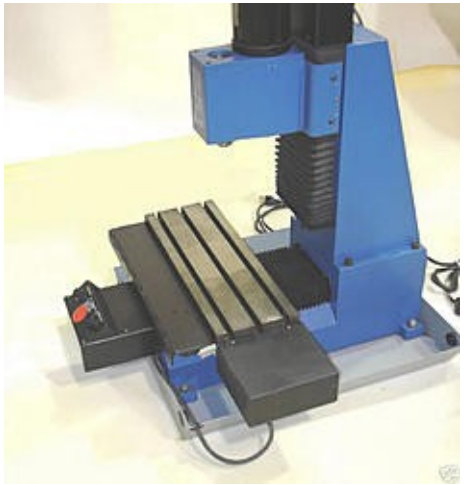
ENGR480 Manufacturing Systems

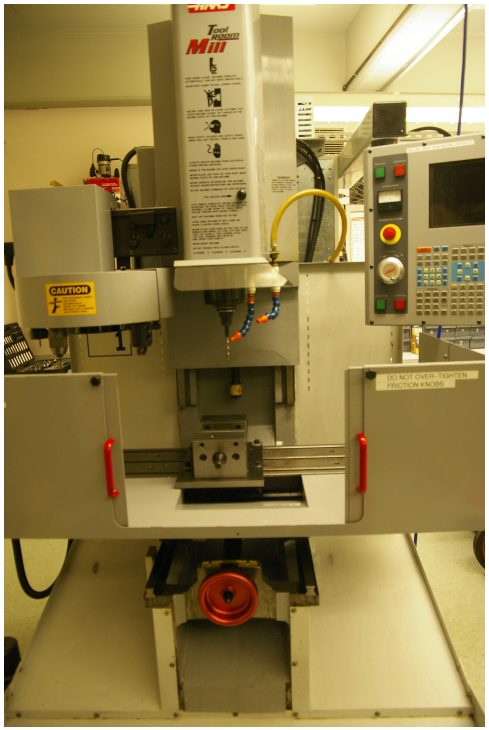
Fall 2015

ENGR480 Manufacturing Systems

- Class Tue 2-5PM (CSP165)
- Lab Thur 2-5PM (KRH105)
- Read Syllabus for other info

Vertical Milling

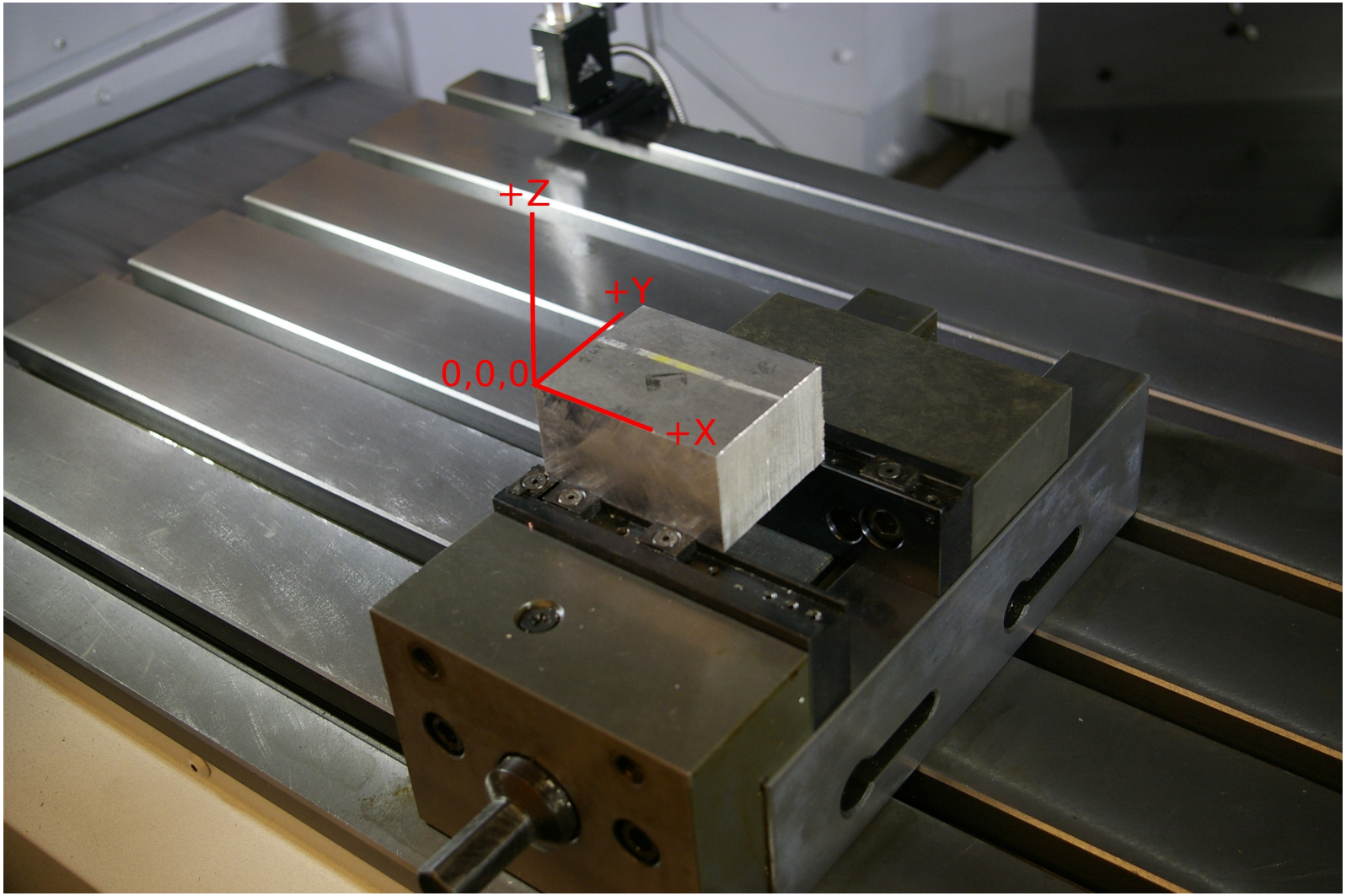




Doing Vertical Milling

- Select stock
  - material, dimension
- Select workholding
  - usually vise or strap clamps
- Select tools & create toolpath
  - Esprit, FeatureCAM, Creo or hand-edited G-code for CNC, by hand for manual
  - MfgSuite does accurate simulation of G-code.
- Set work and tool offsets (for CNC)
- Determine feeds, speeds, and cutting depth
  - Esprit and FeatureCAM help with this for CNC

Coordinate System



Example Program

```
%
O0010 (SIMPLE EXAMPLE FOR NVX)
(OP1- TOP SIDE)
(STOCK- 50MM X 40MM X 50MM)
(G54 ZERO- LEFT FRONT TOP)
G54
G00 G40 G90 G17 G21
(SPOT DRILL HOLES)
T7 M6
G43 H7
S2000 M3
M8
G0 X12.5 Y12.5 Z2.5
G81 Z-2.5 R2.5 F250.0;  (CANNED DRILL CYCLE)
X12.5 Y25.0
X25.0 Y25.0
X25.0 Y12.5
G80 G0 Z2.5;            (CANCEL CANNED CYCLE)
M9
M5
(DRILL 6.35MM HOLES)

G28 Z0
T9 M6
G43 H9
S2000 M3
M8
G0 X12.5 Y12.5 Z2.5
G83 Z-2.5 Q2.5 R2.5 F250.0;  (CANNED DRILL CYCLE)
X12.5 Y25.0
X25.0 Y25.0
X25.0 Y12.5

G80 G0 Z2.5;    (CANCEL CANNED CYCLE)

M9
M5

G28 Z0
M30
%
```

G-Codes for Milling

G00	Rapid positioning
G01	Linear interpolation (feeding)
G02	CW Circular interpolation
G03	CCW Circular interpolation
G04	Dwell
G20	Inch system
G21	Metric system
G28	Return to reference point
G43	Tool Length Compensation

G-Codes for Milling

G54-G59	Select work coord system
G65	Macro call
G81	Drill canned cycle
G83	Peck drill canned cycle
G84	Tapping canned cycle
G90	Absolute coordinates
G91	Incremental coordinates

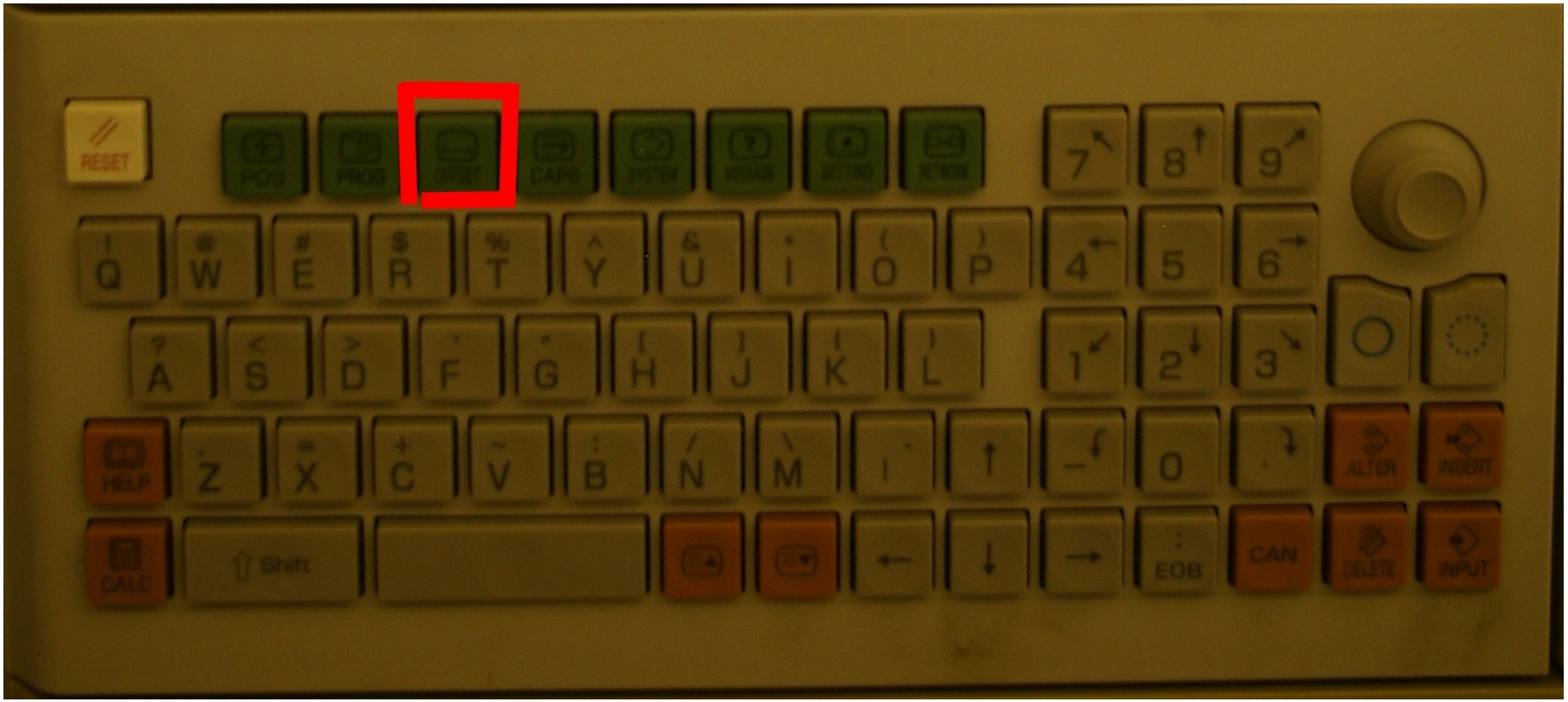
M-Codes for Milling

M00	Program Stop
M01	Opt. Program Stop (panel controlled)
M03	Start spindle (normal rotation)
M04	Start spindle (reverse rotation)
M05	Stop spindle
M06	Tool change
M08	Start coolant
M09	Stop coolant
M30	Program end

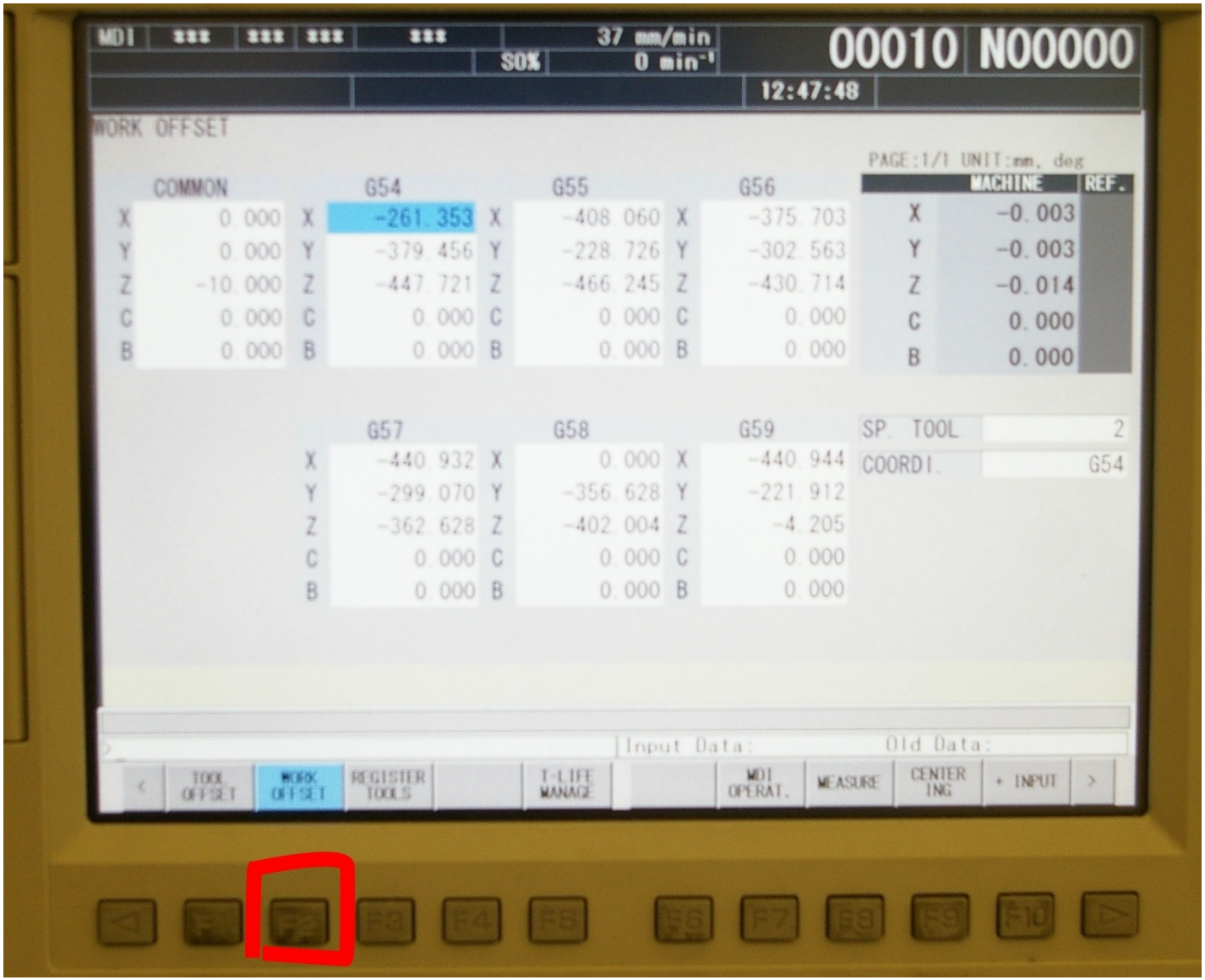
Work Offsets

- Work Offsets
  - G54-G59
  - G54 X & Y aligned with vice jaw left front
  - Set G54 Z to height of top of work (type number, press F1)

Offsets

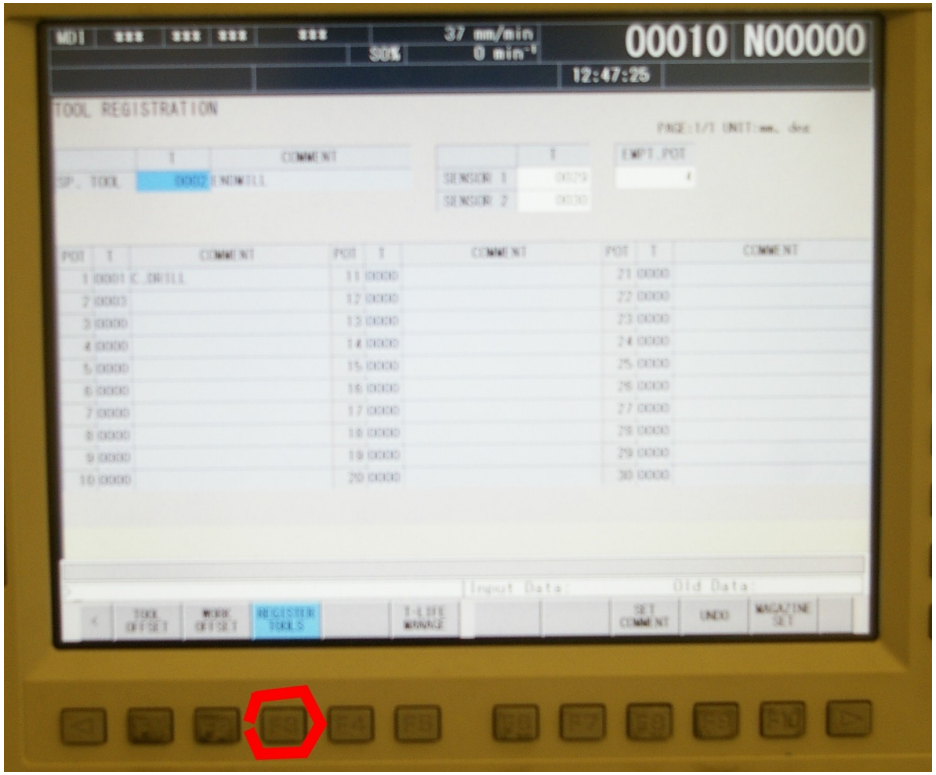

RESET
POS
PROG
OFFSET
CAPS
Q
W
E
R
T
Y
U
I
O
P
A
S
D
F
G
H
J
K
L
HELP
Z
X
C
V
B
N
M
Shift
CALC
7
8
9
4
5
6
1
2
3
0
ALTER
INSERT
EOB
CAN
DELETE
INPUT

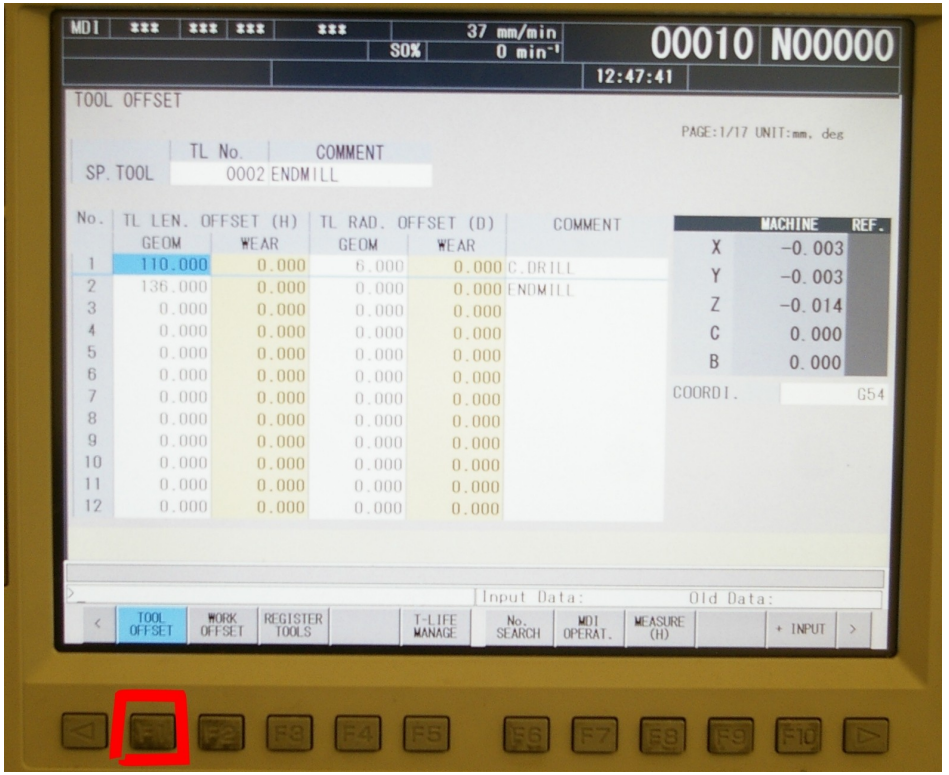
Setting Work Offset



Tool Offsets

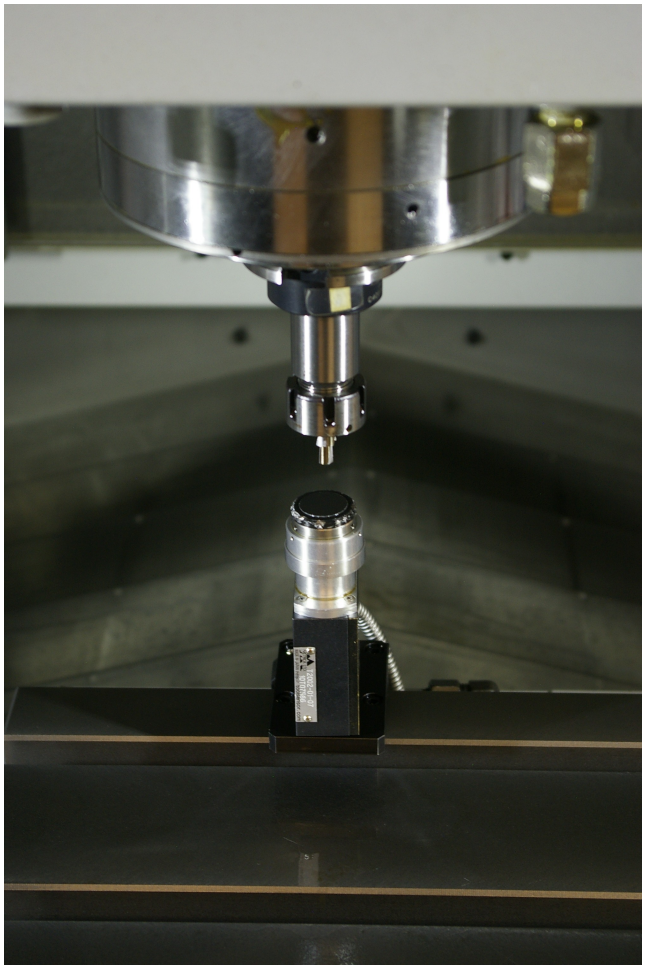
- Enter tool data in offset table
- Put tool in spindle
- Indicate tool number in TOOL REGISTRATION screen

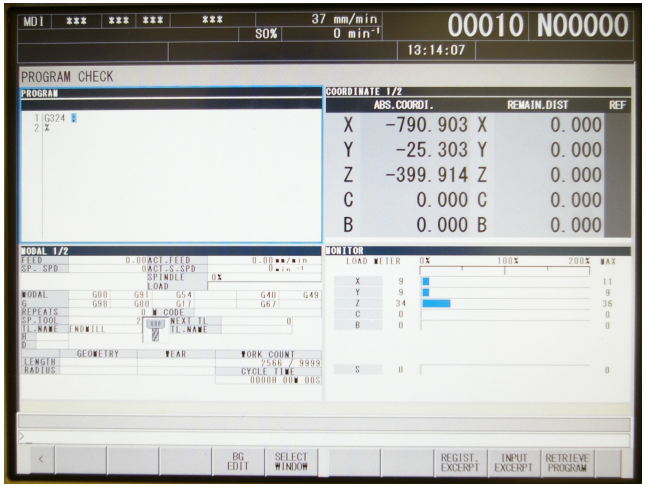




Tool Offsets

- Enter G324 as an MDI command and start





Process

- Rigidity:
  - use shortest tool and tool holder
    - deflection of tool or work causes form error
  - keep workpiece firmly clamped and supported
  - avoid speed/feed/depth combos that chatter
- Heat:
  - use carbide tools when heat is a problem
  - keep chips cleared (liquid or air coolant)
    - hard chips get harder
    - soft chips stick to tool
  - don't go too fast OR too slow
- Chip load:
  - keep volume removed constant!
  - especially watch tool entry, exit, corners

Setting Feeds & Speeds

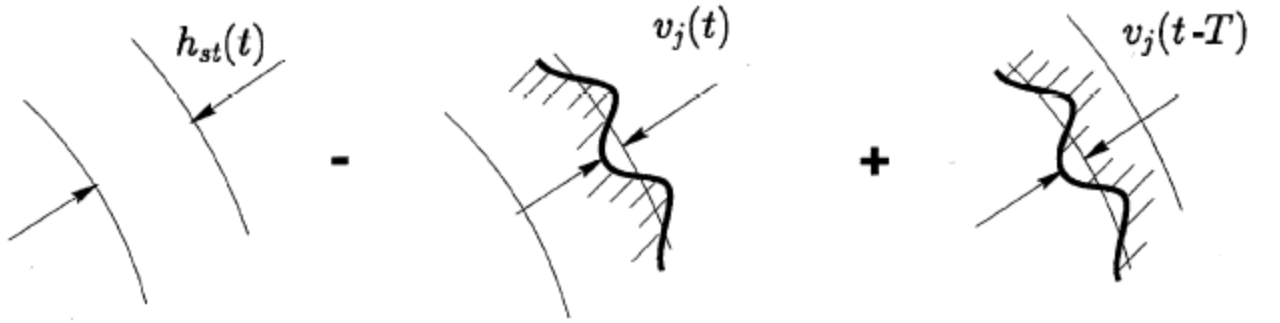
Aluminum (6061, 2024, 7075)				
SFM	Chipload Per Tooth			
2, 3, & 4 Flute	up to .125 dia.	.125-.250 dia.	.250-.500 dia.	.500-1.0 dia.
300-500	.0008-.0020	0015-.0040	0020-.0060	0030-.0090

Tool Steels <30 RC (4140, 4340, A2, D2, O1, S7, P2,H13)				
SFM	Chipload Per Tooth			
2, 3, & 4 Flute	up to .125 dia.	.125-.250 dia.	.250-.500 dia.	.500-1.0 dia.
150-225	.0005-.0010	0008-.0020	0010-.0030	0020-.0040

Carbon Steels <35 RC (A36, 1000's, 1100's, 1300's)				
SFM	Chipload Per Tooth			
2, 3, & 4 Flute	up to .125 dia.	.125-.250 dia.	.250-.500 dia.	.500-1.0 dia.
175-250	.0006-.0015	0010-.0025	0015-.0040	0020-.0050

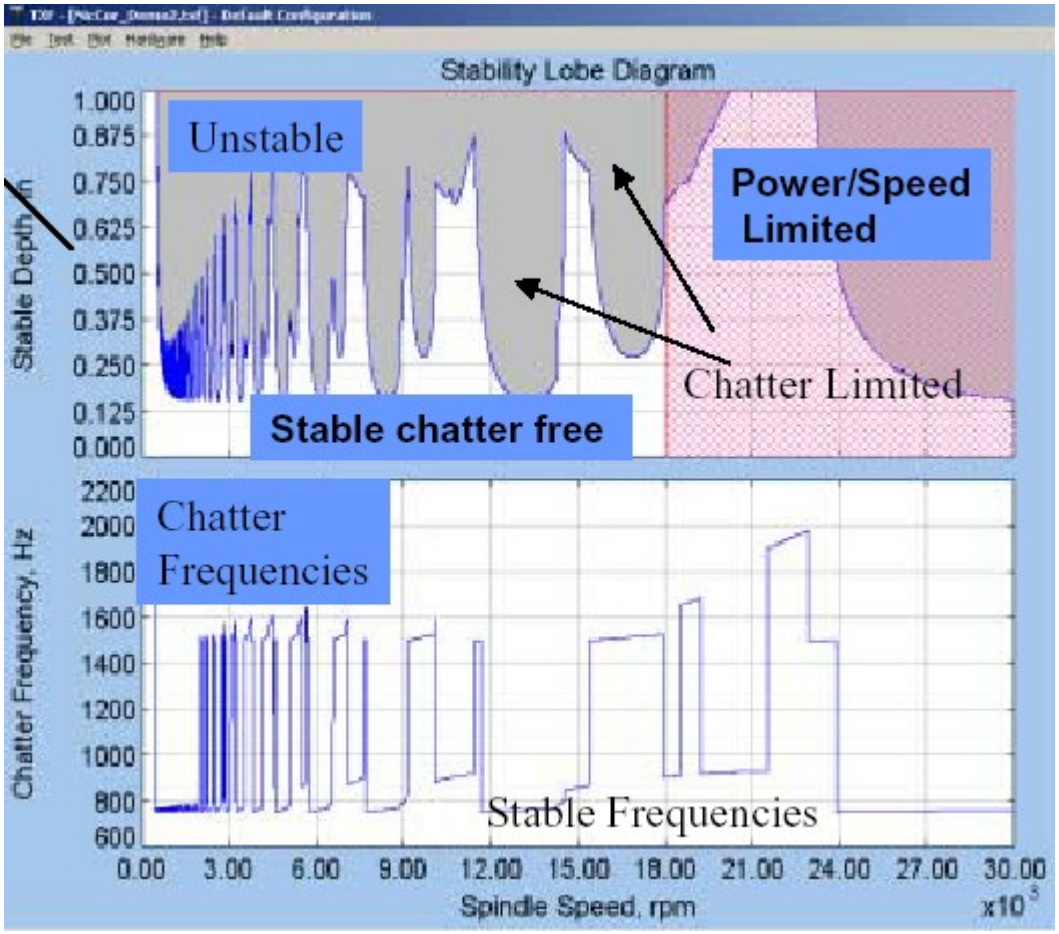
- http://www.custompartnet.com/calculator/milling-speed-and-feed

Vibration

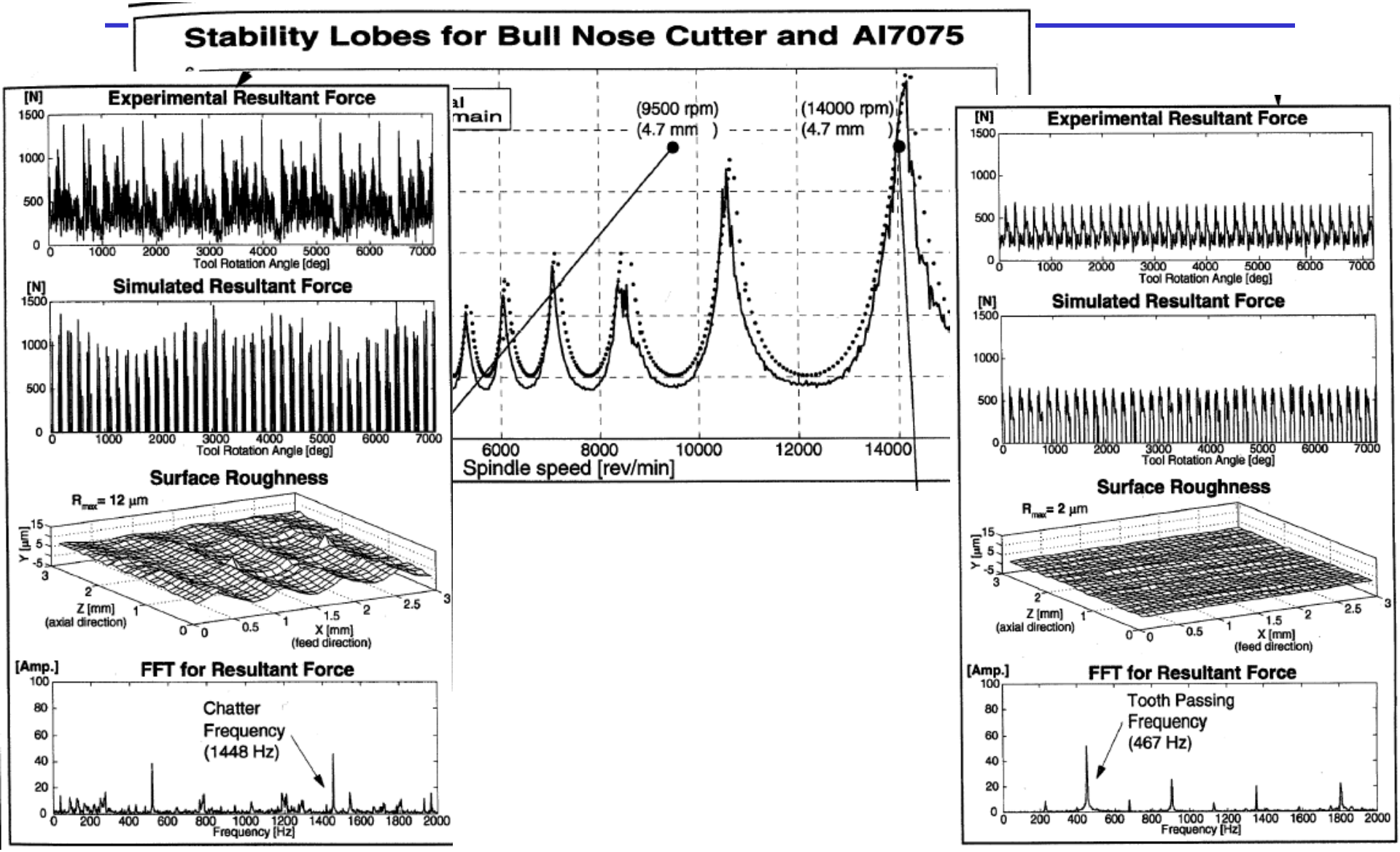

$h_{st}(t)$
-
$v_j(t)$
+
$v_j(t\text{-}T)$
Static chip thickness
-
Vibration at present tooth period
+
Vibration at previous tooth period

Vibration

- For Max Material Removal Rate:
  - Choose highest spindle RPM
  - Tune tool length to stay in a stable lobe at top spindle RPM



Vibration


Stability Lobes for Bull Nose Cutter and Al7075
(9500 rpm)
(4.7 mm)
(14000 rpm)
(4.7 mm)
6000
8000
10000
12000
14000
Spindle speed [rev/min]
[N]
Experimental Resultant Force
Tool Rotation Angle [deg]
Simulated Resultant Force
Surface Roughness
R_max= 12 µm
R_max= 2 µm
Y [µm]
Z [mm]
(axial direction)
X [mm]
(feed direction)
[Amp.]
FFT for Resultant Force
Chatter
Frequency
(1448 Hz)
Tooth Passing
Frequency
(467 Hz)
Frequency [Hz]