

# Section 6: Fixed Subroutines

**Definition** Fixed Subroutines are dedicated cycles, standard in the memory of the control. They are called by the use of an L word (L9101 - L9901) and will use parameters (R0-R4, Z, & F). Fixed subroutines can be used during programs run from memory or DNC operations. Subroutine calls are not allowed in MDI.

**L9101 Probe Functions** See the Probe section for L9101 applications.

**Engraving L9201 Engraving Functions** Engraving functions are invoked by using the L9201 code. The L9201 function is capable of engraving either a constant text/number string or a serialized text/number string. All lettering is uppercase.

- Parameters**
- 1) A tool must have been specified by an **H** or **D** word.
  - 2) The **Z** word defines the final depth of cut for the cycle. The maximum **Z** depth from **R0** plane to final is 2.5 inches.
  - 3) The **R0** word is used to define the clearance plane for the tool to move above the part. The tool retracts to this plane when moving between characters, changing position to continue the same character, or after the last character is engraved.
  - 4) **R1** defines mode selection of four options:
    - a. A value of 0 for standard Gothic font (R1+0.).
    - b. A value of 1 for stencil type Gothic font (R1+1.).
    - c. A value of 2 for serialization standard font (R1+2.).
    - d. A value of 3 for serialization stencil font (R1+3.).
  - 5) **R2** represents the height of characters to be engraved minus the tool diameter. The maximum character height is 2.5 inches.
  - 6) **R3** represents the angle at which the characters are to be engraved.(see figure

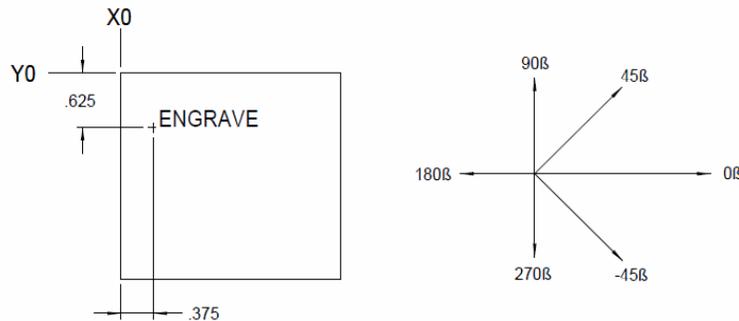
7) **R4** is the serialization increment selector (1-9). Enter the R4 value for the increment amount. R4+1. increments the number by one for each part. R1 must be R1+2 or R1+3 to allow R4 to function.

8) **F** is the feed rate.

The comment or words typed after the ( (left parenthesis) will be engraved.

- Restrictions**
- 1) The maximum number of characters (including spaces) that can be engraved in each use of the L9201 code is 63 minus the number of characters used to code the first part of the L9201 line itself.
  - 2) When serializing, the last of the text/number string must be the number to increment.

**Engraving a Constant String** The procedure to engrave the word “ENGRAVE” .125 inch high, using a .015 inch diameter engraving tool, is shown below:



**Figure 6-1** Engraving a Constant String

- 1) Position the X and Y to the start position (see Computing Start Position on page 6-6).

**Note:** This is true for engraving at an angle of zero degrees (see figure above). When engraving on a non-zero angle the X and Y axis must be shifted properly for the angle programmed.

- 2) Position the Z axis to the Initial Plane.
- 3) Set up the engraving cycle.

**EXAMPLE:** *N1 O1 (SAMPLE ENGRAVING PROGRAM  
 N2 M6 T1  
 N3 (TOOL #1 ENGRAVING TOOL .015 CENTER DRILL  
 N4 G0 G90 S10000 M3 E1 X.375 Y-.6175  
 N5 H1 D1 M8 Z.05 (DIAMETER .015 IN OFFSET PAGE  
 N6 L9201 R0+.05 R1+0 R2+.125 R3+0 Z-.005 F40. (ENGRAVE  
 N7 M5 M9  
 N8 G90 G0 H0 Z0  
 N9 E0 X0 Y0  
 N10 M2*

**Engraving a Serialized String** Serialization is used to engrave numbers on a series of parts while changing the number on each part. The R1 value must be either a 2 or 3 to identify the serialized engraving style. The R4 value must be used to identify the increment amount. This amount is in whole numbers only (to increment decimal numbers, the decimal point must be engraved as a separate character). The numbers to be serialized **MUST** be at the end of the engraving characters.

When serialization is coded, the machine changes the program code to reflect the next number to be engraved. The program code is changed after the control processes the engraving line. To reset the number, the operator must manually change the program code.

**Note:** When the same number is to be engraved on each part, **DO NOT** use serialized engraving.

**EXAMPLE:** *N1 O1 (SAMPLE ENGRAVING PROGRAM  
 N2 M6 T1  
 N3 (TOOL #1 ENGRAVING TOOL  
 N4 G0 G90 S10000 M3 E1 X.375 Y-.6175  
 N5 H1 D1 M8 Z.05  
 N6 L9201 R0+.05 R1+2. R2+.125 R3+0 R4+1. Z-.005 F40. (ENGRAVE 1  
 N7 M5 M9  
 N8 G90 G0 H0 Z0  
 N9 E0 X0 Y0  
 N10 M2*

**Serialization Range** Serialized engraving uses the number of digits at the end of the initial engraving string to set the range of serialization. For instance, if the end of the string is 5 digits (00001), the maximum number engraved will be 99999, and the number engraved after 99999 will be 00000.

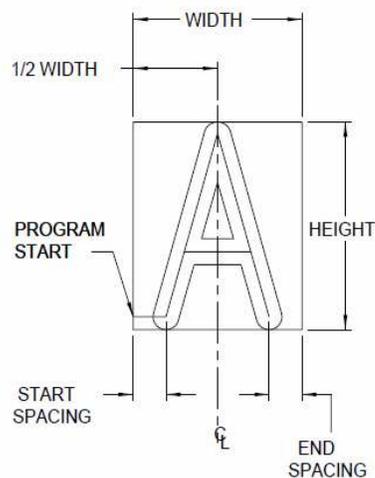
The preceding example engraves ENGRAVE 1 on the first part and ENGRAVE 2 on the second and so on. This example will engrave the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0. After the 0 the number 1 is engraved again. Further, the maximum number of digits that could be coded in this example is five (00000 through 99999), because 58 characters on the L9201 line are used by program code, including the spaces, right parenthesis, and constant portion of the engraving text.

**EXAMPLE:** ENGRAVE 01 serializes the numbers 01 through 99, then 00, and then restarts at 01.

ENGRAVE 0001 serializes the numbers 0001 through 9999, then 0000, and then restarts at 0001.

**Spacing, Positioning, & Tool Path Calculations**

The L9201 Fixed Subroutine uses the Letter Box (the rectangular area around each character) to calculate the tool path for the engraving, beginning at the X, Y position specified in the program.



**Figure 6-2** Letter Box

**Computing Actual Letter Height from the R2 Variable**

The L9201 Fixed Subroutine calculates the actual height of the tool path as follows:

$$\text{Actual height} = (\text{desired letter height}) - (\text{tool diameter})$$

**Computing Start Spacing**

The L9201 Fixed Subroutine calculates the start spacing for each character as follows:

$$\text{Start spacing} = (\text{actual height}) * (\text{start factor})$$

**Computing End Spacing** The L9201 Fixed Subroutine calculates the end spacing for each character as follows:

$$\text{End spacing} = (\text{actual height}) * (\text{end factor})$$

**Computing Start Position** **X:** The L9201 Fixed Subroutine will move to the X position specified in the program, and then move in X the amount calculated for the start spacing of the first character, before beginning the engraving cut.

**Y:** The program must specify a starting Y position that takes into account the tool diameter, so that the tool is initially positioned one-half the tool diameter above the desired baseline of the engraving.

X and Y should be specified together before each L9201 line.

**Computing Engraving Length** Occasionally, it is necessary to calculate the length of the engraving. The procedure for calculating the length is as follows:

- 1) Establish a desired height for the engraving.
- 2) Choose the tool diameter. A recommended value is a diameter equal to .14 times the desired height. Remember to place this diameter in the offset page.
- 3) Calculate the width factor for the engraving, using the Letter Width Table to sum the width for each character or space.
- 4) Calculate the total engraving length using the formula:

$$\text{Engraving length} = (\text{actual height}) * (\text{total width factor})$$

**EXAMPLE:** Calculate the length of the word "ENGRAVE" to be engraved at a height of .125 inches with a tool diameter of .015 inches.

- 1) Tool diameter = .015 inches
- 2) Actual height = (desired letter height) - (tool diameter) = .125 - .015 inches = .110 inches
- 3) Total width factor = the sum of the Letter Width Table's width factors for each character or space.

$$E(.8853)+N(.9573)+G(.9588)+R(.9749)+A(1.0506)+V(1.0147)+E(.8853)=6.7269$$

- 4) The actual engraving length is now given by: .

Engraving length = (actual height) \* (width factor)  
 or, in this example, engraving length = (.110) \* (6.7269) = .73996

**Note:** The tool diameter must be entered in the offset page, and an H word and/or D word must be used in the program prior to calling the L9201

**Letter Width Factor Values** The letter width is based on the box space for each letter. The Start and End factors are used to calculate the distance from the edge of the letter box to the start and end points of the letter.

**Table 1: Letter Width Factor Table**

Character	Width	Start	End
A	1.0506	.2279	.2279
B	.9455	.2279	.1284
C	.9471	.1837	.2677
D	.9441	.2279	.1927
E	.8853	.2279	.2280
F	.9118	.2279	.2294
G	.9588	.2153	.2282
H	.9706	.2279	.2353
I	.4559	.2279	.2280
J	.95	.2279	.2280
K	1.0249	.2279	.2278
L	.8941	.2279	.2280
M	1.0824	.2279	.2280
N	.9573	.2279	.2279
O	.9647	.1779	.1779
P	.9485	.2279	.2279
Q	.9647	.1779	.1779
R	.9749	.2279	.2278
S	.9853	.2279	.2280
T	.9485	.2279	.2279
U	1.0000	.2279	.2280
V	1.0147	.2279	.2280
W	1.2059	.2279	.2279
X	.9559	.2279	.2280
Y	1.0441	.2279	.2280
Z	.9441	.2279	.2280

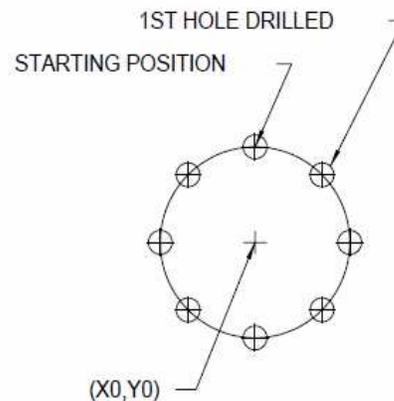
The letter width is based on the box space for each letter. The Start and End factors are used to calculate the distance from the edge of the letter box to the start and end points of the letter.

**Table 2: Letter Width Factor Table**

Character	Width	Start	End
\	.9559	.2279	.2280
!	.7353	.3676	.3677
#	1.0441	.1926	.1927
\$	.9559	.2276	.2280
%	.8676	.2279	.2280
'	.7353	.3676	.3677
&	.9853	.2345	.1453
(	.5855	.2279	.2279
)	.5855	.2279	.2279
*	.9559	.2279	.2280
	1.1029	.2279	.2280
,	.7353	.2941	.2960
-	1.1029	.2279	.2280
.	.7353	.3676	.3677
/	.9559	.2279	.2280
0	.9647	.1779	.1779
1	.6059	.2279	.2280
2	.8926	.2279	.2271
3	.9632	.2279	.2281
4	1.0779	.2279	.2279
5	.9485	.2279	.2089
6	.9118	.2153	.2267
7	.9691	.2279	.2279
8	.9706	.2271	.2282
9	.9118	.2259	.2123
:	.7353	.3676	.3677
;	.7353	.2941	.2957
"	.7704	.2274	.2274
=	1.1029	.2279	.2280
?	.9853	.2279	.2280
Space	.8823		

## Bolt Circle

- L93NN Bolt Circle**
- 1) **R0** represents the I definition of a circle. This is **the X direction and distance** from the starting position to the center.
  - 2) **R1** represents the J definition of a circle. This is **the Y direction and distance** from the starting position to the center.
  - 3) **R2** represents **the angular step between holes**. A positive angular step will move CCW around the bolt circle, while a negative angular step will move CW around the bolt circle.
  - 4) **NN** is the number of holes to be drilled. For example, L9304 is for 4 holes.



**Figure 6-3** 1st Hole Drilled

The drawing above is a 3.0" diameter, 8 hole, evenly spaced bolt circle. The procedure is as follows:

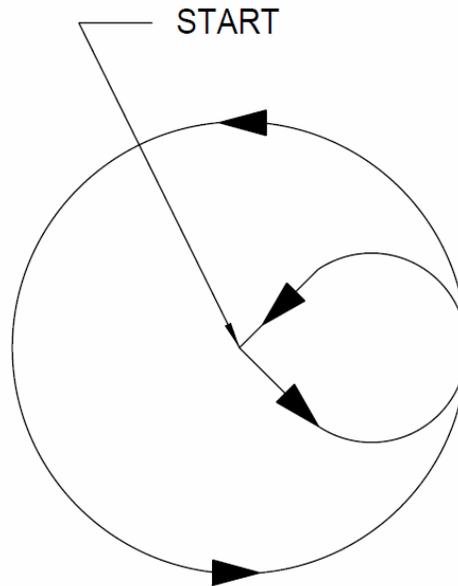
- 1) Position the X,Y axes to the starting position (the last hole of the bolt circle to be drilled) and the Z axis to the I plane.
- 2) Select desired Fixed Cycle.
- 3) Start Bolt Circle subroutine.

### **EXAMPLE:** (Format 1):

```
N1 O1 (BOLT HOLE EXAMPLE
N2 G0 G90 S2000 M3 X0 Y1.5 Position to starting position
N3 H1 M7 Z.1
N4 G81 G99 R0+.1 Z-1.0 F10. Set up Fixed Cycle
N5 L9308 R0+0 R1-1.5 R2-45. Call Bolt Circle Subroutine
N6 M5 M9
N7 G80
```

**Mill Boring  
L94NN Mill Boring  
Cycle  
Counterclockwise**

- 1) A tool must have been specified by an H or D word and the tool diameter **MUST** be in the tool table.
- 2) **R0** represents the feed rate.
- 3) **R1** represents the diameter of hole to be bored.
- 4) **NN** represents the number of repetitions desired.



**Figure 6-4** Boring Cycle Counter Clockwise

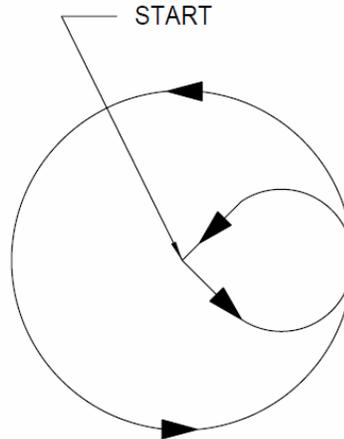
The drawing above is a 1.5 diameter hole to be mill bored. The procedure is as follows:

- 1) Position the X,Y axes to the center.
- 2) Position the Z axis to finished depth.
- 3) Start Mill Boring Cycle.

**EXAMPLE:** *N1 O1 (MILL BORING CCW EXAMPLE  
N2 M6 T1  
N3 G0 G90 S2000 M3 X1.0 Y-1.0  
N4 H1 D1 M7 Z.1  
N5 G1 F10. Z-1.  
N6 L9401 R0+10. R1+1.5  
N7 M5 M9  
N8 G0 H0 G90 Z0*

**L95NN Mill Boring  
Cycle Clockwise**

- 1) A tool must have been specified by an H or D word and the tool diameter **MUST** be in the tool table.
- 2) **R0** represents the feed rate.
- 3) **R1** represents the diameter of hole to be bored.
- 4) **NN** represents the number of repetitions desired.



**Figure 6-5** Hole Diameter

The drawing above is a 1.5 diameter hole to be mill bored. The procedure is as follows:

- 1) Position the X,Y axes to the center.
- 2) Position the Z axis to finished depth, selecting the proper H word or D word to specify the diameter the tool is using.
- 3) Start Mill Boring Cycle.

**EXAMPLE:** *N1 O1 (MILL BORING CW EXAMPLE*  
*N2 M6 T1*  
*N3 G0 G90 S2000 M3 X1.0 Y-1.0*  
*N4 H1 D1 M7 Z.1*  
*N5 G1 F10. Z-1.*  
*N6 L9501 R0+10. R1+1.5*  
*N7 M5 M9*  
*N8 G0 G49 G90 Z0*

## Rectangular Pocket Clean-out

### L9601 Rectangular Pocket Clean-out Counterclockwise

1) A tool must have been specified by an H or D word and the tool diameter **MUST** be in the tool table.

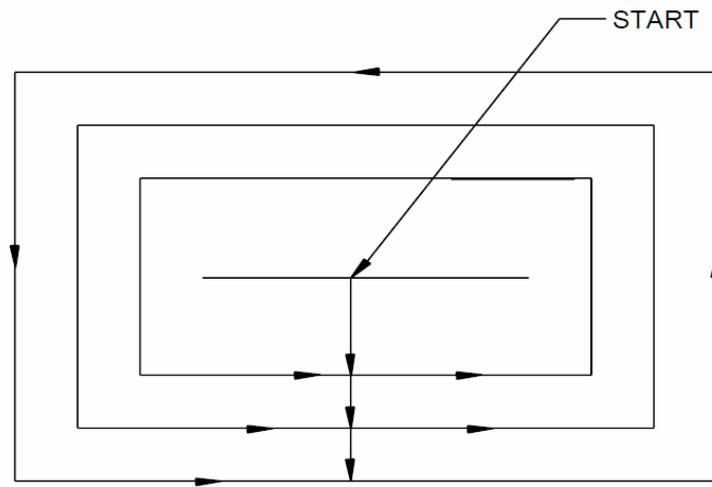
2) **R0** represents the feed rate.

3) **R1** represents the radius on the corner of the tool.

**Note:** This can be used to regulate the step over distance. The larger this number, the less the amount of step over.

4) **R2** represents the overall X dimension.

5) **R3** represents the overall Y dimension.



**Figure 6-6** Counterclockwise Rectangular Pocket Clean-Out

The tool path drawing above shows how a 3.25 by 1.75 rectangular pocket would be cleaned out with a .25" diameter tool. The procedure is as follows:

1) Position the X,Y axes to the center of the pocket.

2) Position the Z axis to finished depth, selecting the proper H or D word to specify the diameter the tool is using.

3) Start Rectangular Pocket Subroutine.

**EXAMPLE:** N1 O1 (RECT CLEANOUT CCW EXAMPLE  
 N2 M6 T1  
 N3 G0 G90 S2000 M3 X1.0 Y1.0  
 N4 H1 D1 M7 Z.1  
 N5 G1 F10. Z-1.  
 N6 L9601 R0+10. R1+.01 R2+3.25 R3+1.75  
 N7 M5 M9  
 N6 G0 G49 G90 Z0

**L9701 Rectangular  
 Pocket Clean-out  
 Clockwise**

1) A tool must have been specified by an H or D word and the tool diameter **MUST** be in the tool table.

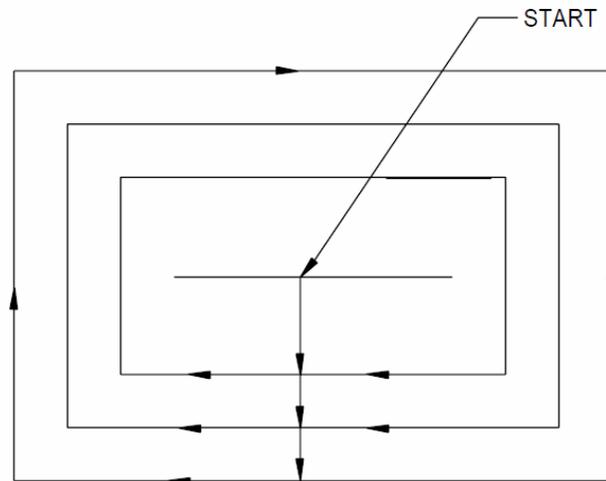
2) **R0** represents the feed rate.

3) **R1** represents the radius on the corner of the tool.

**Note:** This can be used to regulate the step over distance. The larger this number, the less the amount of step over.

4) **R2** represents the overall X dimension.

5) **R3** represents the overall Y dimension.



**Figure 6-7** Clockwise Rectangular Pocket Clean-Out

The tool path drawing above shows how a 3.25 by 1.75 rectangular pocket would be cleaned out with a .25" diameter tool. The procedure is as follows:

1) Position the X,Y axes to the center of the pocket.

2) Position the Z axis to finished depth, selecting the proper H or D word to specify the diameter the tool is using.

3) Start Rectangular Pocket Subroutine.

**EXAMPLE:** *N1O1 (RECT CLEANOUT CW EXAMPLE*  
*N2 M6 T1*  
*N3 G0 G90 S2000 M3 X1.0 Y1.0*  
*N4 H1 D1 M7 Z .1*  
*N5 G1 F10. Z-1.*  
*N6 L9701 R0+10. R1+.01 R2+3.25 R3+1.75*  
*N7 M5 M9*  
*N8 G0 G49 G90 Z0*

## Circular Pocket Clean-out

### L9801 Circular Pocket Clean-out Counterclockwise

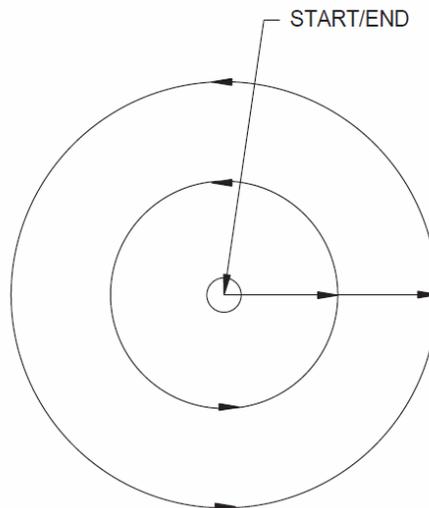
1) A tool must have been specified by an H or D word and the tool diameter **MUST** be in the tool table.

2) **R0** represents the feed rate.

3) **R1** represents radius on the corner of the tool.

**Note:** This can be used to regulate the step over distance. The larger this number, the less the amount of step over.

4) **R2** represents diameter of the pocket.



**Figure 6-8** Counterclockwise Circular Pocket Clean-Out

The tool path drawing above shows how a 1.75 diameter circular pocket would be cleaned out by a .25" diameter tool. The procedure is as follows:

1) Position the X,Y axes to the center.

2) Position the Z axis to finished depth, selecting the proper H or D word to specify the diameter the tool is using.

3) Start Pocket Subroutine.

**EXAMPLE:** *N1 O1 (CIRC CLEANOUT CCW EXAMPLE*  
*N2 M6 T1*  
*N3 G0 G90 S2000 M3 X1.0 Y-1.0*  
*N4 H1 D1 M7 Z.1*  
*N5 G1 F10. Z-1.*

```

N6 L9801 R0+10. R1+.01 R2+1.75
N7 M5 M9
N8 G0 G49 G90 Z0

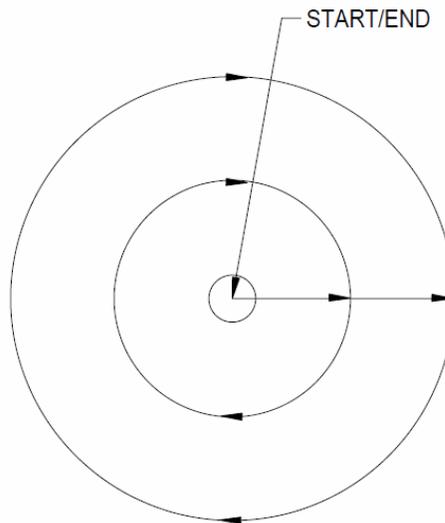
```

**L9901 Circular  
Pocket Clean-out  
Clockwise**

- 1) A tool must have been specified by an H or D word and the tool diameter **MUST** be in the tool table.
- 2) **R0** represents the feed rate.
- 3) **R1** represents radius on the corner of the tool.

**Note:** This can be used to regulate the step over distance. The larger this number, the less the amount of step over.

- 4) **R2** represents the diameter of the pocket.



**Figure 6-9** Clockwise Circular Pocket Clean-Out

The tool path drawing above shows how a 1.75 diameter circular pocket would be cleaned out by a .25" diameter tool. The procedure is as follows:

- 1) Position the X,Y axes to the center.
- 2) Position the Z axis to finished depth, selecting the proper H or D word to specify the diameter the tool is using.
- 3) Start Pocket Subroutine

**EXAMPLE:** *N1 O1 (CIRC CLEANOUT CW EXAMPLE  
N2 M6 T1*

N3 G0 G90 S2000 M3 X1.0 Y-1.0  
N4 H1 D1 M7 Z.1  
N5 G1 F10. Z-1.  
N6 L9901 R0+10. R1+.01 R2+1.75  
N7 M5 M9  
N9 G0 G49 G90 Z0