CNC Controls from the Market Leader:

GE Fanuc Automation was formed in 1986 as a joint venture by General Electric Co. (GE), USA, and FANUC Ltd, Japan. FANUC has had experience in production automation for more than 50 years and is the worldwide market leader in CNC technology. With its broad range of technology, manufacturing and services and roughly 300,000 employees, GE is one of the largest companies in the world.

FANUC and GE Fanuc develop and manufacture state-of-the-art automation products and solutions. The product range includes both entry-level and high-performance CNC products with high-speed functions, digitally controlled servomotors and spindle motors, and user-friendly operator interfaces.

Continuity in the interest of the user

Despite all the innovation with the latest hardware and software, FANUC has always maintained continuity in its product development. The installation dimensions have been maintained wherever possible to make the changeover to new control generations as easy as possible for machine manufacturers. Above all, FANUC has always kept end users in mind. Anybody who has learned to handle a FANUC or a GE Fanuc CNC is able to work with subsequent models within an extremely short period of time – thus saving on training costs.
**High degree of reliability**

The high degree of quality and reliability of FANUC or GE Fanuc controls is already almost legendary. Statistics have shown that their MTBF (mean time between failures) is 14 years: So when the machine tool is operating normally, a control-caused failure will occur statistically only once every 14 years. Users have confirmed this reliability in many surveys, and even the automotive industry – known for its extremely high requirements – uses FANUC or GE Fanuc controls all over the world. This failure statistic has been honored with various awards by many machine tool manufacturers. Success is a mirror of reliability and quality. A total of over 1.4 million FANUC and GE Fanuc CNC controls have been distributed to date all over the world.

**So many satisfied users cannot be mistaken**

In the field of CNC controls, FANUC and GE Fanuc CNCs are the yardsticks against which all others are measured. The standard versions of FANUC or GE Fanuc CNCs cover all production applications, from the simple milling or turning machine to complex systems and machining centers. They control single or double turret lathes, grinding machines, laser machines, stamping machines and electro-erosion machines. Adaptation to the relevant machine is achieved using the extensive range of hardware and the individual software and operator control solutions.

**Automation from one source**

GE Fanuc offers not only controls but also amplifiers, motors, I/O modules, control panels, cables and software solutions, all from one company. All of its CNC products are designed from the outset as a system and matched as a CNC package, so that the optimum performance is attained. The user also gets customer service and warranty services from one source – worldwide.

FANUC has been the forerunner in this technology since the very beginning of CNC development:

- In 1956 FANUC developed the first NC in the non-military sector.
- In 1969 FANUC introduced the first fully modular CNC to the market.
- In 1985 FANUC presented the CNC 0 Series – to date this is the most commonly used CNC in the world with sales of over 400,000 controls.
- In 1997, the start of the i Series – the latest generation of high-precision, high-speed CNCs.
- In 1999 FANUC launched the is series onto the market, the first CNC with Windows® CE.
- In 2001 the i Series MODEL B was introduced, the first CNC with an Ethernet interface as standard.
Both machine tool manufacturers and end users profit from the leading-edge technology of the i Series CNC. Thanks to the integrated LCD, the modular controls are ultra-compact and ultra-flat. The CNCs are equipped with an Ethernet interface as standard and have optional PC functionalities.

Highly integrated circuitry developed in-house contributes towards miniaturization and a low component count. This contributes considerably to our renowned reliability and dependability.

Thanks to the limited number of components, the design of the control enclosure is simplified and requires a minimum of wiring.

If the control and the monitor are separated, an optical fiber connection provides failure-proof data interchange at distances of up to 100 m.

A similar optical fiber connection can also be utilized between the control and the drives. Digital technology throughout ensures that any data transfer can be performed quickly and loss-free.

**Technology for Our Customer**

### Applications:
- Metalworking
- Wood, Marble and Glass Working
- Manufacturing Cells
- Laser, Water jet, Plasma and Glass Cutting
- EDM
- Handling
- etc.

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**Speed and precision**
- Nano CNC system
- High-speed precision machining
- High-speed PMC
- 5-axis machining
- NURBS

**Operator friendliness**
- Continuity in product development
- Ergonomic menu configuration
- Easy workshop programming

**Openness and modularity**
- Individual configuration
- Ethernet as standard
- Openness for components from other manufacturers
**Speed and Precision**

High speed and precision are two terms that are fundamentally contradictory. The higher the speed, the more the precision decreases – and vice versa. Although GE Fanuc’s developers cannot change this basic physical law, they have managed to jointly enhance speed and precision to a very high level. The functionalities of the i Series CNC make a contribution towards this.

**Nano CNC system**

Nano interpolation is a highlight of the Series 16i/18i/18s-MB5 CNCs. This calculates the positioning commands for the digital precision servo-system with nanometer resolution. This interpolation, without rounding the Nano value to the smallest command increment, enables the digital system to track the tool path very accurately and smoothly thereby achieving a very high surface quality.

The High Response Vector control (HRV) servo-control, together with Nano interpolation, generate smooth motion resulting in high surface quality. These two features ensure a smooth servo-feed by exploiting servo-motor structure, exact current measurement, high-resolution pulse encoder (16,000,000/rev) and fast response servo-control. The HRV filter suppresses mechanical resonance and ensures a stable servo-system with high amplification.

Several resonance frequencies can be blocked. Fast Digital Signal Processor (DSPs) and advanced algorithms for automatic current control provide a fast response characteristic and stable current control circuit.

Shorter control loop sampling and a high-resolution detector contribute to the responsive and precise control system.

![Tapering at an X : Y ratio of 3 : 1](image)
High-speed precision machining

In conjunction with a fast RISC processor, the AI Nano High-Precision Contour Control (AI Nano HPCC) allows machining with Nano interpolation at an optimal feedrate to fully exploit the machine capabilities.

With AI Nano HPCC, the acceleration values for the individual axes can be set separately, thus considering the differing inertia of the different axes. This results in smooth acceleration and deceleration resulting in a significantly reduced path error. Further, the feedrate adapts itself automatically to the programmed contour, although the motion always remains within the acceleration ranges permitted for each axis.

Jerk control is another function that ensures smooth motion and therefore high surface quality. Contours with sudden changes in direction, force sudden change in acceleration, causing mechanical shock. Jerk control reduces such awkward transitions by smoothing the acceleration profile, thus reducing the shock.

The smooth motion, especially at the region of block transitions, results in an improved surface quality.

High-speed PMC

The Programmable Machine Control (PMC) is very important in relation to high speed. A specific PMC processor is used in the i series CNC, processing even extensive control sequences at lightning speed. The execution time for PMC basic commands is 0.033µs per instruction step.

The CNC and PMC exchange information via a high-speed interface through which custom functions can also be integrated. The CNC now has, as standard, ladder diagram monitoring and editing functions for easier interplay with the PMC.

In addition, the improved signal tracking function allows problem-free maintenance on site.
The Series 16i-MB/18i-MB5 CNCs support 5-axis machining in an inclined plane. Further, with the aid of a fast RISC processor they also support simultaneous 5-axis machining. All standard machine configurations are supported. The machine tool can rotate the tool head, the rotary table or a combination of the two.

5-Axis Machining Highlights

- The rotational axes can be controlled and commanded easily to position the tool vertically to the inclined machining plane.
- Tool Center Point control (TCP) (Tool length compensation for simultaneous 5-axis machining): If the direction of the tool axis changes, the movement at the tool center point is controlled in such a way that the tool center point follows the programmed curve.
- The user can set a tool at a specific angle to the surface (Draft Angle) to avoid the zero speed zone of a spherical cutter.
- Three-dimensional cutter radius compensation enables the control system to compensate the milling cutter radius in a plane that runs vertically to the inclined tool direction. For Head Type machine configurations, it also compensates the leading edge of an inclined tool motion.
- An arc or a helix can be specified in the inclined plane, and for 5-axis simultaneous machining.
- The user can manually traverse the tool without difficulty by advancing it via a handwheel or in Jog mode along an inclined surface with the tool being vertical to that surface. This allows the user to retract the tool in the tool direction, manually via Jog mode or handwheel. The tool can be rotated manually around its tool center point.
NURBS

The Series 16i/18i/18i MB5 CNCs provide the facility to use NURBS curves. NURBS present the original shape very accurately, since most CAD systems often store their geometrical data in a NURBS format.

Using NURBS makes it possible to exploit their mathematical properties such as continuous transition among blocks. This reduces the jerk – mechanical shock – and ensures smooth, uniform surfaces. As a side effect this also can increase tool and machine life.

In comparison to an NC part program consisting of consecutive small program blocks, a NURBS part program is distinctly smaller. A higher transfer rate from host computer to CNC is not required.

NURBS interpolation supports up to five axes simultaneously and enables extremely complex machining operations.

Tool center point control for 5-axis machining

Tool radius compensation for 5-axis machining
Operator Friendliness and Easy Maintenance

A modern CNC must have high-performance capability and at the same time must be easy to operate. Even the standard products of the iSeries CNC provide an operator interface that is simply structured and self-explanatory. Anybody who has a command of one FANUC or GE Fanuc CNC is also able to work with any other model. Continuity in further development ensures this.

In all modernization measures, such as touch screens, embossed keys etc., the operator control concept has been retained so that extensive training courses are unnecessary.

Easy machine preparation

Easy handling begins with preparation of the machine. A single screen enables convenient setting of the parameters for machining, depending on the relevant machine configuration.

For workpiece setup, a selected screen provides simple instructions by which the user can calibrate the measuring sensor and then measure the position, surfaces, angle, etc., on the part.

Programming

The user has several ways of producing an NC program. Simple programs can be generated without difficulty via the standard screens. These operator interfaces are also suitable for quickly and easily checking and amending existing programs.

If the machining becomes more complicated, the user frequently prefers the assistance of a CAD/CAM software system. The NC program, which is produced in an external computer, can be transferred via a DNC connection or data carrier to the control unit.

Particularly popular is the interface, available on the display unit, for a PCMCIA memory card. This can be used for data input and output.
GE Fanuc offers special software for workshop programming. The highlight is the Manual Guide \textit{i}. In version \textit{i}, the developers have united the functionalities of the two predecessor versions, \textit{T} (turning) and \textit{M} (milling). With Manual Guide \textit{i}, the user can now configure software for a turning, milling or compound machine.

Manual Guide \textit{i} is a cycle control with a simplified CNC operator interface used to program cycles. Various functionalities are available to make communication as easy as possible.

- All relevant information is on a single CNC screen, so the user does not have to switch constantly between several screens and get lost at some stage in all the pop-up windows.
- Intuitive working is ensured via icons so that even a skilled worker is in a position, without any special CNC programming experience, to be able to write a program without any documentation whatsoever.
- The user can graphically and interactively construct on-screen the part to be machined, and simulate it in the volume model.
- The user can also edit the NC programs with a word processing program and cut or paste random program segments.
- In addition, comments are displayed on the bottom area of the screen relating to the \textit{G} and \textit{M} codes marked by the cursor.

**Maintenance friendliness**

Easy handling of the CNC includes practical maintenance and service tools. The maintenance-friendly \textit{i} Series CNC puts extensive tools at the disposal of the user:

- On the regular maintenance screen the user can display the remaining service life of the machine components that have to be regularly replaced.
- The user can file and call up information on the maintenance information screen.
- If any faults occur, a well arranged alarm and process data archive allows system diagnosis and convenient troubleshooting.
- Alarms can be polled in a dialogue on the error diagnosis screen. This also applies to the servo-alarm and spindle alarms.
- A Help screen provides alarm-related detailed information and the relevant diagnostics. These Help screens can be produced and adapted machine-specifically by the machine manufacturer.
- The user can take advantage of remote monitoring, provided that the control has an Internet connection.
- At our service center, experts will analyze the problem and can frequently help from afar. If a service call is necessary, the service engineer receives important information so that he can select the right parts and optimally prepare his visit.
A CNC-controlled machine tool requires close collaboration between the machine tool and control manufacturer for optimum performance. GE Fanuc therefore offers the machine tool manufacturer the possibility of configuring the control’s operator interface to suit his own needs and to introduce his own functions. GE Fanuc has not only made the controls open for this purpose, but also offers support on various levels. The result is the increased user friendliness of the machine tool.

Openness and Modularity

Customized adaptation

Screen display and operator control: Via C-EXECUTER the machine-tool manufacturer can create special screens, which can be used instead of the standard CNC screens. The programming language is C.

The FANUC PICTURE program supports the user in compiling his own screens by arranging components as graphical elements.

CNC functions: Machine tool manufacturers can generate custom library of macros that use M and G codes. In this way they can provide their users with fixed cycles that can be called off at the press of a button.

PMC programming: Machine tool manufacturers can also influence the machine control. For example, they can develop applications that are modeled on structured sequences of ladder logic.

Ethernet as standard

GE Fanuc has performed pioneer work in the field of the network capability of CNCs. Since 2001 the iSeries MODEL B has been equipped with an Ethernet interface as standard. Network connection is available either via the integrated Ethernet interface or via a PCMCIA card.

The exchange of large volumes of data via Fast Ethernet (up to 100Mb/s) is possible simultaneously between several computers. This is of particular importance for data communication between production plants and the host computer of a manufacturing plant.

Large NC programs, used for the machining of free-formed surfaces, are transferred with Ethernet and are stored on a built-in ATA flash card or hard disk and are executed at a high processing speed.
Open CNC

The i Series Open CNC is what its name states. It is the optimum combination of a CNC and a computer via a serial high-speed interface, enabling the transfer of large volumes of data. With it, GE Fanuc supports individual applications on special machines that have to be matched to special customer requirements by the machine tool manufacturers.

The i Series Open CNC allows individual operator control of CNC machine tools via a graphic user interface (GUI), the exchange of large data volumes via networks, tool file management via a database and more.

The i Series Open CNC is available with two types of operating system, Windows® or Windows® CE.

The Series 160i/180i/210i CNC consist of a stand-alone CNC with a Windows® computer which is connected to the CNC display via a high-speed optical fiber interface (HSSB).

The Series 160i/180i/210i CNCs are open CNCs with Windows® CE. This compact operating system makes do without a hard disk and for this very reason provides extreme reliability in harsh deployment conditions. These controls are available either as an integrated CNC complete with a CNC display or as a stand-alone version. Here again the Windows® CE computer is connected to the CNC via a high-speed optical fiber interface (HSSB).

Open communication

The i Series CNC controls are open at field level. Many I/O components can be integrated via commonly available bus systems (FL-net, PROFIBUS-DP, DeviceNet, I/O Link II).

Safety inside

Dual Check Safety is the safety function integrated into the CNC in accordance with the European safety standard. A special processor for the monitoring of safety-related parameters tracks the actual position and speed of the servomotors, spindle motors and of the I/O interface, and by means of its redundancy ensures system of its safety.
# Technical Data

## Model Available

<table>
<thead>
<tr>
<th>Model Available</th>
<th>16/i60/i60a</th>
<th>18/i80/i80a</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB/TB/LB/PB/LPB/WB</td>
<td>MB/MBS/TB/LB/PB/WB</td>
<td></td>
</tr>
</tbody>
</table>

## Max. Controlled Axes
(Machine Axes x Paths + Loader)

<table>
<thead>
<tr>
<th>Axes</th>
<th>20</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Controlled Axes</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Simultaneous Controlled Axes</td>
<td>6</td>
<td>4 (5 for MB5)</td>
</tr>
<tr>
<td>Controlled Path</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Loader Control Axes</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Max. Spindle Control</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

## Power Mate CNC Manager for additional Axes on I/O LINK

- PMC Systems: SB7 or SD7
- µs per Step: 0.0033
- Power Mate CNC Manager for additional Axes on I/O LINK
- PMC Systems: SB7 or SD7
- µs per Step: 0.0033

## Max. DI/DO Points

<table>
<thead>
<tr>
<th>Points</th>
<th>64,000</th>
<th>64,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel Mount I/O Modules</td>
<td>2,048/2,048</td>
<td>2,048/2,048</td>
</tr>
</tbody>
</table>

## Decentralized Fieldbus I/O Modules

- Maximum Resolution: 0.0001mm, 0.0001deg, 0.00001inch
- Maximum Resolution: 0.00001mm, 0.00001deg, 0.000001inch

## Number of Expansion Slots Available (LCD Mounted Version)

- 0, 2, 3 or 4
- 1 or 3

## Number of Expansion Slots Available (Standalone Version)

- 1 or 3

## Expansion Slot Option Boards Available

- 64 Bit RISC Processor
- RISC Processor/Data Server
- Sub-CPU
- PMC C Language
- Loader Control
- Data Server/ATA Interface
- HSSB
- PROFIBUS DP
- DeviceNet
- Fast Ethernet
- I/O Link II
- FL-Net
- Serial Communication
- Analog Input Board
- Ethernet on Board
- Open CNC System
- RS232
- (160/i160/a)
- (180/i180/a)
- Communications

## Front Access PCMCIA Slot

- Memory Card
- Ethernet Card
- Modem Card

## Standard Display

- Monochrome LCD Screen: 7.2” or 9.5”
- Color TFT LCD Screen: 8.4” or 10.4”

## CNC Display with Windows® (160/i160/210/i only)

<table>
<thead>
<tr>
<th>Processor</th>
<th>Intel® Celeron™ / Pentium®</th>
<th>Intel® Celeron™ / Pentium®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>Up to 512MB</td>
<td>Up to 512MB</td>
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<tr>
<td>Min Hard Disk Size</td>
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<td>Windows® 2000/XP</td>
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<tr>
<td>Serial Ports</td>
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<tr>
<td>Front Access PCMCIA</td>
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<tr>
<td>Ethernet Port (100BASE-TX)</td>
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<tr>
<td>Front Access PCMCIA</td>
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<td>●</td>
</tr>
<tr>
<td>Color TFT LCD Screen</td>
<td>10.4”, 12.1” or 15.0”</td>
<td>10.4”, 12.1” or 15.0”</td>
</tr>
<tr>
<td>Screen Resolution</td>
<td>Up to 1,024 X 768</td>
<td>Up to 1,024 X 768</td>
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</tbody>
</table>

For a detailed list of functions, refer to the i-Series-MODEL B specifications GFTE-525 or the manual GFZ-83522EN.
<table>
<thead>
<tr>
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<td>Processor: HITACHI SH-4</td>
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<td>CompactFlash™ Card</td>
<td>CompactFlash™ Card</td>
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<tr>
<td>Color TFT LCD Screen</td>
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<td>10.4&quot; or 12.1&quot;</td>
<td>10.4&quot; or 12.1&quot;</td>
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<tr>
<td>Screen Resolution</td>
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<td>Up to 800 X 600</td>
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<td>Ethernet Port</td>
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<tr>
<td>Touch Screen</td>
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<td>Handy Machine</td>
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<td>PMC C Language</td>
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<tr>
<td>CNC Macro Executor</td>
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<td>CNC Custom Macro</td>
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<td>Conversational</td>
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<tr>
<td>Programming</td>
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<td>Remote Diagnostic</td>
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<td>Customization</td>
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<td>Milling Functions</td>
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<td>Turning Functions</td>
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<tr>
<td>Compound Machining Function</td>
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<tr>
<td>Electronic Gear Box/Hobbing Functions</td>
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<tr>
<td>Milling Functions</td>
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<td>Punching Functions</td>
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<tr>
<td>Laser Function</td>
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<td>EDM Functions</td>
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<td>Tool Functions</td>
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<td>Measurement Functions</td>
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<tr>
<td>Guidance for Machine Preparation Functions</td>
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<td>Accuracy Compensation Functions</td>
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<td>Linear/Circular Interpolation</td>
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<td>Nano Interpolation</td>
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<td>Nano Smoothing</td>
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<tr>
<td>Advanced Preview Control</td>
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<td>AI Contour Control</td>
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<td>Advanced Acceleration/Deceleration Control Functions</td>
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</tbody>
</table>

1. **Intel® Celeron™ / Pentium®**
   - Up to 512 MB
   - 40 GB
   - Windows® 2000/XP

2. **Model Available MB/MB/MB/MB**
   - Hitachi SH-4
   - CompactFlash™ Card
   - 10.4" or 12.1" Screen
   - Up to 800 X 600 Screen Resolution

3. **Touch Screen**
   - Optional

4. **Handy Machine Operator Panel**
   - Optional

5. **PMC C Language**
   - ●

6. **CNC Macro Execute**
   - ●

7. **CNC Custom Macro**
   - ●

8. **CNC Language Executor**
   - ●

9. **Conversational Programming**
   - ●

10. **Display**
    - ●

11. **Graphic Display**
    - ●

12. **Status/Program/Parameters**
    - ●

13. **Ladder Monitoring/Editing**
    - ●

14. **Servo/Spindle Setup**
    - ●

15. **Alarm/Operation History**
    - ●

16. **Remote Diagnostic**
    - ●

17. **Multi-Language Support**
    - ●

18. **Customization**
    - ●

19. **Milling Functions**
    - ●

20. **Turning Functions**
    - ●

21. **Compound Machining Function**
    - ●

22. **Electronic Gear Box/Hobbing Functions**
    - ●

23. **Grinding Functions**
    - ●

24. **Punching Functions**
    - ●

25. **Laser Function**
    - ●

26. **EDM Functions**
    - ●

27. **Tool Functions**
    - ●

28. **Measurement Functions**
    - ●

29. **Guidance for Machine Preparation Functions**
    - ●

30. **Accuracy Compensation Functions**
    - ●

31. **Linear/Circular Interpolation**
    - ●

32. **Exponential Interpolation**
    - ●

33. **Helical Interpolation**
    - ●

34. **Involute Interpolation**
    - ●

35. **Cylindrical Interpolation**
    - ●

36. **Polar Coordinate Interpolation**
    - ●

37. **Hypothetical Interpolation**
    - ●

38. **Conical/Spiral Interpolation**
    - ●

39. **Smooth Interpolation**
    - ●

40. **Nano Interpolation**
    - ●

41. **NURBS Interpolation**
    - ●

42. **5 Axis Machining Functions**
    - ●

43. **3D Circular Interpolation**
    - ●

44. **Nano Smoothing**
    - ●

45. **Advanced Preview Control**
    - ●

46. **AI Contour Control**
    - ●

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48. **High Precision Contour Control**
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51. **Jerk Control**
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52. **Rigid Tapping**
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53. **Synchronous Control**
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54. **Tandem Control**
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55. **Advanced Tandem Control Functions**
    - ●

56. **Torque Control**
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CNC controls are not everything. GE Fanuc offers what an automated machine tool needs – amplifiers, servomotors, spindle motors, I/O modules, stationary and mobile operator control terminals and the relevant cables for them. All of its CNC products are designed from the outset as a system and are optimally matched as a CNC package.

To support our customers, we have created an extensive global support and service network. We offer a variety of support services and programs to help you get your GE Fanuc CNC up and running and keep it at maximum productivity.

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