



CNC Technical Solutions Phase 4 Outline

Phase 4 Training 100 hours

This is an instructor lead class which utilizes our custom designed CNC simulators which are used to cover both the Electrical and Electronic theory and practice applications, debug and maintenance of sophisticated CNC controls and factory automation.

- 1.0 15/16i Control Series and Designations**
- 1.1 Machine Configurations**
 - 1.1.1 Vertical Mill
 - 1.1.2 Horizontal Mill
 - 1.1.3 Horizontal Lathe.....
 - 1.1.4 Vertical Lathe.....
 - 1.1.5 Machine Mechanical Diagram.....
 - 1.1.6 The Manufacturing Process
- 2 Basic Hardware Structure**
- 2.1 Block Diagram.....**
 - 2.1.1 BOOT ROM.....
 - 2.1.2 FROM.....
 - 2.1.3 DRAM.....
 - 2.1.4 SRAM –
 - 2.1.5 DIGITAL I/O –
 - 2.1.6 PMC –
 - 2.1.7. AXIS CONTROL.....
 - 2.1.8 SPINDLE CONTROL.....
 - 2.1.9 SERIAL I/F.....
 - 2.1.10 CRT CONTROLLER.....
- 2.2 System Boot-Up Sequence**
 - 2.2.1 System Boot-Up screen.....
- 2.3 How the CNC Functions**
 - 2.3.1 PMC Function.....
 - 2.3.2 CNC Function.....
 - 2.3.3 Servo Function
 - 2.3.4 Spindle Function.....



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- 2.3.5 Machine Function
- 3 The CNC-Machine Interface**
- 3.1 G-Codes – M-Codes**
- 3.1.1 G-Codes
- 3.1.2 M-Codes
- 3.2 PMC Software**
- 3.3 Interfacing Hardware**
- 3.3.1 I/O Rack
- 3.3.2 Operator Panel Connection Unit
- 3.3.3 Connection Units
- 4 Fanuc Trainer Model 15/16i
- 4.1 Description of Operator Panel Functions:**
- 4.2 Mode Selection:
- 4.2.1 EDIT
- 4.2.2 Memory/Auto
- 4.2.3 Tape
- 4.2.4 MDI
- 4.2.5 Step/Handle
- 4.2.6 Jog
- 4.2.7 Zero Return
- 4.3 Overrides:**
- 4.3.1 Feedrate Override
- 4.3.2 Jog Override
- 4.3.3 Rapid Override
- 4.3.4 Spindle Override
- 4.4 Pushbuttons**
- 4.4.1 Cycle Start
- 4.4.2 Feed hold
- 4.4.3 Single block
- 4.4.4 Block delete
- 4.4.5 Optional stop
- 4.4.6 Dry run
- 4.4.7 Machine lock
- 4.4.8 Z-Axis lock



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| 4.5 Other | |
| 4.5.1 Program protect | |
| 4.5.2 Emergency Stop | |
| 4.6 Screen Display and Operation | |
| 4.7 Operation of the MDI Panel | |
| 4.8 The Function keys | |
| 4.9 Soft keys and Hardkeys | |
| 4.9.1 POS – Position Screen | |
| 4.9.2 PROG - Program Screen | |
| 4.9.3 P-CHECK-Program Check Screen | |
| 4.9.4 OFFSET - Offset Screen..... | |
| 4.9.5 Work Zero Offset Screen | |
| 4.9.6 Handy Setting Screen..... | |
| 4.9.7 SETTING (TIMER) Screen | |
| 4.9.8 SETTING – (GENERAL Softkey))..... | |
| SERVICE – Service Screens..... | |
| 4.9.9 PARAMETER – Parameter screen | |
| 4.9.10 MESSAGE – Message Screens..... | |
| 5 Parameter Review..... | |
| 5.1 Parameter setting formats | |
| 5.2 Setting Parameters from the MDI | |
| 5.2.1 Set PWE Bit Review | |
| 5.3 Description of Parameters | |
| 5.4 Parameter Classifications | |
| 5.4.1 Parameter 10 (Related to Setting) | |
| 5.4.2 Parameter 107 (Related to Timers)..... | |
| 5.4.3 Parameter 1005 (Related to Axis control) | |
| Parameters related to Coordinate System | |
| 5.4.4 Parameters related to Coordinate System (Cont)..... | |
| 5.4.5 Parameters (Related to Feedrate) | |
| 5.4.6 Parameters related to Acceleration/Deceleration | |
| 5.4.7 Parameter 2000 (Related to DI/DO)..... | |
| 5.4.8 Parameter 2201 (Related to CRT/MDI and Editing) | |
| 5.4.9 Parameter 2400 (Related to Program | |



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- 5.4.10 Parameter 3000 (Related to Serial Spindle Output and Cs Contour Control Function)
- 5.4.11 Parameter 4646 (Related to Waveform Diagnosis Function).....
- 5.4.12 Parameter 4821 (Related to Graphic Display).....
- 5.4.13 Parameter 5000 (Related to Reader/Punch Interfaces).....
- 5.4.14 Parameters (Related to Stroke Limit).....
- 5.4.15 Parameter 5270-5279(Related to Position Switching Function)
- 5.4.16 Parameter 5226 (Related to Reference Marks).....
- 5.4.17 Parameter 5420 (Related to pitch Error Compensation)..... **Error! Bookmark not defined.**
- 5.4.18 Parameter 5426 (Related to Gradient Compensation)
- 5.4.19 Parameter 5481 (Related to Straightness Compensation)
- 5.4.20 Parameter 5606 (Related to Spindle Control)
- 5.4.21 Parameter 5610-5660 (Related to Ridged Tapping with series 15TT).....
- 5.4.22 Parameter 5991 (Related to Electronic Gear Box (EGB))
- 5.4.23 Parameter 6000 (Related to Tool Offsets).....
- 5.4.24 Parameter 6080-6115 (Related to Three Dimentional Cutter Compensation)
- 5.4.25 Parameter 6004 (Related to Cylindrical Interpolation Cutting Point Compensation
- 5.4.26 Parameter 6200 (Related to Canned Cycles).....
- 5.4.27 Parameter 6400 (Related to Scaling and Coordinate Rotation).....
- 5.4.28 Parameter 6611 (Related to Automatic Corner Override).....
- 5.4.29 Parameter 6620 (Related to Automatic feedrate Control using Involute Interpolation)
- 5.4.30 Parameter 6820 (Related to Uni-Directional Positioning)
- 5.4.31 Parameter 7000 (Related to Custom Macros).....
- 5.4.32 Parameter 7110 (Related to Restarting Programs and Blocks and Tool Retraction and Recovery)
- 5.4.33 Parameter 7200 (Related to Skip function)
- 5.4.34 Parameter 7300 (Related to Automatic Tool Compensation (for series 15-t only) and Automatic Tool Length Measurement (for series 15-M only).....
- 6 File Input/Output
- 6.1 Boot System.....**
- 6.2 Starting the Boot System**
- 6.3 System Monitor Main Menu.....**
- 6.4 System Files and User Files.....**
- 6.5 Series Control Backup and Restore by Memory Card.....**
 - 6.5.1 Backup CNC Memory by Memory Card.....



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|--|--|
| 6.5.2 Restore CNC Memory by Memory Card | |
| 6.6 RS-232C Basics..... | |
| 6.6.1 Description of signals..... | |
| 6.6.2 Cable Configuration | |
| 6.7 Code Table..... | |
| 6.8 RS-232-C Interface Transmission Methods | |
| 6.9 FANUC RS232C Alarm List..... | |
| 6.10 Backup/Restore Operation..... | |
| 6.13 Series Model B Control Backup and Restore..... | |
| 6.13.1 Series RS232 Parameter Setup..... | |
| 6.16 Series Control Backup by RS232..... | |
| 6.16.1 CNC Option Parameters | |
| 6.16.2 CNC Parameter Output to PC..... | |
| 6.16.3 PMC Parameter Output to PC..... | |
| 6.16.4 LADDER Output to PC..... | |
| 6.16.5 G-Code Programs Output to PC | |
| 6.16.6 Tool Offset Data Output to PC | |
| 6.16.7 Macro Variable Output to PC (option) | |
| 6.16.8 Pitch Error Compensation Output to PC (option)..... | |
| 6.17 Series Control Restore by RS232 | |
| 6.17.1 Binary to Hexadecimal Conversion | |
| 6.17.2 CNC Parameter Input to CNC..... | |
| Press the E-STOP button on the operator panel..... | |
| 6.17.3 PMC Parameter Input to PMC | |
| 6.17.4 PMC Parameter By Hand Input to PMC..... | |
| 6.17.5 G-Code Program Input to CNC | |
| 6.17.6 Tool Offset Data Input to CNC | |
| 6.17.7 Macro Variable Input to CNC (option) | |
| 6.17.8 Pitch Error Compensation Input to CNC (option)..... | |
| 7 CNC Hardware..... | |
| 7.2 CNC Components | |
| 7.2.1 Total Connection Diagram | |
| 7.2.2 ub Board..... | |
| 7.2.3 Outline of Hardware..... | |



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| 7.2.4 Control unit configuration | |
| 7.3 Hardware of the Fanuc 15/16i..... | |
| 7.3.1 Power Supply and CPU modules..... | |
| 7.4 Power Supply Module | |
| 7.8 PCB Board List FANUC Model B | |
| 7.9 I/O Connection Diagram | |
| 7.9.1 JD1A – JD1B..... | |
| 7.9.1 Connection between bases (with I/O Unit A)..... | |
| 7.9.2 Operator Panel Connection Unit | |
| 7.9.3 Connection Unit 1 & 2..... | |
| 7.9.4 Digital Input Modules | |
| 7.9.5 Digital Output Modules..... | |
| | |
| 8 Troubleshooting | |
| 8.1 CNC Troubleshooting | |
| 8.2 CNC Alarms..... | |
| 8.3 Model 15/16i Alarm Table | |
| 000 Please Power Off / PW0000 Power Must Be Off..... | |
| 8.3.1 010 Improper G-Code..... | |
| 8.3.2 SR 822 Communication Error / Overrun Error..... | |
| 8.3.3 SR 830 DR Signal OFF / SR 831 CD Off (2)..... | |
| 8.3.4 R 824 Buffer Overflow..... | |
| 8.3.5 OT 032 Needs ZRN / (ABS PCDR)..... | |
| 8.3.6 OT 034 Battery Zero / (ABS PCDR)..... | |
| 8.3.7 SV 013 Improper V-Ready OFF..... | |
| 8.3.8 SV 008 Excess Error (STOP)..... | |
| 8.3.9 SV 009 Excess Error (MOVING)..... | |
| 8.3.10 OT 301 Servo Motor Overheat..... | |
| 8.3.11 SVC 023 Thermal OVC..... | |
| 8.3.12 OT 001(+) /OT 002 (-) Over Travel : Soft 1 & Soft 2..... | |
| 8.3.13 OT 007(+) / OT 008 (-) Over Travel Hardware +/-..... | |
| 8.3.14 Alarm 700 Over Heat at Control Unit..... | |
| 8.3.15 Operation Failures | |



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| <i>Will Not Cycle Start (Cycle Start LED is OFF)</i> | |
| 8.3.16 <i>Will Not Cycle Start (Cycle Start LED is ON)</i> | |
| 8.3.19 <i>Feed Rate Override is 0% = 1</i> | |
| 8.3.20 <i>Interlock / Start Lock = 1</i> | |
| 8.3.21 <i>Spindle Speed Arrival Check = 1 SARA F229 #3</i> | |
| 8.3.22 <i>Will Not Perform JOG Axis Movement</i> | |
| 8.3.23 <i>JOG Feed Rate is 0% = 1</i> | |
| 8.3.24 <i>Will Not Perform HANDLE Axis Movement</i> | |
| 8.3.25 <i>Maintenance manual Chapter 5</i> | |
| 8.3.26 <i>NC Status Display</i> | |
| 8.4 System Alarms | |
| 8.4.1 <i>System alarms when the CNC is turned on</i> | |
| 8.4.2 <i>System alarms while the CNC is operating</i> | |
| 9 Alpha Servos and Spindles | |
| 9.1. Alpha Servo Motor | |
| 9.1.1 <i>The Stator</i> | |
| 9.1.2 <i>The Rotor</i> | |
| 9.2 Servo Motor Motion | |
| 9.3 Alpha Pulse Coders | |
| 9.3.1 <i>PA and PB</i> | |
| 9.3.2 <i>Grey Code Signals C1, C2, C4 and C8</i> | |
| 9.3.3 <i>PZ</i> | |
| 9.4 I64 Incremental Pulse Coder Home Return | |
| 9.5 A64 Absolute Position Coder Home Return | |
| 9.6 Pulse Coder Cable Wiring | |
| 9.7 Servo Interface Types | |
| 9.8 System Connection Diagram | |
| 9.9 Alpha System Hardware Diagram | |
| 9.9.1 <i>Power Up Sequence</i> | |
| 9.10 Power Supply Module PSM | |
| 9.10.1 <i>RECTIFIER</i> | |
| 9.10.2 <i>CONVERTER</i> | |
| 9.10.3 <i>Power supply start up sequence</i> | |
| 9.11 Servo Module SVM | |



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| 9.11.1 INVERTER | |
| 9.12 Alpha Amplifier Confirmation | |
| 9.12.1 Checkout Procedure | |
| 9.13 Servo Control Concepts | |
| 9.13.1 How the CNC Converts Program information into a Motion Command | |
| 9.13.2 Basic Block Diagram..... | |
| 9.13.3 Position Loop, Position Command and Feedback..... | |
| 9.13.4 Velocity Loop, Velocity Command (VCMD) and Speed Feedback (TSA) | |
| 9.13.5 Torque Loop, Torque Command (TCMD) and Current Feedback (IR and IS) | |
| 9.14 Servo Motor Torque | |
| 9.15 Stopping a Servo Motor..... | |
| 9.15.1 Dynamic Braking..... | |
| 9.15.2 Regeneration | |
| 9.16 Servo Concepts..... | |
| 9.16.1 Over Current Protection | |
| 9.16.2 HCAL..... | |
| 9.16.3 OVC..... | |
| 9.17 Troubleshooting FANUC Digital SERVO Systems Quick Reference Guide | |
| 9.18 Alarm Details..... | |
| 9.18.1 FBA (Feedback alarm)..... | |
| 9.18.2 OFA (Overflow alarm)..... | |
| 9.18.3 DCA (DC bus alarm)..... | Error! Bookmark not defined. |
| 9.18.4 HVA (High voltage alarm) | |
| 9.18.5 HCA (High current alarm) | |
| 9.18.6 OVC (Over current alarm)..... | |
| 9.18.7 LV (Low voltage alarm)..... | |
| 9.18.8 OVL (Overload "overheat" alarm)..... | |
| 9.19 Checking AC Servo Motors | |
| 9.19.1 AC Servo Motor Codes | |
| 10 Alpha Spindle Systems (Overview) | |
| 10.1 Spindle Motor Construction..... | |
| 10.1.1 The Rotor..... | |
| 10.1.2 The Stator..... | |
| 10.2 How an Induction Motor Works..... | |



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- 10.2.1 Torque, Speed and Loading.....
- 10.2.2 Speed Sensor Feedback
- 10.2.3 Position Coder Interface.....
- 10.2.4 Basic Block Diagram
- 10.2.5. PMC control of the spindle.....
- 10.3. Terms.....**
 - 10.3.1. M03, M4, M5 and M19.....
 - 10.3.2. FIN.....
 - 10.3.3. *SSTP.....
 - 10.3.4. SOV.....
 - 10.3.5. GR(x).....
 - 10.3.6. SOR.....
 - 10.3.7. RxxO and RxxI.....
 - 10.3.8. SIND.....
 - 10.3.9. SGN.....
- 10 PMC Interface
- 10.1. Summary:**
- 10.2. PMC Description**
- 10.3. PMC General Interface.....**
 - 10.3.1 I/O Type Description
- 10.4 Sink / Source Description.....**
 - 10.4.1 Sink
 - 10.4.2 Source
- 10.5. I/O LINK Description**
 - 10.5.1. BASE UNIT.....
 - 10.5.2. GROUP #.....
 - 10.5.3. BASE #.....
 - 10.5.4. MODULE NAME.....
- 10.6. I/O Link Connection Configuration**
- 10.7. I/O Module Description**
 - 10.7.1. Fixed Input Addresses
- 10.7.2. Input modules.....
 - 10.7.3. Output modules
 - 10.7.4. SPECIAL MODULES.....



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| 10.8 Signal Table-Interface between CNC and PMC-NA or NB | |
| 10.9 EXECUTION SEQUENCE OF RELAYS | |
| 10.9.1 LOGIC CIRCUITS..... | |
| 10.9.2 MECHANICAL RELAY CIRCUIT | |
| 10.9.3 PMC RELAY CIRCUIT..... | |
| 11 PMC Instruction Description..... | |
| 11.1 BASIC ELEMENTS OF PMC LADDER | |
| 12 PRIORITY LEVELS OF PMC MODEL NA/NB..... | |
| 12.1 High priority | |
| 12.2 Medium priority | |
| 13.Functional instructions List 15/16i | |
| 13.1 Functional Instructions Descriptions | |
| 13.1.1 END1 (1st LEVEL SEQUENCE PROGRAM END) | |
| 13.1.2 END2 (2ND LEVEL SEQUENCE PROGRAM END) | |
| 13.1.3 END3 (3rd LEVEL SEQUENCE PROGRAM END) | |
| 13.1.4 TMR (VARIABLE TIMER BY PMC PARAMETER)..... | |
| 13.1.5 TMRB (FIXED TIMER)..... | |
| 13.1.6 TMRC (TIMER)..... | |
| 13.1.7 CTR (COUNTER) | |
| 13.1.8 CTRC (COUNTER)..... | |
| 13.1.9 DCNV (DATA CONVERSION)..... | |
| 13.1.10 DEC (DECODE) | |
| Binary Decoding Example | |
| 13.1.12 ROTB (BINARY ROTATION CONTROL)..... | |
| 13.1.13 ADDB (BINARY ADDITION) | |
| 13.1.14 SUBB (BINARY SUBTRACTION) | |
| 13.1.15 MULB (BINARY MULTIPLICATION)..... | |
| 13.1.16 DIVB (BINARY DIVISION) | |
| 13.1.17 MOVB (TRANSFER OF 1 BYTE)..... | |
| 13.1.18 DISPB (DISPLAY PMC MESSAGE) | |
| 14 PMC Ladder Logic | |
| 14.1 2 Basic Ladder Logic..... | |
| 14.1.2 Normally Open Contact..... | |
| 14.1.3 Logical ANDing..... | |



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- 14.1.4 Logical ORing
- 14.1.4 Normally Closed Contact
- 14.1.5 Logic Combinations
- 14.1.6 Latch and Hold Circuit.....
- 14.2 Ladder Address Types**
 - 14.2.1 X – Physical Inputs
 - 14.2.2 Y – Physical Outputs.....
 - 14.2.3 R – Internal Relays
 - 14.2.4 D – Data Registers
 - 14.2.5 T – Timer Address
 - 14.2.6 C – Counter Address
 - 14.2.7 K – Keep Relays
- 14.3 Search Menu**
 - 14.3.1 TOP or BOTTOM Soft key
 - 14.3.2 SEARCH Soft key.....
 - W-SRCH Soft key.....
 - 14.3.3 F-SRCH Soft Key.....
- 14.4 PMC Parameters**
 - 14.4.1 Setting Parameter Write Enable.....
 - 14.4.2 TIMER Setting Display.....
 - 14.4.3 COUNTER Setting Display
 - 14.4.4 KEEP RELAY Setting Display.....
 - 14.4.5 DATA Table Display
- 15 PMC Diagnostics.....
- 15.1 PCPRM Screens**
- 15.2 Trace Screen**
 - 15.2.1 BYTE TRACE
 - 15.2.2 Two BYTE TRACE
 - 15.2.3 PMC Alarm Screen
 - 15.2.4 I/O Check Screen
- 16 Machine Alarm Troubleshooting**
- 16.1 MESSAGE DATA TABLE**
- 16.2 MESSAGE NUMBER**
- 16.3 A Address Alarm Troubleshooting**



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16.4 M-Codes.....

 16.4.1 *Common M-Codes*.....

 16.4.2 *M-Code Processing*