

TITLE		
CLSFCUT Interface Specification		
Document Type: Software specification	Part No: 300319	Revision: 01

1. Description

This document describes the interface specification for *.cls file, which is called as CLSFCUT file format. The file contains tool path information for the robotic cutting.

2. References

- 2.1 ISO 4343:2000, Industrial automation systems – Numerical control of machines –NC processor output – Post processor commands
- 2.2 700188, Rev01, Procedure for Use of NX Software for Implant Module Generation Process
- 2.3 P/N 300072, Spec, Cutfile ASCII Format
- 2.4 P/N 300071, Spec, Cutfile Binary Format
- 2.5 P/N 300321, Interface Specification for TSolution One.
- 2.6 P/N 300317, Interface Specification for cut message display for TSolution One.

3. Background

In the CAM(Computer Aided Machining) industry, to describe the cutting tool path, a language commonly referred as G-Code is used which typically characterized as G command, as of G01, G02 etc. And as there are many NC (Numerically controlled) machine brands and models, actual G code syntax or specification for each NC machine may have slight variation, as of some command is supported by a machine and not supported by other machine.

Meanwhile, ISO 4343 describe a language used for the post processor commands, which usually referred as CLDATA(Cutter Location DATA), or CLS(Cutter Location Source) or CLSF(Cutter Location Source File), which is more versatile than G-code.

It is common practice in the CAM industry that an off-the-shelf CAM software generate tool path as CLS, then a post-processor which is suited for a specific NC machine controller translate the CLS file as G-code for the actual machine. The translation of the CLS to G-code include not only the simple translation of the motion command, but also translation of the command which is impossible in the specific machine to a set of possible commands, offset of the tool path, speed control or optimization of the code.

For example, NX CAD/CAM software, which is currently used for the implant module generation by THINK surgical, also outputs the tool path as CLS file format, which can be treated with appropriate postprocessor.

When compared with the CUT file format used for the THINK surgical product, the CLS file provides similar information as they both provide the tool path for a cutting job; but also they have many difference as CLS contains many more types of commands for the turning or drilling job and is more versatile in the control of the machine.

In this document, interface specification for CLSFCUT(Cutter Location Source File style CUT) is described; the CLSFCUT format provides a more direct interface with commercial CAM system to the cut path specification. The CLSFCUT file support is currently limited compared to the number of commands the CLS format supports, but does include special commands added for the support of THINK surgical product's compatibility.

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4. CLSFCUT file specification

- 4.1 CLSFCUT file have extension of *.cls, and ASCII file.
- 4.2 Following command supported in the CLSFCUT file. Refer NX documentation for the detailed syntax of the command.

Table 1: Command list for CLSFCUT

Command and syntax	Description
\$\$ e.g. \$\$comment	comment
UNITS/ e.g. UNITS/INCH or UNITS/MM	Unit of the values
TOOL PATH/[string],TOOL,TOOLID	Start of a operation. A tool path may contain multiple operations.
GOTO/ x,y,z,l,j,k track previous tool location. If any argument omitted then it is assumed that those values are the same as with previous location. Translates as line command in CUT format.	Make linear movement of the tool tip in Cartesian space from previous location
CIRCLE <center> <arcdir> <rad> GOTO <endpos> <enddir>	CLSFCUT circle command itself does not provides information of the full arc; it requires previous point and next point defined in the CLSFCUT, as circle itself only provides center and radius. Note that In CLSFCUT, arc by circle movement not necessarily connected to the previous point and next point; but it shall be assumed that it is connected.
From <point> <direction>	Tool moves to the specified location in the robot joint space.
FEDRAT / MMPM,float	speed (mm/sec)
LOAD/TOOL, toolid	cutter toolid
MSYS	Transformation matrix of the coordinates in the file
\$\$CUT string	For backward compatibility, any commands as the CUT file syntax.
COOLNT/ON or COOLNT/OFF	Control irrigation. In default the irrigation is turned on when the cutter is turned on.
OPSKIP/ON or OPSKIP/OFF	The part of the tool path from the OPSKIP/ON can be skipped to the start of the next operation.
SPINDL/RPM,(rpm),CLW	Turn on the cutting motor (cutter spindle)
SPINDL/OFF	Turn off the cutting motor
DISPLY/(string,key)	Show message to the user, if numeric key is used, use P/N300317 Cut message display specification to interpret.

- 4.3 CLSFCUT file can be translated into CUT file format. See Table 1 for translational dictionary.

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Table 2: Mapping between CLSFCUT and CUT with command translation and rules

CLSFCUT	CUT
If first line start as \$\$CUT header [string] then add header [string] to cut; otherwise add header [filename] to CUT	header [string]
UNITS/INCH	if this command happens, apply scaling of 1/25.4 to all positional value
TOOL PATH/[string],TOOL,TOOLID	phase [string]
GOTO/ x,y,z,l,j,k track previous tool location. If any argument omitted then assume those value same with previous location. Translate as line command.	line5b <prevPos> <prevDir> <commandedPos> <commandedDir>
CIRCLE <center> <arcdir> <rad> GOTO <endpos> <enddir> CLSFCUT circle command itself does not provides information of the full arc; it requires previous point and next point defined in the CLSFCUT, as circle itself only provides center and radius. Note that In CLSFCUT, arc by circle movement not necessarily connected to the previous point and next point; but it shall be assumed that it is connected.	arc5b <prevpos> <middlepos> <endpos> <prevdir> <enddir> middlepos calculated from previous point, end point, circle center. Arc angle is equal or less than 180 degree and if arc angle is 180 degree then direction of arc determines the rotation direction.
From <point> <direction>	point <point> if direction provided then orient <direction> point <point>
FEDRAT / MPPM,float	speed (mm/sec)
LOAD/TOOL, toolid	cutter toolid
\$\$string	comment string
\$\$CUT string	string
all other command as of PAINT, RAPID etc which is not defined above	comment CLSFCUT [CLSFCUT command]
If first line start as \$\$CUT header [string] then add header [string] to cut; otherwise add header [filename] to CUT	header [string]
UNITS/INCH	if this command happens, apply scaling of 1/25.4 to all positional value
TOOL PATH/[string],TOOL,TOOLID	phase [string]
FEDRAT / MPPM,float	speed (mm/sec)
LOAD/TOOL, toolid	cutter toolid
END-OF-PATH	End of file
MSYS	Transformation
\$\$Guide message (or key)	Guide message (or key)

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5. Disposition

Any changes to definitions contained within the implant support software require the generation of new implant modules (ref P/N 700175).

6. Appendix

Sample CLSFCUT file format. (First 175 lines)

```

$$CUT header ZMLs4 20150618 190451
TOOL PATH/PRECU,TOOL,100000
FEDRAT/MMPM,1000.000
GOTO/10.0000,0.0000,-60.0000,-0.116400,-0.000000,-0.993202
$$CUT checkpoint PRECU < 10.0000, 0.0000, -60.0000 > 0.0001
TLDATA/MILL,8.2500,0.0000,5.0800,0.0000,0.0000
$$ centerline data
PAINT/PATH
PAINT/SPEED,10
LOAD/TOOL,102862
PAINT/COLOR,186
RAPID
$$CUT accel 0.030 0.030
$$CUT decel_on
FEDRAT/MMPM,1500.000
$$CUT fcparms 0.025 0.040 0.010 4.000
$$CUT startshape sh0 10
GOTO/10.0000,0.0000,-60.0000,-0.116400,-0.000000,-0.993202
GOTO/10.0000,0.0000,-60.0000,-0.116400,-0.000000,-0.993202
SPINDL/RPM,1050,CLW
PAINT/COLOR,6
GOTO/27.4327,-0.0013,-35.5780,-0.116400,-0.000000,-0.993202
PAINT/COLOR,31
$$CUT decel_off
FEDRAT/MMPM,420.000
$$CUT fcparms 0.007 0.005 0.010 4.000
GOTO/27.3960,0.4130,-35.5780,-0.115697,-0.004500,-0.993274
FEDRAT/MMPM,540.000
$$CUT fcparms 0.009 0.007 0.010 4.000

```

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GOTO/27.1026,0.8056,-35.5780,-0.112501,-0.008900,-0.993612
 FEDRAT/MMPM,1080.000
 \$\$CUT fcparms 0.018 0.025 0.010 4.000
 GOTO/26.6795,1.1621,-35.5780,-0.107898,-0.012800,-0.994080
 FEDRAT/MMPM,1080.000
 \$\$CUT fcparms 0.018 0.026 0.010 4.000
 GOTO/25.8783,1.4286,-35.5780,-0.099204,-0.015701,-0.994943
 FEDRAT/MMPM,1380.000
 \$\$CUT fcparms 0.023 0.037 0.010 4.000
 GOTO/23.0209,1.4801,-35.5780,-0.067997,-0.016299,-0.997552
 FEDRAT/MMPM,1380.000
 \$\$CUT fcparms 0.023 0.035 0.010 4.000
 GOTO/21.4984,1.5090,-35.5780,-0.051302,-0.016701,-0.998544
 FEDRAT/MMPM,1320.000
 \$\$CUT fcparms 0.022 0.033 0.010 4.000
 GOTO/18.9883,1.5521,-35.5780,-0.023599,-0.017200,-0.999574
 \$\$CUT endshape sh0 10
 \$\$CUT startshape sh1 10
 FEDRAT/MMPM,1260.000
 \$\$CUT fcparms 0.021 0.031 0.010 4.000
 GOTO/16.8503,1.5884,-35.5780,-0.000000,-0.017601,-0.999845
 FEDRAT/MMPM,1140.000
 \$\$CUT fcparms 0.019 0.029 0.010 4.000
 GOTO/14.6098,1.6265,-35.5780,0.024701,-0.018001,-0.999533
 FEDRAT/MMPM,1080.000
 \$\$CUT fcparms 0.018 0.026 0.010 4.000
 GOTO/11.6878,1.6761,-35.5780,0.056900,-0.018500,-0.998208
 FEDRAT/MMPM,1020.000
 \$\$CUT fcparms 0.017 0.023 0.010 4.000
 GOTO/9.7246,1.7094,-35.5780,0.078503,-0.018801,-0.996737
 FEDRAT/MMPM,960.000
 \$\$CUT fcparms 0.016 0.021 0.010 4.000
 GOTO/8.1123,1.7368,-35.5780,0.096099,-0.019100,-0.995189
 FEDRAT/MMPM,780.000
 \$\$CUT fcparms 0.013 0.016 0.010 4.000

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GOTO/5.1634,1.8497,-35.5780,0.127996,-0.020299,-0.991567
 FEDRAT/MMPM,780.000
 \$\$CUT fcparms 0.013 0.015 0.010 4.000
 GOTO/4.7046,1.8003,-35.5780,0.133003,-0.019700,-0.990920
 FEDRAT/MMPM,720.000
 \$\$CUT fcparms 0.012 0.015 0.010 4.000
 GOTO/4.4355,1.7159,-35.5780,0.135892,-0.018799,-0.990545
 FEDRAT/MMPM,720.000
 \$\$CUT fcparms 0.012 0.014 0.010 4.000
 GOTO/4.0563,1.5130,-35.5780,0.139904,-0.016600,-0.990026
 FEDRAT/MMPM,660.000
 \$\$CUT fcparms 0.011 0.012 0.010 4.000
 GOTO/3.5842,1.0428,-35.5780,0.144995,-0.011400,-0.989367
 \$\$CUT endshape sh1 10
 \$\$CUT startshape sh2 10
 FEDRAT/MMPM,600.000
 \$\$CUT fcparms 0.010 0.011 0.010 4.000
 GOTO/3.3349,0.5297,-35.5780,0.147702,-0.005800,-0.989015
 FEDRAT/MMPM,600.000
 \$\$CUT fcparms 0.010 0.009 0.010 4.000
 GOTO/3.2554,-0.0013,-35.5780,0.148502,-0.000000,-0.988912
 FEDRAT/MMPM,480.000
 \$\$CUT fcparms 0.008 0.005 0.010 4.000
 GOTO/3.5215,-0.9507,-35.5780,0.145696,0.010400,-0.989275
 FEDRAT/MMPM,480.000
 \$\$CUT fcparms 0.008 0.005 0.010 4.000
 GOTO/3.5397,-0.9801,-35.5780,0.145598,0.010700,-0.989286
 FEDRAT/MMPM,720.000
 \$\$CUT fcparms 0.012 0.014 0.010 4.000
 GOTO/3.9382,-1.4287,-35.5780,0.141194,0.015599,-0.989859
 \$\$CUT checkpoint ck1 < 4.6442, -1.3507, -40.5275 > 0.0105
 FEDRAT/MMPM,1080.000
 \$\$CUT fcparms 0.018 0.025 0.010 4.000
 GOTO/4.6852,-1.8001,-35.5780,0.133199,0.019700,-0.990893
 FEDRAT/MMPM,1200.000

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$$CUT fcparms 0.020 0.030 0.010 4.000
GOTO/8.5938,-1.7351,-35.5780,0.090799,0.019100,-0.995686
FEDRAT/MMPM,1320.000
$$CUT fcparms 0.022 0.033 0.010 4.000
GOTO/10.6422,-1.7006,-35.5780,0.068399,0.018700,-0.997483
FEDRAT/MMPM,1260.000
$$CUT fcparms 0.021 0.031 0.010 4.000
GOTO/12.7769,-1.6641,-35.5780,0.044901,0.018300,-0.998824
FEDRAT/MMPM,1200.000
$$CUT fcparms 0.020 0.030 0.010 4.000
GOTO/14.6055,-1.6322,-35.5780,0.024801,0.018001,-0.999530
$$CUT endshape sh2 10
$$CUT startshape sh3 10
FEDRAT/MMPM,1140.000
$$CUT fcparms 0.019 0.027 0.010 4.000
GOTO/16.8503,-1.5923,-35.5780,-0.000000,0.017601,-0.999845
FEDRAT/MMPM,1020.000
$$CUT fcparms 0.017 0.025 0.010 4.000
GOTO/18.9859,-1.5530,-35.5780,-0.023599,0.017100,-0.999575
FEDRAT/MMPM,960.000
$$CUT fcparms 0.016 0.022 0.010 4.000
GOTO/21.4771,-1.5047,-35.5780,-0.050998,0.016599,-0.998561
FEDRAT/MMPM,900.000
$$CUT fcparms 0.015 0.019 0.010 4.000
GOTO/22.9873,-1.4747,-35.5780,-0.067599,0.016200,-0.997581
FEDRAT/MMPM,720.000
$$CUT fcparms 0.012 0.015 0.010 4.000
GOTO/25.7553,-1.4117,-35.5780,-0.097898,0.015500,-0.995076
FEDRAT/MMPM,660.000
$$CUT fcparms 0.011 0.013 0.010 4.000
GOTO/26.6433,-1.1604,-35.5780,-0.107503,0.012700,-0.994124
FEDRAT/MMPM,660.000
$$CUT fcparms 0.011 0.011 0.010 4.000
GOTO/27.1143,-0.8091,-35.5780,-0.112699,0.008900,-0.993589
FEDRAT/MMPM,600.000

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$$CUT fcparms 0.010 0.010 0.010 4.000
GOTO/27.2772,-0.6162,-35.5780,-0.114401,0.006700,-0.993412
FEDRAT/MMPM,600.000
$$CUT fcparms 0.010 0.010 0.010 4.000
GOTO/27.3421,-0.5194,-35.5780,-0.115104,0.005700,-0.993337
FEDRAT/MMPM,600.000
$$CUT fcparms 0.010 0.010 0.010 4.000
GOTO/27.3850,-0.4152,-35.5780,-0.115598,0.004500,-0.993286
$$CUT endshape sh3 10
$$CUT startshape sh4 10
FEDRAT/MMPM,780.000
$$CUT fcparms 0.013 0.017 0.010 4.000
GOTO/27.4327,-0.0013,-35.5780,-0.116400,-0.000000,-0.993202
FEDRAT/MMPM,780.000
$$CUT fcparms 0.013 0.017 0.010 4.000
GOTO/27.3960,0.4130,-35.5591,-0.115697,-0.004500,-0.993274
FEDRAT/MMPM,840.000
$$CUT fcparms 0.014 0.018 0.010 4.000
GOTO/27.1026,0.8056,-35.5402,-0.112501,-0.008900,-0.993612
FEDRAT/MMPM,1080.000
$$CUT fcparms 0.018 0.025 0.010 4.000
GOTO/26.6795,1.1621,-35.5212,-0.107898,-0.012800,-0.994080
FEDRAT/MMPM,1080.000
$$CUT fcparms 0.018 0.026 0.010 4.000
GOTO/25.8783,1.4286,-35.5023,-0.099105,-0.015701,-0.994953
FEDRAT/MMPM,1440.000
$$CUT fcparms 0.024 0.038 0.010 4.000
GOTO/23.0209,1.4801,-35.4644,-0.067897,-0.016299,-0.997559
FEDRAT/MMPM,1440.000
$$CUT fcparms 0.024 0.037 0.010 4.000
GOTO/21.4984,1.5090,-35.4265,-0.051197,-0.016599,-0.998551
FEDRAT/MMPM,1380.000
$$CUT fcparms 0.023 0.035 0.010 4.000
GOTO/18.9883,1.5521,-35.2749,-0.023499,-0.017100,-0.999578
FEDRAT/MMPM,1320.000

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$$CUT fcparms 0.022 0.034 0.010 4.000
GOTO/17.9912,1.5690,-35.1233,-0.012500,-0.017300,-0.999772
FEDRAT/MMPM,1320.000
$$CUT fcparms 0.022 0.034 0.010 4.000
GOTO/17.3639,1.5797,-34.9718,-0.005600,-0.017301,-0.999835
$$CUT endshape sh4 10

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