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Automation systems and integration — Numerical control of machines — Program format and definitions of address words —

Part 1: Data format for positioning, line motion and contouring control systems

Systèmes d'automatisation industrielle et intégration — Commande numérique des machines — Format de programme et définitions des mots adresses —

Partie 1: Format des données pour les systèmes de positionnement, de commande paraxiale de mouvement et de contourage

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 6983-1 was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 1, *Physical device control*.

This second edition cancels and replaces the first edition (ISO 6983-1:1982), which has been technically revised.

The following changes have been made to the first edition:

— the content has been restructured in a more logical order;

— the commonly used preparatory (G) and miscellaneous (M) function codes have been grouped in one standard (see Annex E);

— address indexing has been introduced (see 6.2);

— the equal (=) sign has been added to allow for axis indexing (see 6.2.1);

— new data formats have been specified to existing programming methods: helical interpolation (see 7.3); dwell time (see Clause 13); thread cutting (see Clause 11).

ISO 6983 consists of the following parts, under the general title *Automation systems and integration — Numerical control of machines — Program format and definitions of address words*:

— *Part 1: Data format for positioning, line motion and contouring control systems*

The following parts are under preparation:

— *Part 2: Coding of miscellaneous functions M (class 1 to 8)* [Technical Report]

Introduction

ISO 6983 describes a word address program format for machine control programs on different data storages, e.g. perforated tape, magnetic media, universal serial bus (USB) stick, hard disk, floppy disk, random-access memory (RAM), etc., or provided from a remote data source. ISO 6983 covers variable block format only and is not intended to specify machine design.

ISO 6983 is intended to specify the program format for the control program to be used for numerical controls (NC) on machines/machine tools. However, ISO 6983 can also be used for all kinds of geometric specifications and interactions with machines.

The program format specified by ISO 6983 is commonly referred to as “G code programming” or “ISO programming”.

Compliance with ISO 6983 does not guarantee interchangeability of machine control programs between different machines/machine tools. Annex D details some of the additional considerations necessary to ensure this interchangeability.

Automation systems and integration — Numerical control of machines — Program format and definitions of address words —

Part 1: Data format for positioning, line motion and contouring control systems

1 Scope

This part of ISO 6983 specifies requirements and makes recommendations for a data format for positioning, line motion and contouring control systems used in the numerical control of machines. This part of ISO 6983 helps the co-ordination of system design in order to minimize the variety of program manuscripts required, to promote uniformity of programming techniques, and to foster interchangeability of input programs between numerically controlled machines of the same classification by type, process, function, size and accuracy. It is intended that simple numerically controlled machines be programmed using a simple format, which is systematically extensible for more complex machines.

This part of ISO 6983 is not intended for use in the specialized cases of numerically controlled flame cutting machines and drafting machines used specifically and exclusively in the shipbuilding industry. In this application, a related format ("the ESSI Format") is specified in ISO 6582.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2806, *Industrial automation systems — Numerical control of machines — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2806 apply.

4 Program format

The machine program shall be structured in blocks of data, which contain sets of commands to the control system. A block shall consist of a number of words each of which is a specific instruction to the control system.

A character designated "end of block" shall terminate every block of data and in addition shall precede the first block of data.

A "program start" character shall precede all control data including "end of block". It is recommended that it should be used as an "absolute rewind stop" character.

All alphabetic, numeric and special characters shall conform to Annex A. Those characters required for reproducing a hard copy of the machine program, listed in Annex A as “non printing characters”, shall be ignored by the control equipment, with the exception of the LF/NL (end of block) character.

If there is any group of characters that is not to be processed in accordance with this part of ISO 6983, this group shall be within parenthesis characters (control out – control in). Any such group shall not contain either “:” or “%” characters. This group may be processed for display purposes, e.g. as instructions to an operator.

Where it is necessary to identify a machine program, this identification should be placed immediately after the program start character and before the first “end of block” character. If the identification contains alpha characters, the entire identification should be enclosed with parentheses. Where it is desired to identify a machine program number word, the program number word should be placed immediately after the first “end of block” for this identification. If the program number is greater than the system can store or display, the least significant digits shall be displayed.

It is recommended that the alignment code should be used at all positions in the program at which it is permissible to start the machine sequence. When used, this code shall be as defined in 6.3. The alignment function character “:” may be used as an intermediate rewind stop character.

The “/” (slash) character shall be used to provide an “optional block skip” function validated at the option of the operator. When used, this character shall immediately precede the “sequence number” word.

A general classification of the format shall be used to detail the capabilities of a system and machine configuration. This is called the general format classification and is defined in Annex B.

A classification of the data in a block shall be used to specify the programming detail for a system and machine configuration. This is called the detailed format classification and is described in Annex C.

For position values or length values, either metric or inch units of length shall be used.

When a system has the ability to use machine programs which have been prepared in either system of measurement, preparatory codes shall be used to signify whether the coded data is in metric or inch values. The mode of control shall be selected by one of the following G codes (preparatory function codes):

— G70 inch data input;

— G71 metric data input.

5 Format make-up

5.1 Data block

A block of data shall consist of the following:

a) the sequence number word;

b) the data word;

Tab characters, which are optional for the tabulation of a printed copy of the data, may be inserted between words but shall be ignored by the control system.

5.2 Data words

The data words shall be presented in the following sequence and shall be not repeated within one block. However, existing control systems may permit the repetition of non dimensional words, but it is recommended for maximum machine program interchangeability that this facility should not be used.

The sequence is as follows:

a) the preparatory words “G”;

b) the “dimension” words, which shall be arranged in the following sequence: X, Y, Z, U, V, W, P, Q, R, A, B, C;

c) the “interpolation or thread cutting lead words” I, J and K, which apply only to a specific group of axes and shall immediately follow that group; the words shall conform in detail to Clauses 7 or 11;

d) the “feed function” word (or words), which applies to one or more of several axes and shall follow the last dimension word to which it applies and immediately follow the applicable interpolation parameter words; the word shall conform in detail to 6.3;

e) the “spindle speed function” word (or words);

f) the “tool function” word (or words);

g) the “miscellaneous function” word (or words).

5.3 Omitted words

Words may be omitted in a specific block of data. This should be understood as meaning that there is no change in the condition of the machine with respect to the function denoted by the omitted word. Therefore, the “end of block” character may be used after any complete word. Instructions that are inherently executed in a single block shall be repeated whenever necessary.

6 Words

6.1 All words

The address character shall be the first in the word and it shall be followed by an algebraic sign, if required, and then by digital data. The address character shall be in accordance with Annex A.

The implicit position of the decimal sign shall be defined by the detailed format classification (see Annex C). All control systems shall accept implicit decimal sign programming. Optionally, the decimal sign character may be recognized.

Implicit decimal sign and explicit decimal sign format shall not be mixed in any machine program.

In the explicit decimal sign format mode, words from which the decimal sign is missing shall be interpreted as whole numbers. The procedure for recognition of explicit decimal sign format shall be defined in the detailed format classification (see Annex C).

In order to reduce the amount of data with the implicit decimal sign format, either leading zeros only, or trailing zeros only, shall be omitted. It is recommended that leading zeros should be omitted.

Zero omission shall be specified in the detailed format classification (see Annex C).

With explicit decimal sign format, both leading zeros before the decimal sign and trailing zeros after the decimal sign may be omitted.

EXAMPLE 1 X1030 represents a dimension of 1 030 mm in the X-axis.

EXAMPLE 2 X.03 represents a dimension of 0,03 mm in the X-axis.

In either decimal format, a dimension containing only zeros shall be expressed by at least one zero.

6.2 Address indexing

6.2.1 Axis indexing

For machine tools with a higher number of axes, the address indexing may be used. This index digit of the address shall follow directly after the address character. The index shall be an unsigned integer greater zero (0). The maximum index value is specified in the machine description. Leading zeros may be omitted.

For the separation of the index value and the address value, the equal (=) sign is used.

EXAMPLE G00 X1=123.456 Y1=234 Z2=10.1 F100 S1000.

Indexing of addresses may be mixed with non-indexed addresses if there are addresses which have no relation to any indexed address.

NOTE This axis indexing is used in ISO 841.

6.2.2 General indexing

For machine tools with a higher number of axes, auxiliary axis, spindles, tool magazines, etc., address indexing may be used. This index digit of the address shall follow directly after the address character. The index shall be an unsigned integer greater zero (0). The maximum index value is specified in the machine description. Leading zeros may be omitted. The indexing of G codes is not intended.

For the separation of the index value and the address value, the equal (=) sign is used.

EXAMPLE G00 X1=123.456 Y1=234 Z1=10.1 F1=100 M1=3 S1=1000.

Indexing of addresses may be mixed with non-indexed addresses if there are addresses which have no relation to any indexed address.

This indexing can also be used for machine tools with more work groups. This work grouping can be realized by grouping the axis systems using the address indexing, e.g.:

— X1=, Y1=, Z1=, G1=, M1=, S1=, … in the first axis system (work group 1);

— X2=, Y2=, Z2=, G2=, M2=, S2=, … in the second axis system (work group 2).

6.3 Dimension words

It shall be possible to use both absolute dimension words and incremental (relative) dimension words. The mode of the control shall be selected by one of the following G codes:

a) G90 Absolute dimension;

b) G91 Incremental dimensions.

All linear dimensions shall be expressed in millimetres or inches and decimal fractions thereof.

Angular dimensions shall be expressed either in degrees and decimal parts thereof, or in revolutions or decimal parts of a revolution. The use of degrees and decimal parts of a degree is recommended for the expression of all angular dimensions.

The algebraic sign (+ or −) is part of the dimension word, and shall follow the address character and shall precede the numerical character. If the sign is omitted, a plus (+) sign shall be assumed. The control system shall use the negative sign for a negative absolute dimension word and for a negative direction movement with an incremental word.

The resolution of the linear and angular dimensions used in the program shall be defined by the detailed format classification (see Annex C).

6.4 Non-dimensional words

6.4.1 Sequence number

The number of digits shall be specified by the detailed format classification (see Annex C). If a sequence number word in a machine program contains more digits than are specified by a particular control equipment, the least significant digits shall be displayed.

It is recommended that at all positions in the program at which it is permissible to start a machine sequence, the alignment code should replace the sequence number address character N.

6.4.2 Preparatory function

The preparatory function shall be expressed by the address character G followed by a coded number in accordance with Annex E.

6.4.3 Feed function

The number of digits shall be designated by the detailed format classification (see Annex C).

Selection of the type of feed function shall be by the following preparatory (G) codes:

a) G93 Inverse time;

b) G94 Feed per minute;

c) G95 Feed per revolution.

It is recommended that when the feed is independent of spindle speed, the digits should represent directly the vectorial motion in millimetres per minute or inches per minute.

When the feed is dependent on spindle speed, it is recommended that the digits should represent directly the vectorial motion in millimetres per revolution or inches per revolution.

When the feed is applied to a rotary motion only, it is recommended that the digits should represent directly the vectorial motion in degrees per minute.

When simultaneous interpolation in both linear and rotary axes are possible, independent of spindle speed, the rate of vectorial motion may be expressed as a feed command. This feed command shall be the reciprocal of time in minutes to execute the block and is equivalent to the vector velocity (expressed in millimetres or inches per minute) divided by the vector distance of the tool path (expressed in millimetres or inches). When this facility requires a change in the detailed format classification, the revised F word format should be specified. Alternatively, the feed can be specified by the speed of the vectorial motion along the tool path.

It is recommended that preparatory code G00 should be used for rapid positioning (see Annex E).

As an alternative, if the F word is used for traverse, the code shall be specified in the detailed format classification and it shall be defined as modal or non-modal.

For any combination of interdependent axes which can be moved simultaneously or sequentially with the principal axes, the F character shall be used as address for the feed word. An independent axis which can be moved simultaneously with the principal axes shall use the E character as address for the feed word.

As an alternative to the recommended practice, the feed function may consist of a two-digit code with increasing arbitrary values of feed rate represented by increasing code number.

6.4.4 Spindle function

The number of digits shall be designated by the detailed format classification (see Annex C). Where necessary, selection of the type of spindle speed function shall be made by the following preparatory (G) codes:

a) G96 Constant surface speed;

b) G97 Revolutions per minute.

It is recommended that when the digits represent RPM, they shall represent directly the spindle rotation in revolutions per minute.

When the digits represent surface speed (see Clause 12), the digits shall represent metres per minute or feet per minute.

As an alternative to the recommended practice, the spindle function may consist of a two-digit code, with increasing arbitrary values of spindle speed represented by increasing code number.

6.4.5 Tool function

The T word shall be used for tool selection and optionally the same word may select the tool compensation offset. When tool compensation offset is selected by a different word, the D word is recommended. The T word, and the D word if used, shall be designated by the detailed format classification (see Annex C).

6.4.6 Miscellaneous function

The miscellaneous function shall be expressed by a coded number in accordance with Annex E.

6.4.7 Parameters

For a flexible programming method, calculations of axis values or setting of parameters for a subroutine are necessary. The kind of use of these features shall be specified in the manual, i.e.

— which address character is used as parameter: P, Q or R;

— which operations are allowed, e.g. arithmetic, trigonometric, logical;

— which memory addresses are used for the parameters.

In these cases, the parameter index is the memory location of the parameter, and address indexing is mandatory.

EXAMPLE 1 R11 = 22.2 (The content of parameter R11 is set to 22.2)

EXAMPLE 2 R29 = R9 + R15 (Parameter content addition, result is stored in parameter R29)

EXAMPLE 3 X2 = 105 + R9 (X2-position results of addition of 105 and the content of R9)

7 Programming methods for interpolation

7.1 Principles

Interpolation is performed over a pre-determined portion of a given curve. The portion interpolated is called a “span” and may be covered by one or more blocks of information. Data necessary to define a “span” shall obey one or more of the principles below.

a) An appropriate G code shall be used to define the functional nature of the curve, i.e. linear, circular or parabolic.

b) The starting point of each span shall be identical to the end point of the previous span and, therefore, it is not necessary to repeat this point in the new block. Each subsequent point of the span for which coordinates are specified shall require a separate block of information and shall use a valid dimension address, such as X, Y or Z.

c) Interpolation parameters shall be addressed I, J or K and shall be used for defining the geometric properties of the curve as defined for each interpolation method.

d) In cases where an algebraic sign is required with the interpolation parameter word, it shall follow the address character and precede the numeric characters. If the sign is omitted, a plus sign shall be assumed.

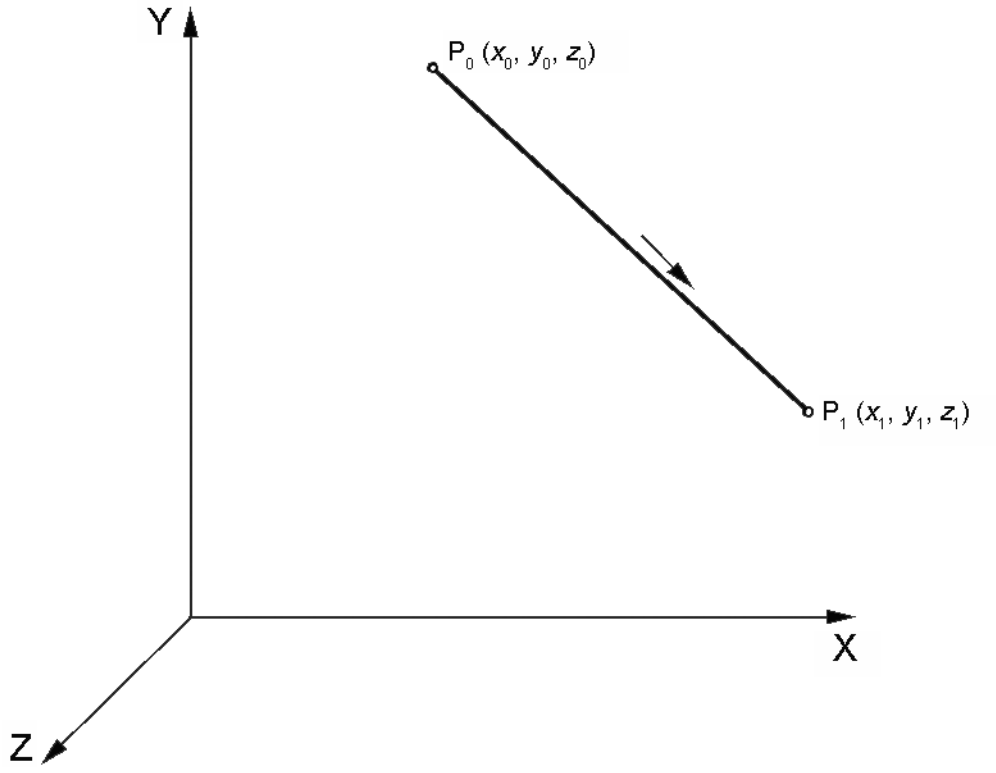
7.2 Linear interpolation

A straight line span shall be defined in one block which contains

a) the G function word (if not currently active). G01 linear interpolation;

b) the coordinates of the end point, which shall be expressed as dimension words (see 6.3).

The example in Figure 1 shows the geometric properties of the span and gives an example of the coordinate values to be programmed.



Using end point (G01XYZF)

Absolute dimensions	Incremental dimensions
$X = x_1$	$X = x_1 - x_0$
$Y = y_1$	$Y = y_1 - y_0$
$Z = z_1$	$Z = z_1 - z_0$

Figure 1 — Example of linear interpolation in the XY plane for motion from point P_0 to P_1

7.3 Circular interpolation

Circular interpolation defines a circular span lying in a plane parallel to one of the three principal planes of reference. The example in Figure 2 shows the geometric properties of a typical circular span and gives an example of the coordinate and interpolation values to be programmed. It is recommended that circular interpolation should be programmed by defining the span (up to full circle) in one block. As an alternative, the programming of circular interpolation may be limited to a span lying in a quadrant for each block.

The block shall contain

a) the G function word (if not currently active): the G02 Circular interpolation arc clockwise (CW); the G03 Circular interpolation arc counter-clockwise (CCW);

b) the coordinates of the end point, which shall be expressed in either absolute or incremental dimensions and addressed by any valid motion address, such as X, Y or Z;

c) the interpolation parameters addressed I, J and K, which define the centre of the arc.

It is recommended that the I, J and K words should be the incremental (relative) dimension from the starting point to the centre of the circle, irrespective of whether the dimension words are incremental or absolute, as follows:

— I will be the dimension parallel to X;

— J will be the dimension parallel to Y;

— K will be the dimension parallel to Z.

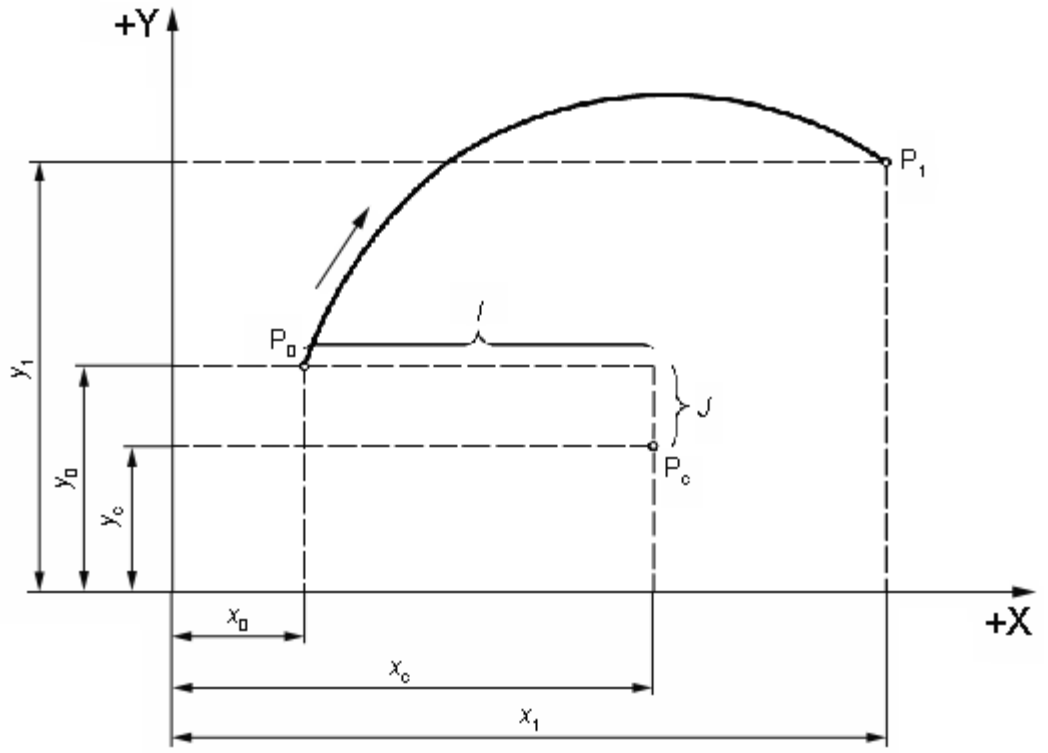
Systems that do not require an algebraic sign for circular interpolation shall ignore any sign character in the interpolation word. As an alternative, the I, J, and K words shall be programmed in the same mode as the dimension words.

When circular interpolation is to be combined with simultaneous linear interpolation (the so-called “helical interpolation”), the plane of circular interpolation shall be selected by a preparatory function. Interpolation blocks shall be as specified with the addition of a third dimension word, which shall indicate the end point of the linear motion.

EXAMPLE
```
N10 G17                    (Plane selection)
N15 G1 G90 X0 Y0 Z0 F50    (Linear interpolation to X0 Y0 Z0)
N20 G2 X20 Y20 I20 J0 Z10  (Helical interpolation clockwise 90 degrees)
```

The speed of the linear movement is determined in a way that both movements (circular and linear) finish at the same time.

Where a preparatory function is required to select one of the principal planes of reference, the code shall be selected in accordance with Annex E.



G02XYIJF

Absolute dimensions	Incremental dimensions
$X = x_1$	$X = x_1 - x_0$
$Y = y_1$	$Y = y_1 - y_0$
$I = x_c - x_0$	$I = x_c - x_0$
$J = y_c - y_0$	$J = y_c - y_0$

Figure 2 — Example of circular interpolation in the XY plane for motion from point P_0 to P_1

7.4 Parabolic interpolation

7.4.1 Parabolic interpolation defines a parabolic span lying in any plane.

It is recommended that the method of programming of the span should be by definition by three points. The intermediate point and the end point shall be programmed in successive blocks. The example in Figure 3 shows the geometric properties of the span and gives examples of meanings of the coordinate values to be programmed. The first block shall contain

a) the G-function word (if not currently active): G06 Parabolic interpolation;

b) the coordinates of the intermediate point.

The following block shall contain the coordinates of the end point. The coordinates of all points shall be expressed in either absolute or incremental dimensions and addressed by any valid motion address, such as X, Y or Z.

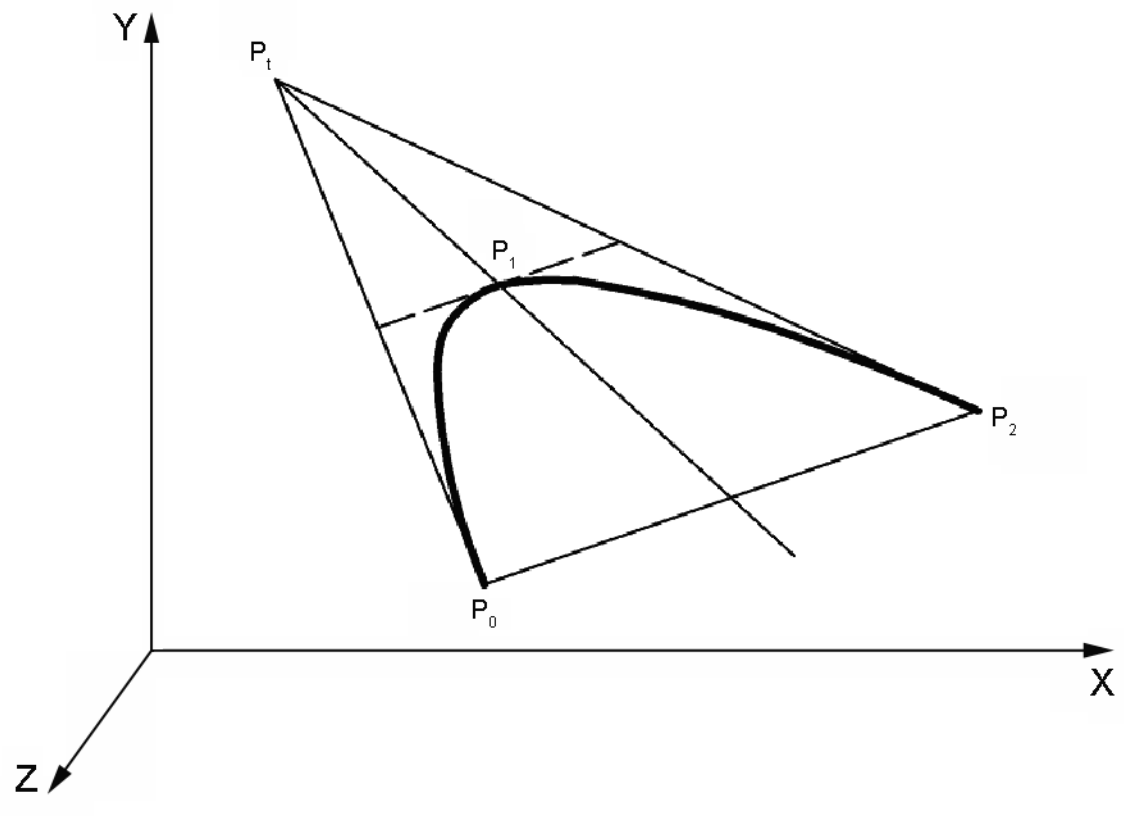
7.4.2 Alternatively, the span may be defined in one block using interpolation parameters. The block shall contain

a) the G-function word (if not currently active): G06 Parabolic interpolation;

b) the coordinates of the end point, which shall be expressed in either absolute or incremental dimensions and addressed by any valid motion address, such as X, Y or Z;

c) the interpolation parameters addressed by I, J, K.

I, J, K should be the coordinates of the tangent intersection point.



Key

P_0 start point

P_t tangent intersection point

P_1 intermediate point (tangent parallel to P0, P2)

P_2 end point

Using intermediate point (G06YXZF) and end point (XYZ)

Block	Absolute dimensions	Incremental dimensions
First block	$X = x_1$ $Y = y_1$ $Z = z_1$	$X = x_1 - x_0$ $Y = y_1 - y_0$ $Z = z_1 - z_0$
Second block	$X = x_2$ $Y = y_2$ $Z = z_2$	$X = x_2 - x_1$ $Y = y_2 - y_1$ $Z = z_2 - z_1$

Figure 3 — Example of parabolic interpolation in three axes by the method of programming in two successive blocks

8 Tool length offset and tool offset

When tool length offset is included, it provides the possibility of moving a tool a distance along the Z-axis equal to the value entered into the control equipment. The offset distance, and where applicable the sign, may be inserted via manual data input switches or other means.

When tool offset is included, usually for lathes, it provides the possibility of moving a tool a distance along specified axes, normally X and Z. The offset value shall be inserted as described above.

The offset move shall be possible without the use of any preparatory codes. Removal of the offset shall be accomplished by a zero (0) value in the digits of the tool function that are allocated to selection of the offset value.

9 Tool radius (diameter) offset

When the tool radius (diameter) offset is included, it provides the possibility of moving a tool the same distance along both the X- and Y-axes to the value entered into the control equipment (half for diameter offset). The offset distance, and where applicable the sign, may be inserted via manual data input switches or other means.

The control equipment shall provide preparatory codes to signify the block in which the offset shall be added first.

It is recommended to use the preparatory codes G43 Tool offset positive and G44 Tool offset negative (see Annex E) to signify the block in which the offset shall be introduced and whether it shall be added or subtracted from the commanded axis dimension. As an alternative to G43/G44, the D address can be used to signify a positive tool offset. The offset can be cancelled by G40 (see Annex E).

10 Cutter compensation

When cutter compensation is included in a control system, it provides the possibility of modifying the tool path to take into account the dimension of the actual tool.

Compensation shall be applied to the following contouring modes:

— linear interpolation;

— circular interpolation.

The compensation parameter shall be determined by values entered into the control system store, via manual data input or other means. The store position shall be identified by the T word, unless a separate D address has been used. The range of compensation shall be specified in the control system specification. Cutter compensation may be applied to a succession of motion blocks which include circular interpolation. Compensation shall not, however, be introduced or removed in circular interpolation blocks.

The control system shall provide the preparatory functions G40, G41 and G42 (the operation of these G codes is specified in Annex E). The compensation shall be applied to all motion generated from blocks containing G41 or G42 and all subsequent blocks until G40 is read, when the operational T word store identity has a value other than zero. Before a further T word (or D word) is programmed, a G40 shall be used to remove the original compensation.

11 Thread cutting

When the feature thread cutting is incorporated in the control system, the data required shall be the axis move, the lead and a preparatory code.

The preparatory functions to commence constant lead thread cutting and at completion to reset the program are detailed in Annex E (G33 Thread cutting).

The dimension words X, Y and/or Z shall be used as specified in 6.2.

The address characters to be used for the lead shall be I for the lead in the X-axis, J for the lead in the Y-axis, and K for the lead in the Z-axis. As an alternative to I, J or K, the address F or E can be used to specify the lead.

The lead dimensions shall be expressed in millimetres or inches and the decimal fractions thereof for one revolution of the spindle. The number of digits shall be designated by the detailed format classification (see Annex C). There shall not be an algebraic sign.

The feed functions word is not required with constant lead and shall not be programmed.

For variable lead threads, the I, J and K words shall be the initial lead dimensions. The rate of increase or decrease in lead per revolution shall be expressed in millimetres per revolution squared or inches per revolution squared and addressed by character F. When the F word is used in this manner, it shall be specified in the detailed format classification (see Annex C). As an alternative to I, J or K (initial lead) and F (rate of increase or decrease in lead), the address F can be used to specify the initial lead and the address K to specify the rate of increase or decrease in lead per revolution.

12 Constant surface speed

When this feature is incorporated in the control system, a preparatory code shall be used to signify that the S word is the required surface speed (see 5.3).

The preparatory code G96 shall be used to start the constant surface speed operation and G97 shall revert the S word back to revolutions per minute.

When a limitation of the spindle speed is necessary, it should be programmed by G92 and the S word. The digits of the S word define the maximum allowed spindle speed in RPM. The preparatory function G92 and the S word should be programmed in a block prior to that containing G96 calling for constant surface speed.

13 Dwell

A delay between moves shall be programmed in a separate block containing G04. It is recommended that the duration of the dwell time is specified by the F word, the P word or the X word. The delay shall be in seconds when G94 is operative and in revolutions of the spindle if G95 is operative.

It is recommended that the resolution of the dwell time should be 0,1 s or 0,1 revolutions, or as specified in the detailed format classification. As an alternative, the delay may be set by other means.

14 Reset states

14.1 General

It is recommended that the system should assume the following operation modes at power turn-on or after the miscellaneous function M02 (End of program) or M30 (End of data) have been read. Exceptions shall be defined in the detailed format classification.

14.2 Point to point and line motion controls

The control system should have power-on with the following states operational:

— G00 Positioning;

— G40 Cutter compensation/tool radius offset cancel;

— G71 Metric data;

— G80 Fixed cycle cancel;

— G90 Absolute dimension data;

— G94 Feed per minute.

14.3 Contouring controls other than those on lathes

The control system should have power-on with the following states operational:

— G01 Linear interpolation;

— G17 XY plane selection;

— G40 Cutter compensation/tool radius offset cancel;

— G71 Metric data;

— G80 Fixed cycle cancel;

— G90 Absolute dimension data;

— G94 Feed per minute.

14.4 Contouring controls on lathes

The control system should have power-on with the following states operational:

— G01 Linear interpolation;

— G40 Cutter compensation/tool radius offset cancel;

— G71 Metric data;

— G80 Fixed cycle cancel;

— G90 Absolute dimension data;

— G94 Feed per minute;

— G97 Revolutions per minute.

Annex A
(normative)

List of characters used from ISO/IEC 646

The implementation of this coded character set shall include a parity check bit on track number 8 to provide even parity. Only the characters listed in Table A.1 shall be used.

Table A.1 — Address characters

Character	ISO/IEC 646 reference	Meaning
A	4/1	Angular dimension about X-axis
B	4/2	Angular dimension about Y-axis
C	4/3	Angular dimension about Z-axis
D	4/4	Second tool function
E	4/5	Second feed function
F	4/6	First feed function
G	4/7	Preparatory function
H	4/8	Unassigned
I	4/9	Interpolation parameter of thread lead parallel to X
J	4/10	Interpolation parameter of thread lead parallel to Y
K	4/11	Interpolation parameter of thread lead parallel to Z
L	4/12	Unassigned
M	4/13	Miscellaneous function
N	4/14	Sequence number
O	4/15	Unassigned
P	5/0	Tertiary dimension parallel to X or parameter
Q	5/1	Tertiary dimension parallel to Y or parameter
R	5/2	Tertiary dimension parallel to Z or parameter
S	5/3	Spindle speed function
T	5/4	First tool function
U	5/5	Secondary dimension parallel to X
V	5/6	Secondary dimension parallel to Y
W	5/7	Secondary dimension parallel to Z
X	5/8	Primary dimension X
Y	5/9	Primary dimension Y
Z	5/10	Primary dimension Z

Table A.1 (*continued*)

Character	ISO/IEC 646 reference	Meaning
0	3/0	0
1	3/1	1
2	3/2	2
3	3/3	3
4	3/4	4
5	3/5	5
6	3/6	6
7	3/7	7
8	3/8	8
9	3/9	9
%	2/5	Program start
(	2/8	Control out[a]
)	2/9	Control in[a]
+	2/11	Plus
,	2/12	Comma
-	2/13	Minus
.	2/14	Decimal sign
/	2/15	Optional block skip
:	3/10	Alignment function
=	3/13	Equal (used for axis indexing)
TAB	0/9	Tabulation[b]
LF/NL	0/10	End of block[b]
CR	0/13	Carriage return[b]
SP	2/0	Space[b]
DEL	7/15	Delete[b]

[a] See Clause 4.

[b] Non-printing characters.

Annex B
(normative)

General format classification

B.1 General

The format classification shall consist of two groups of characters, as defined below.

B.2 First group

The first group of two (2) alpha characters shall contain one character pertaining to positioning/line motion/ contouring and one character pertaining to units of measurement, as follows:

a) character pertaining to positioning/line motion/ contouring

   — “P” for positioning only, or

   — “L” for positioning and line motion, or

   — “D” for positioning, line motion and contouring, or

   — “C” for contouring only;

b) character pertaining to units of measurement

   — “M” for metric units of measurement, or

   — “I” for inch units of measurement, or

   — “N” for control equipment that accepts both metric and inch units of measurement.

B.3 Second group

The second group shall comprise three digits denoting the geometrical characteristics of both machine and control systems, as follows:

a) the first digit shall show the number of motions controlled either digitally or symbolically (i.e. by limit switch);

b) the second digit shall show the number of motions controlled by the dimension words;

c) the third digit shall show the number of simultaneously controlled motions.

B.4 Example

For example, a classification “PM 322” denotes a control system which has the following characteristics:

— positioning only (“P”);

— metric units of measurement (“M”);

— 3 motions controlled by the control system;

— 2 motions controlled by numerical data (the third, the Z-axis, by limit switches);

— 2 motions can be positioned simultaneously.

Annex C
(normative)

Detailed format classification

The detailed classification shall specify the words and length thereof that are required by the system, and shall detail the special characters that may be programmed, in the following order:

a) the program start character symbolized by “%” (percent sign);

b) the alignment character symbolized by “:” (colon);

c) the optional block skip character symbolized by “/” (slash);

d) the explicit decimal sign symbolized by “DS” (.);

e) any letter used as an address for a word in the system, and recorded in the proper sequence.

The address character of every dimension word shall be followed by three digits:

— the first digit is a zero, which indicates that leading zeros can be omitted;

— the second digit indicates the number of decimal decades ahead of the decimal sign;

— the third digit indicates the number of decades after the decimal sign.

If the algebraic signs are required, the plus (+) sign shall be inserted between the address and the first digit. If trailing zeros may be omitted instead of leading zeros, the zero (0) shall be the last digit instead of the first.

Non-dimensional words which specify decimal values shall be coded in the same manner as dimensional words, e.g. interpolation parameters, feed and speed functions.

Other non-dimensional words shall have up to two digits following the address character, the first digit being a 0 (zero) if leading zeros can be omitted, and the last digit indicating the maximum number of digits in the word. If trailing zeros may be omitted instead of leading zeros, the zero shall be the last digit instead of the first.

When a facility changes the detailed format classification of a word, the change shall be indicated against that facility.

The end of block character shall be symbolized by an asterisk (*).

EXAMPLE %:/DS N03 G02 X+053 Y+053 Z+053 F031 S04 T04 M02* (with dwell facility, the F word becomes F022)

The above example denotes a system with explicit decimal sign, program start, alignment and block skip features. Leading zero suppression is confirmed with the following meaning of the data words:

— three-digit sequence number;

— two-digit preparatory function;

— X dimension with algebraic sign, five digits to the left of the decimal sign and three to the right;

— Y dimension with algebraic sign, five digits to the left of the decimal sign and three to the right;

— Z dimension with algebraic sign, five digits to the left of the decimal sign and three to the right;

— four-digit feed rate, three digits to the left of the decimal sign and one to the right (changes to two digits to the left of the decimal sign and two to the right when a dwell is programmed);

— four-digit spindle function;

— four-digit tool function;

— two-digit miscellaneous function.

NOTE The program format does not provide for space characters. Spaces between elements in the above example are only for the clarity of the text.

Annex D
(normative)

Notes for program interchangeability

The notes in this annex are for the guidance of users who wish to have interchangeability of control programs between differing machine tools and control systems (i.e. numerical controls).

It shall be determined that the machines have the same or similar configuration and capability, and that the controls have the same format specification.

Interchangeability of control programs is unlikely to be possible between different machine tools of a complex nature, e.g. machines with multi-spindles or lathes with varying lead during a thread cutting mode.

However, it may be possible to program a workpiece for these machines to this part of ISO 6983 when the complex facility of the machine is not required.

The degree of interchangeability will depend on the conformity of the machines with respect to function, capability, range, horsepower, geometric relationship of axes, preparatory, miscellaneous and tooling functions, and other considerations.

Machine axis dynamics, such as maximum step velocity capability and concerning capability, should be considered.

Machine function codes (e.g. M, S, T) should be analyzed to make sure that required machine functions are taken into account. This includes auxiliary code-initiated sequencing for tool changers, clamps, pallet shuttles, spindles, etc.

It is recommended that the “optional stop” code (M01) be included in data block where spindle speed changing or tool indexing, for example, is required to be performed manually on one of the machines. The optional stop facility would be selected when a function needs to be operated manually. A control not recognizing these machine function codes in the program should ignore them, but the consequences should be analyzed for protection of the operator, machine, and workplace.

With respect to feed and speed coding, the programmer shall review the feeds and speeds to determine whether correct operation will result between the interchanged systems.

With respect to non-programmed functions, certain functions are normally controlled by the operator. These include mirror image, axis interchange, amount of cutter compensation, floating zero or zero offset, and similar functions.

Any G or M code which is used but not specifically defined (see Annex E) shall be checked for compatibility.

Some control systems permit more than one preparatory function word in a single block. For maximum interchangeability, only one such word should be coded per block.

Annex E
(normative)

Preparatory (G) and miscellaneous (M) function codes

E.1 Coding of preparatory (G) function codes

Preparatory (G) function codes are represented by the letter G followed by a two-digit integer (unsigned) (see Table E.1). Some modern controls have extended the G code to integers containing three or more digits, however, harmonization is not possible due to different usage. Consequently, this part of ISO 6983 covers only the two-digit G codes commonly used.

Table E.1 — Assignment of preparatory (G) function codes

Code	Function	Description	Duration[a]
G00	Rapid positioning	A mode of control in which movement to the programmed point occurs with maximum, e.g. rapid, feed rate; a feed rate previously programmed is ignored but not cancelled, and the movements in different axes may be uncoordinated.	FRC(a)
G01	Linear interpolation	A mode of control, used for a uniform slope or straight line motion, that uses the information contained in a block to produce velocities proportional to the distances to be moved in two or more axes simultaneously.	FRC(a)
G02	Circular interpolation arc clockwise Remark to circular interpolation	Circular interpolation in which the curvature of the path of the tool with respect to the workpiece is clockwise when the plane of motion is viewed in the negative direction of the axis perpendicular to it. A mode of contouring control that uses the information contained in one block to produce an arc or a circle, the velocities of the axes used to generate the arc being varied by the control.	FRC(a)
G03	Circular interpolation arc counter-clockwise	Circular interpolation in which the curvature of the path of the tool with respect to the workpiece is counter-clockwise when the plane of motion is viewed in the negative direction of the axis perpendicular to it.	FRC(a)
G04	Dwell	A timed delay of programmed or established duration, not cyclic or sequential; i.e. not an interlock or hold.	TBO
G05	Unassigned[b]		DDFC
G06	Parabolic interpolation	A mode of contouring control which uses the information contained in one or more blocks to produce a span of a parabola. The velocities of the axes used to generate this arc are varied by the control.	FRC(a)
G07 to G08	Unassigned[b]		DDFC
G09	Exact stop[c]	Used to stop the movement of the axis (for a short time) after the end of the block.	TBO
G10 to G16	Unassigned[b]		DDFC

Table E.1 (*continued*)

Code	Function	Description	Duration[a]
G17	XY plane selection	Used to identify the plane for such functions as circular interpolation, cutter compensation; and others as required.	FRC(b)
G18	ZX plane selection		FRC(b)
G19	ZY plane selection		FRC(b)
G20 to G24	Unassigned[b]		DDFC
G25 to G29	Permanently unassigned[d]		DDFC
G30 to G32	Unassigned[b]		DDFC
G33	Thread cutting, constant lead	Mode selection for machines equipped for thread cutting.	FRC(a)
G34	Thread cutting, increasing lead[c]	Constantly increasing lead.	
G35	Thread cutting, decreasing lead[c]	Constantly decreasing lead.	
G36 to G39	Permanently unassigned[d]		DDFC
G40	Cutter compensation cancel	Command which cancels any cutter compensation (diameter or radius') or tool offset.	FRC(d)
G41	Cutter compensation left	Direction of cutter compensation of the tool path looking from the cutter in the direction of the relative cutter motion.	FRC(d)
G42	Cutter compensation right		
G43	Tool offset positive[c]	Indicates that the value of the tool offset shall be added to the coordinate dimension of the relevant block, or blocks.	FRC(*d)
G44	Tool offset negative[c]		
G45 to G52	Unassigned[b]		DDFC
G53	Dimension shift cancel[c]	Suppresses any program zero shift.	FRC(f)
G54 to G59	Zero shifts[ce]	Displaces the program zero relative to the machine datum.	FRC(f)
G60	Exact stop[c]	Used to stop the movement of the axis (for a short time) after each block.	FRC(g)
G61 to G62	Unassigned[b]		DDCF
G63	Tapping[c]	The selection for the particular case shall be defined in the format specification.	TBO
G64	Continuous-path mode[c]	Used to move the axis with programmed feed rate across two or more blocks (no exact stop at each end of block).	FRC(g)
G65 to G69	Unassigned[b]		DDCF
G70	Dimension input inch[c]	Mode selection for dimension input.	FRC(m)
G71	Dimension input metric[c]		
G72 to G73	Unassigned[b]		DDCF
G74	Home position[c]	Used to move the axes specified in the block to home position.	TBO
G75 to G79	Unassigned[b]		DDCF
G80	Fixed cycle cancel	Fixed cycles will discontinue.	FRC(e)
G81 to G89	Fixed cycle[f]	A preset series of operations which direct machine axis movements and/or cause spindle operation to complete such actions as boring, drilling, tapping or combinations thereof.	FRC(e)

Table E.1 (*continued*)

Code	Function	Description	Duration[a]
G90 G91	Absolute dimension[c] Incremental dimension[c]	Mode of control for interpretation of dimensions as relative to a specified origin or relative to the previously programmed position.	FRC(i)
G92	Preload registers[c]	Used to modify or set registers by the programmed data words. No motion occurs.	TBO
G93 G94 G95	Inverse time federate[c] Feed per minute Feed per revolution	Feed input is reciprocal to the time to execute the block. Feed rate units are millimetres/inches per minute. Feed rate units are millimetres/inches per revolution.	FRC(k)
G96 G97	Constant surface speed Revolutions per minute[c]	The spindle speed codes specify the constant surface speed in meters/feet per minute. The spindle speed is automatically controlled to maintain the programmed value. The spindle speed codes specify the spindle speed in revolutions per minute.	FRC(l)
G98 to G99	Unassigned[b]		DDFC
G100 to G999	Unassigned[b]	Three-digit G code.	DDFC

[a] The following abbreviations for duration are used in this table:

— DDFC designated in the detailed format classification;

— FRC(α) function retained until cancelled or superseded by a subsequent command of the same letter designation (modal); in the case of (*d), the cancel or replacement function shall be one of those designated by letter d without or between parentheses;

— TBO this block only: function affects only the block within which it appears.

[b] Unassigned codes are for individual use. However, in future International Standards or future revisions, particular meanings may be allocated to these unassigned preparatory function code numbers.

[c] When this code is not used for the described purpose or the function is not provided by the control, the code is unassigned and available for other use.

[d] Permanently unassigned codes are for individual use and are not intended to be assigned in future revisions.

[e] Previously assigned to specific axes.

[f] See Table E.2.

Table E.2 — Fixed cycles

Fixed cycle code	Movement in	At bottom		Movement out to feed start	Typical use
		dwell	spindle		
G81	feed	—	—	rapid	drill spot drill
G82	feed	yes	—	rapid	drill counterbore
G83	intermittent	—	—	rapid	deep hole
G84	forward spindle feed	—	reverse	feed	tap
G85	feed	—	—	feed	bore
G86	start spindle speed	—	stop	rapid	bore
G87	start spindle speed	—	stop	manual	bore
G88	start spindle speed	yes	stop	manual	bore
G89	feed	yes	—	feed	bore

E.2 Coding of universal miscellaneous (M) function codes

E.2.1 Coding principles for M functions

The coding principles for M functions are as described below.

a) M functions are represented by a two-digit code or, if necessary, by a three-digit code.

b) In numerical control units of machines not requiring the use of all the M functions defined, a set of two-digit codes may be used. In this case, the hundreds digit is not taken into account by the control and shall not appear in the program.

c) The assignment of digits (units, tens and hundreds) for M functions corresponding to specific duty classes shall be carried out to facilitate the use of two-digit codes to the maximum. The use of identical codes for different functions in the same application is prohibited.

d) Table E.3 defines the universal miscellaneous M functions which have the same definition in all classes.

e) Each of the M functions defined is assigned to a specific “class” corresponding to a hundreds digit (see E.2.2).

E.2.2 M function classes

The M function classes, which will be described in ISO/TR 6983-2, are as follows:

— Class 0: NC universal command;

— Class 1: milling, horizontal boring machines and turning centres;

— Class 2: lathes, vertical turning machines, vertical boring machines and turning centres;

— Class 3: grinding machines and measuring machines;

— Class 4: flame, plasma, laser, waterbeam cutting and wire cut EDM;

— Class 5: multi-carrier, multi-head, multi-spindle machines and associated handling;

— Class 6: punching and nibbling machines;

— Class 7: permanently unassigned – can be used for individual (custom) application;

— Class 8: to be used for code extension.

Table E.3 — Miscellaneous (M) function coding (class 0)

Code	Function	Description	Comments[a]
M00	Program stop	A miscellaneous function command to cancel the spindle or other functions (e.g. coolant function) and terminate further processing after the completion of commands in the block.	AAM TBO
M01	Optional (planned) stop	A miscellaneous function command similar to a program stop except that the control ignores the command unless the operator has previously pushed a button to validate the command.	AAM TBO
M02	End of program	A miscellaneous function indicating completion of workpiece. Cancels spindle or other function (e.g. coolant function) after completion of all commands in the block. Used to reset control and/or machine.	AAM TBO
M03	Spindle CW	A miscellaneous function command to start the spindle rotation in the clockwise (CW) direction. The spindle (rotation) speed is specified with the S-Word.	FRC
M04	Spindle CCW	A miscellaneous function command to start the spindle rotation in the counter-clockwise (CCW) direction. The spindle (rotation) speed is specified with the S-Word.	FRC
M05	Spindle OFF	A miscellaneous function command to cancel the spindle rotation.	FRC
M06	Tool change	Command to execute the change of tool(s) manually or automatically, not to include tool selection. May or may not automatically shut-off coolant and spindle.	DDFC TBO
M07		See ISO/TR 6983-2	
M08		See ISO/TR 6983-2	
M09		See ISO/TR 6983-2	
M10 M11	Clamp workpiece Unclamp workpiece	Can pertain to machine slides, workpiece, fixture, spindle etc.	DDFC TBO
M30	End of data	A miscellaneous function which cancels spindle or other function (e.g. coolant function) after completion of all commands in the block. Used to reset control and/or machine. Resetting control will include return to the program start character.	AAM TBO
M48[b]	Cancel M49		
M49[b]	Bypass override	A miscellaneous function which deactivates a manual spindle or feed override and returns the parameter to the programmed value.	AAM AWM
M60[b]	Workpiece change	A miscellaneous function indication that the workpiece needs to be removed or reoriented. Cancels spindle and coolant functions after completion of all commands in the block.	TBO

[a] The following abbreviations are used as comments in this table:

— AAM action after motion: function acts after completion of commanded motion in its block;

— AWM action with motion: function acts with commanded motion in its block;

— DDFC designated in the detailed format classification;

— FRC(α) function retained until cancelled: function retained until cancelled or superseded by an appropriate subsequent command (modal);

— TBO this block only: function affects only the block within which it appears.

[b] These M codes are available for individual use.

Bibliography

[1] ISO/IEC 646, *Information technology — ISO 7-bit coded character set for information interchange*

[2] ISO 841, *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

[3] ISO 6582, *Shipbuilding — Numerical control of machines — ESSI format*

[4] ISO/TR 6983-2[1)], *Automation systems and integration — Numerical control of machines — Program format and definition of address words — Part 2: Coding of miscellaneous functions M (class 1 to 8)*

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