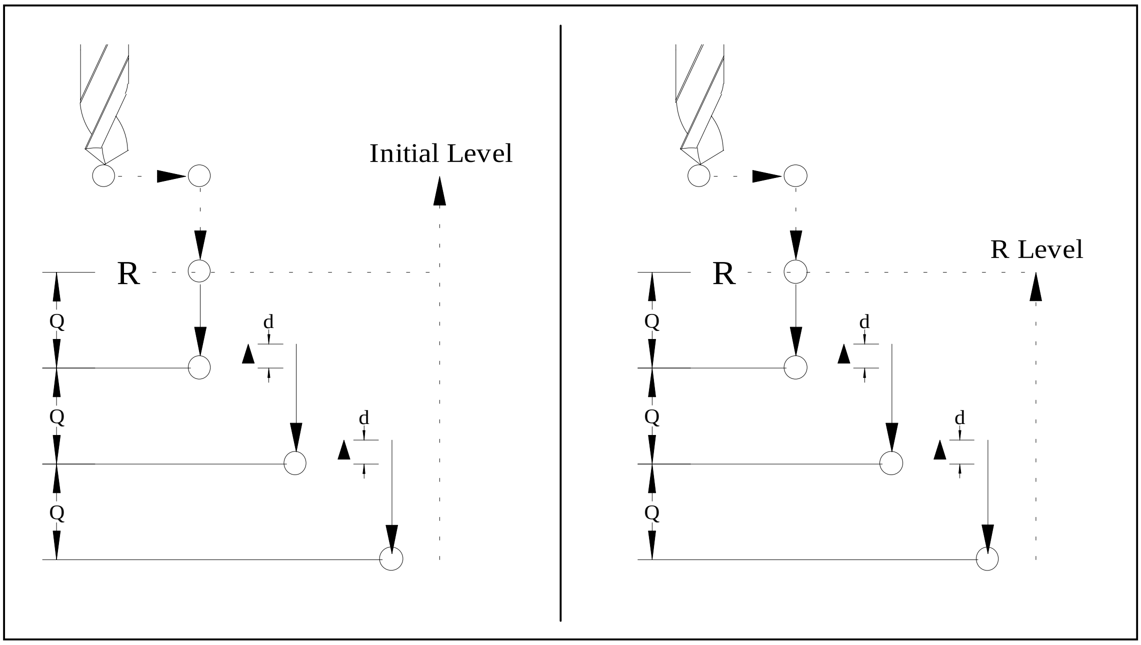
High Speed Peck Drilling
G73

G73 [G98 or G99 X? Y?] Z? R? Q? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
Q? = Modal incremental depth of cut for each peck
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G73 (G98)	G73 (G99)



S1000 M3 ;	**- Spindle start.**
G73 G99 X? Y? Z? R? Q? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

This cycle creates a peck at the programmed pecking value (Q?) with a short chip break retraction at a value as set in parameter 5114 before creating the next peck at value Q?.

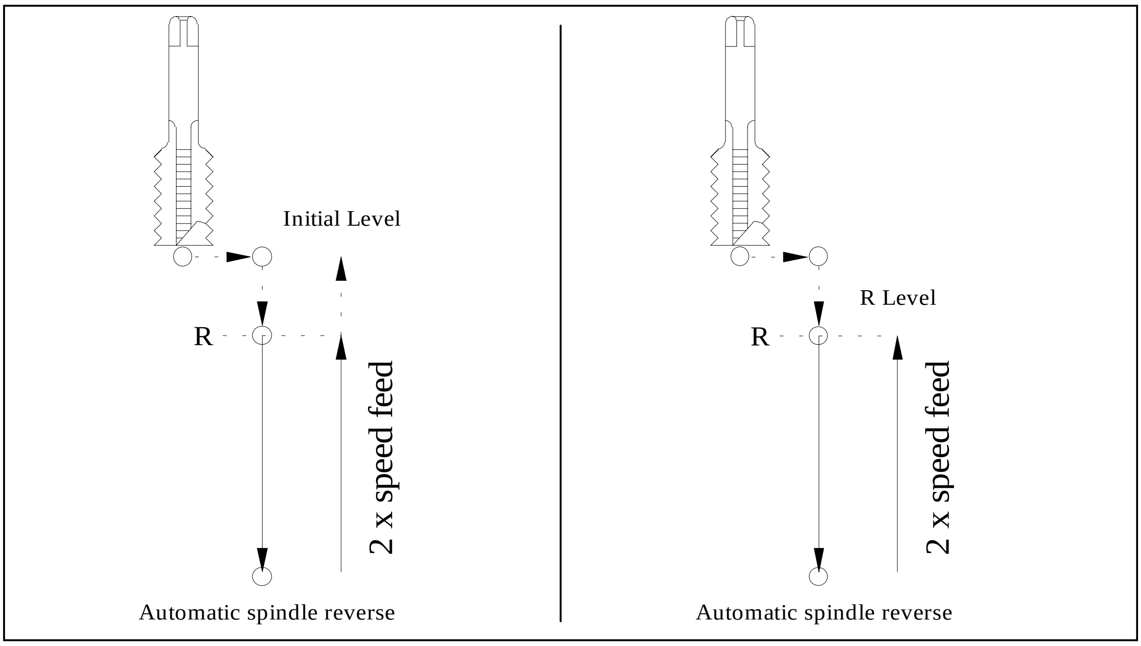
At Z finish position the tool retracts automatically.

Left Hand Tapping
G74

G74 [G98 or G99 X? Y?] Z? R? [Q?] F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
Q? = Modal incremental depth of cut for each peck
F? = Modal cutting feedrate
[ ] denotes optional input for the first hole.

G74 (G98)	G74 (G99)



S1000 ;	**- Spindle speed.**
G74 G99 X? Y? Z? R? Q? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

This cycle can create a peck at a value of Q? if programmed with either a short chip break retraction or a full retraction as set in parameter 5200 #5 (1 = full retract).

At Z finish position the tool retracts at twice speed/feed automatically.

Adding G95 (feed/revolution) on the line of program, the feedrate = the pitch of tap.
i.e. M8 x 1.25 pitch tap
G98 G95 G74 X? Y? Z? R? F1.25 M?

Ensure the next tool is set back to G94 (feed per minute) if programming feed per minute.

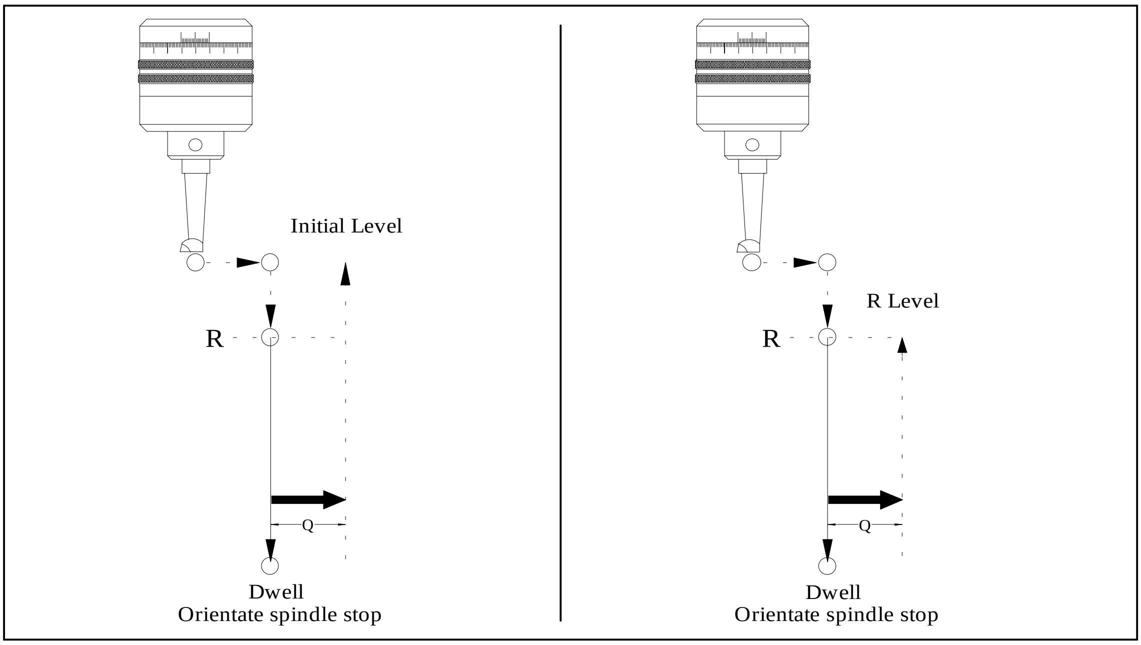
Fine Boring
G76

G76 [G98 or G99 X? Y?] Z? R? Q? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
Q? = Modal incremental axis shift off centreline.
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G76 (G98)	G76 (G99)



S1000 M3 ;	**- Spindle start.**
G76 G99 X? Y? Z? R? Q? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

This cycle is a finish boring cycle and will shift off bore centre line at depth after the spindle stops and orientates to the toolchange angle. The shift is dependent on parameter 5101 as:

7	6	5	4	3	2	1	0	Bit Number	
		0	0					X+	Shift
		0	1					X-	
		1	0					Y+	
		1	1					Y-	

<u>At Z finish position the tool retracts automatically.</u>

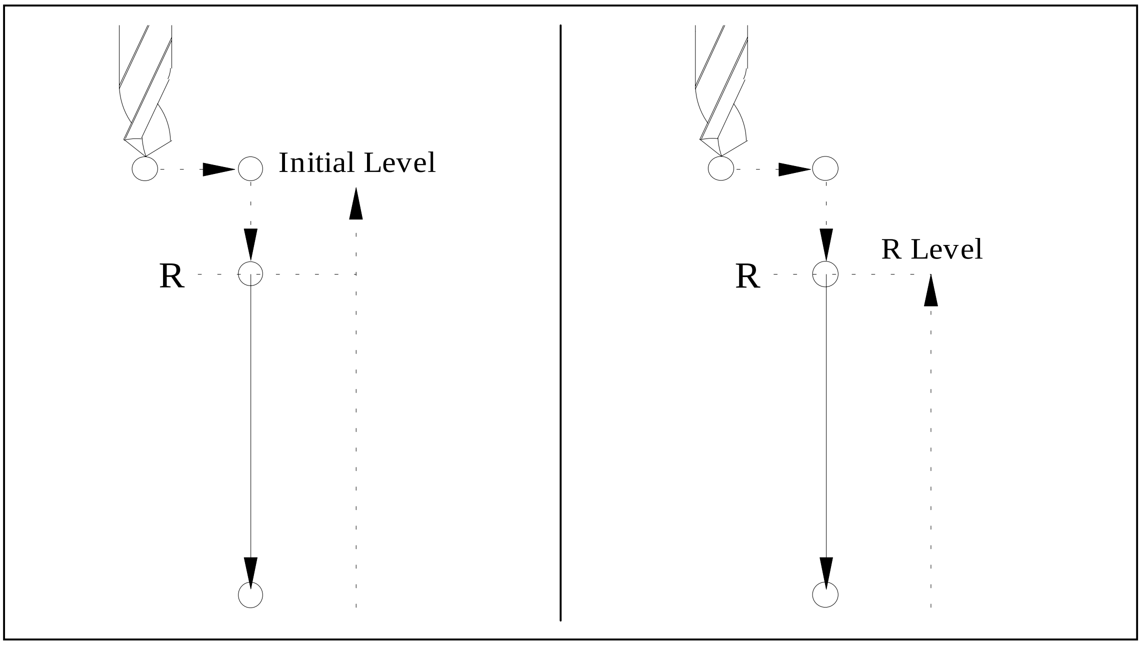
Drilling
G81

G81 [G98 or G99 X? Y?] Z? R? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G81 (G98)	G81 (G99)



S1000 M3 ;	**- Spindle start.**
G81 G99 X? Y? Z? R? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

At Z finish position the tool retracts automatically.

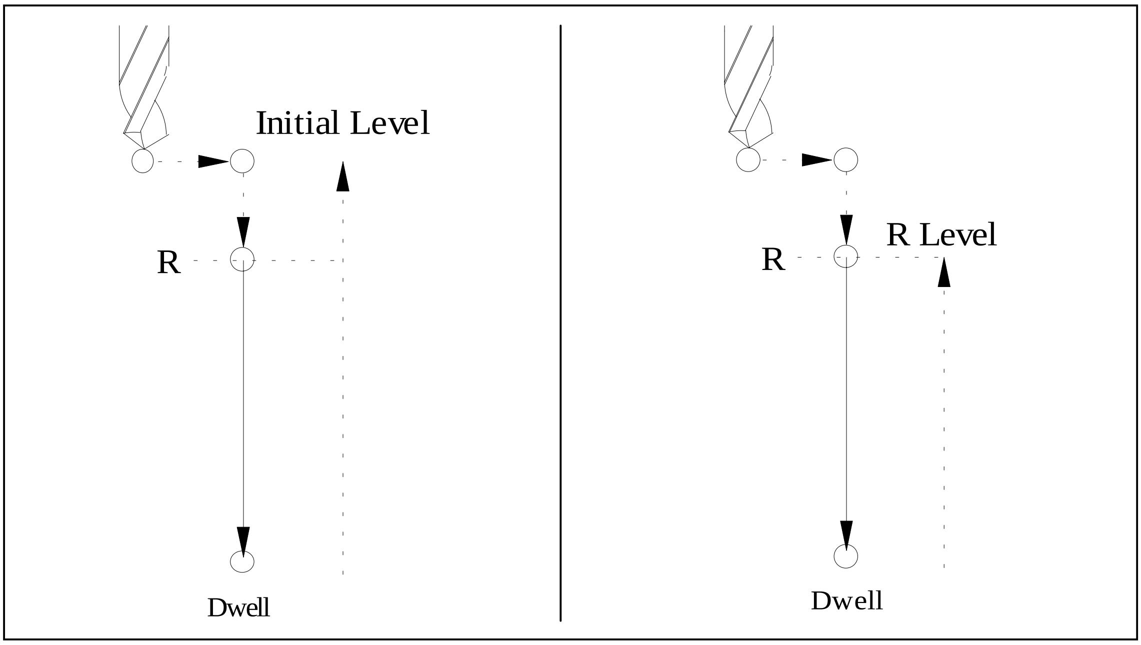
Drilling
G82

G82 [G98 or G99 X? Y?] Z? R? P? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
P? = Dwell time in milliseconds (1sec. = P1000)
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G82 (G98)	G82 (G99)



S1000 M3 ;	**- Spindle start.**
G82 G99 X? Y? Z? R? P? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

At Z finish position the tool retracts automatically.

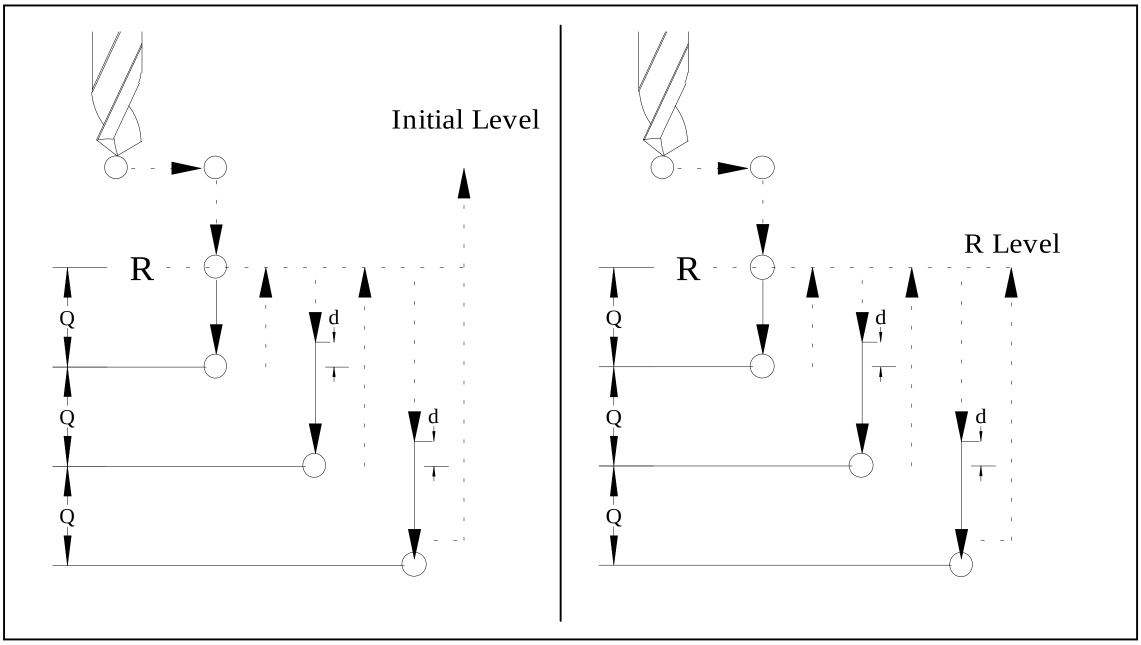
Peck Drilling
G83

G83 [G98 or G99 X? Y?] Z? R? Q? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
Q? = Modal incremental depth of cut for each peck
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G83 (G98)	G83 (G99)



```
S1000 M3 ;                           - Spindle start.
G83 G99 X? Y? Z? R? Q? F? M? ;       - Position to 1st hole setting all data.
X? ;                                 - Position to 2nd hole.
Y? ;                                 - Position to 3rd hole
G0 G90 G80 Z100  ;                   - Tool to a safe height (G80 cancel)
```

This cycle creates a peck at the programmed pecking value (Q?) with a full chip break retraction back to R position. The tool repositions itself into the hole and stops above the last peck position at a value as set in parameter 5115 before creating the next peck at value Q?.

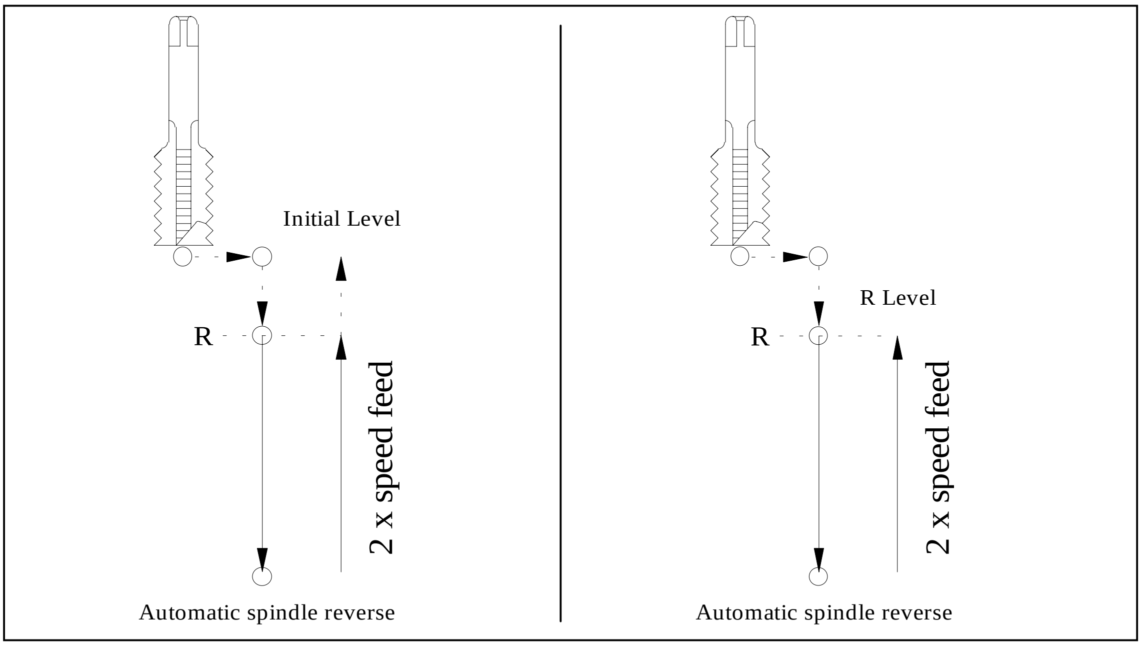
At Z finish position the tool retracts automatically.

Right Hand Tapping
G84

G84 [G98 or G99 X? Y?] Z? R? [Q?] F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
Q? = Modal incremental depth of cut for each peck
F? = Modal cutting feedrate
[ ] denotes optional input for the first hole.

G84 (G98)	G84 (G99)



S1000 ;	**- Spindle speed.**
G84 G99 X? Y? Z? R? Q? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

This cycle can create a peck at a value of Q? if programmed with either a short chip break retraction or a full retraction as set in parameter 5200 #5 (1 = full retract).

At Z finish position the tool retracts at twice speed/feed automatically.

Adding G95 (feed/revolution) on the line of program, the feedrate = the pitch of tap.
i.e. M8 x 1.25 pitch tap
G98 G95 G84 X? Y? Z? R? F1.25 M?

Ensure the next tool is set back to G94 (feed per minute) if programming feed per minute.

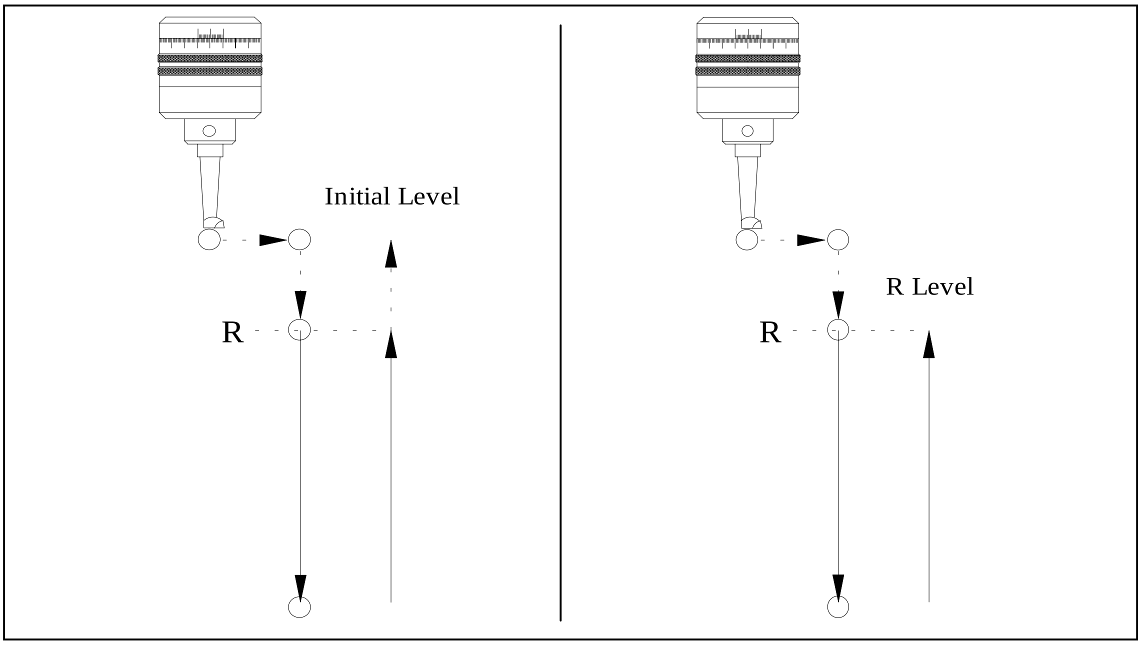
Boring
G85

G85 [G98 or G99 X? Y?] Z? R? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G85 (G98)	G85 (G99)



S1000 M3 ;	**- Spindle start.**
G85 G99 X? Y? Z? R? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

This cycle feeds to the programmed depth position and will then retract back out of the hole at the same speed/feedrate.

At Z finish position the tool retracts automatically.

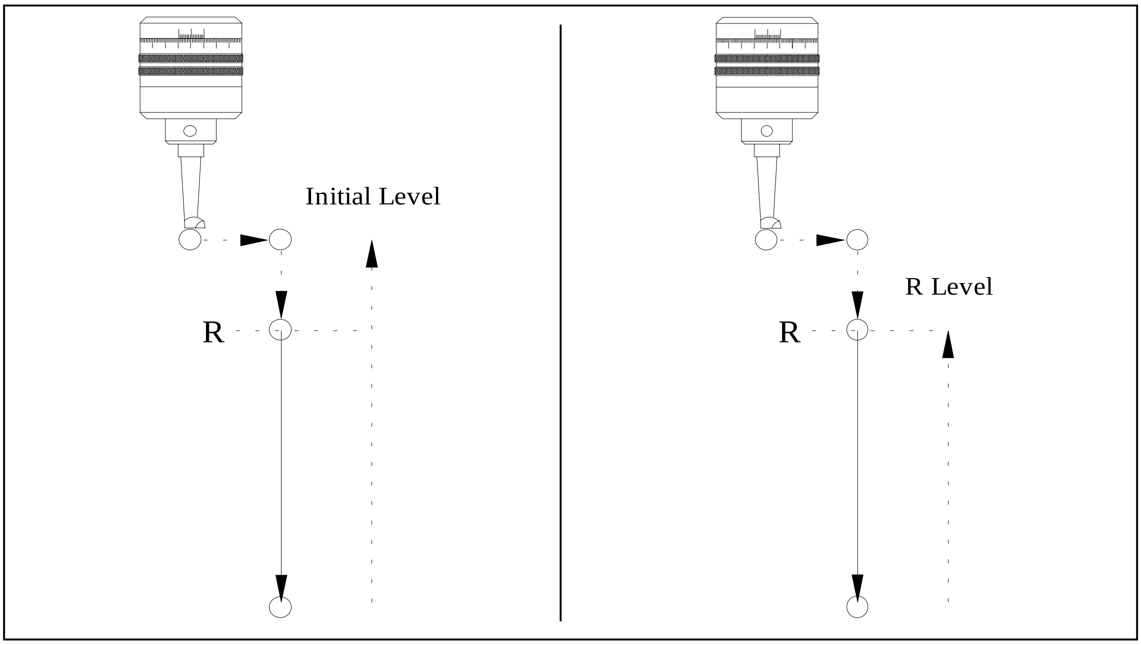
Boring
G86

G86 [G98 or G99 X? Y?] Z? R? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G86 (G98)	G86 (G99)



```
S1000 M3 ;                       - Spindle start.
G86 G99 X? Y? Z? R? F? M? ;      - Position to 1st hole setting all data.
X? ;                             - Position to 2nd hole.
Y? ;                             - Position to 3rd hole
G0 G90 G80 Z100  ;               - Tool to a safe height (G80 cancel)
```

This cycle feeds to the programmed depth position and will then retract back out of the hole at rapid feedrate.

At Z finish position the tool retracts automatically.

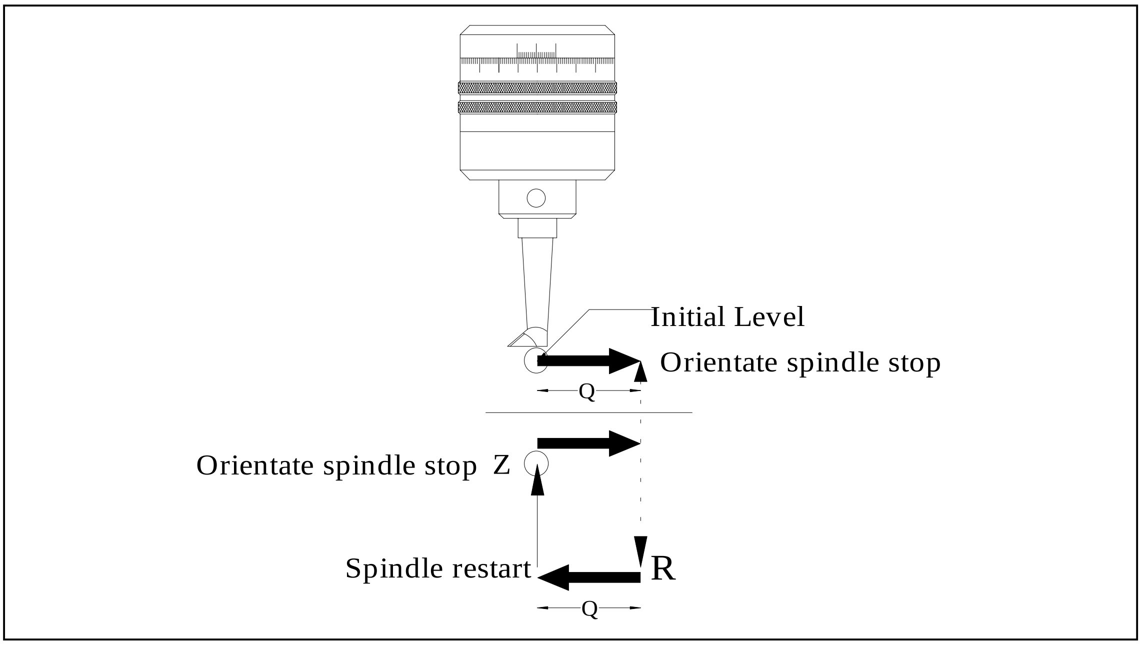
Back Boring
G87

G87 G98 [X? Y?] Z? R? Q? [P?] F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
Q? = Modal incremental axis shift off centreline.
P? = Dwell time in milliseconds (1sec. = P1000)
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G87 (G98)



```
S1000 M3 ;                              - Spindle start.
G87 G98 X? Y? Z? R? Q? P? F? M? ;       - Position to 1st hole setting all data.
X? ;                                    - Position to 2nd hole.
Y? ;                                    - Position to 3rd hole
G0 G90 G80 Z100  ;                      - Tool to a safe height (G80 cancel)
```

This cycle creates a machining cycle as counterbores or chamfers at the bottom of a hole. The tool positions itself above the hole with the spindle at orientation position, rapids thro' hole off centreline, repositions on centreline with the spindle revolving to allow feed motion up. Opposite sequence to above for retraction.

See G76 parameter shift notes

At Z finish position the tool retracts automatically.

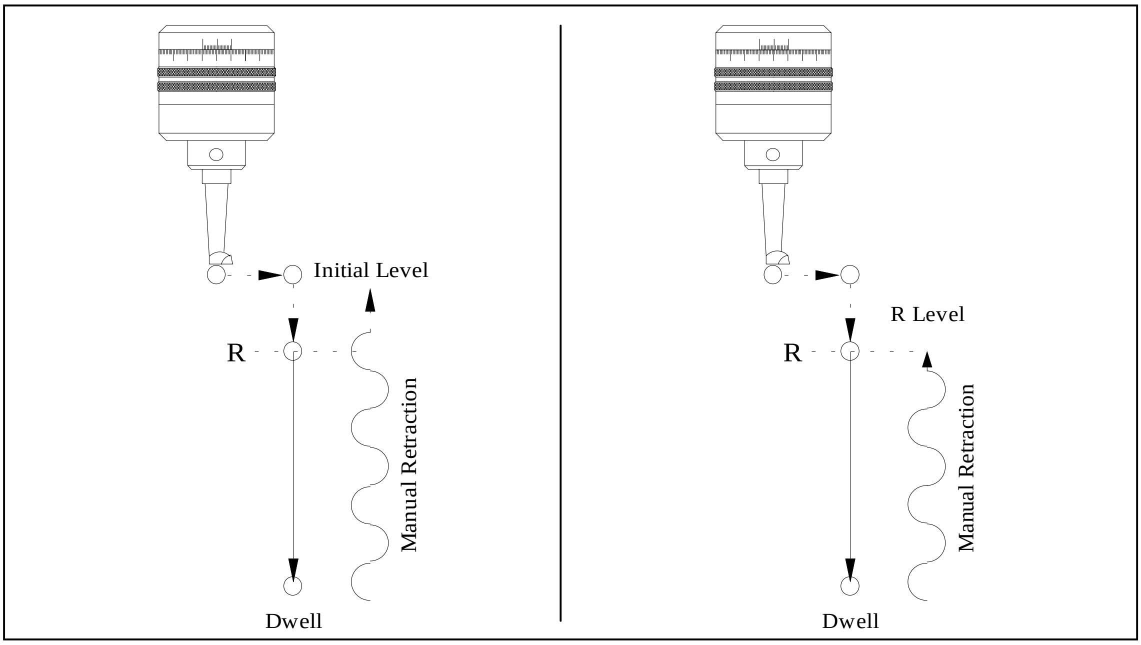
Boring
G88

G88 [G98 or G99 X? Y?] Z? R? Q? [P?] F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
P? = Dwell time in milliseconds (1sec. = P1000)
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G88 (G98)	G88 (G99)



```
S1000 M3 ;                           - Spindle start.
G88 G99 X? Y? Z? R? P? F? M? ;       - Position to 1st hole setting all data.
X? ;                                 - Position to 2nd hole.
Y? ;                                 - Position to 3rd hole
G0 G90 G80 Z100  ;                   - Tool to a safe height (G80 cancel)
```

This cycle will automatically stop the spindle at Z position after dwell. The tool is then manually retracted out of the hole using the handwheel or power feeds. At the requested return position the spindle will restart and rapid motion is performed to the next position for cycle.

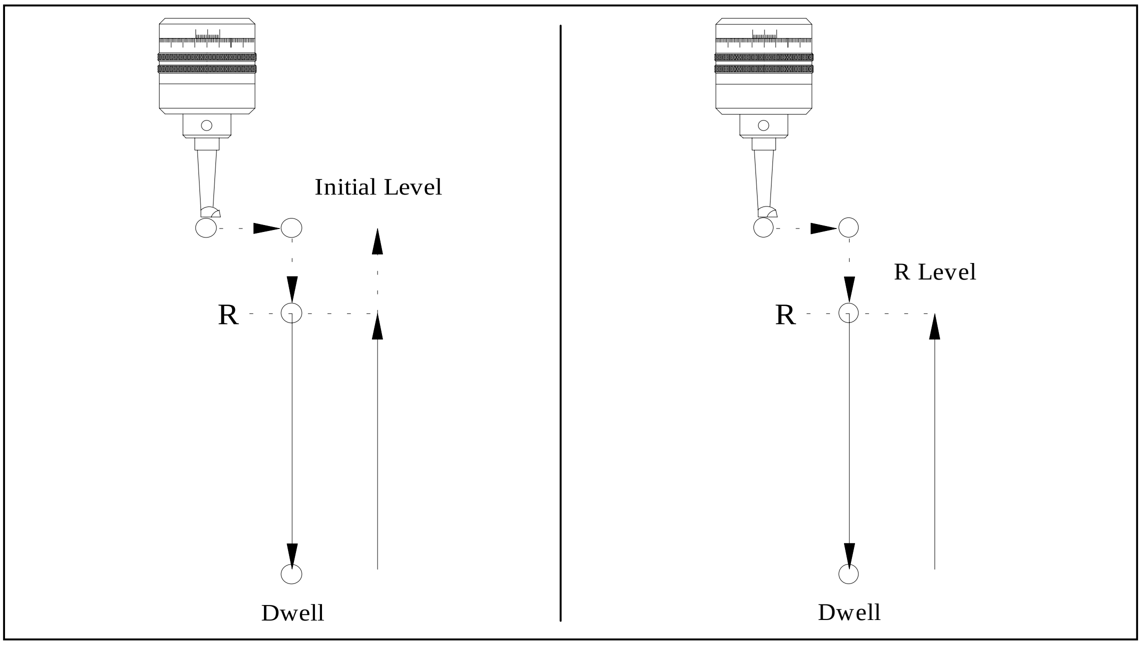
Boring
G89

G89 [G98 or G99 X? Y?] Z? R? Q? P? F?

X? = Modal hole centre position
Y? = Modal hole centre position
Z? = Modal absolute hole depth position
R? = Modal tool starting position above hole surface
P? = Dwell time in milliseconds (1sec. = P1000)
F? = Modal cutting feedrate

[ ] denotes optional input for the first hole.

G89 (G98)	G89 (G99)

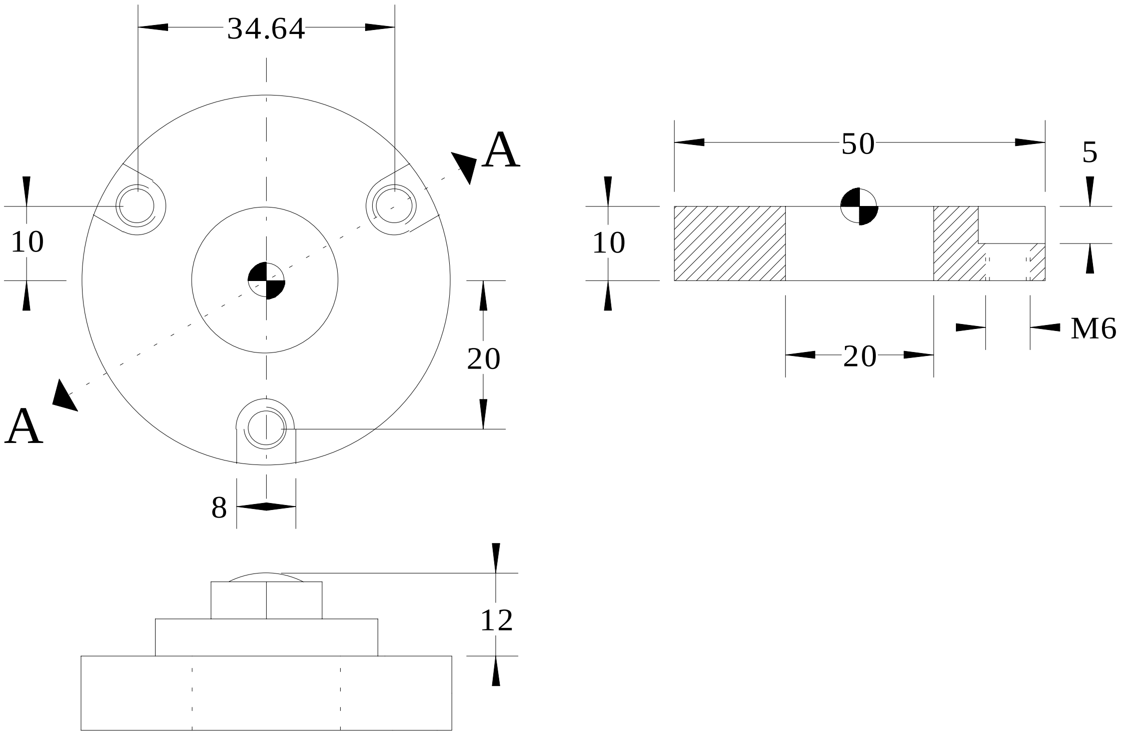


S1000 M3 ;	**- Spindle start.**
G89 G99 X? Y? Z? R? P? F? M? ;	**- Position to 1st hole setting all data.**
X? ;	**- Position to 2nd hole.**
Y? ;	**- Position to 3rd hole**
G0 G90 G80 Z100 ;	**- Tool to a safe height (G80 cancel)**

This cycle feeds to the programmed depth position, dwells, then retract back out of the hole at the same speed/feedrate.

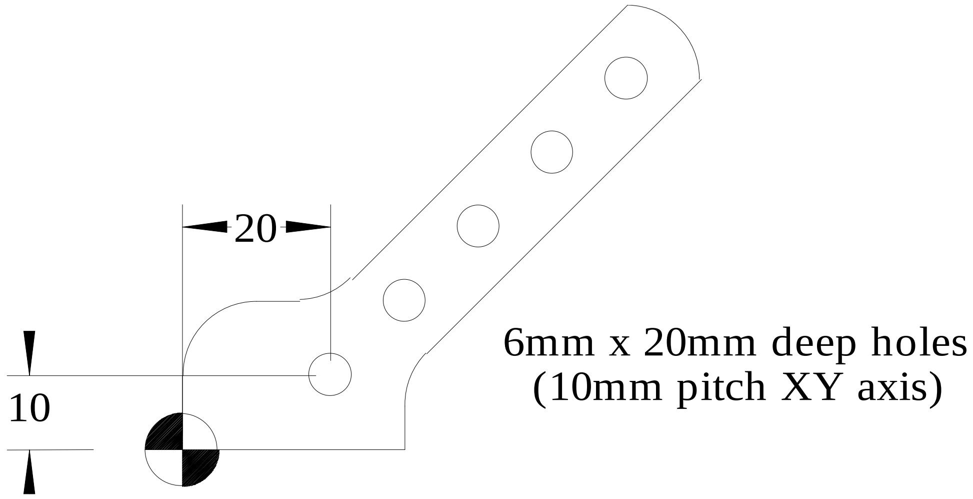
At Z finish position the tool retracts automatically.

Hole Example



Fixture View

Repeats



```
O1000 ;
T1 M6 (Toolchange line - 6mm Drill) ;
(Repeat Drilling of holes using K word) ;
G0 G90 G40 G21 G17 G94 G80 ;
G54 X20 Y10 S? M3 ;
G43 Z100 H? ;
Z3 ;
G81 G99 R3 Z-20 F? M8 ;
G91 X10 Y10 K4 ;
G80 ;
G0 G90 Z100 ;
M30 ;
```

By using a numerical “K” word on an incremental X &or Y axis during a canned cycle allows the cycle to repeat (as the above example).
(K0 = no Z axis action for the specified line).

The maximum allowable repeats are 9999.

9

Sub-Programming

The control provides the ability to access other part programs stored inside the main directory.
If the Sub-program being called is stored in the main directory (stored as a normal program with the letter O as the header), then access is by the use of an M98 command followed by the sub-program number preceded with a letter P.

i.e. **N10 M98 P1004**

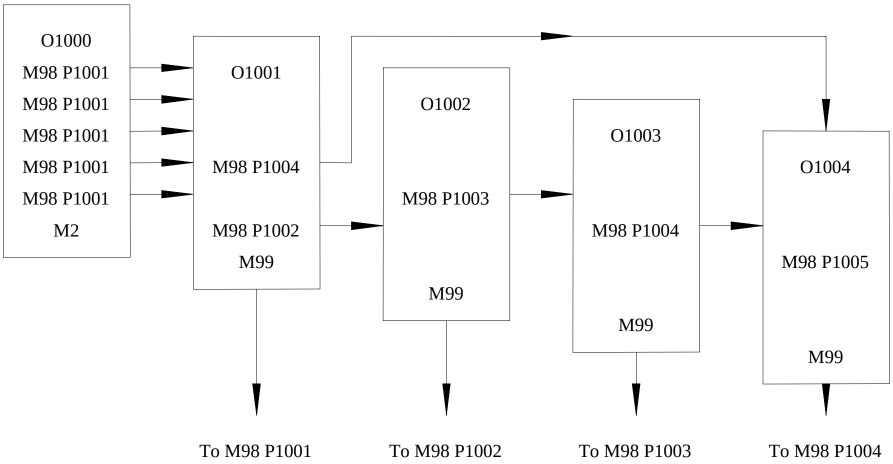
To enable the control to return to the last program position for the program to continue, then an M99 command on the last line of program in the sub-program will enable this.

i.e. **N100 M99**

Notes:

1) When a sub-program is being written, the letter O is still assigned to the program number.
2) When a sub-program is called, the letter P is assigned to the program number.
3) M99 can also be written at the end of a main program, and would result in a continuous program loop.

Sub-programs can be nested to a maximum of 4 levels as below:



There is no limit to the amount of sub-programs called within each nested level.

Sub-Program repeats

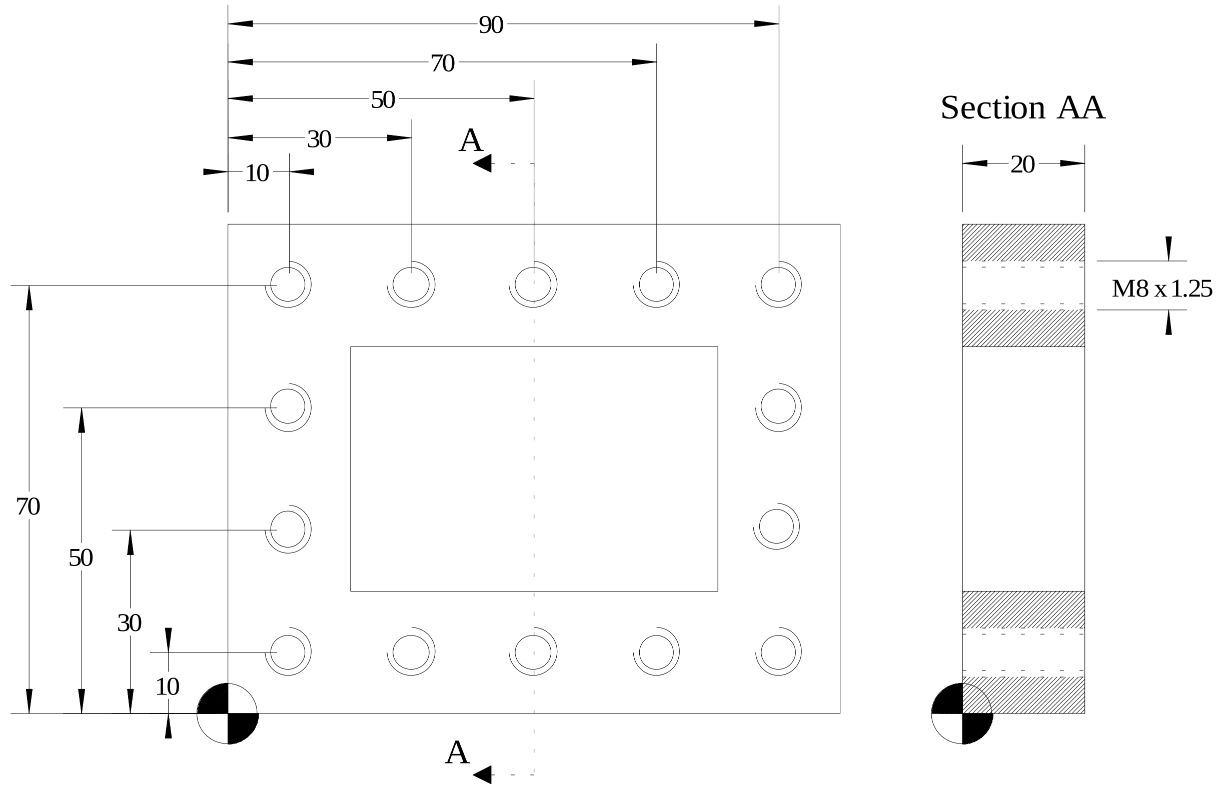
The control also has the ability to contain a repeat command as part of the M98 program line.
When the program line is written with the M98 P1004 command the control actually reads the line of information as M98 P00001004 , the first 4 digits after the P word being the repeat amount.
To repeat a sub-program (O1004) 33 times, the program line would read as follows:
i.e. **M98 P331004**

The control also has the ability to jump to a specific program line number on its return to the main program using the M99 command as:
i.e. **M99 P100**

This command above will move the control to line number N100 in the main program.

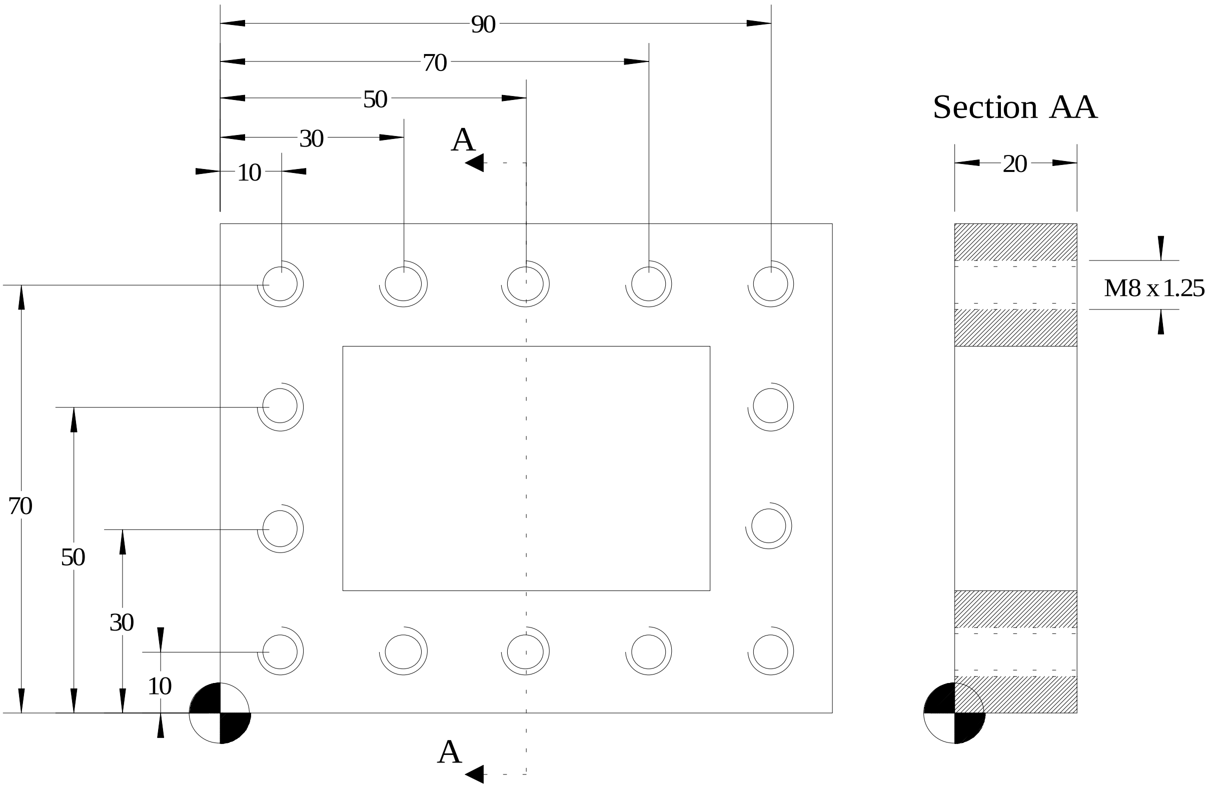
Sub-Programming

"Normal Program"



```
O1000 ;
T1 M6  ;
G0 G90 G40 G21 G17 G94 G80 ;
G54 X10 Y10 S? M3 ;
G43 Z100 H1 ;
Z5 ;
G81 R3 Z-20 F? M8 ;
Y30 ;
Y50 ;
Y70 ;
X30 ;
X50 ;
X70 ;
X90 ;
Y50 ;
Y30 ;
Y10 ;
X70 ;
X50 ;
X30 ;
G80 ;
G0 G90 Z100
T2 M6  ;
G0 G90 G40 G21 G17 G94 G80 ;
G54 X10 Y10 S? M3 ;
G43 Z100 H1 ;
Z5 ;
G84 G99 G95 R3 Z-20 F1.25 M8 ;
Y30 ;
Y50 ;
Y70 ;
X30 ;
X50 ;
X70 ;
X90 ;
Y50 ;
Y30 ;
Y10 ;
X70 ;
X50 ;
X30 ;
G80 ;
G0 G90 Z100 ;
T0 M6 ;
M30 ;
```

Sub-Programming
"Sub-Program version"

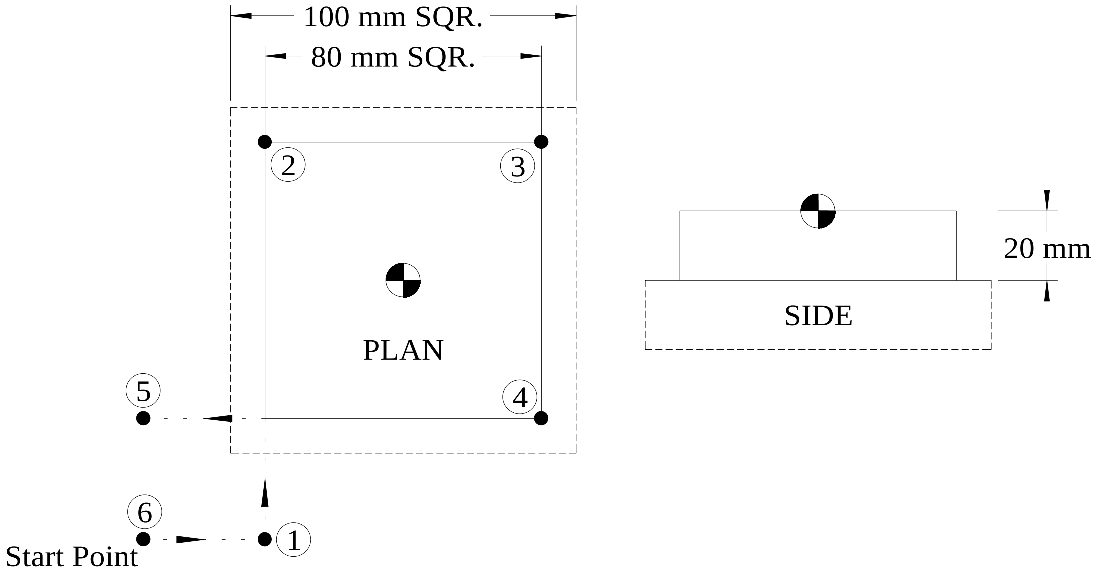


```
O1000 ;
N1 T1 M6  ;
N2 G0 G90 G40 G21 G17 G94 G80 ;
N3 G54 X10 Y10 S? M3 ;
N4 G43 Z100 H1 ;
N5 Z5 ;
N6 G81 R3 Z-20 F? M8 ;
N7 M98 P1001 ;
N8 G0 G90 Z100
N9 T2 M6  ;
N10 G0 G90 G40 G21 G17 G94 G80 ;
N11 G54 X10 Y10 S? M3 ;
N12 G43 Z100 H1 ;
N13 Z5 ;
N14 G84 G99 G95 R3 Z-20 F1.25 M8 ;
N15 M98 P1001 ;
N16 G0 G90 Z100 ;
N17 T0 M6 ;
N18 M30 ;
```

```
O1001 ;
N101 Y30 ;
N102 Y50 ;
N103 Y70 ;
N104 X30 ;
N105 X50 ;
N106 X70 ;
N107 X90 ;
N108 Y50 ;
N109 Y30 ;
N110 Y10 ;
N111 X70 ;
N112 X50 ;
N113 X30 ;
N114 G80 ;
N115 M99 (back to N7 & N15) ;
```

Sub-Programming

“Contour pecking”



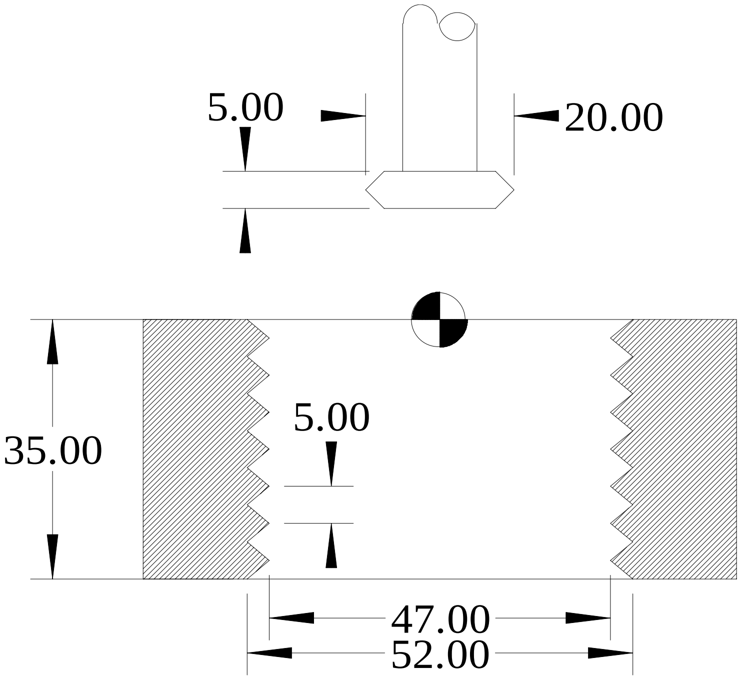
```
O4000 ;
T? M6  ;
G0 G90 G40 G21 G17 G94 G80 (Safety default line) ;
G54 X-75 Y-75 S? M3 (Absolute Start Point.) ;
G43 Z100 H? (Initial check height)
Z5 (Rapid to a position above material.) ;
G1 Z0 F? (Feed to surface top) ;
M98 P104001 (Call sub-program & repeat 10 times) ;
G0 G90 Z100 (Move to Safe height above material.) ;
M30 (End program leaving tool in the spindle ready for next load.)
```

```
O4001 ;
G1 G91 Z-2 (Incremental peck depth) ;
G90 G41 X-40 D? M8 (Move to position 1 with comp. - Switch on coolant) ;
Y40 (Move to position 2.) ;
X40 (Move to position 3.) ;
Y-40 (Move to position 4.) ;
X-75 (Move to position 5 - Clear of material - cutter diameter) ;
G40 Y-75 (Cancel compensation) ;
M99 ;
```

Sub-Programming

“Single Point Tools”

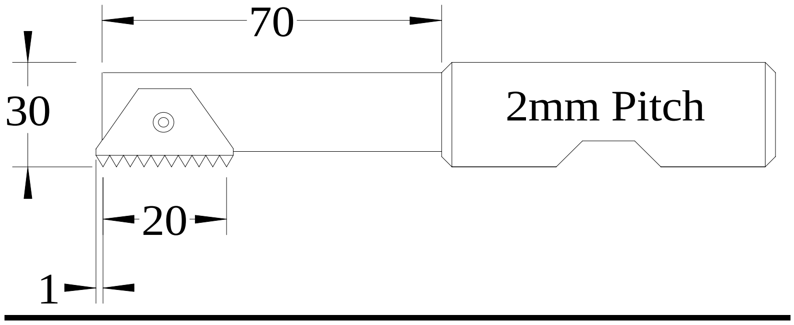
Absolute & Incremental Programming



```
O2000 ;
T1 M6 (Tool change line.) ;
G0 G90 G40 G21 G17 G94 G80  (Safety Line.) ;
G54 X0 Y0 S? M3 (Move to centreline of bore) ;
G43 Z100 H? (Set tool length) ;
Z5 (Move to bore top) ;
G1 Z-38.75 F? (Feed to depth + ¼  of pitch for arcing ON + nose width/2.) ;
G91 Y5 (Move to Arc On bore centre 26(AR) – 21(SR) = 5(YD) incrementally) ;
G41 X21 D?  (Apply compensation as a straight line.) ;
G3 X-21 Y21 Z1.25 R21 (This line creates a ¼  arc + Z movement of a ¼ of pitch) ;
M98 P72001 ;
X-21 Y-21 Z1.25 R21 (This line creates a ¼  arc + Z movement of a ¼  of pitch) ;
G1 G40 X21 (Cancel Compensation as a straight line) ;
G0 G90 Z100 (Clear the workpiece) ;
M30 (End the Program) ;
```

```
O2001 ;
Z5 J-26 (This incremental line will create 1 pitch of 5mm.) ;
M99 ;
```

Sub-Programming
"Multi toothed Tools"
Absolute & Incremental Programming



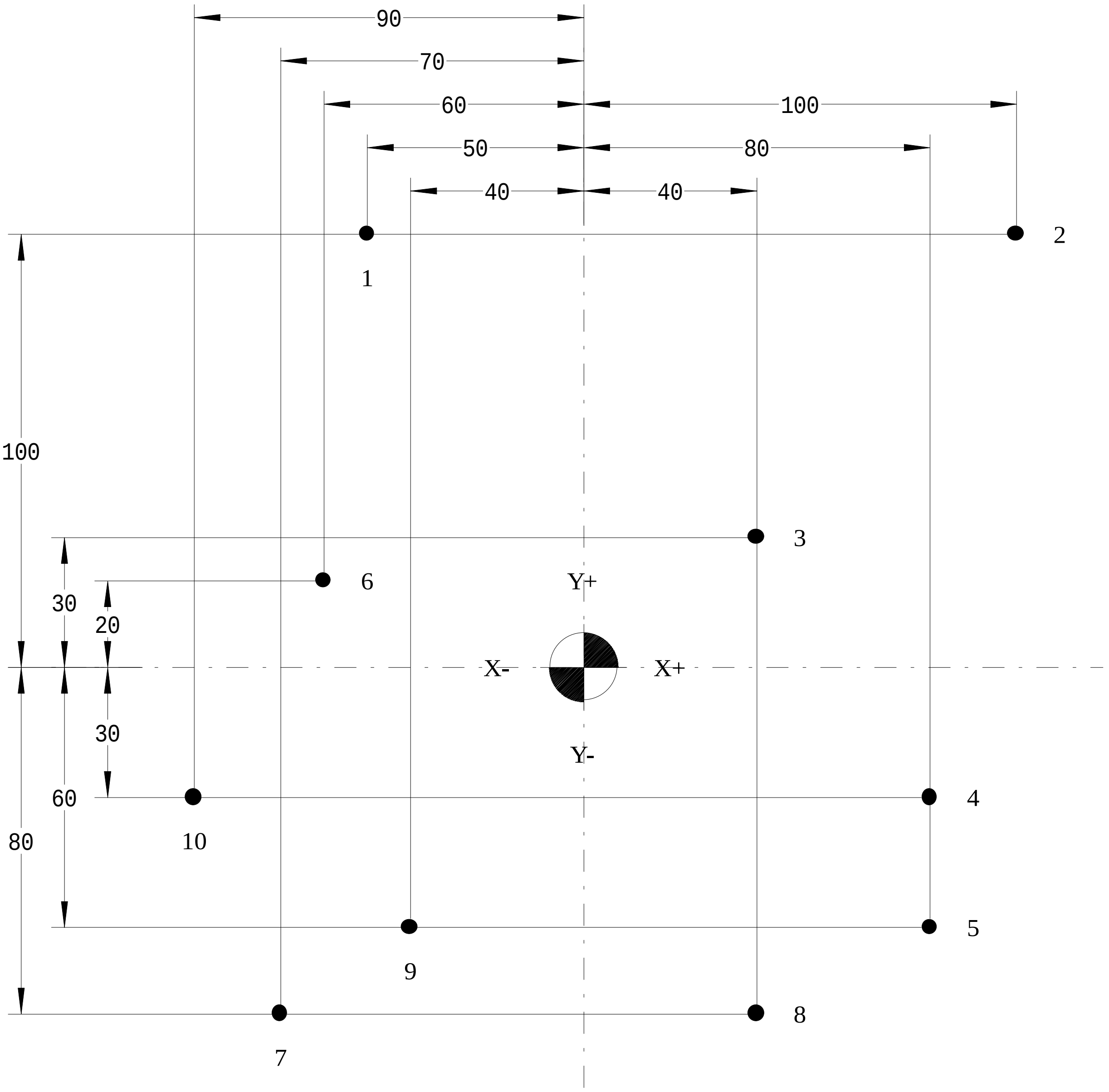
***Produce a Thread M60 x 2mm pitch (60mm Deep)**

```
O3000 ;
T1 M6 (Tool change line.) ;
G0 G90 G40 G21 G17 G94 G80 (Safety Line.) ;
G54 X0 Y0 S? M3 (Move to centreline of bore) ;
G43 Z100 H? (Set tool length) ;
Z5 (Move to feed clearance) ;
G1 Z-61.5 F? (To depth + ¼ of pitch for arcing ON + ½ tooth form width to tool end) ;
M98 P3001 ;
G0 G90 Z-41.5 (Subtract edge length from 1st Z positioning move 61.5 – 20 = 41.5) ;
M98 P3001 ;
G0 G90 Z-21.5 (Subtract edge length from 2nd  Z positioning move 41.5 – 20 = 21.5) ;
M98 P3001 ;
G0 G90 Z100 (Clear the workpiece) ;
M30 (End the Program.) ;
```

```
O3001 ;
G91 Y10 (Move to Arc On bore centre 30(AR) – 20(SR) = 10(YD)) ;
G1 G91 G41 X20 D? (Apply compensation as a straight line) ;
G3 X-20 Y20 Z0.5 R20 (This line creates a ¼ arc + Z movement of a ¼ pitch) ;
Z2 J-30 (This line will create 1 pitch.) ;
X-20 Y-20 Z0.5 R20 (Creates a ¼ arc + Z movement of a ¼ of pitch) ;
G1 G40 X20 (Cancel Compensation as a straight line) ;
Y-10 (Move to Main arc centre) ;
M99
```

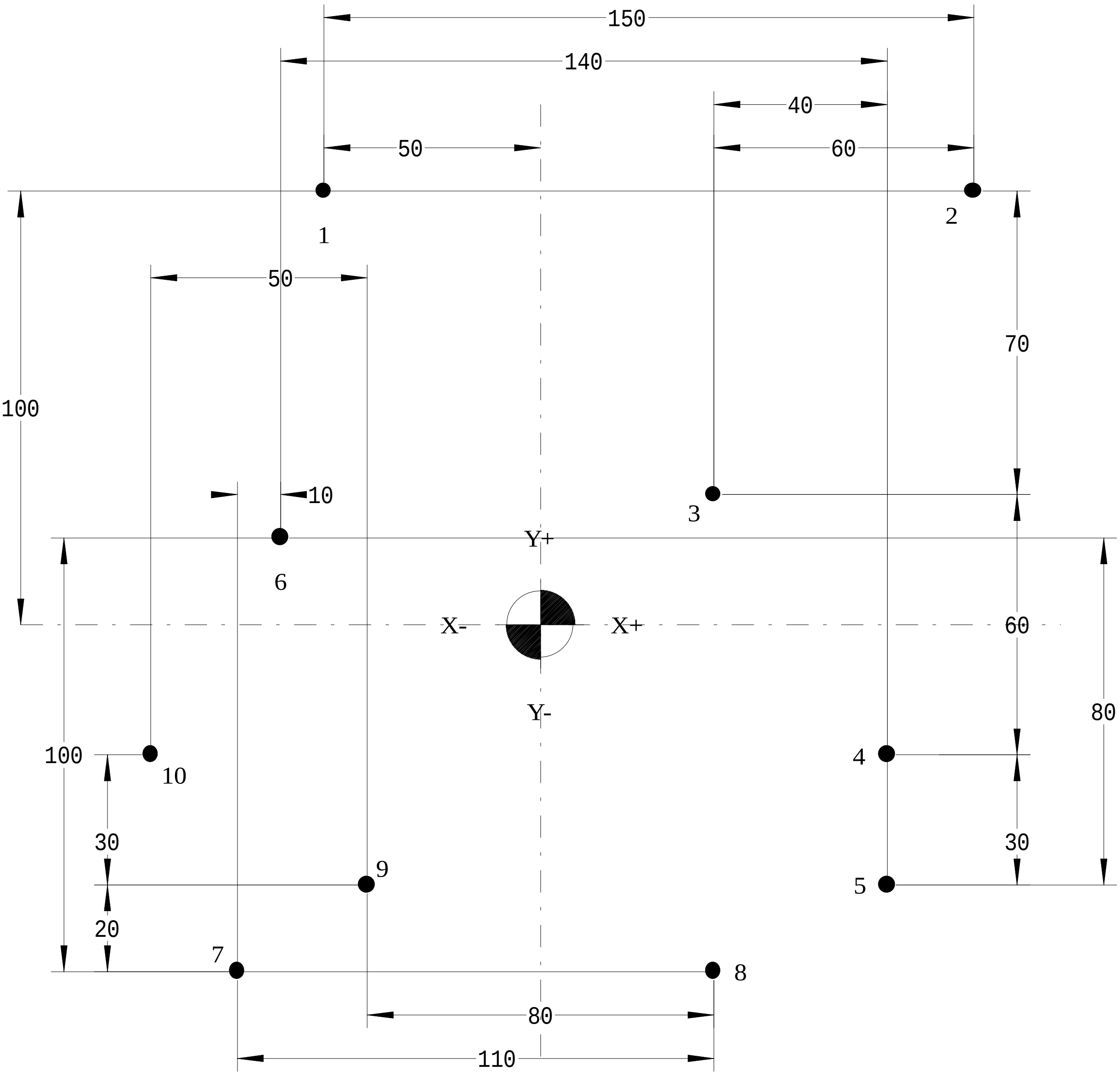
10

G90 Absolute Example Programming



```
N1 G90 X-50 Y100
N2 X100
N3 X40 Y30
N4 X80 Y-30
N5 Y-60
N6 X-60 Y20
N7 X-70 Y-80
N8 X40
N9 X-40 Y-60
N10 X-90 Y-30
```

G91 Incremental Example Programming



N1 G90 X-50 Y100

N2 G91 X150

N3 X-60 Y-70

N4 X40 Y-60

N5 Y-30

N6 X-140 Y80

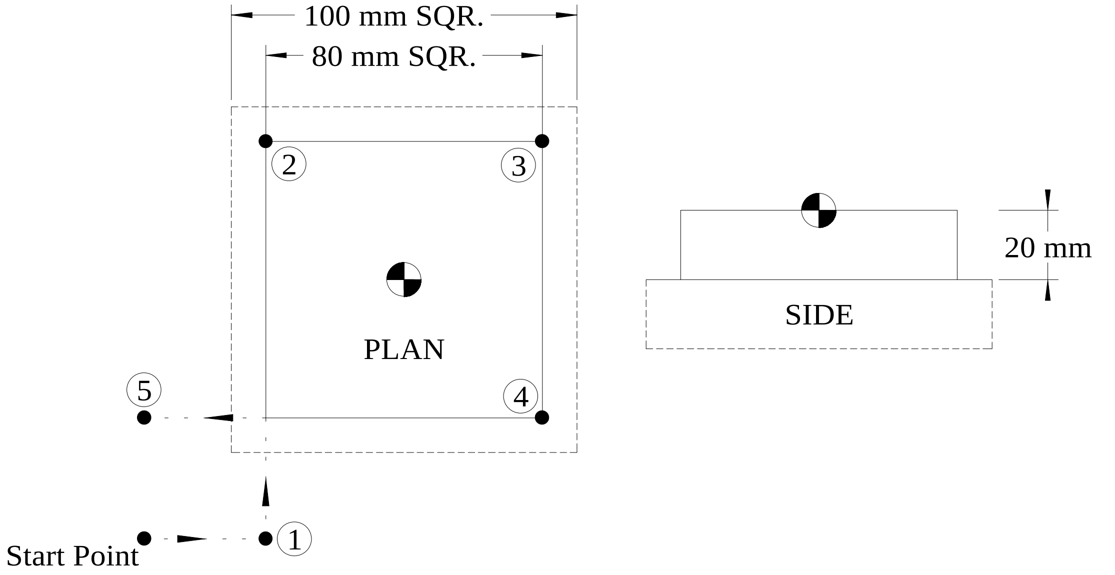
N7 X-10 Y-100

N8 X110

N9 X-80 Y20

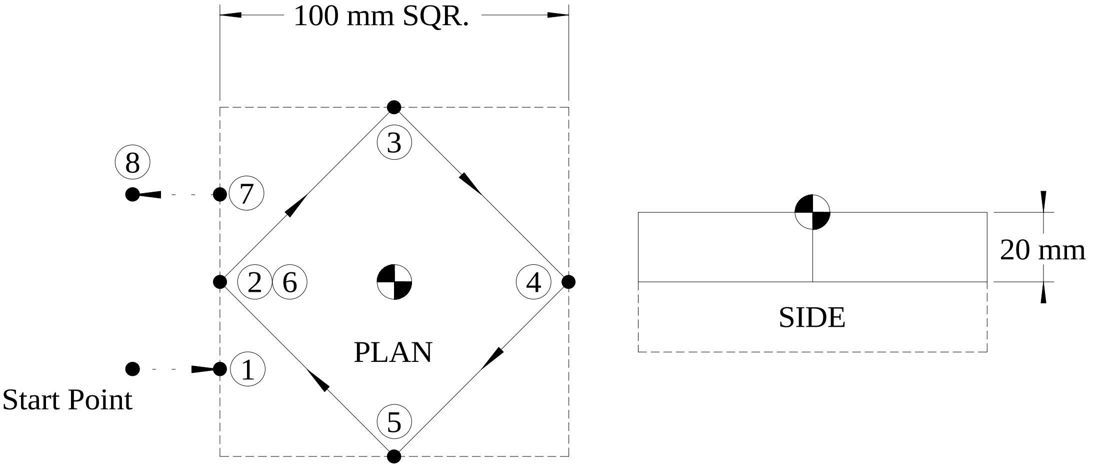
N10 X-50 Y30

Point to Point - example 1 (no compensation)



```
O1000
T? M6
(Linear / Feed - Absolute) ;
G0 G90 G40 G21 G17 G94 G80
G54 X-75 Y-75 S? M3
G43 Z100 H?
Z5
G1 Z-20 F?
X-40
Y40 M8
X40
Y-40
X-75
G0 G90 Z100
M30
```

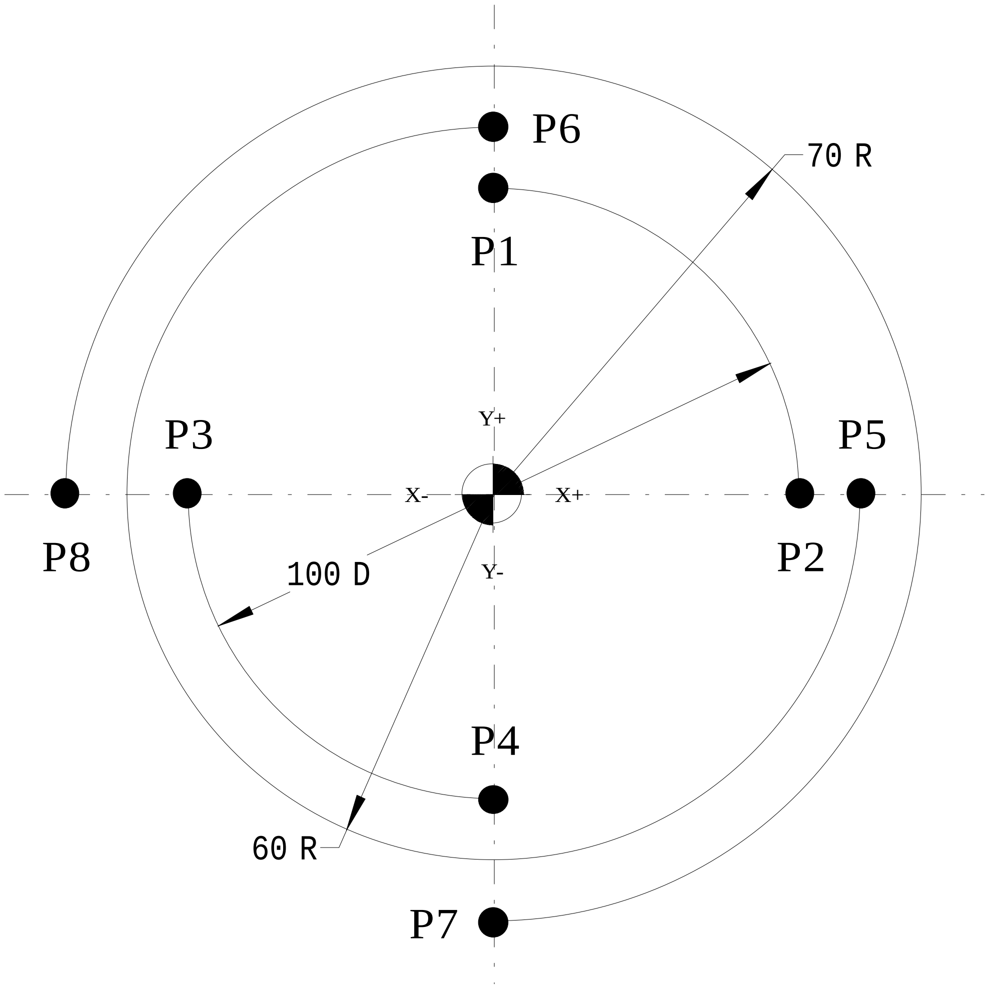
Point to Point - example 2 (no compensation)



```
O1000
T? M6
(Linear / Feed - Absolute) ;
G0 G90 G40 G21 G17 G94 G80
G54 X-75 Y-25 S? M3
G43 Z100 H?
Z5
G1 Z-20 F?
X-50 M8
Y0
X0 Y50
X50 Y0
X0 Y-50
X-50 Y0
Y25
X-75
G0 G90 Z100
M30
```

Circular Programmed Movements – e.g. 1

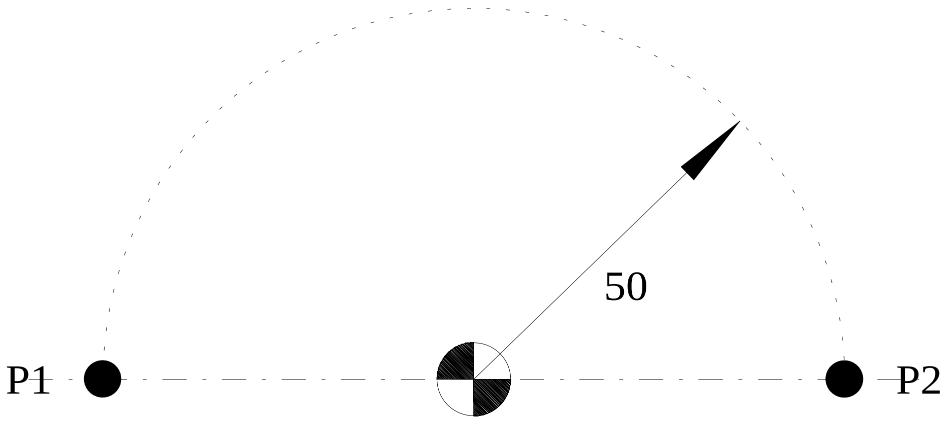
(Absolute)



1	G90 G0 X0 Y50 G2 X50 Y0 R50
2	G90 G0 X-50 Y0 G3 X0 Y-50 R50
3	G90 G0 X60 Y0 G2 X0 Y60 R-60
4	G90 G0 X0 Y-70 G3 X-70 Y0 R-70

Circular Programmed Movements – e.g. 2

(Absolute)



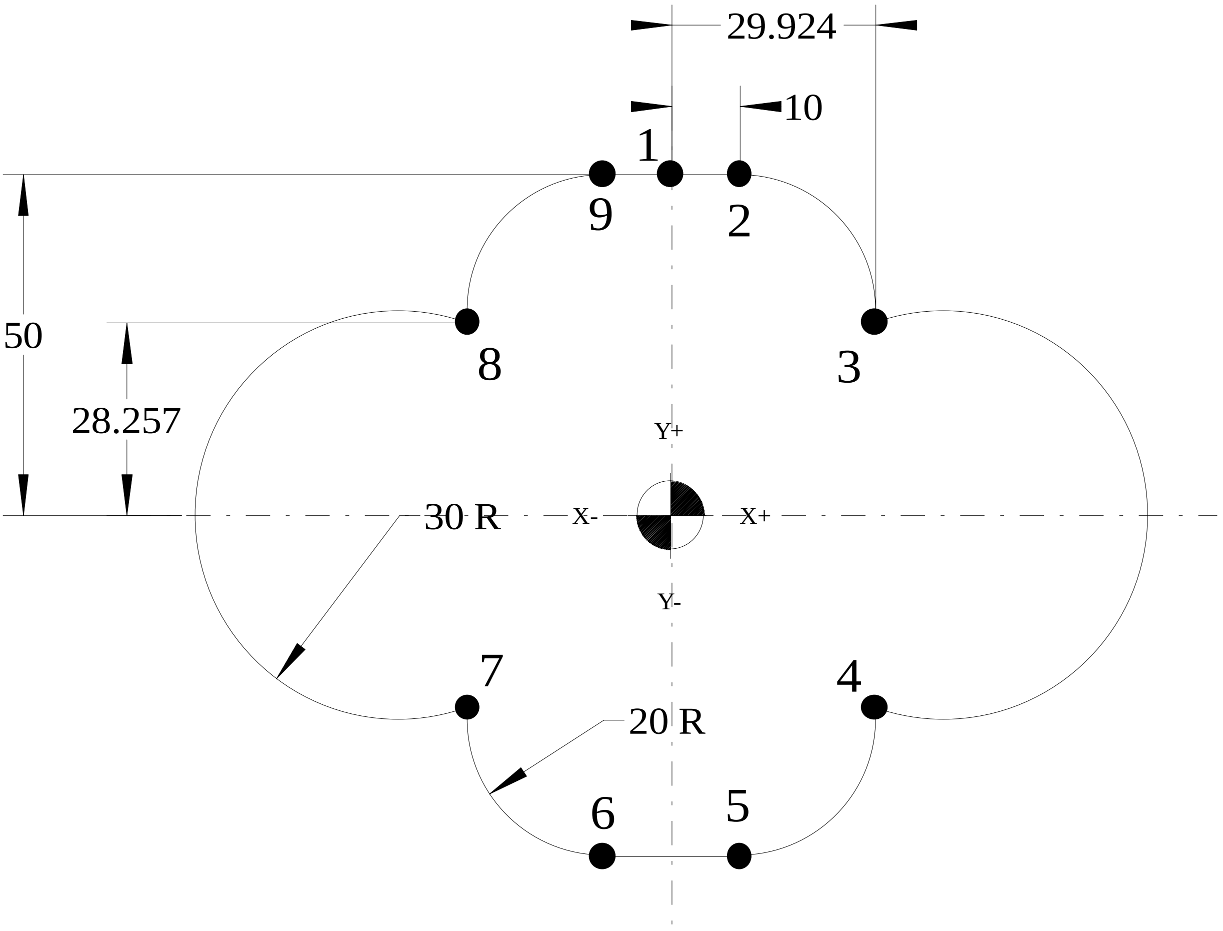
1

```
G90 G0 X-50 Y0
G2 X50 R50
```

2

```
G90 G0 X50 Y0
G3 X-50 R50
```

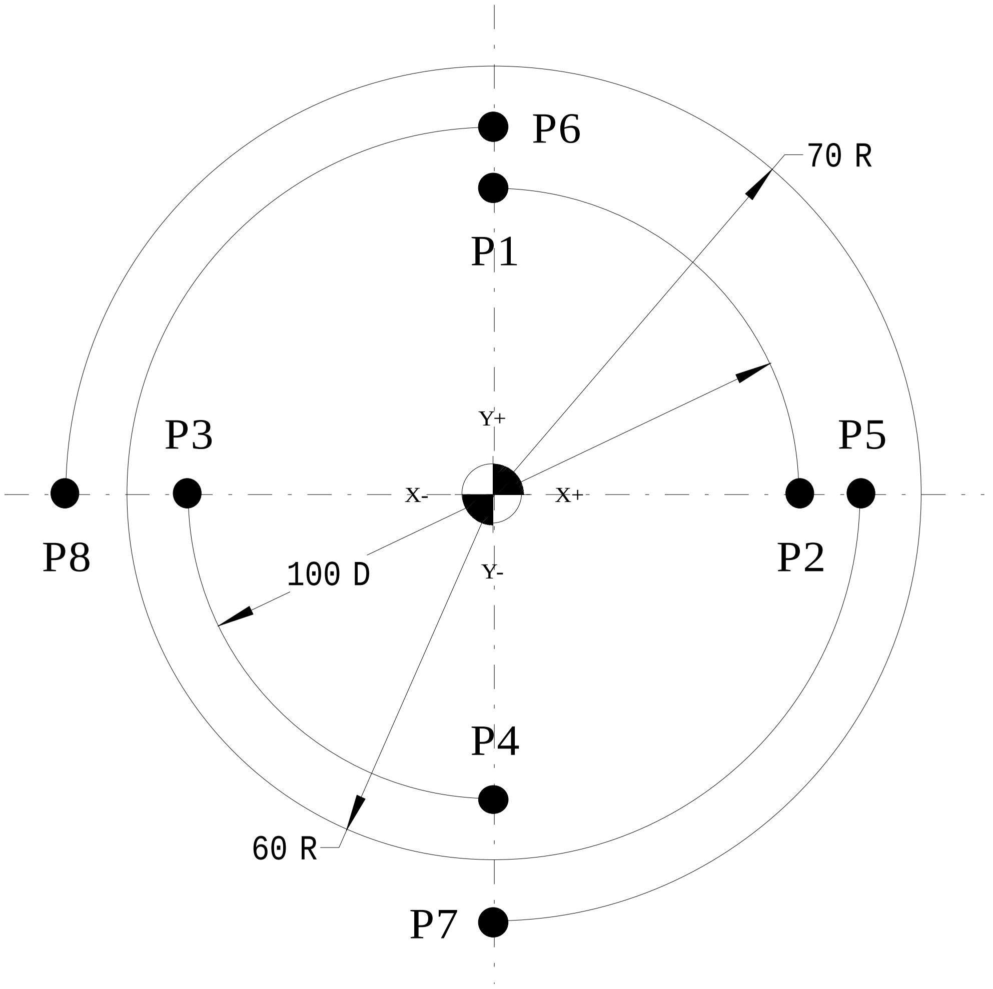
Circular Programmed Movements – e.g. 3



	1 G0 X0 Y50
1	2 G1 X10
2	3 G2 X29.924 Y28.257 R20
3	4 Y-28.257 R-30
4	5 X10 Y-50 R20
5	6 G1 X-10
6	7 G2 X-29.924 Y-28.257 R20
7	8 Y28.257 R-30
8	9 X-10 Y50 R20
9	1 G1 X0

Circular Programmed Movements – e.g. 4

(Incremental)



1

```
G90 G0 X50 Y0
G91 G2 X50 Y-50 R50
```

2

```
G90 G0 X-50 Y0
G3 X-50 Y-50 R50
```

3

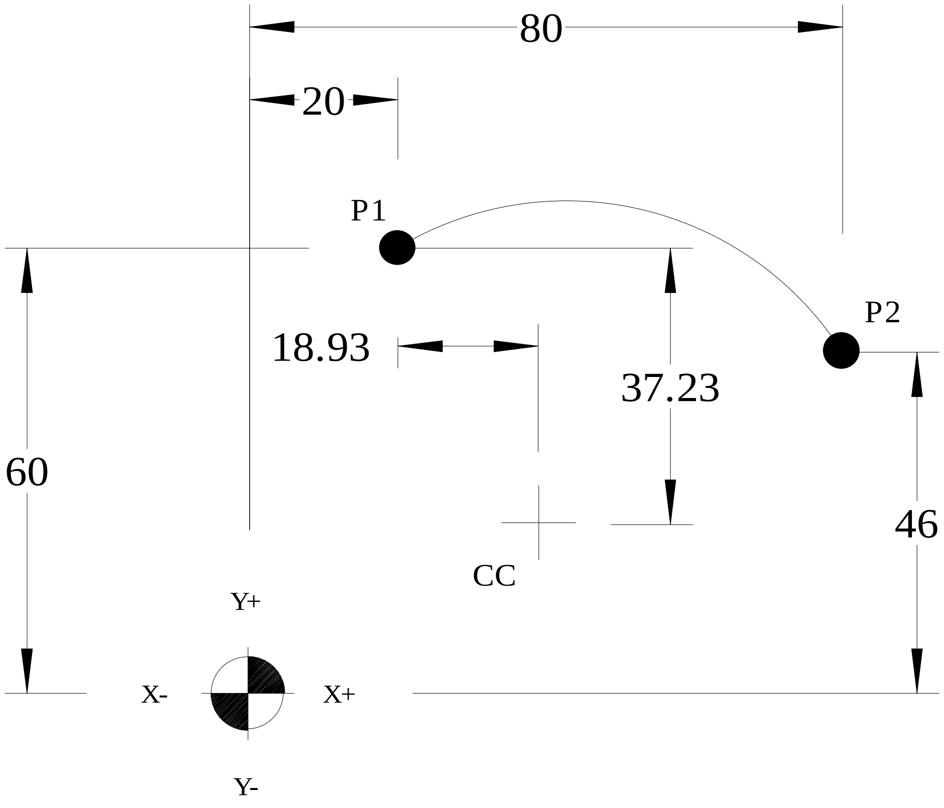
```
G90 G0 X60 Y0
G2 X-60 Y60 R-60
```

4

```
G90 G0 X0 Y-70
G3 X-70 Y70 R-70
```

Circular Programmed Movements – e.g. 5

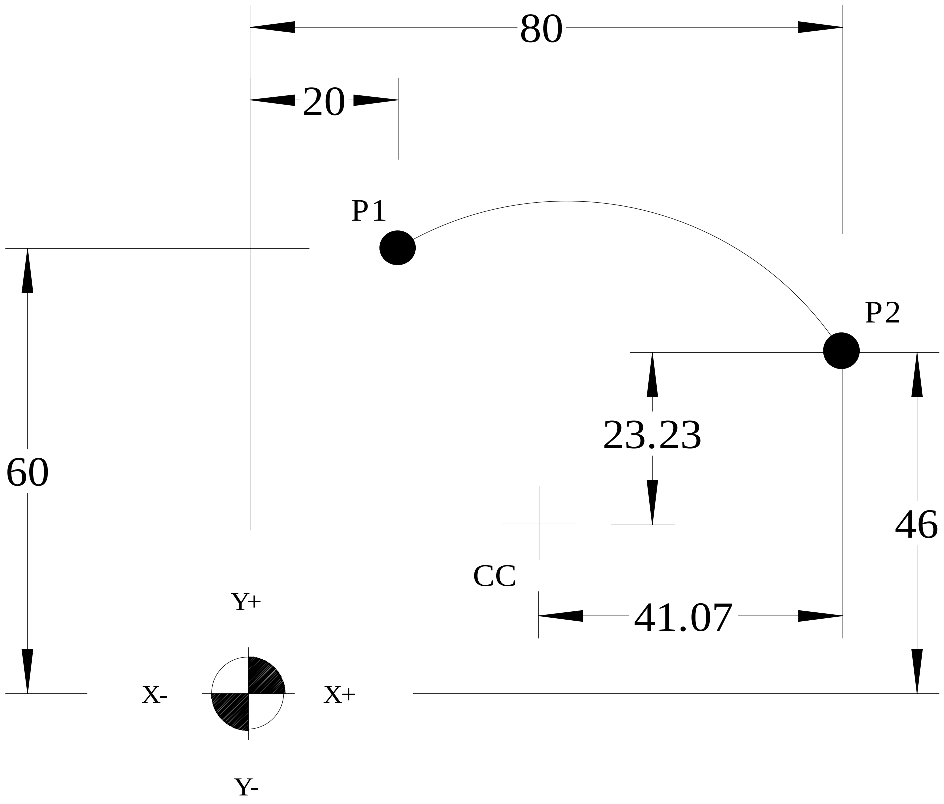
X & Y (Absolute), I & J (Incremental)



G90 G0 X20 Y60
G2 X80 Y46 I18.93 J-37.23

Circular Programmed Movements – e.g. 6

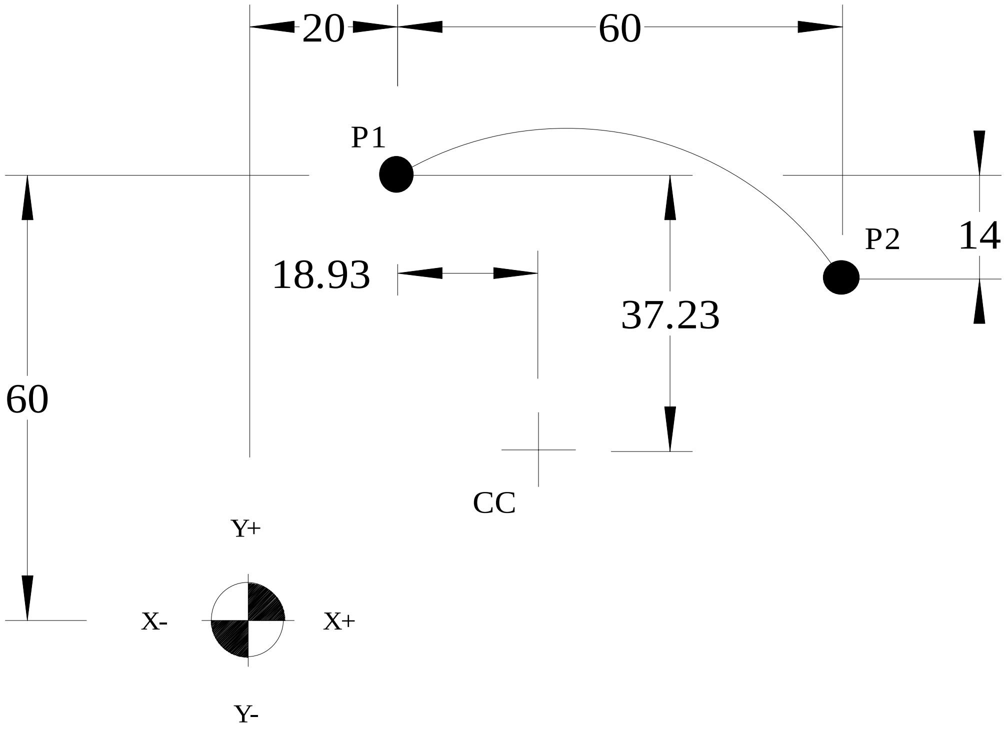
X & Y (Absolute), I & J (Incremental)



G90 G0 X80 Y46
G3 X20 Y60 I-41.07 J-23.23

Circular Programmed Movements – e.g. 7

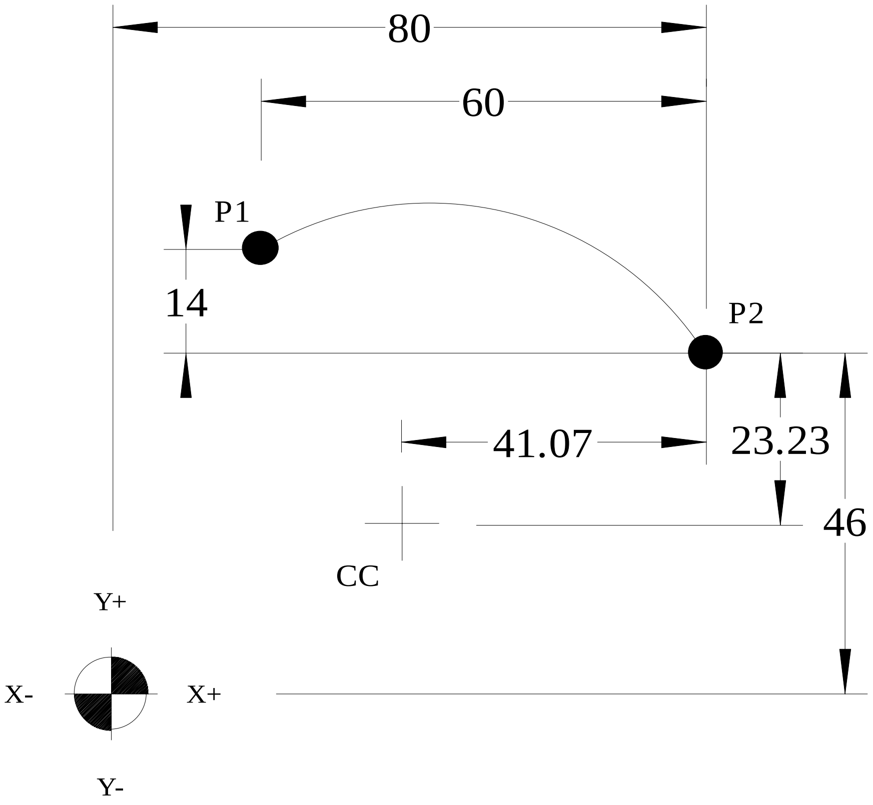
X & Y, I & J (Incremental)



G90 G0 X20 Y60
G91 G2 X60 Y-14 I18.93 J-37.23

Circular Programmed Movements – e.g. 8

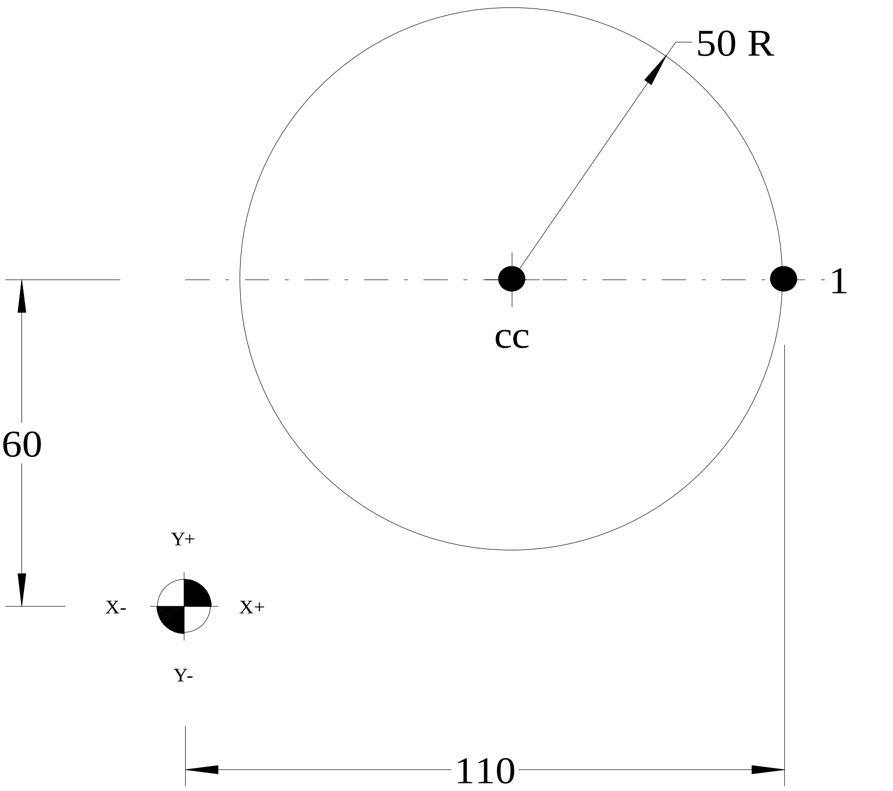
X & Y, I & J (Incremental)



G90 G0 X80 Y46
G91 G3 X-60 Y14 I-41.07 J-23.23

Full Circular Movements – e.g.9

I & J (Incremental)



G90 G0 X110 Y60
G2 X110 Y60 I-50 J0

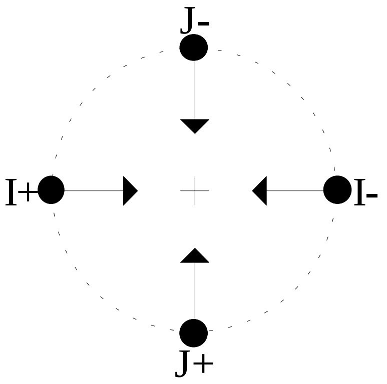
*__Note:__
The end points are taken from the job datum and the circle centre positions are "Incremental" from the start point 1.

G90 G0 X110 Y60
G2 I-50

*__Note:__
The end points and circle centre positions are taken from the "Start point"

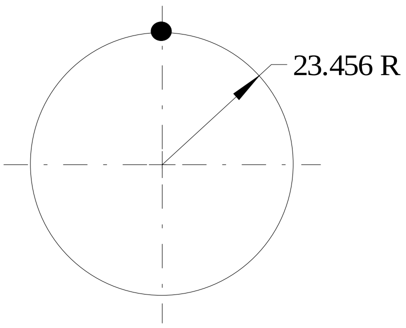
Full Circular Movements – e.g.10

By selecting a pole point of a circle (12, 3, 6 or 9 o'clock position) and using an "Incremental line of program" to create a full circle, all values on this line of program will have a zero value except for the I or J axis on the appropriate pole axis which will represent the radius to be produced:
i.e. G91 G2 X0 Y0 I0 J-50

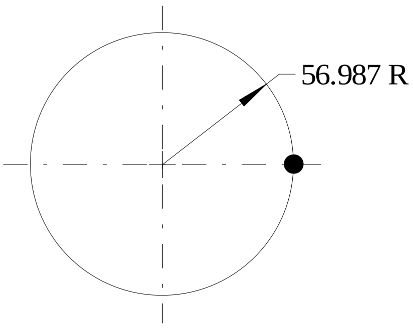


Since the I & J are already incremental the G91 is active on the X & Y values only. If starting from a pole axis, the only axis that needs programming is the pole axis that represents the radius.
i.e. G2 J-50

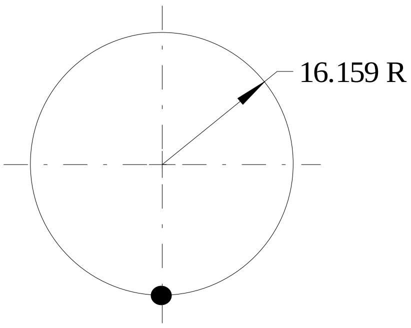
Create the line of circle program for each of the following quadrant points in the diagrams below using "Clockwise".



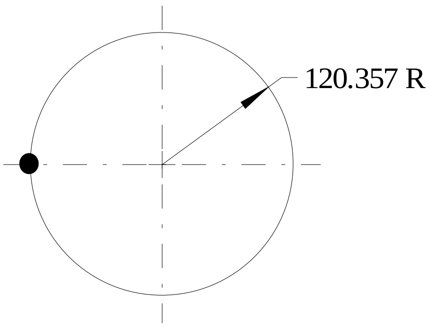
G2 J-23.456



G2 I-56.987

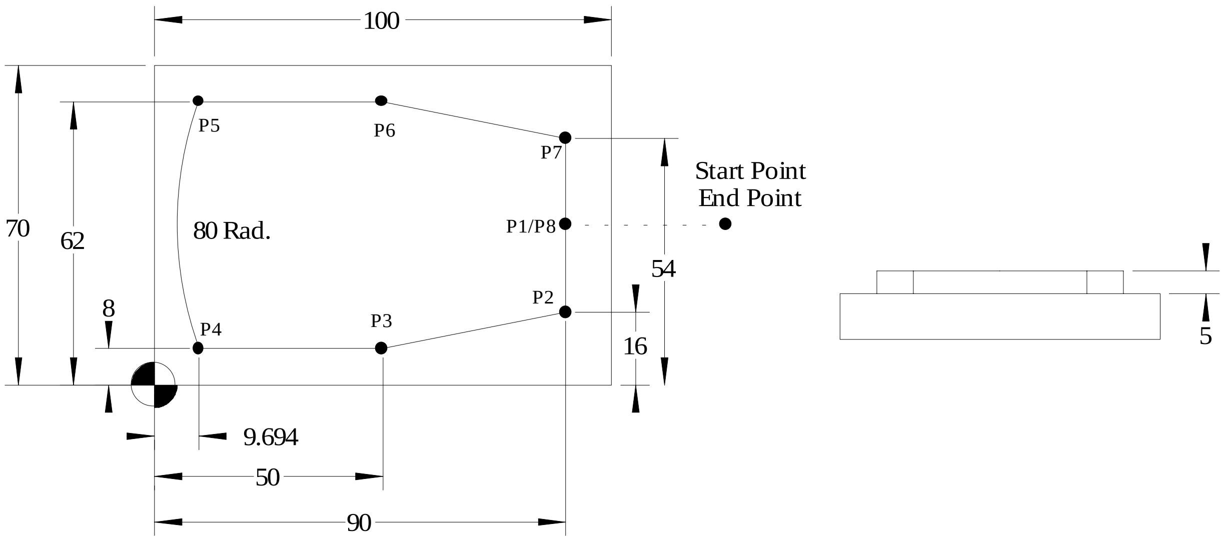


G2 J16.159



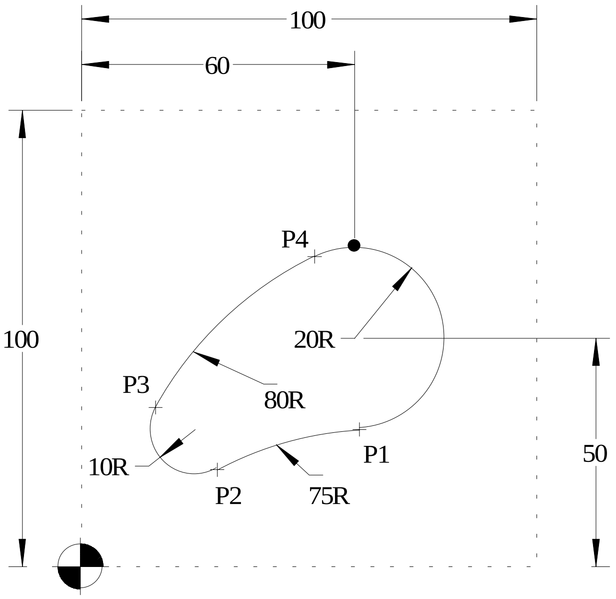
G2 I120.357

Compensation e.g. 1

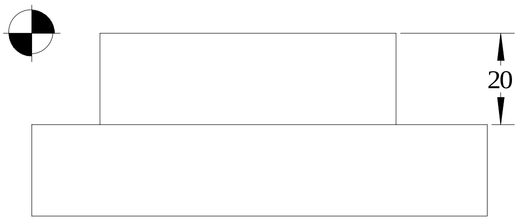


```
O1000
T1 M6
G0 G90 G40 G21 G17 G94 G80
G54 X125 Y35 S? M3
G43 Z100 H?
Z5
G1 Z-5 F?
G41 X90 D? M8
Y16
X50 Y8
X9.694
G2 Y62 R80
G1 X50
X90 Y54
Y35
G40 X125
G0 G90 Z100 M30
```

Compensation e.g. 2



Plan

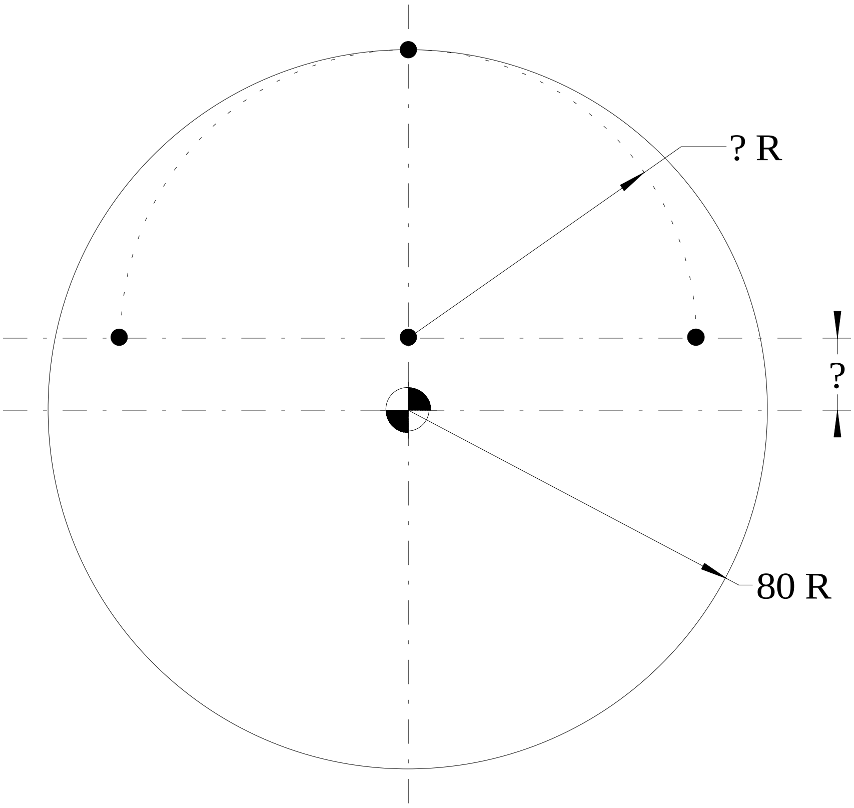


Front

	P1	**P2**	**P3**	**P4**
X	61.11	29.738	16.257	51.266
Y	30.031	21.194	34.854	67.992

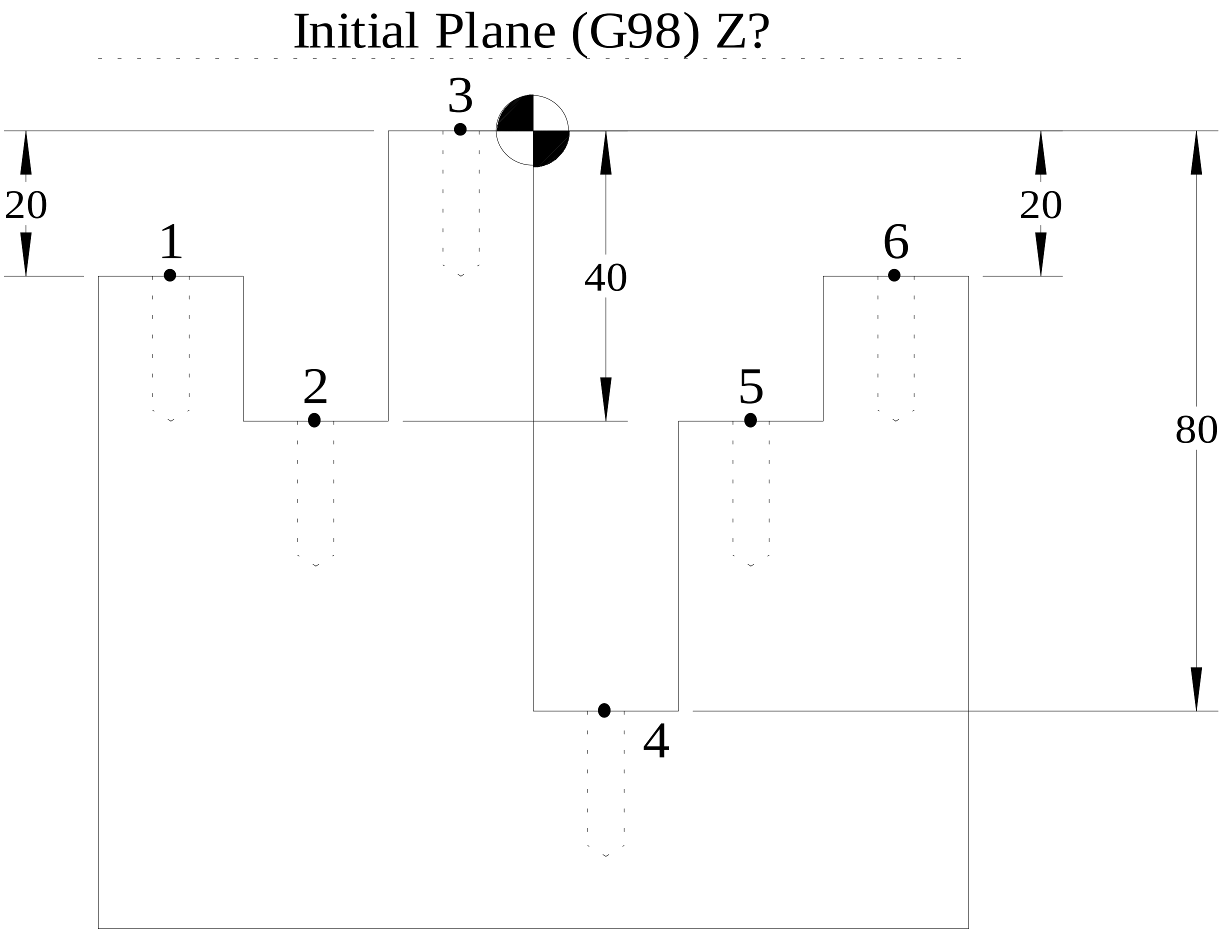
```
O1000
T? M6
(Circular Arc Example) ;
G0 G90 G40 G21 G17 G94 G80
G54 X-50 Y-120 S? M3
G43 Z100 H?
Z5
G1 Z-20 F?
G41 Y70 D?
X60 M8
G2 X61.11 Y30.031 R20
G3 X29.738 Y21.194 R75
G2 X16.257 Y34.854 R10
X51.266 Y67.992 R80
X60 Y70 R20
G1 X150
G40 Y120
G0 G90 Z100
M30
```

Circle Tangent Compensation e.g. 1



```
O1000
T? M6
(Internal circular contour - Arc on / Arc off) ;
G0 G90 G40 G21 G17 G94 G80
G54 X0 Y20 S? M3
G43 Z100 H?
Z5
G1 Z-? F?
G41 G91 X60 D? M8
G3 X-60 Y60 R60
J-80
X-60 Y-60 R60
G1 G40 X60
G0 G90 Z100
M30
```

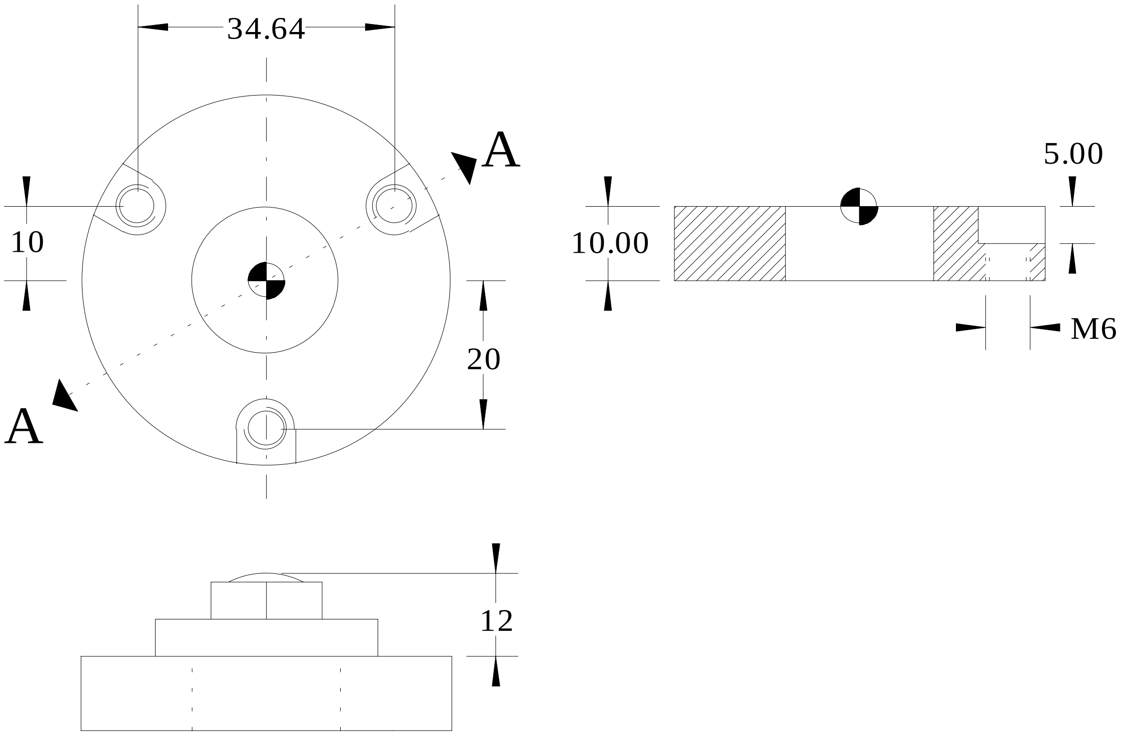
Hole Canned Cycles
“G98/G99” & “R” Positions



Section View YZ plane
All holes 20mm Deep

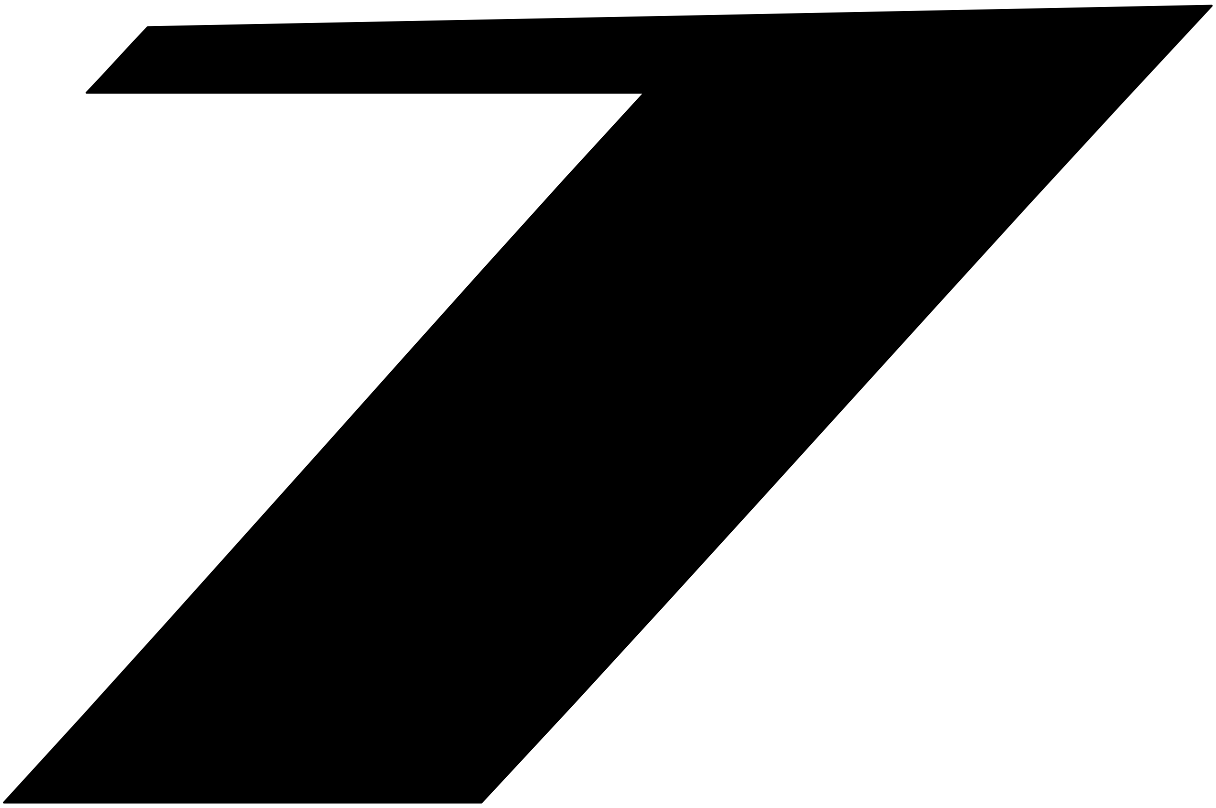
Z5
G99 R-17 Z-40
G98 R-37 Z-60
G99 R3 Z-20
G98 R-77 Z-100
R-37 Z-60
R-17 Z-40

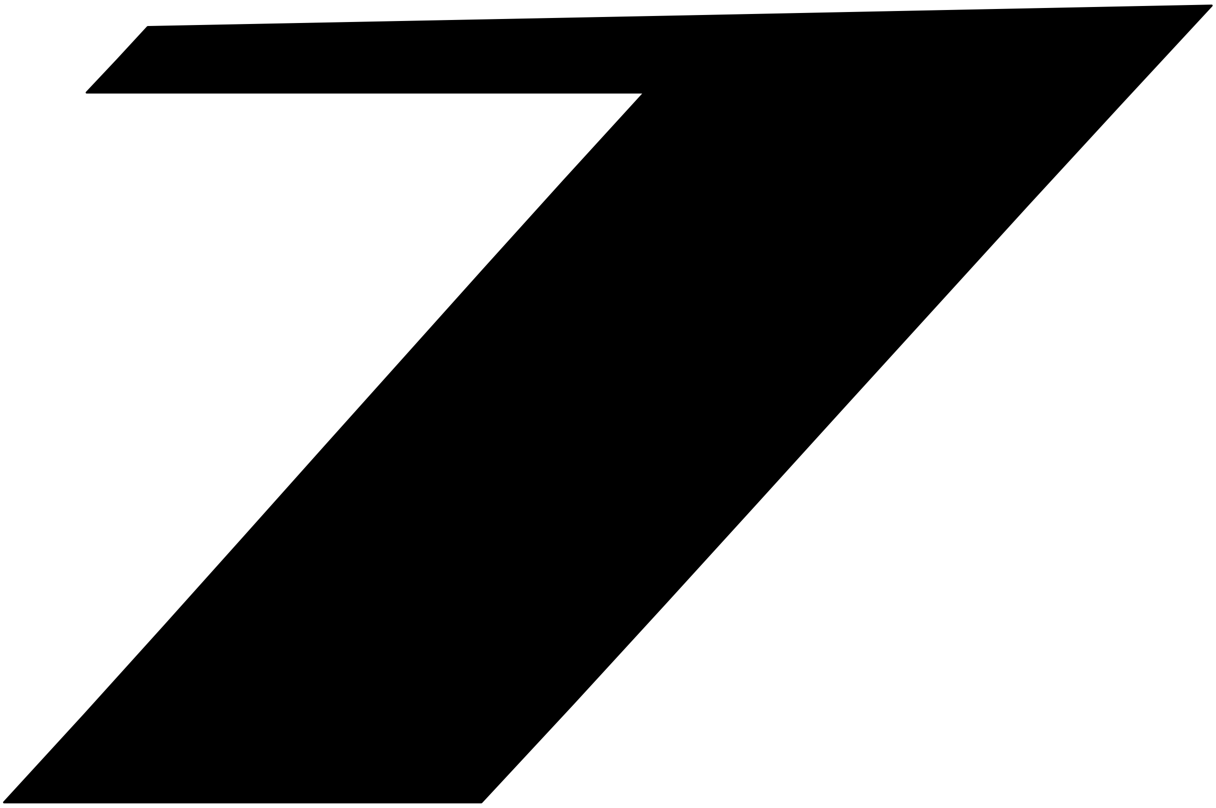
Hole Example



Fixture View

```
O1000
T? M6
G0 G90 G40 G21 G17 G94 G80
G54 X0 Y-20 S? M3
G43 Z100 H?
Z15
G81 G98 R-2 Z-12 F? M8
X17.32 Y10
X-17.32
G80
G0 G90 Z100 M1
T? M6
G0 G90 G40 G21 G17 G94 G80
G54 X0 Y-20 S? M3
G43 Z100 H?
Z15
G84 G95 G98 R-2 Z-15 F1 M8
X17.32 Y10
X-17.32
G80
G0 G90 Z100 M30
```





Macro's

Macro Variables

Local variables - #1 to #33

Local variables can only be used within a custom macro (program or subprogram) to hold data such as the results of calculations.

When the power is turned off, all Local variables are initialised to null (nothing).

i.e.
#21 = 35
G1 X#21 Y#21

or

#21 = 35
#21 = #21 + 10

Note :
#0 = Null value

Common Variables - #100 to #149 (#199) / #500 to #532 (#999)

Common variables can be shared among different custom macros (program or subprogram) and again are used to hold data such as the results of calculations.
When the power is turned off, all #100 to #149 (#199) Common variables are initialised to null.
Variables #500 to #533 (#999) will hold data even when the power is turned off.

As an option, common variables #150 to #199 and #533 to #999 are also available.

System Variables - #1000 -

This is used as part of the computers pre-set registers and are used to read and write a variety of NC data such as the current position and tool compensation values all of which can be found in the programming manual.

i.e..
#4109 = Current Feedrate

System Variables (#1000 -)

The following System Variables are the ones applicable to the current set-up of the machine configuration as by Cincinnati Machine

Tool compensation C

Compensation Number	Tool Length (H)		Cutter Compensation (D)	
	Geometry	Wear	Geometry	Wear
1	#11001 (#2201)	#10001 (#2001)	#13001	#12001
:	:	:	:	:
200	#11201 (#2400)	#10201 (#2200)	:	:
:	:	:	:	:
999	#11999	#10999	#13999	#12999

Macro Alarms

Variable Number	Function
#3000	When a value from 0 - 200 is assigned to variable #3000, the CNC stops with an alarm. After the expression, alarms message not longer than 26 characters can be described. The screen displays the alarm number by adding 3000 to the value in the variable #3000 along with the alarm message.

Example:

#3000 = 1(TOOL NOT FOUND) ;
The alarm screen displays "3001 TOOL NOT FOUND"

Time Variables

Variable Number	Function
#3001	This variable functions as a timer that counts in 1 millisecond increments at all times. When the power is turned on, the value is of this variable is set to zero. When 2147483648 milliseconds is reached, the value of this timer returns to zero.
#3002	This variable functions as a timer that counts in 1-hour increments when the cycle start lamp is on. This timer preserves its value even when the power is turned off. When 9544.371767 hours is reached, the value of this timer returns to zero.
#3011	This variable can be used to read the current date (year/month/day). This is converted to a decimal number E.g. September 28, 1994 is represented as 19940928.
#3012	This variable can be used to read the current time (hours/minutes/seconds). This is converted to a decimal number E.g. 3:34:56 p.m. is represented as 153456.

Number of machined parts

Variable Number	**Function**
#3901	Number of completed machined parts
#3902	Number of required parts.

System Information

Variable number	**Function**
#4001	G0, G1, G2, G3, G33
#4002	G17, G18, G19
#4003	G90, G91
#4004	(Group 04 codes)
#4005	G94, G95
#4006	G20, G21
#4007	G40, G41, G42
#4008	G43, G44, G49
#4009	G73, G74, G76, G80-G89
#4010	G98, G99
#4011	G50, G51
#4012	G65, G66, G67
#4013	G96, G97
#4014	G54-G59
#4015	G61-G64
#4016	G68, G69
#4022	(Group 22 codes)
#4102	B code
#4107	D code
#4109	F code
#4111	H code
#4113	M code
#4114	Sequence number
#4115	Program number
#4119	S code
#4120	T code
#4130	P code (number of the currently selected additional workpiece coordinate system)

Example:

When #1 = #4001 is executed, the result in #1 would be 0,1,2,3, or 33

Workpiece Coordinate System Variables

Axis	**Function**	**Variable number**	
First axis	External workpiece zero point offset	#2500	#5201
	G54 workpiece zero point offset	#2501	#5221
X	G55 workpiece zero point offset	#2502	#5241
	G56 workpiece zero point offset	#2503	#5261
	G57 workpiece zero point offset	#2504	#5281
	G58 workpiece zero point offset	#2505	#5301
	G59 workpiece zero point offset	#2506	#5321
Second axis	External workpiece zero point offset	#2600	#5202
	G54 workpiece zero point offset	#2601	#5222
Y	G55 workpiece zero point offset	#2602	#5242
	G56 workpiece zero point offset	#2603	#5262
	G57 workpiece zero point offset	#2604	#5282
	G58 workpiece zero point offset	#2605	#5302
	G59 workpiece zero point offset	#2606	#5322
Third axis	External workpiece zero point offset	#2700	#5203
	G54 workpiece zero point offset	#2701	#5223
Z	G55 workpiece zero point offset	#2702	#5243
	G56 workpiece zero point offset	#2703	#5263
	G57 workpiece zero point offset	#2704	#5283
	G58 workpiece zero point offset	#2705	#5303
	G59 workpiece zero point offset	#2706	#5323
Fourth axis	External workpiece zero point offset	#2800	#5204
	G54 workpiece zero point offset	#2801	#5224
A	G55 workpiece zero point offset	#2802	#5244
	G56 workpiece zero point offset	#2803	#5264
	G57 workpiece zero point offset	#2804	#5284
	G58 workpiece zero point offset	#2805	#5304
	G59 workpiece zero point offset	#2806	#5324

System Position Information

Variable number	**Position Information**	**Coordinate system**	**Tool compensation**	**Read during motion**
#5001-#5005	Block end point	Workpiece	Not Included	Enabled
#5021-#5025	Current position	Machine	Included	Disabled
#5041-#5045	Current position	Workpiece		
#5061-#5065	Skip signal position			Enabled
#5081-#5085	Tool length offset value			Disabled
#5101-#5105	Deviated servo position			

- The first digit (i.e. #500**1**) represents an axis number (1=X, 2=Y, 3=Z, 4=A, 5=B).

Mathematical expressions

Function	**Format**	**Remarks**
Definition	#i = #j	
Addition Subtraction Multiplication Division	#i = #j + #k #i = #j - #k #i = #j * #k #i = #j / #k	
Sine Cosine Tangent Arctangent	#i = SIN[#j] #i = COS[#j] #i = TAN[#j] #i = ATAN[#j]	The angle is specified in degrees. 90 degrees and 30 minutes is typed as 90.5 degrees.
Square root Absolute Rounding off Rounding down Rounding up Natural Logarithms Exponential function	#i = SQRT[#j] #i = ABS[#j] #i = ROUND[#j] #i = FIX[#j] #i = FUP[#j] #i = LN[#j] #i = EXP[#j]	

Mathematical operators

Operator	**Meaning**
EQ	**Equal to (=)**
NE	**Not equal to!**
GT	**Greater than (>)**
GE	**Greater than or equal to!**
LT	**Less than (<)**
LE	**Less than or equal to!**

The order in which the control evaluates expressions is important, since a change in the order of evaluation can result in a change of the resulting value.

The order of evaluation follows standard algebraic practise.
That is:
1) The inner most parenthetic expression is evaluated first.
2) The next to inner set is solved next and each is solved in turn working towards the end of the sum.

The order of solving arithmetic operations within parentheses or when parentheses are not present is as follows:
1) All multiplication, division and modulo operations are performed in order from left to right.
2) All addition and subtraction are performed in order from left to right.
3) Relational operators are evaluated.

Typical Error **2+[2/10] = 2.2** OR **[2+2]/10 = 0.4**

Conditional Branch statement (IF)

The control allows a conditional expression to be programmed. If the statement is read true a branch to a sequence number specified in the statement line occurs. If the statement is read false then the next program line is read. A conditional statement must include an operator between two variables or between a variable & constant and must be enclosed in brackets [ ]

Conditional repetition example

```
Repeat 5 times
#1 = 0
N10 (Label at start of loop)
#1 = # 1 + 1
“PROGRAM”
IF [#1 LT 5] GOTO 10
```

Repetition statement (WHILE - D0)

The control allows a conditional expression to be programmed. If the statement is read true, a repeat is specified until the statement is read false. If the statement is read false, then the next program line is read after the END program line.. A conditional statement must include an operator between two variables or between a variable & a constant and must be enclosed in brackets [ ]. The identification number of the DO-END loop is limited to 3 and can be used as many times as desired. Overlapping Repetition statements cannot overlap.

Conditional repetition example

Correct	**Incorrect**
Repeat 5 times #1 = 0 WHILE [#1 LT 5] DO 2 #1 = # 1 + 1 “PROGRAM” END 2	Repeat 5 times #1 = 0 WHILE [#1 LT 5] DO 2 #1 = # 1 + 1 “PROGRAM” WHILE [#1 LT 5] DO 3 END 2 “PROGRAM” END 3
	This is Correct Repeat 5 times #1 = 0 WHILE [#1 LT 5] DO 2 #1 = # 1 + 1 “PROGRAM” WHILE [#1 LT 5] DO 3 “PROGRAM” END 3 “PROGRAM” END 2

Macro Call

A macro program (Macro sub-program) can be called using the following methods instead of the use of an M98 code:

Macro Call	**Simple call (G65)** **Modal Call (G66, G67)**

With a **non-modal** G65 command, data contained with this line of program can be passed to the macro sub-program. This is not possible with the M98 command.

The **modal** G66 command will call the macro sub-program on every program line within the main program until the G66 command is cancelled with a G67 command.
Information passed to the macro sub-program using G66 is only active on macro's contained in the sub-program that are used for axis motion and not calculations.

G65/G66 Macro Simple Call

G65 P? L? <argument - values>
Where:
G65 = Non-modal macro call command.
P? = Number of sub-program to call.
L? = Number of times to repeat the sub-program.
<argument - values> = Data to be passed to the variables in the sub-program.

Example:

```
O1000
G65 P1001 L2 A35 B45 ;

O1001 ;
G91 G0 X#1  Y#2 ;
M99 ;
```

Argument - Values

Address	**Variable number**
A	#1
B	#2
C	#3
D	#7
E	#8
F	#9
H	#11
I	#4
J	#5
K	#6
M	#13

Address	**Variable number**
Q	#17
R	#18
S	#19
T	#20
U	#21
V	#22
W	#23
X	#24
Y	#25
Z	#26

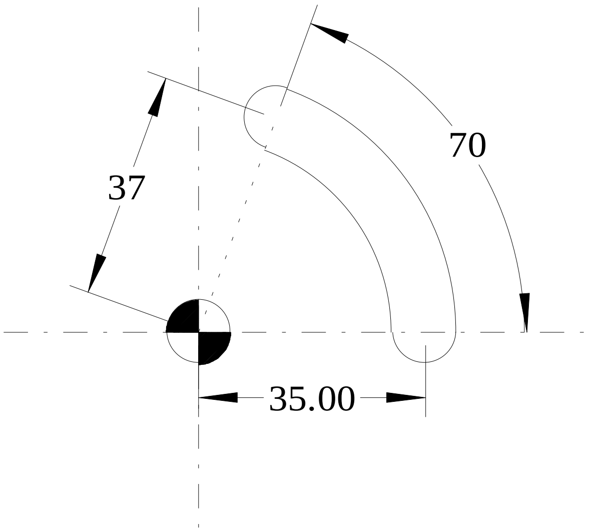
G65 Macro for a Counterbore

```
T? M6 (ENDMILL)
G0 G90 G40 G21 G17 G94 G80
G54 X? Y? S? M3 (Move to bore centre)
G43 Z? H?
;
G65 P1001 A? D?
(A = C/BORE DIAMETER)
(D = RADIUS OFFSET NUMBER)
M30

O1001
#11=[[#1*0.8]/2]
#12=[[#1/2]-#11]
G91 Y#12
G41 X#11 D#7
G3 X-#11 Y#11 R#11
J-[#1/2]
X-#11 Y-#11 R#11
G1 G40 X#11
G0 G90 Z100
M99
```

Macro for Internal Helical

```
T? M6  (THREADMILL)
G0 G90 G40 G21 G17 G94 G80
G54 X? Y? S? M3 (Move to bore centre)
G43 Z? H?
;
G65 P1002 A? B? D?
(A = THREAD DIAMETER)
(B = PITCH)
(D = RADIUS OFFSET NUMBER)
M30

O1002
#11=[[#1*0.8]/2]
#12=[[#1/2]-#11]
;
G91 Y#12
G41 X#11 D#7
G3 X-#11 Y#11 R#11 Z#2/4
J-[#1/2] Z#2
X-#11 Y-#11 R#11 Z#2/4
G1 G40 X#11
G0 G90 Z100
M99
```

G65 Macro for an Increasing Radius.



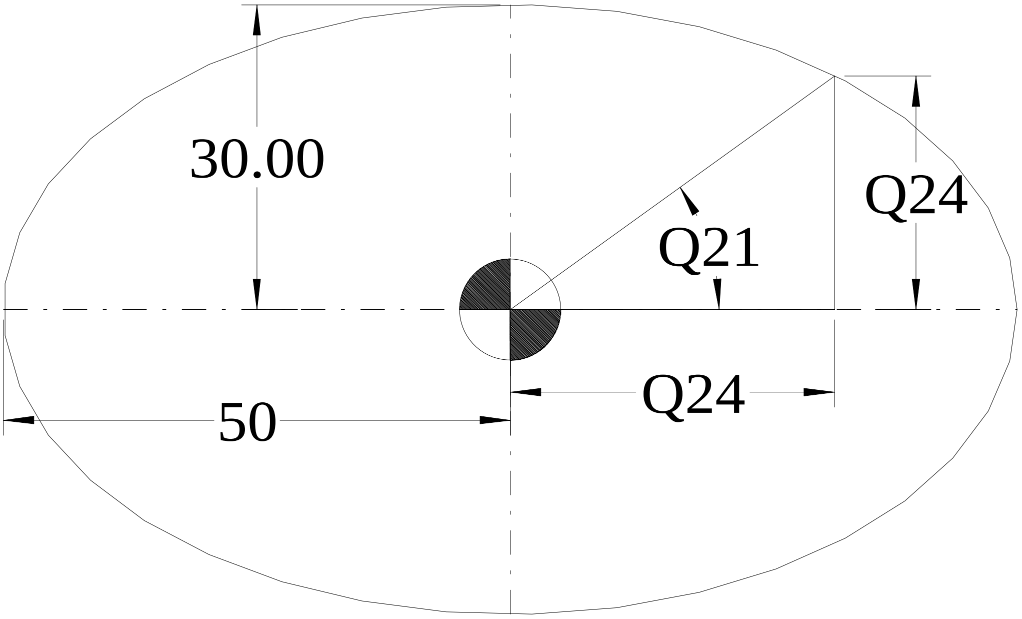
A = #1 (Start Angle 0 degrees)
B = #2 (Start Radius)
C = #3 (Increment angle for accuracy calculations.)
I = #4 (Finish Angle)
J = #5 (Finish radius)
K = #6 (Milling feed)

```
O2222
T5 M6
G0 G90 G40 G21 G17 G94 G80
G54 X35 Y0 S500 M3
G43 Z100 H?
Z5
G1 Z-0.5 F200
G65 P8999 A0 B35 C0.01 I70 J37 K500
G0 G90 Z100 M30
```

```
O8999
#7 = #4 / #3
#8 = [[#5 - #2] / #7]
N1 #2 = #2 + #8
#1 = #1 + #3
#9 = #2 * COS [ #1 ]
#10 = #2 * SIN [ #1 ]
G1 X#9 Y#10 F#6
IF [#1 LT #4] GOTO 1
G0 Z10
M99
```

1) **Total no. of moves 70 / 0.01**
2) **Increase in radius 37-35/7000**
3) **Next Radius i.e. 35+inc. radius.**
4) **Increase in angle**
5) **New X axis position**
6) **New Y axis position**
7) **Feed move to new positions**
8) **If new angle is less than finish angle go to line N1.**

G65 Macro for Internal Elipse



```
T1 M6
G0 G90 G40 G21 G17 G94 G80
G54 X0 Y0 S? M3
G43 Z5 H?
G1 Z-? F?
#20 = 2 ; Incremental degree calculation
#21 = 0 ; Start Angle
#22 = 30 ; Y Axis Radius
#23 = 50 ; X Axis Radius
G41 X#23  D? ; Compensation motion to right side of internal pocket
N10 #21 = [#21 + #20]  ; Angular Count
#24 = SIN[#21]  ; Incremental Y axis calculation
#25 = COS[#21] ; Incremental X axis calculation
#24 = [#24*#22]  ; Absolute Y calculation
#25 = [#25*#23]  ; Absolute X calculation
X#25 Y#24 ; Movement in X & Y axis
IF [#21 LT 360] GOTO 10 ; Restart if less than 360 degree motion
IF [#21 GT 360] GOTO 20 ; If final angle becomes greater than 360 degrees recalculate
IF [#21 EQ 360] GOTO 30 ; Finish if total angle is equal to 360 degree
N20 #21 = 360
GOTO 10
N30 G40 X0
G0 G90 Z100 M30
```

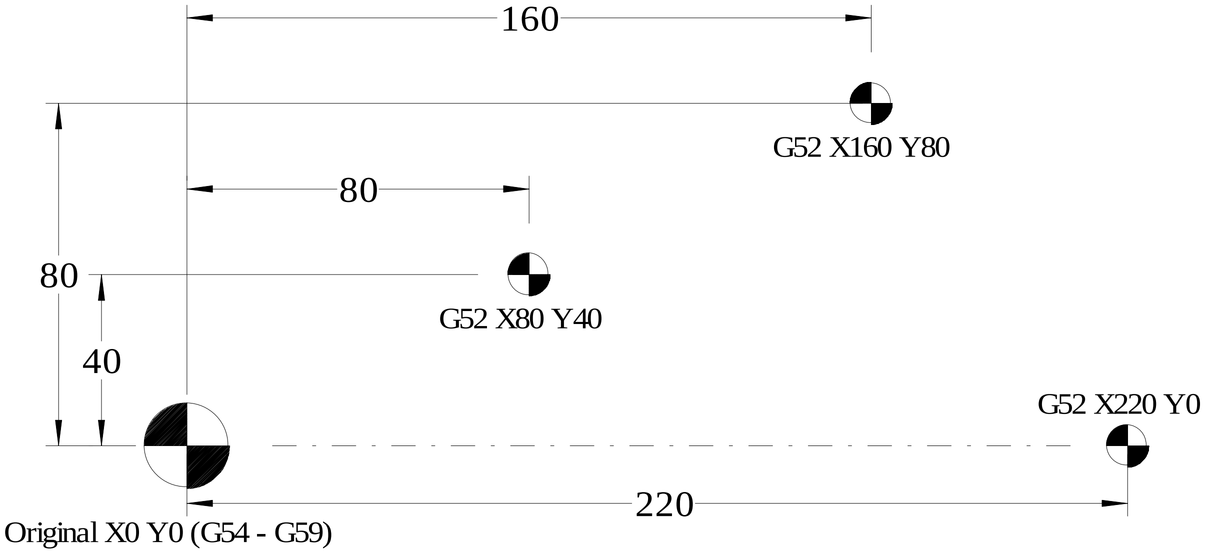
Datum Shift

Datum Shift

A temporary shift of the set datum can be achieved within the program itself. This shift is known as a “Local Co-ordinate System”.

The use of a G52 command with an absolute axis position allows this temporary shift of the workpiece co-ordinate which has been set.

This code cannot be used Incrementally



The datum shift must be cancelled when finished with.

The following are ways to achieve this:

1) Programming G52 with zero axis motion
2) Data reset
3) End of program
4) Machine power off

Rotation

Rotation

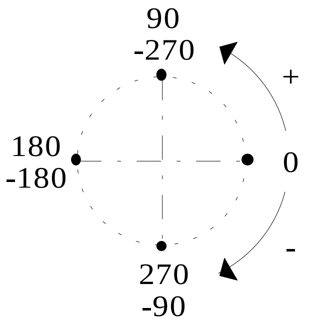
(Option)

A programmed shape can be rotated around a programmed pole position. Programming a **G68** with an axis position for the centre of rotation together with the angle of rotation will do this.

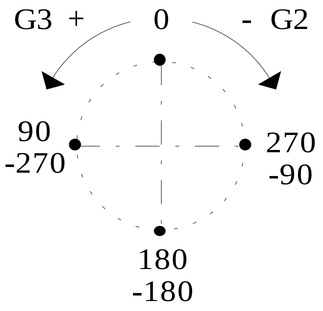
G68 X? Y? R?

Where:
X? & Y? = Centre of rotation
R? = Angle of rotation around the current plane (R+ = Anti-clockwise)

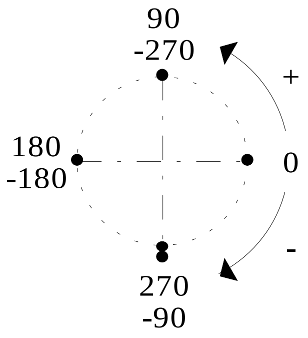
All information programmed after this line of command will instruct the control to calculate the new axis position at the displaced angle.
The smallest increment of angular displacement = 0.001 Deg.



G17
XY Plane (Z-)
Plan View



G18
XZ Plane (Y-)
Front View



G19
YZ Plane (X-)
Side View

If the X & Y values are not programmed then the current tool position becomes the rotation pole centre.

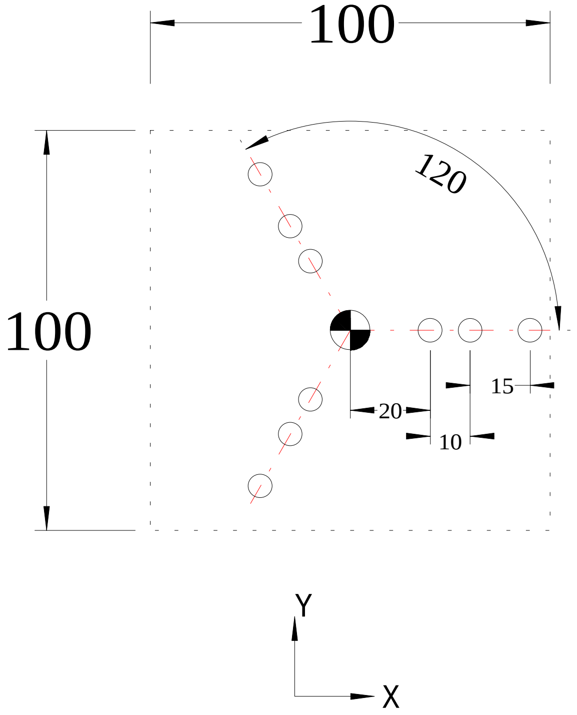
Incremental can be used with G68 rotation. The X, Y & R are established as incremental values if G68 is specified with a G91 code.

The Rotation must be cancelled when finished with.

The following are ways to achieve this:

1) Programming G69
2) Data reset
3) End of program
4) Machine power off

Rotation



All holes 20mm Deep

```
T1 M6
G0 G90 G40 G21 G17 G94 G80
G54 X20 Y0 S? M3
G43 Z100 H?
Z5
G81 R3 Z-20 F? M8
X30
X45
G68 X0 Y0 R120
X20 Y0
X30
X45
G68 X0 Y0 R240
X20 Y0
X30
X45
G69 G80
G0 G90 Z100 M30
```

Programmable Coolant

Automatic Coolant Jet Control (Option)

The Coolant Jet System, mounted beneath the spindle carrier, has eight positions to ensure the coolant is directed to the cutting tip of any tool within the maximum tool length and diameter specified for the machine.

The group of miscellaneous codes (M15 E1 - M15 E8) control the positioning of the Automatic Coolant Jet.

The coolant must be activated before programming the automatic coolant nozzle

The table below is used to identify the M code to an active tool length and radius. Code M15 E1 is associated with the smallest/shortest tool and code M15 E8 is associated with the largest/longest tool.

M Code Selection						
Tool Length		Upto 100	Upto 150	Upto 200	Upto 250	Over 250
Tool Radius	>50	M15E3	M15E5	M15E6	M15E7	M15E8
	<50	M15E2	M15E4	M15E5	M15E6	M15E6
	<30	M15E2	M15E3	M15E4	M15E5	M15E6
	<15	M15E1	M15E2	M15E3	M15E4	M15E5

Example:

M15 E4 is selected for an end mill tool, 170 mm long with a radius of 30 mm. When an M6 command is processed, the control automatically retracts the coolant jet to the M15 E1 position to ensure clearance with the tool magazine guard. The coolant jet will remain in position on completion of the tool change until another M15 code from the group is programmed.

Also the coolant jet can be programmed to move to a calculated position relative to the active tool length and radius by utilizing code M15 with no “E” word.

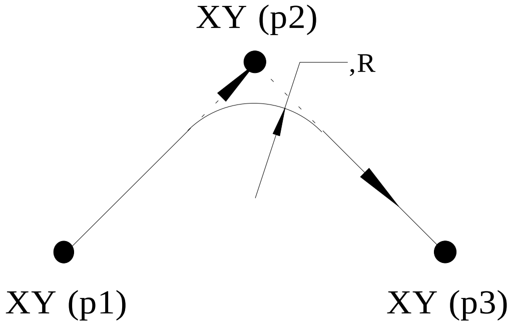
Example Program:

T1 M6	
G54 X? Y? S? M3	
G43 Z100 H1	Establish length offset
Z5	
G1 Z-? F? M8	Switch on coolant
G41 X? D?	Establish radius offset
M15	Activate Automatic Coolant
Y?	

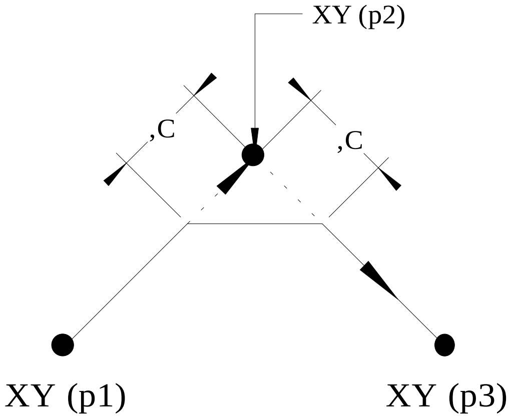
Corner Radius/Chamfer

Corner Radius & Uniform Chamfers
(Option)

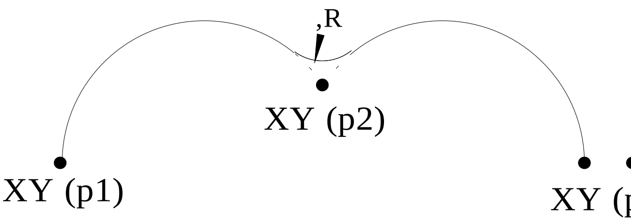
Blend chamfers and Blend Radii can be created within a program with the aid of short word addresses (,C for chamfers and ,R for radius).
The word address ,C & ,R are **Non-Modal** values and are added to the program line on the approach to the **known intersection programmed point.**



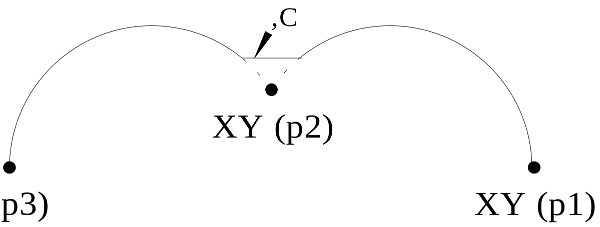
```
(p1) G1 X? Y?
(p2) X? Y? ,R?
(p3) X? Y?
```



```
(p1) G1 X? Y?
(p2) X? Y? ,C?
(p3) X? Y?
```



```
(p1) X? Y?
(p2) G2 X? Y? R? ,R?
(p3) X? Y? R?
```



```
(p1) X? Y?
(p2) G3 X? Y? R? ,C?
(p3) X? Y? R?
```

Programmable Data Entry

Programmable Data Entry

(Option)

Certain areas of the Fanuc control can be written to from a part program using a G10 command with various pieces of information.

The types of transferable data can include information to the Tool offsets & Fixture offsets.

Tool data entry

Tool Length	**G10 L10 P? R?**
Tool Length Wear	**G10 L11 P? R?**
Tool Radius	**G10 L12 P? R?**
Tool Radius Wear	**G10 L13 P? R?**

Where:
G10 = Code to transfer data
L? = Appropriate tool column
P? = Tool offset row number
R? = Value within the allowed range.

Fixture Offset data entry

Fixture Offset	**G10 L2 P? X? Y? Z?**

Where:
G10 = Code to transfer data
L2 = Fixture Offset data
P? = Fixture Offset data number
(P1=G54, P2=G55, P3=G56, P4=G57, P5=G58, P5=G59)
X, Y, Z = Axis value to be transferred

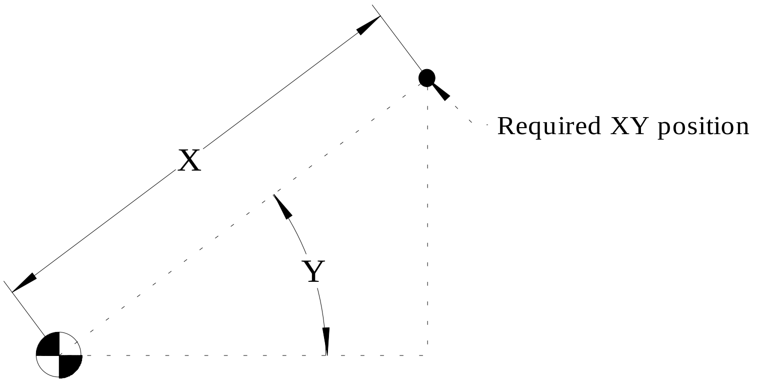
Using G91 on the G10 program line of information will add the value to the existing data.

Polar Co-ordinates

Polar Co-ordinate Command

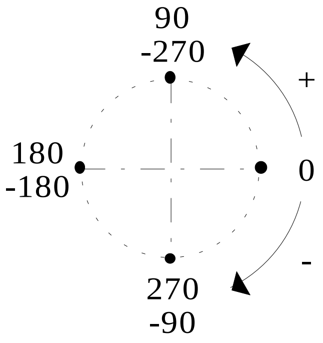
(Option)

The control has the ability to position itself to an endpoint in any plane using a **G16** code with only information regarding the length of the move from the X, Y & Z datum point with the angle of the line as that of a right angled triangle.
All angles are relative to the current plane.

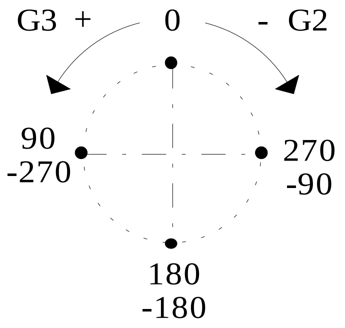


G16 G17 X? Y?

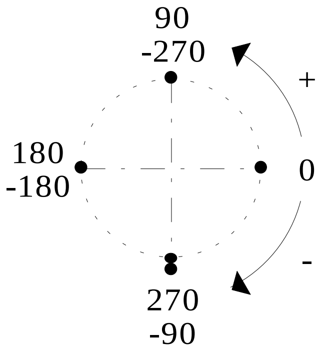
Where:
G16 = Polar command
G17 = XY Plane
X? = Hypotenuse of the right angle triangle
Y? = Angle of the hypotenuse line from the 0 Deg. point as below.



G17
XY Plane (Z-)
Plan View



G18
XZ Plane (Y-)
Front View



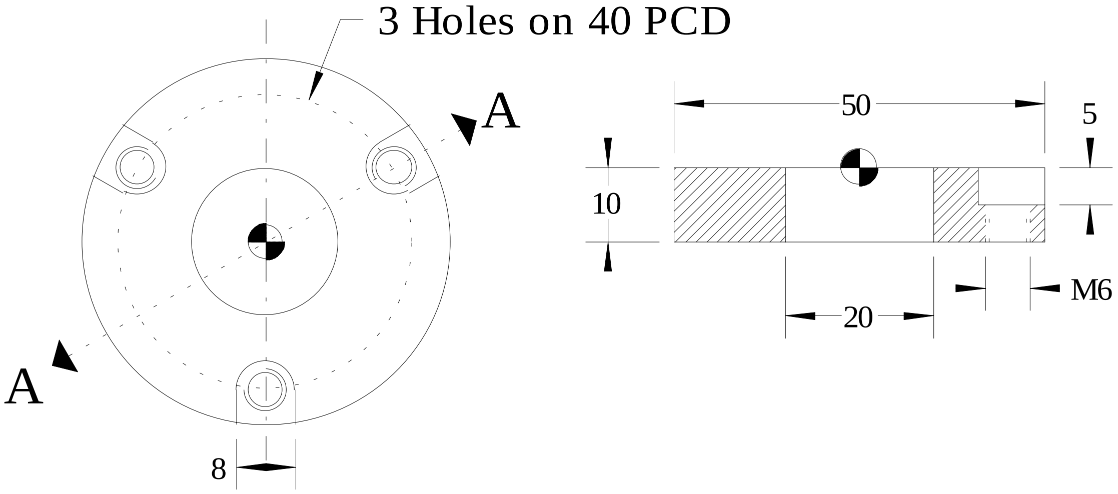
G19
YZ Plane (X-)
Side View

It is also possible to use G91 Incremental to control the angle.

G16 Polar command is cancelled by the programming of a G15 command.

Polar Co-ordinate Command

Hole position Example

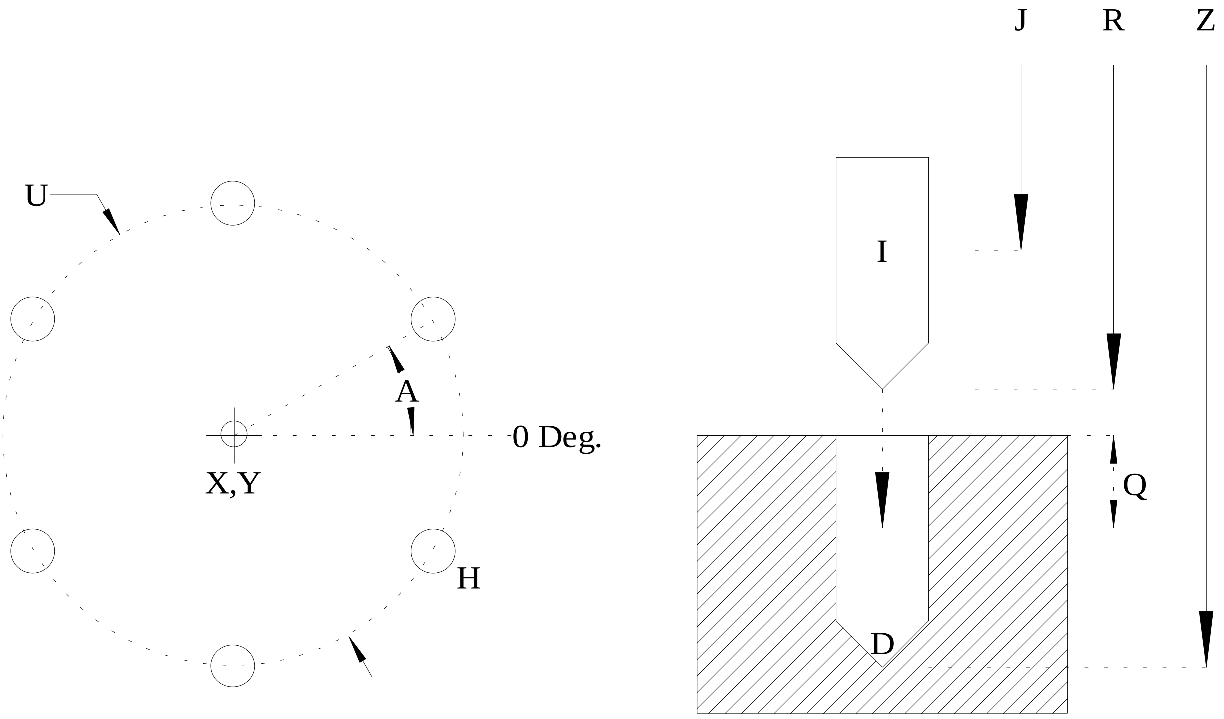


```
T? M6
G0 G90 G40 G21 G17 G94 G80
G54 X0 Y0 S? M3
Z5
G81 G16 G98 X20 Y30 R-2 Z-10 F? M8
Y150
Y270
G15 G80
G0 G90 Z100
T? M6
G0 G90 G40 G21 G17 G94 G80
G54 X0 Y0 S? M3
Z5
G84 G16 G95 G98 X20 Y30 R-2 Z-10 F1 M8
Y150
Y270
G15 G80
G0 G90 Z100
M30
```

User Supplement Cycles

Circular Hole Pattern

A variable number of holes can be requested in the circular hole pattern as well as specifying the required drilling cycle.



G65 P8951 [X? Y?] Z? R? [A?] U? H? I? J? [Q? D?]

[ ] denotes optional inputs.
If no X & Y axis are on the line of program then the current tool position will become the PCD centre.

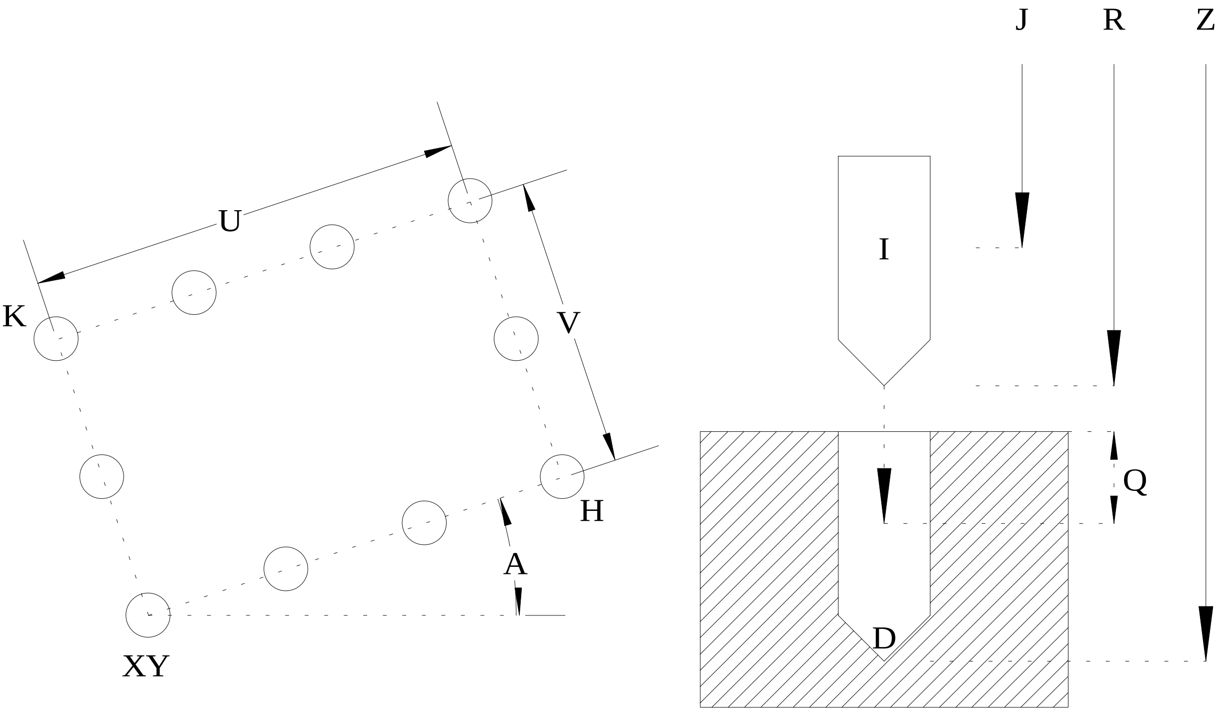
G	Cycle Call (G65)	**U**	Diameter of PCD
P	8951 – Bolt hole circle	**H**	No. of holes
X	X axis to PCD centre	**I**	Drilling cycle
Y	Y axis to PCD centre	**J**	Return point code (98 / 99)
Z	Z axis hole end position	**Q**	Peck depth (G73/G83) *
A	Angle of hole from 0	**D**	Dwell
R	R Plane		

Note

1) I must be programmed before J
2) *Q is mandatory with I83 or I73
3) A absent = zero angle
4) D absent = no dwell

Rectangular Hole Pattern

A different number of holes can be requested in both X & Y axis in a rectangular pattern, optionally rotated at an angle specifying the required drilling cycle.



G65 P8952 [X? Y?] U? V? R? Z? H? [A?] I? J? [Q? D?]

[ ] denotes optional inputs.
If no X & Y axis are on the line of program then the current tool position will become the 1st hole position.

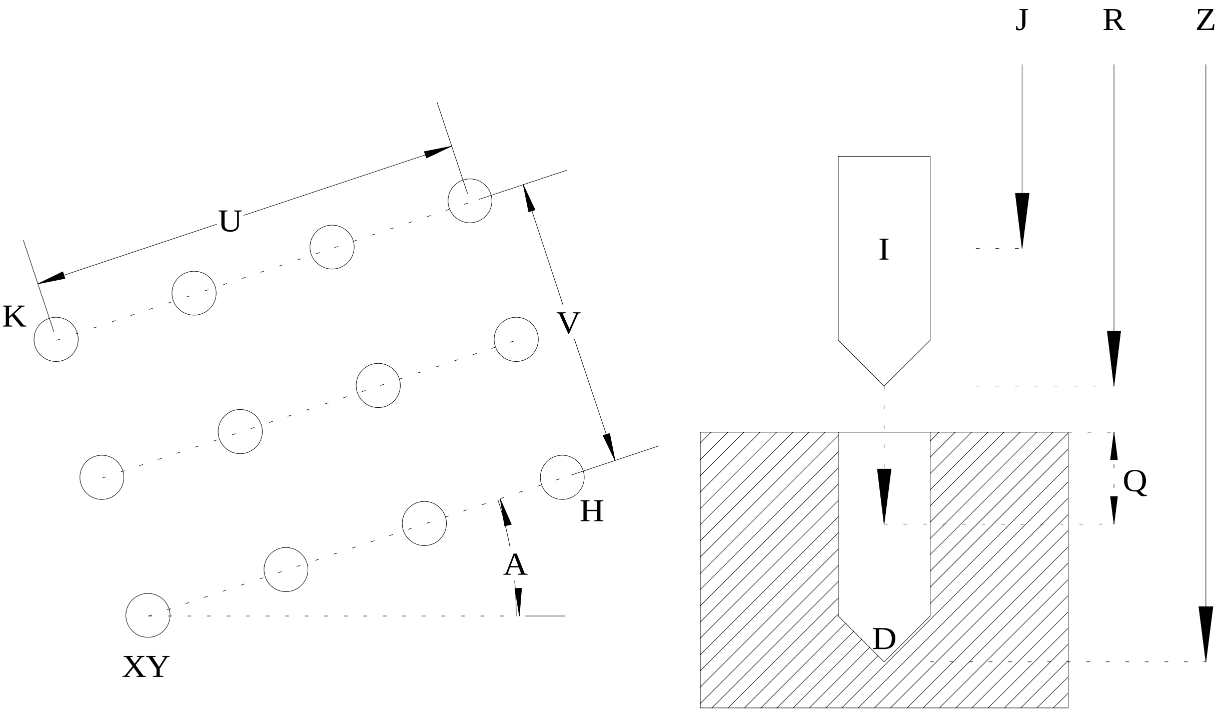
G	Cycle Call (G65)	**U**	Length in the X axis
P	8952 – Rectangular pattern	**V**	Length in the Y axis
X	X axis to 1st hole	**I**	Drilling cycle
Y	Y axis to 1st hole	**J**	Return point code (98 / 99)
Z	Z axis hole end position	**Q**	Peck depth (G73/G83) *
A	Angle of rotation from 0	**D**	Dwell
R	R Plane	**H**	No. of holes in the X axis
		K	No. of holes in the Y axis

Note

1) I, J & K are programmed in alphabetical order
2) *Q is mandatory with I83 or I73
3) A absent = zero angle
4) D absent = no dwell

Grid or Line Hole Pattern

A Grid or Line of holes can be specified, optionally rotated at an angle specifying the required drilling cycle.



G65 P8953 [X? Y?] U? V? R? Z? H? [A?] I? J? [Q? D?]

[ ] denotes optional inputs.
If no X & Y axis are on the line of program then the current tool position will become the 1st hole position.

G	Cycle Call (G65)	**U**	Length in the X axis
P	8953 – Grid or Line	**V**	Length in the Y axis
X	X axis to 1st hole	**I**	Drilling cycle
Y	Y axis to 1st hole	**J**	Return point code (98 / 99)
Z	Z axis hole end position	**Q**	Peck depth (G73/G83) *
A	Angle of rotation from 0	**D**	Dwell
R	R Plane	**H**	No. of holes in the X axis
		K	No. of holes in the Y axis

Note

1) I, J & K are programmed in alphabetical order
2) *Q is mandatory with I83 or I73
3) A absent = zero angle
4) D absent = no dwell

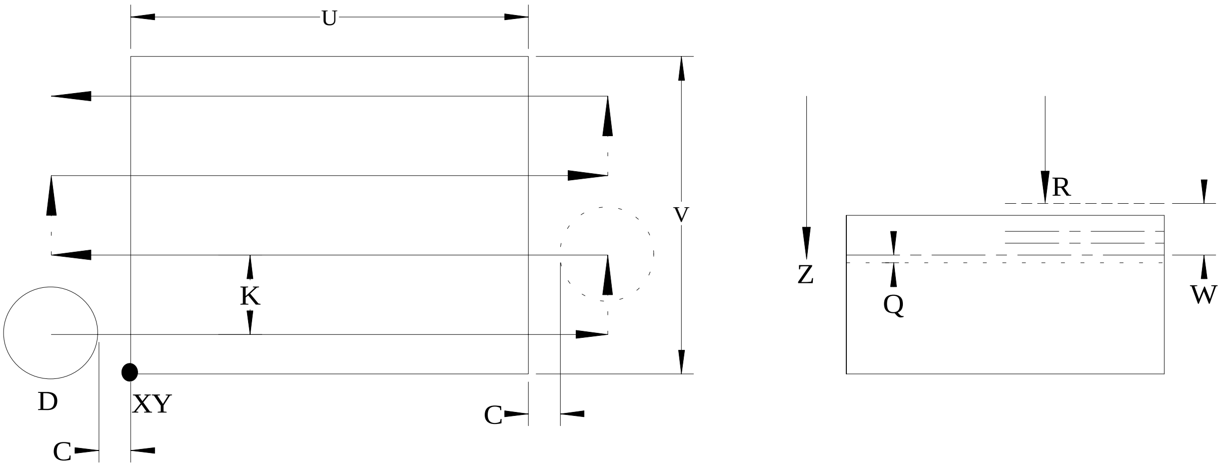
For a line of holes in the X axis: H > 1, K = 1
For a line of holes in the Y axis: K>1, H = 1

Rectangular Facing

Bi-directional facing in the X & Y axis can be performed with the ability to also make allowances for finishing results.

G65 <u>P8954</u> X? Y? U? V? R? Z? W? C? K? [Q? F? S?] D?

[ ] denotes optional inputs.



G	Cycle Call (G65)	**U**	Length in the X axis
P	8954 – Rectangular face	**V**	Length in the Y axis
X	X axis to L/H corner	**K**	Cut width % (10% – 80%)
Y	Y axis to L/H corner	**D**	Tool radius offset number
Z	Z axis end position	**Q**	Finish allowance
R	R Plane	**F**	Finish feedrate *
W	Number of cuts in Z axis	**S**	Finish speed *
C	Clearance		

Note

1) *Mandatory with Q?
2) If U < V then machining will be performed in the Y axis.
3) If U > V then machining will be performed in the X axis.

Roughing Feed/Speed

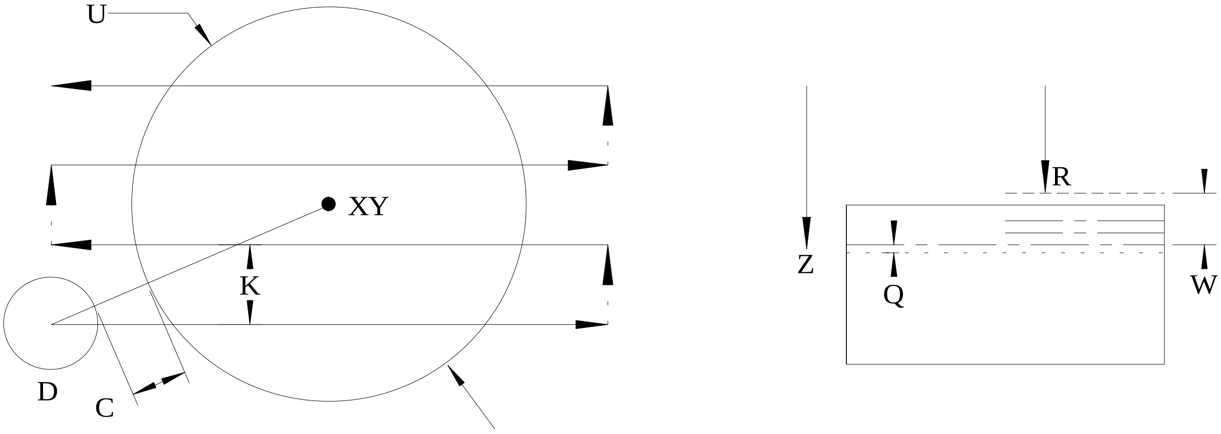
The roughing feed and speed are programmed before the cycle call.

Circular Facing

Bi-directional facing in the X & Y axis of a circular billet can be performed with the ability to also make allowances for finishing results.

G65 P8955 X? Y? U? R? Z? W? C? K? [Q? F? S?] D?

[ ] denotes optional inputs.



G	Cycle Call (G65)	**U**	Diameter of billet
P	8955 – Circular Face	**K**	Cut width % (10% – 80%)
X	X axis to centre	**D**	Tool radius offset number
Y	Y axis to centre	**Q**	Finish allowance
Z	Z axis end position	**F**	Finish feedrate *
R	R Plane	**S**	Finish speed *
W	Number of cuts in Z axis		
C	Clearance		

Note

1) *Mandatory with Q?

Roughing Feed/Speed

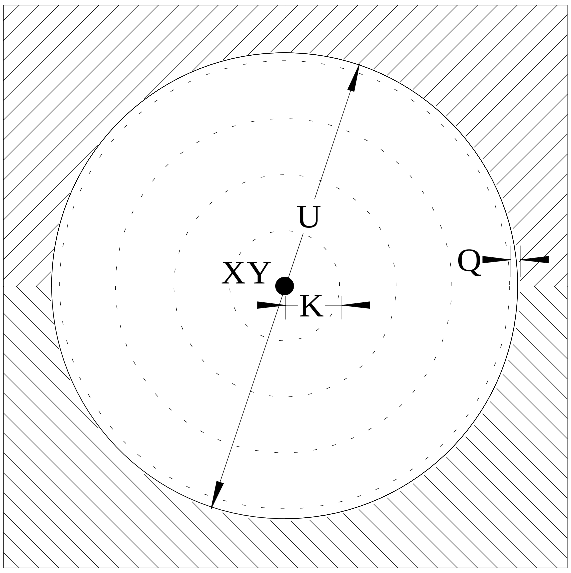
The roughing feed and speed are programmed before the cycle call.

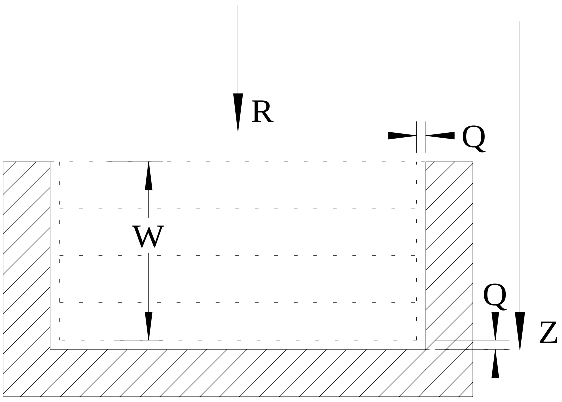
Circular Pocket

Internal circular pocketing can be performed with the ability to also make allowances for finishing results.

G65 P8956 X? Y? U? R? Z? W? E? K? [Q? F? S?] D?

[ ] denotes optional inputs.





G	Cycle Call (G65)	U	Diameter of pocket
P	8956 – Circular Pocket	K	Cut width % (10% – 80%)
X	X axis to centre	D	Tool radius offset number
Y	Y axis to centre	Q	Finish allowance
Z	Z axis end position	F	Finish feedrate *
R	R Plane	S	Finish speed *
W	Number of cuts in Z axis	E	Z axis feed

Note

1) *Mandatory with Q?
2) Climb milling (down cut) is performed.

Roughing Feed/Speed

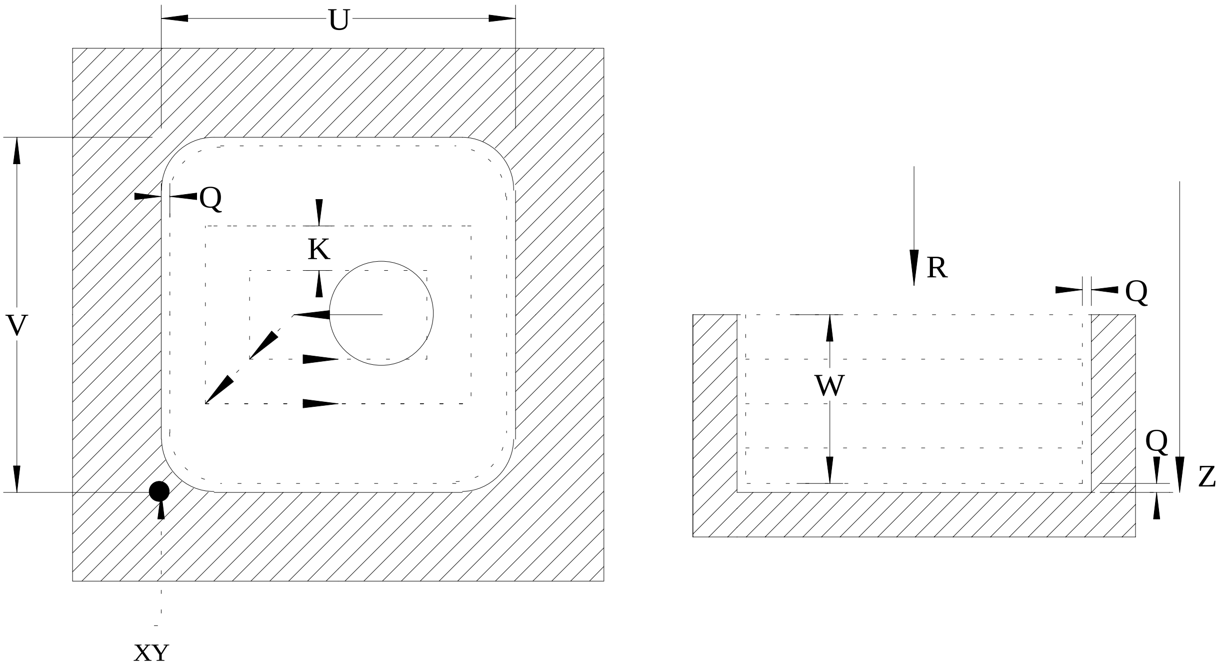
The roughing feed and speed are programmed before the cycle call.

Rectangular Pocket

Internal rectangular pocketing can be performed with the ability to also make allowances for finishing results.

G65 P8957 X? Y? U? V? R? Z? W? E? K? [Q? F? S?] D?

[ ] denotes optional inputs.



G	Cycle Call (G65)	**V**	Y axis width
P	8957 – Rectangular Pocket	**K**	Cut width % (10% – 80%)
X	X axis to centre	**D**	Tool radius offset number
Y	Y axis to centre	**Q**	Finish allowance
Z	Z axis end position	**F**	Finish feedrate *
R	R Plane	**S**	Finish speed *
W	Number of cuts in Z axis	**E**	Z axis feed
U	X axis length		

Note

1) *Mandatory with Q?
2) Climb milling (down cut) is performed.

Roughing Feed/Speed

The roughing feed and speed are programmed before the cycle call.