

Numerical Control

Numerical Control (NC) is simply a means of directing some or all of the functions of a machine automatically from numerical instructions. These numerical instructions are introduced to the machine by some form of stored input medium such as a punched or magnetized tape. The Machine Control Unit (MCU) interprets these instructions and directs the machine through the required operations with a combination of speed, accuracy, and consistency that cannot be equalled by human operators. Although the machine tool industry is the most conspicuous use area of NC, any mechanism requiring controlled motion is a candidate for numerical control.

Contouring And Point-To-Point

There are two basic types of machine tool control. The simplest is *point-to-point* in which the tool or part is directed to a position and a machine operation such as drilling or punching is performed. The path to that point is of consequence only in terms of time required for movement or obstacles that may exist along that path. Positioning control is another term for point-to-point control.

A more sophisticated NC concept is *continuous path* or *contouring control*. The continuous-path MCU precisely commands tool path in multiple axes and receives confirmation of actual path through feedback.

When feedback is used in an NC system, it is called a *closed-loop* system. Closed-loop requires a *command* signal from the MCU to the machine and feedback to the control from the *position* transducer on the machine. In an open-loop system you do not have feedback. Most open-loop systems depend on stepping motors to maintain positioning accuracy. There is usually a sacrifice of fast feedrate and accuracy in open-loop systems.

The Tektronix 1701 two-axis and the 1702 three-axis MCU's are closed-loop, continuous-path units that are also useful for point-to-point control.

Programming

The 1701 and 1702 MCU's use *absolute dimensioning*. The MCU references all positions to one, common zero-reference point. Tektronix absolute dimensioning is in one quadrant of a Cartesian coordinate system resulting in the following advantages:

- (1) Part programming is directly related to the dimensions of a part drawing.
- (2) Part program additions or deletions can easily be made.
- (3) Starting in the middle of a part program is much simpler.

The 1701 and 1702 combine features of the point-to-point and continuous-path control. The absolute dimensioning, typically found in point-to-point control, is combined with interpolation techniques of contouring control, enabling the MCU's to adapt to both point-to-point and continuous path applications. *Full floating-zero* is a standard feature in Tektronix MC that allows the zero-reference point to be established manually at any position over the full travel of the machine.

There are two types of tape coding recognized by the numerical control industry. The standard for the industry is the familiar USASCII Code. However, previous to the development and wide-spread use of USASCII, the numerical control industry had its own standard, the EIA Code. The EIA Code is the more common in the U.S.; USASCII is generally finding acceptance in the European market. The 1701 and 1702 can accept either code by simply changing a circuit card.

Auxiliary Functions

The purpose of a machine control unit is not merely to control a position or move. The control must also decode from tape and indicate to the machine tool miscellaneous and preparatory functions to be performed.

Tektronix Machine Control Units have a standard feature, the ability to command the machine tool to perform up to 80 *miscellaneous functions*. Examples of miscellaneous functions would be:

- (1) Control of the insertion and retraction of cutting tool, punch, or drill on a 2-axis control.
- (2) Turning the coolant on or off for a cutting tool or drill.
- (3) Positioning a turret and selecting a tool.

During a part program it may be desirable to change the mode of operation of the numerical control via *preparatory functions*. Examples of preparatory functions would be:

- (1) Selecting linear or circular interpolation on a contouring control.
- (2) Inhibiting the deceleration function of the control.

There are other auxiliary functions listed under options.

Tektronix NC

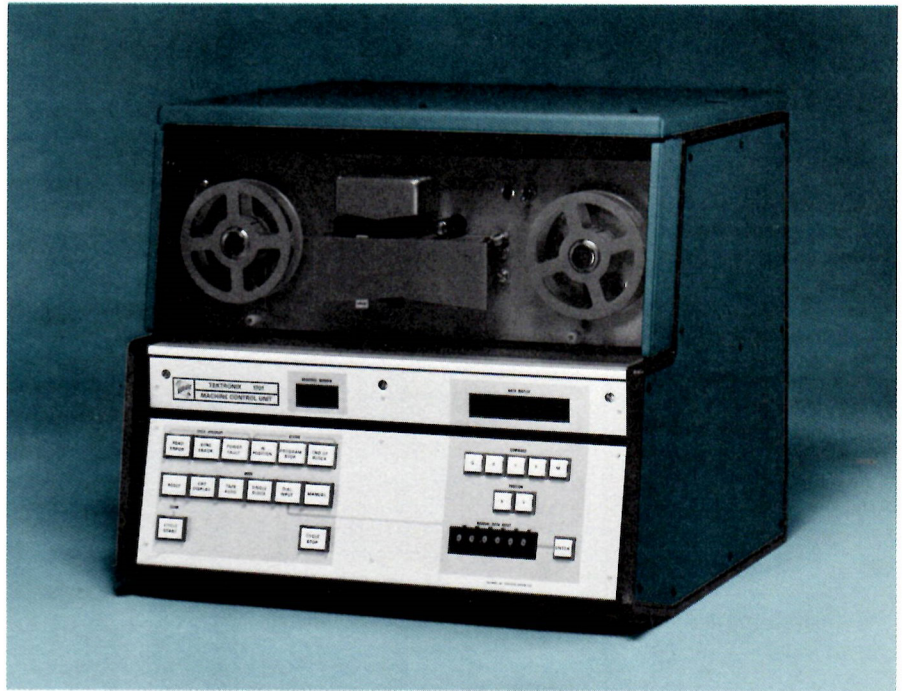
Tektronix has entered the NC field with two- and three-axis, closed-loop, continuous-path machine control units. These machine control units (MCU) are a direct result of the influence of our own extensive machine tool user experience (from programming to machining) combined with established product design skills. Tektronix MCU's offer the machine tool user and the machine tool manufacturer the new program tape verification option, along with easier maintenance through functional layout and many features not found in other units in its price range. In addition, Field Engineering support is available through 58 Field Offices.

Fast Tape-Verification

Unique to the 1701 and 1702 Machine Control Units is the built-in ability to interface the 611 Storage Display Unit for previewing tool centerline path. The 611 reveals the programmed tool path before actual machining takes place and graphically reveals most programming errors. Most programming errors are time-wasting, gross errors. They are potentially destructive in terms of ruined workpieces, broken tools, or even machine damage.

When verifying a part-program tape, the speed at which tool path is displayed is as fast as the tape reader. By using reader speed instead of machine speed, minimum time is required for tape checkout. Time savings in tape previewing are more than ten times better than usual verification methods. The capacity to check tape in less than a minute, instead of 20 or 30 minutes, is a breakout of the confining practice of proof by actual machine operation or laborious step-by-step programming checks. Another plus is that the tape verification is performed on the same machine control unit that controls the machine to be programmed and no computer is required.

- OPTIONAL, FAST TAPE-VERIFICATION
- DIRECT FEEDRATE PROGRAMMING
- FULL FLOATING ZERO
- 0.0001-INCH RESOLUTION
- COMMAND, POSITION, AND SEQUENCE READOUT
- MANUAL DATA INPUT
- EXCELLENT NOISE IMMUNITY



Standard features of these units include: Linear interpolation; command and position readout for each axis; plus readout capability of G, F and M functions on the 1701. Readout of G and F functions is available on the 1702. Readouts aid in analyzing program and machine errors. Manual Data Input (MDI) allows limited program modifications. Data entered through MDI is not entered on program tape. Direct feedrate programming is provided as well as automatic acceleration and deceleration. Adjustments are minimized, requiring only three per axis of control.

The 1701/1702 units include TTL integrated logic circuitry on plug-in circuit boards, a power supply, an operator's control panel, a sequence number and position readout panel, and a tape reader. An interface to the 611 Storage Display Unit is also standard. The optional 611 Storage Display Unit, used in tape verification, is designed to interface with the 4601 Hard Copy Unit. With this additional option, permanent, reproducible copies are produced in 18 seconds.

Retrofit And Original Equipment

Tektronix Machine Control Units conform to the standards of the machine tool industry so that they interface readily with the many machine tools that are designed for NC. Tektronix MCU's will retrofit to many existing, non-NC machine tools through recognized industry procedures and techniques. Your Tektronix Field Engineer or Representative can provide you with detailed information.

STANDARD FEATURES

1701 Two Axis and 1702 Three Axis MCU's

Resolution—0.0001 inch.

Command Register Range—0 to +99.9999 inches each axis.

Maximum Slide Departure—99.9999 inches each axis.

Position Register Range—-99.9999 to +99.9999 inches each axis.

Maximum Feedrate—240 inches per minute.

Manual Data Input (MDI) Switches—Six-decimal digits, from 00.0000 to 99.9999.

Floating Zero—Full range.

Programming Format—Word address, absolute dimensions.

Acceleration/Deceleration—Automatic.

Sequence Number Readout—0 to 999.

Command and Position Readout—00.0000 to 99.9999.

Basic Clock Rates—2 MHz, within 4%.

Logic Type—TTL Series 74N logic and $TT\mu L$ 9000 defined in terms of positive logic using the following definitions: Low Voltage Level = Logic 0, High Voltage Level = Logic 1.

Input Power Requirements—115/230 V, 50/60 Hz, ≈ 400 W at 115 V/60 Hz.

Line Noise Immunity—1200 V, 1 ms; 100 kHz to 30 MHz, 40 dB.

1701 and 1702

Machine Control Units

SPECIAL-PURPOSE PRODUCTS

ENVIRONMENTAL CHARACTERISTICS

Temperature (Ambient)—Non-operating, -40°C to $+60^{\circ}\text{C}$; operating, $+10^{\circ}\text{C}$ to $+45^{\circ}\text{C}$; during calibration, $+20^{\circ}\text{C}$ to $+30^{\circ}\text{C}$, 1/2 hour stabilization period required.

Humidity—to 95%.

OTHER CHARACTERISTICS

Dimensions and Weights

Height	18 3/8 in	46.8 cm
Width	20 7/16 in	52.0 cm
Depth	20 1/2 in	52.2 cm
Net Weight	≈115 lb	≈52.1 kg
Domestic Shipping Weight	≈130 lb	≈58.9 kg

Finish—Vinyl painted cast aluminum sides, anodized aluminum front panel, top cover is vinyl painted aluminum plate.

Mounting—Four 5/16 × 18 tapped holes in the bottom.

INCLUDED STANDARD ACCESSORIES

1701/1702 user's manual (070-1072-00); 1701/1702 maintenance manual (070-1100-00); Remex Tape Reader manual (062-1259-00); mating power twistlock connector (131-0170-00); machine interface mating connector (131-0239-00); three transducer interface mating connectors (134-0049-00).

1701 Machine Control Unit	\$9,750
1702 Machine Control Unit	\$11,000

OPTIONAL FEATURES

NO COST OPTIONS

Metric Operation—Provides for operation in metric units in place of English units. (Metric system resolution is 0.01 mm with maximum register range of 9999.99 mm.)

ASCII Code—Permits the 1701 or 1702 to accept USASCII Code RS358 in place of EIA Code RS244.

Fast Feedrate—Provides feedrates of 255 inches per minute at 0.0002-inch resolution or 1,000 inches per minute at 0.001-inch resolution.

Leading Zero Option—This option changes the operation of the 1701/1702 so that leading zeros (in the axis commands only) must be programmed, but trailing zeros are not required. This is for those installations where programming trailing zeros in the axis commands would become much more of a chore than programming leading zeros.



Machine Control Unit With Fast Tape-Verification Option

ADDITIONAL COST OPTIONS

S & T Functions—A combined option which provides both spindle speed control and selection of tools. Both speed and tool selection is programmed via two-digit codes (00 to 79).

Order Option 5 **ADD \$850**

G80 Series—Provides a selection of seven repetitive routines for drilling, boring, and tapping operations. Specific requirements of machine tool must be known; price is available by special quote.

Circular Interpolation—Provides simplified data format for programming circular motion within a quadrant.

Feedrate Override—Gives the operator the ability to manually override all traverse rates from 25% to 120% of programmed feedrate.

Order Option 9 **ADD \$300**

Jog Switch—Provides variable-feedrate manual positioning control plus a 0.0001 inch and 0.001 inch stepping feature for setup and maintenance.

Order Option 10 **ADD \$500**

Additional M Functions—In addition to the standard internal functions (program stop-rewind, etc.), up to 79 functions can be provided for auxiliary machine operations.

611 Storage Display Unit **\$2695**

4601 Hard Copy Unit **\$3750**

U.S. Sales Prices FOB Beaverton, Oregon
Please refer to General Information page