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Automation systems and integration — Physical device control — Data model for computerized numerical controllers —

Part 14: Process data for sink electrical discharge machining (sink-EDM)

Systèmes d'automatisation et intégration — Commande des dispositifs physiques — Modèle de données pour les contrôleurs numériques informatisés —

Partie 14: Données de procédé pour l'usinage de baisse électrique (baisse EDM)

Reference number
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Contents

Page

Foreword ..... **iv**
Introduction ..... **v**
1 Scope **1**
2 Normative references **1**
3 Terms and definitions **1**
4 Process data for sink-EDM **2**
4.1 Header and references 2
4.2 Manufacturing features for sink-EDM 2
4.3 Machining operation for sink-EDM 3
Annex A (informative) **EXPRESS listing** **13**
Annex B (informative) **EXPRESS-G** **16**
Bibliography **26**

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 1, *Physical device control*.

ISO 14649 consists of the following parts, under the general title *Automation systems and integration — Physical device control — Data model for computerized numerical controllers*:

— *Part 1: Overview and fundamental principles*

— *Part 10: General process data*

— *Part 11: Process data for milling*

— *Part 12: Process data for turning*

— *Part 13: Process data for wire electrical discharge machining (wire-EDM)*

— *Part 14: Process data for sink electrical discharge machining (sink-EDM)*

— *Part 111: Tools for milling machines*

— *Part 121: Tools for turning machines*

— *Part 201: Machine tool data for cutting processes* [Technical Specification]

Gaps in numbering were intentionally left in order to allow further additions. ISO 14649-10 is the ISO 10303 Application Reference Model (ARM) for process-independent data. ISO 10303 ARMs for specific technologies are added after ISO 14649-10. ISO 14649 is harmonized with ISO 10303 in the common field of Product Data over the whole life cycle. ISO 14649-1 describes the different fields of standardization between ISO 14649, ISO 10303 and CNC manufacturers with respect to implementation and software development.

Introduction

ISO 14649-10 describes the general process data for numerical controlled machining and includes its schema. The subject of this schema (called machining_schema) is the definition of data types, which are generally relevant for different technologies (e.g. milling, turning, sink-EDM). It includes the definition of the workpiece, a feature catalogue containing features, which might be referenced by several technologies, the general executables and the basis for an operation definition. Not included in this schema are geometric items and presentations, which are referenced from the generic resources of ISO 10303, and the technology-specific definitions, which are defined in separate parts of ISO 14649.

ISO 14649-10 is not a stand-alone standard. Its implementation needs at least one additional technology-specific part (e.g. ISO 14649-11 for milling). This part of ISO 14649 describes sink Electrical Discharging Machining (sink-EDM) and it defines technology-specific data types representing the machining process for sink-EDM.

The main text of this part of ISO 14649 provides definitions and explanations of the data entities needed to provide control data information to an EDM controller.

The EXPRESS forms of the entities are given again in Annex A without the explanatory text for information.

Annex B provides an alternative view of these entities, with the different figures showing graphical representations of different elements. These figures are purely informative: a detailed explanation of the entities in the figures is given in the corresponding text definitions.

In addition, the schema uses machining features similar to ISO 10303-224. The description of process data is carried out using EXPRESS language as defined in ISO 10303-11. The encoding of the data is carried out using ISO 10303-21.

Automation systems and integration — Physical device control — Data model for computerized numerical controllers —

Part 14: Process data for sink electrical discharge machining (sink-EDM)

1 Scope

This part of ISO 14649 specifies the technology-specific data element needed as process data for sink-EDM. Together with the general process data described in ISO 14649-10, it describes the interface between computerized numerical controller and the programming system (i.e. CAM system or shop-floor programming system) for sink-EDM. It can be used for sink-EDM operations on this kind of machine.

The scope of this part of ISO 14649 does not include tools for any other technologies (e.g. turning, grinding). Tools for these technologies are described in other parts of ISO 14649.

2 Normative references

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

ISO 14649-10, *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers — Part 10: General process data*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14649-10 and the following apply.

3.1
roughing
machining operation used to cut a part

Note 1 to entry: While the aim of roughing is to remove large quantities of material in a short time, the surface quality is usually not important.

Note 2 to entry: The roughing operation is usually followed by the *finishing* (3.2) operation.

3.2
finishing
machining operation whose aim is to reach the tolerance of the feature required

Note 1 to entry: The finishing operation is usually preceded by the *roughing* (3.1) operation and followed by the *surface finishing* (3.3) operation.

3.3
surface finishing
machining operation whose aim is to reach the required surface quality

Note 1 to entry: The surface finishing operation is usually preceded by the *finishing* (3.3) operation.

4 Process data for sink-EDM

4.1 Header and references

The following listing gives the header and the list of entities which are referenced within this schema.

```
SCHEMA sink_edm_schema;
(*
Version 3 of Jan 13, 2002
Author: Gabor Erdos
Your email contact: Gabor Erdos <gabor.erdos@epfl.ch>
*)
REFERENCE FROM machining_schema (*ISO 14649-10*)
(
length_measure,
bounding_geometry_select,
machine_functions,
machining_operation,
machining_tool,
material,
property_parameter,
technology,
toleranced_length_measure,
machining_feature,
plane_angle_measure,
axis1_placement,
machining_strategy,
bounded_curve,
rot_speed_measure,
pressure_measure,
advanced_brep_shape_representation,
direction,
rot_direction,
radial_direction,
toolpath,
toolpath_type,
toolpath_speedprofile,
toolpath_list
);
```

4.2 Manufacturing features for sink-EDM

4.2.1 General

The sink-EDM features defined in this subclause are the features that are specific for sink-EDM technology, and are not defined in ISO 14649-10. The base class for all sink-EDM features is the machining_feature, defined in ISO 14649-10.

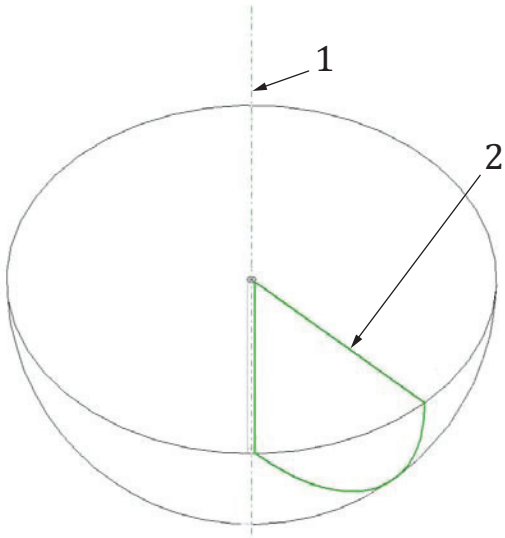
4.2.2 Sink-EDM volumetric pocket

The sink_edm_volumetric_pocket describes a special sink-EDM cavity feature. This feature is created by orbiting the reference point of the tool axis within closed volume. The final shape of the pocket is defined by the outline shape of the tool. The closed volume is defined as a revolved feature, where the feature_boundary curve is revolved around the axis.

```
ENTITY sink_edm_volumetric_pocket
SUBTYPE OF (machining_feature);
feature_boundary: bounded_curve;
axis: axis1_placement;
END_ENTITY;
```

feature_boundary: Defines the cross section of the revolved feature. The feature_boundary lies within the features xz-plane (see Figure 1)IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

axis: Specifies the axis of the revolving operation. The axis lies within the features xz-plane (see Figure 1)



Key

1	axis
2	feature_boundary

Figure 1 — Sink_edm_volumtric_pocket

4.3 Machining operation for sink-EDM

4.3.1 General

This subclause introduces all the machining operations and technology-specific data that are needed for sink-EDM.

4.3.2 Sink-EDM machining operation

The sink_edm_machining_operation classes define the machining process for a limited area of the workpiece, i.e. the contents of a machining workingstep. This entity is inherited by the machining_workingstep class defined in ISO 14649-10. This class defines additional information needed by the sink-EDM machining. It is a subtype of entity machining_operation defined in ISO 14649-10.

```
ENTITY sink_edm_machining_operation
SUBTYPE OF (machining_operation);
first_depth: OPTIONAL length_measure;
depth_of_step: OPTIONAL length_measure;
approach: OPTIONAL approach_retract_strategy;
retract: OPTIONAL approach_retract_strategy;
END_ENTITY;
```

first_depth: If it is defined the sinking is done in multi-step and this define the depth of the first step.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</ Tbl_no_borders>” “” </Tbl_no_borders>

depth_of_step: Depth of each additional step (repeated until the depth of the hole is reached).

approach: Optional information about approach (plunge) strategy to reach the first cut. If multiple layers are cut, as specified by first_depth, this strategy will also be used to move from one layer to the start point of the next layer. By default, the NC controller decides about the approach strategy. It may decide not to use any approach movement at all if the start point of cutting coincides with the end point of cutting for the preceding operation. If its_toolpath is given, this attribute will be ignored.

retract: Optional information about retract strategy after finishing the last cut. By default, the NC controller decides about the retract strategy. It may decide not to use any retract movement at all if the end point of cutting coincides with the start point of cutting for the next operation. If its_toolpath is given, this attribute will be ignored.

4.3.3 Sink-EDM technology

This entity defines the technological parameters of the sink-EDM operation. It is a subtype of entity technology defined in ISO 14649-10. Since the number of technology parameters are machine dependent, the technology contains only a list that can contain any number of property parameters.

```
ENTITY sink_edm_technology
SUBTYPE OF (technology);
spindle: OPTIONAL rot_speed_measure;
sync_spindle_and_z_feed: BOOLEAN;
other_generator_parameters: SET [0:?] OF property_parameter;
END_ENTITY;
```

spindle: Rotational speed of the tool. As defined for rot_speed_measure, positive values indicate tool rotation in mathematical positive direction of the c axis, i.e. counter-clockwise motion if looking from the tool holder to the workpiece. Note that usual cutting tools require clockwise motion so the value of this attribute will typically be negative.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

sync_spindle_and_z_feed: If true, the feed rate in z and spindle speed are synchronized. It is used together with the synchronized_feed strategy.

other_generator_parameters: Set of other parameters of the generator of generic type.

4.3.4 Sink-EDM machining functions

The entity describes the state of various functions of the machine (e.g. coolant) to be applied during the time span of an operation. It is a subtype of entity machine_functions defined in ISO 14649-10.

```
ENTITY sink_edm_machine_functions
SUBTYPE OF (machine_functions);
flush: BOOLEAN;
aspiration: BOOLEAN;
flush_pressure: OPTIONAL pressure_measure;
other_functions: SET [0:?] OF property_parameter;
END_ENTITY;
```

flush: If true, the flush is activated to clean the “chips” and debris from the spark gap. IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</ Tbl_no_borders>” “” </Tbl_no_borders>

aspiration: If true, the aspiration is activated to clean the “chips” and debris from the spark gap.

flush_pressure: Optional specification of the pressure of the dielectric fluid.

other_functions: Optional list of other functions of generic type.

4.3.5 Sink-EDM machining strategy

4.3.5.1 General

The sink_edm_machining_strategy class specifies the strategy to be used when executing the operation. When it is specified it will modify the final offset toolpath generation method. It is a subtype of entity machining_strategy defined in ISO 14649-10.

```
ENTITY sink_edm_machining_strategy
ABSTRACT SUPERTYPE OF (ONEOF (contour_parallel,along_vector,synchronized_feed))
SUBTYPE OF(machining_strategy);
END_ENTITY;
```

4.3.5.2 Contour parallel machining

Sinking in several paths following the contour of the feature. Similar to the contour parallel milling strategy defined in ISO 14649-11 (see Figure 2).

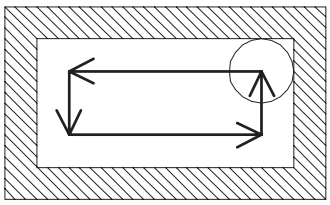


Figure 2 — Contour parallel machining

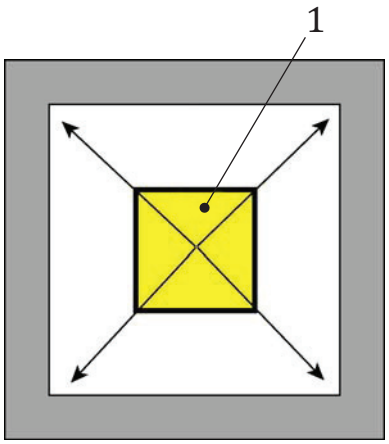
```
ENTITY contour_parallel
SUBTYPE OF(sink_edm_machining_strategy);
rotation_direction: OPTIONAL rot_direction;
stepover_direction: OPTIONAL radial_direction;
END_ENTITY;
```

rotation_direction: The direction of the spiral path (clockwise or counterclockwise) as seen from the top of the feature. The default is counterclockwise. The attribute cutmode, if given, takes precedence over this attribute.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </ Tbl_no_borders>

stepover_direction: If this attribute is outside_in, sink-EDM will start at the outer contour and proceed towards the centre. This is the default. Otherwise, it will start at the centre and proceed towards the outer contour.

4.3.5.3 Along vector machining

Sinking along the direction of the specified vector. Typical strategy to enlarge pockets by moving the sink tool along the specified vectors (see Figure 3).



Key

1 tool

Figure 3 — Along vector strategy

```
ENTITY along_vector
SUBTYPE OF(sink_edm_machining_strategy);
corner_vectors: LIST [0:?] OF direction;
END_ENTITY;
```

corner_vectors: Defines the direction for the tool movement. The start point is defined by the cut_start_point attribute of the machining_operation entity.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

4.3.5.4 Synchronized feed

The synchronized feed strategy specifies how the sink tool is rotated as it is plunged into the material. The axis rotation amount is defined as the rotation around the z-axis of the feature coordinate system. The angle is calculated from the x-axis of the same coordinate system.

```
ENTITY synchronized_feed
SUBTYPE OF(sink_edm_machining_strategy);
spindle_rotation_amount: plane_angle_measure;
END_ENTITY;
```

spindle_rotation_amount: Defines the amount of rotation of the tool axis.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

4.3.6 Sink-EDM tool

This class describe the properties of the tool used in sink-EDM machining. It is a subtype of entity machining_tool defined in ISO 14649-10.

```
ENTITY sink_edm_tool
SUBTYPE OF (machining_tool);
coolant_through_tool: OPTIONAL BOOLEAN;
pilot_length: OPTIONAL length_measure;
its_geometry: OPTIONAL advanced_brep_shape_representation;
its_bounding_geometry: OPTIONAL bounding_geometry_select;
its_material: OPTIONAL material;
other_parameters: SET [0:?] OF property_parameter;
END_ENTITY;
```

coolant_through_tool: Does the tool body have through-the-tool coolant capabilities? (Valid values: Yes, No), (ISO/TS 13399-3:2007, Table 2).IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

pilot_length: Length from the tip of the tool to the start of the sinking region.

its_geometry: An exact description of the tool’s geometry according to ISO 10303-514.

its_bounding_geometry: By this attribute the tool’s bounding geometry might be defined as a box, a cylinder or a geometry according to the definition of the entity advanced_brep_shape_representation (ISO 10303-203, ISO 10303-514).

its_material: The material attribute identifies the tool material. This data shall be used for determining the technological process parameters for the manufacturing process.

other_parameters: Optional set of parameters of generic type.

4.3.7 Approach retract strategy

4.3.7.1 General

Base class for the approach (plunge) and retract strategy. All approach and retract strategies are defined relative to the start or end point of the cutting operation, whether this is explicitly given in the operation of determined by the NC controller. The resulting start point of the approach or end point of the retract movement are defined to be the start and end point of the current operation. The feed rate on the approach or retract path is the feed rate specified for the related start or end point, respectively, of cutting.

```
ENTITY approach_retract_strategy
ABSTRACT SUPERTYPE OF (ONEOF (plunge_strategy, air_strategy, along_path));
tool_orientation: OPTIONAL direction;
END_ENTITY;
```

tool_orientation: Only for machines with five-axis positioning capabilities. This specified the tool orientation at the beginning or end, respectively, of the approach or retract movement. IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

4.3.7.2 Plunge strategy

4.3.7.2.1 General

This is the base class for all approach movements which include cutting of material. This is typically the case for pocketing operations where the approach to the depth of the first cutting layer or between cutting layers requires the removal of material in order to create the approach path.

All plunge movements are guaranteed to occur within the boundaries of the underlying feature. All plunge movements will start at the retract plane valid for the current operation. They will end in the start point of the cutting operation, with the tangent of its approach path coinciding with the tangent of the ensuing cutting motion.

```
ENTITY plunge_strategy
ABSTRACT SUPERTYPE OF (ONEOF (plunge_toolaxis, plunge_ramp, plunge_helix, plunge_zigzag))
SUBTYPE OF (approach_retract_strategy);
END_ENTITY;
```

4.3.7.2.2 Plunge tool axis

Plunge in the direction of the tool axis (see Figure 4).

If the milling tool itself is unable to cut its way into the layer, a plunge drilling operation with a separate tool is required. As each operation can have only one tool, this will require the definition of a preceding drilling_type_operation. In this case, no plunge strategy should be given for the milling_type_operation, and the cut_start_point of both the milling_type_operation and the drilling_type_operation must coincide.

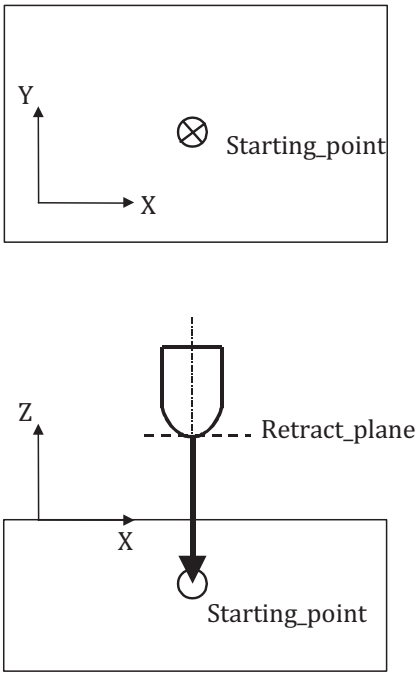


Figure 4 — Plunge tool axis

```
ENTITY plunge_toolaxis
SUBTYPE OF (plunge_strategy);
END_ENTITY;
```

4.3.7.2.3 Plunge ramp

Plunge on a linear path which forms an angle with the feature surface (see Figure 5).

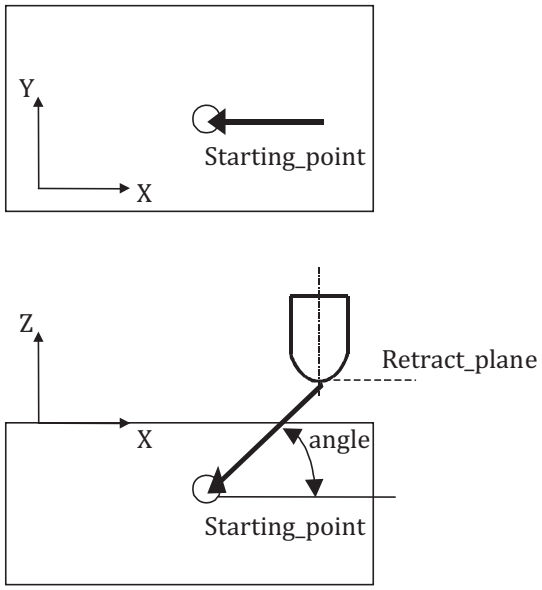


Figure 5 — Plunge ramp

```
ENTITY plunge_ramp
SUBTYPE OF (plunge_strategy);
angle: plane_angle_measure;
END_ENTITY;
```

angle: The angle of the ramp movement versus the surface in the end point of the approach. Note that the start and end point can be calculated from the restrictions in this subclause.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

4.3.7.2.4 Plunge helix

Plunge movement forming a helix. The path is defined by specifying the radius and grade of the helix. A circular movement can be specified by setting grade to zero (see Figure 6).

```
ENTITY plunge_helix
SUBTYPE OF (plunge_strategy);
radius: length_measure;
angle: plane_angle_measure;
END_ENTITY;
```

radius: Radius of the helical movement.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

angle: The angle of the helical movement versus the surface in the end point of the approach. Note that the start and end point can be calculated from the restrictions in this subclause.

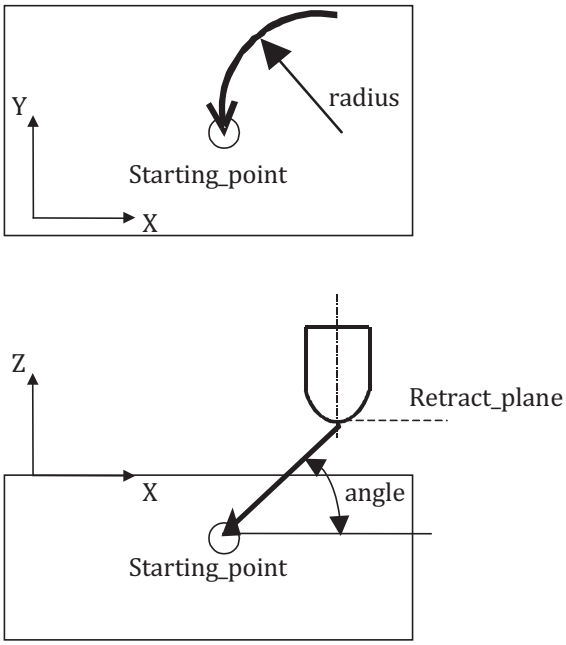


Figure 6 — Plunge helix

4.3.7.2.5 Plunge zigzag

Plunge movement using a zigzag motion. This is similar to the ramp-type movement, except the cutter changes direction if it touches a feature boundary or if the path length would exceed the specified width of the zigzag pattern (see Figure 7).

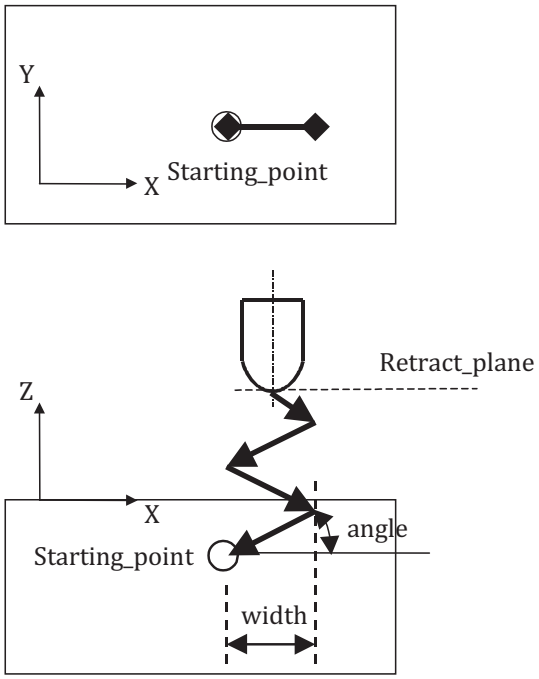


Figure 7 — Plunge zigzag

```
ENTITY plunge_zigzag
SUBTYPE OF (plunge_strategy);
angle: plane_angle_measure;
```

```
width: length_measure;
END_ENTITY;
```

angle: The angle of the movement versus the surface in the end point of the approach. Note that the start and end point can be calculated from the restrictions in this subclause.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

width: The width of the zigzag path perpendicular to the direction of the descent.

4.3.7.3 Air strategy

4.3.7.3.1 General

This is the base class for all approach or retract movements through the air.

Unlike the plunge_strategy types these movements are not limited to the inside of the feature. All of these movements shall take place in a plane which is defined by the normal of the machined feature and the tangent of the cutting path in the start or end point, respectively, of the related cutting movement. If the start or end point lies at the intersection of two planes, as may be the case for bottom_and_side_milling operations, the surface normal is deemed to be the intermediate direction between the two normals.

Note that for side milling operations, e.g. for the milling of a contour, the resulting movements will be in the xy-plane of the machine coordinate system.

```
ENTITY air_strategy
ABSTRACT SUPERTYPE OF (ONEOF (ap_retract_angle, ap_retract_tangent))
SUBTYPE OF (approach_retract_strategy);
END_ENTITY;
```

4.3.7.3.2 Approach retract angle

The movement is heading towards the start or from the end point in an angle to the surface. For plane milling, this may typically be an angle of 0 degrees in order to move straight from outside the workpiece into the material.

```
ENTITY ap_retract_angle
SUBTYPE OF (air_strategy);
angle: plane_angle_measure;
travel_length: length_measure;
END_ENTITY;
```

angle: Approach or lift angle versus the surface in the end point of the approach or the start point of the lift, respectively.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

travel_length: The length of the angular approach. After travel_length has been reached, the tool will proceed to the retract plane using the shortest connection and vice versa.

4.3.7.3.3 Approach retract tangent

The movement is heading towards the start or from the end point in a curve. The motion start or ends in the retract plane valid for the current operation. If the specified radius for this motion is smaller than the distance to the retract plane as specified in the attribute retract_plane of the current operation, the remaining path will be executed in linear motion perpendicular to the retract plane.

```
ENTITY ap_retract_tangent
SUBTYPE OF (air_strategy);
radius: length_measure;
END_ENTITY;
```

radius: The radius of the approach or retract movement.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

4.3.7.4 Along path

Approach or lift movement on a general path. This should be used if full control of the tool orientation during approach is required or for other special purposes.

```
ENTITY along_path
SUBTYPE OF (approach_retract_strategy);
path: toolpath_list;
END_ENTITY;
```

path: Specification of a general path for approach or lift movement. Note that the path is specified in a special coordinate system. The origin is the start or end point of the cutting operation, the axes are oriented like the local coordinate system of the feature.IF “x_+3” “<Tbl_no_borders>” “”<Tbl_no_borders> IF “x_+3” “<Tbl_no_borders>” “” <Tbl_no_borders>IF “x_-3” “</Tbl_no_borders>” “”</Tbl_no_borders> IF “x_-3” “</Tbl_no_borders>” “” </Tbl_no_borders>

Annex A
(informative)

EXPRESS listing

The following EXPRESS is the whole schema of this part of ISO 14649.

```
SCHEMA sink_edm_schema;
(*
Version 3 of Jan 13, 2002
Author: Gabor Erdos
Your email contact: Gabor Erdos <gabor.erdos@epfl.ch>
*)
REFERENCE FROM machining_schema (*ISO 14649-10*)
(
length_measure,
bounding_geometry_select,
machine_functions,
machining_operation,
machining_tool,
material,
property_parameter,
technology,
toleranced_length_measure,
machining_feature,
plane_angle_measure,
axis1_placement,
machining_strategy,
bounded_curve,
rot_speed_measure,
pressure_measure,
advanced_brep_shape_representation,
direction,
rot_direction,
radial_direction,
toolpath,
toolpath_type,
toolpath_speedprofile,
toolpath_list
);
(* ********************************************************** *)
(* Sink-EDM volumetric pocket feature *)
(* ********************************************************** *)
ENTITY sink_edm_volumetric_pocket
SUBTYPE OF (machining_feature);
feature_boundary: bounded_curve;
axis: axis1_placement;
END_ENTITY;
(* ********************************************************** *)
(* Sink-EDM operation *)
(* ********************************************************** *)
ENTITY sink_edm_machining_operation
SUBTYPE OF (machining_operation);
first_depth: OPTIONAL length_measure;
depth_of_step: OPTIONAL length_measure;
approach: OPTIONAL approach_retract_strategy;
retract: OPTIONAL approach_retract_strategy;
END_ENTITY;
(* ********************************************************** *)
(* Sink-EDM technology *)
(* ********************************************************** *)
ENTITY sink_edm_technology
SUBTYPE OF (technology);
spindle: OPTIONAL rot_speed_measure;
sync_spindle_and_z_feed: BOOLEAN;
```

```
other_generator_parameters: SET [0:?] OF property_parameter;
END_ENTITY;
(* ********************************************************** *)
(* Sink-EDM machine functions *)
(* ********************************************************** *)
ENTITY sink_edm_machine_functions
SUBTYPE OF (machine_functions);
flush: BOOLEAN;
aspiration: BOOLEAN;
flush_pressure: OPTIONAL pressure_measure;
other_functions: SET [0:?] OF property_parameter;
END_ENTITY;
(* ********************************************************** *)
(* Sink-EDM tool *)
(* ********************************************************** *)
ENTITY sink_edm_tool
SUBTYPE OF (machining_tool);
coolant_through_tool: OPTIONAL BOOLEAN;
pilot_length: OPTIONAL length_measure;
its_geometry: OPTIONAL advanced_brep_shape_representation;
its_bounding_geometry: OPTIONAL bounding_geometry_select;
its_material: OPTIONAL material;
other_parameters: SET [0:?] OF property_parameter;
END_ENTITY;
(* ********************************************************** *)
(*Sink-EDM Machining strategy *)
(* ********************************************************** *)
ENTITY sink_edm_machining_strategy
ABSTRACT SUPERTYPE OF (ONEOF (contour_parallel,along_vector))
SUBTYPE OF(machining_strategy);
END_ENTITY;
ENTITY contour_parallel
SUBTYPE OF(sink_edm_machining_strategy);
rotation_direction: OPTIONAL rot_direction;
stepover_direction: OPTIONAL radial_direction;
END_ENTITY;
ENTITY along_vector
SUBTYPE OF(sink_edm_machining_strategy);
corner_vectors: LIST [0:?] OF direction;
END_ENTITY;
(* ********************************************************** *)
(* approach retract strategy *)
(* ********************************************************** *)
ENTITY approach_retract_strategy
ABSTRACT SUPERTYPE OF (ONEOF (plunge_strategy, air_strategy, along_path));
tool_orientation: OPTIONAL direction;
END_ENTITY;
ENTITY plunge_strategy
ABSTRACT SUPERTYPE OF (ONEOF (plunge_toolaxis, plunge_ramp, plunge_helix, plunge_zigzag))
SUBTYPE OF (approach_retract_strategy);
END_ENTITY;
ENTITY plunge_toolaxis
SUBTYPE OF (plunge_strategy);
END_ENTITY;
ENTITY plunge_ramp
SUBTYPE OF (plunge_strategy);
angle: plane_angle_measure;
END_ENTITY;
ENTITY plunge_helix
SUBTYPE OF (plunge_strategy);
radius: length_measure;
angle: plane_angle_measure;
END_ENTITY;
ENTITY plunge_zigzag
SUBTYPE OF (plunge_strategy);
angle: plane_angle_measure;
width: length_measure;
END_ENTITY;
ENTITY air_strategy
ABSTRACT SUPERTYPE OF (ONEOF (ap_retract_angle, ap_retract_tangent))
SUBTYPE OF (approach_retract_strategy);
```

```
END_ENTITY;
ENTITY ap_retract_angle
SUBTYPE OF (air_strategy);
angle: plane_angle_measure;
travel_length: length_measure;
END_ENTITY;
ENTITY ap_retract_tangent
SUBTYPE OF (air_strategy);
radius: length_measure;
END_ENTITY;
ENTITY along_path
SUBTYPE OF (approach_retract_strategy);
path: toolpath_list;
END_ENTITY;
END_SCHEMA; (*sink_edm_schema *)
```

Annex B
(informative)

EXPRESS-G

The figures in this annex show the graphical representations of different elements:

— Figure B.1 shows the sink-EDM tool definition;

— Figure B.2 shows the sink-EDM machine functions;

— Figure B.3 shows the sink-EDM machining operation;

— Figure B.4 shows the technology and strategy definitions;

— Figure B.5 shows the volumetric pocket and plunge strategy definitions;

— Figure B.6 shows the approach-retract and air strategies;

— Figure B.7 shows the machining strategy and plunge zigzag;

— Figure B.8 shows the plunge helix and retract tangent definitions;

— Figure B.9 shows the retract angle and plunge ramp;

— Figure B.10 shows the contour parallel and along path definitions;

— Figure B.11 shows the along vector and synchronized feed definitions.

These figures are purely informative: a detailed explanation of the entities in the figures is given in the corresponding text definitions in Clause 4.

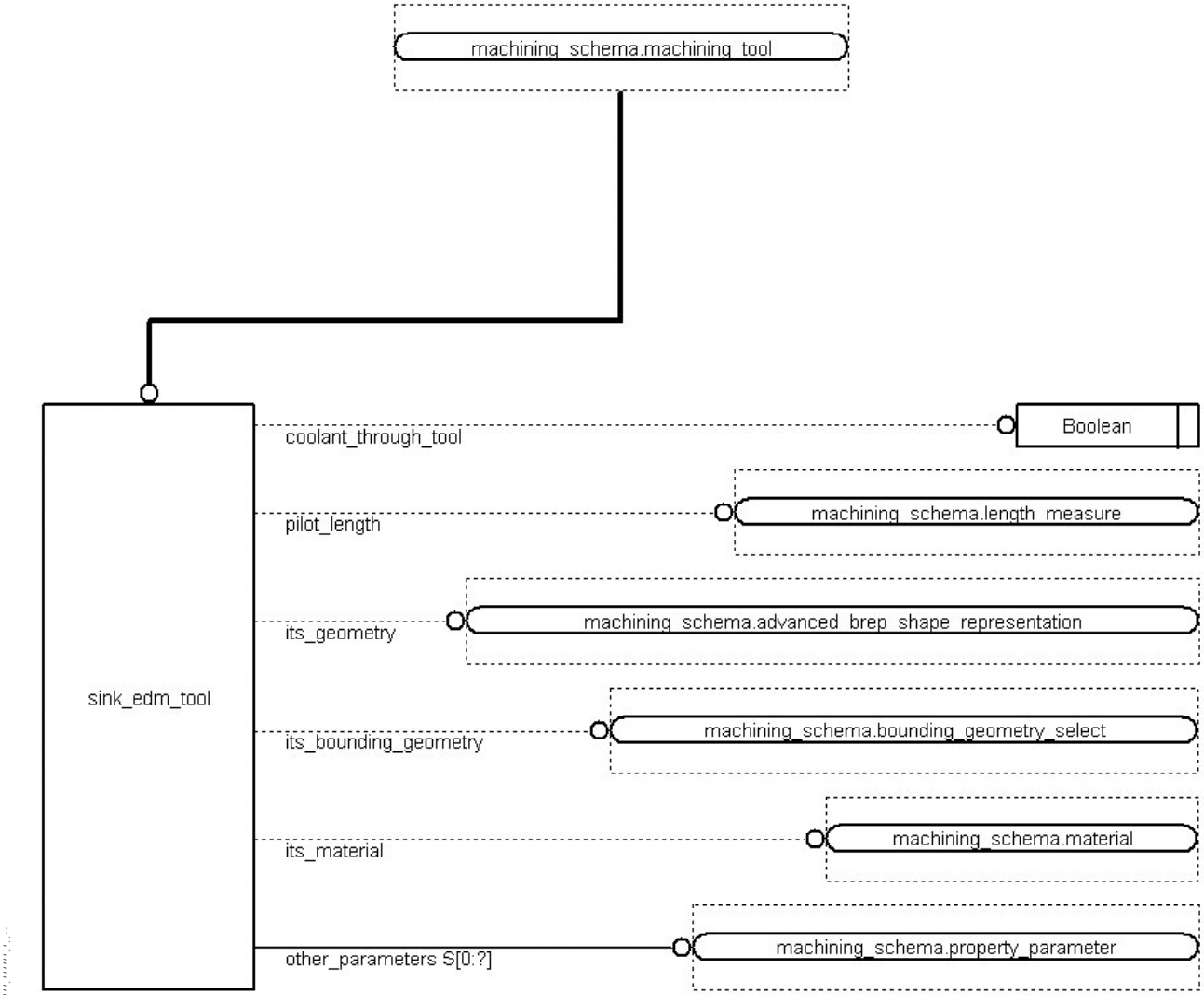


Figure B.1 — Express-G diagram 1

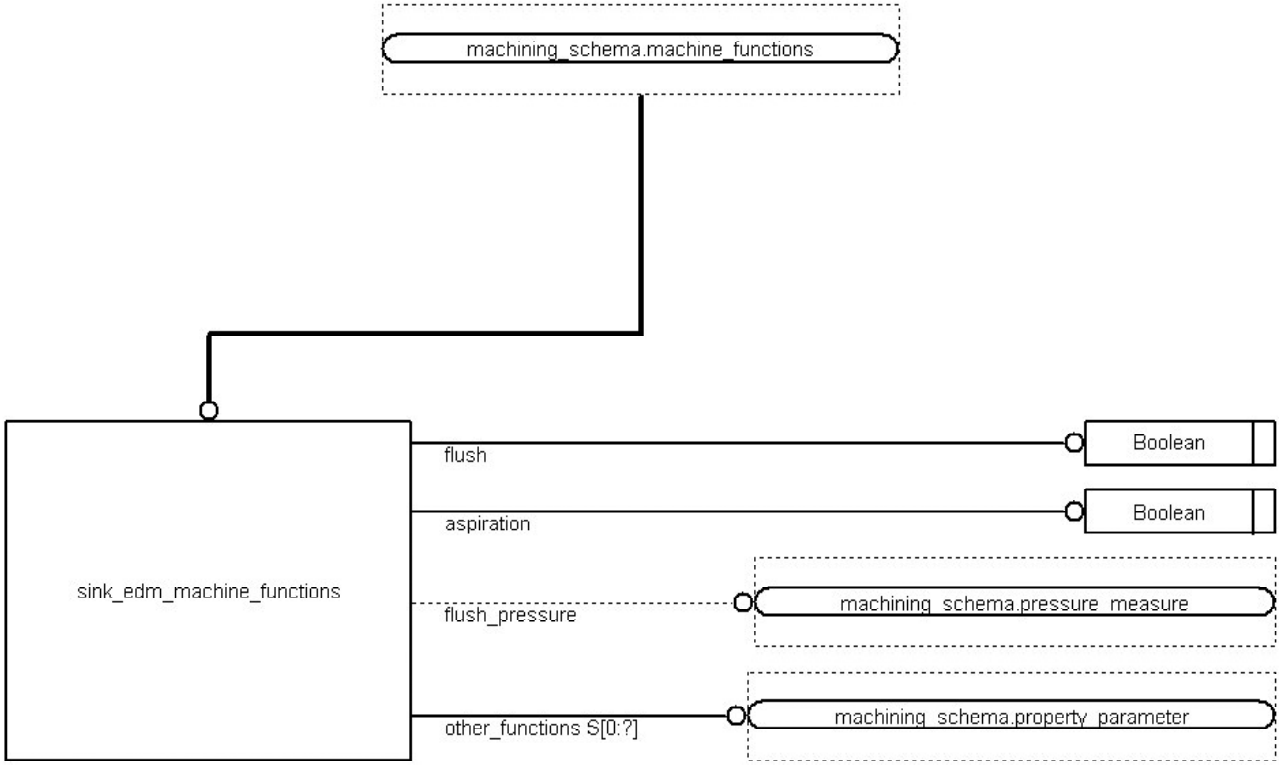


Figure B.2 — Express-G diagram 2

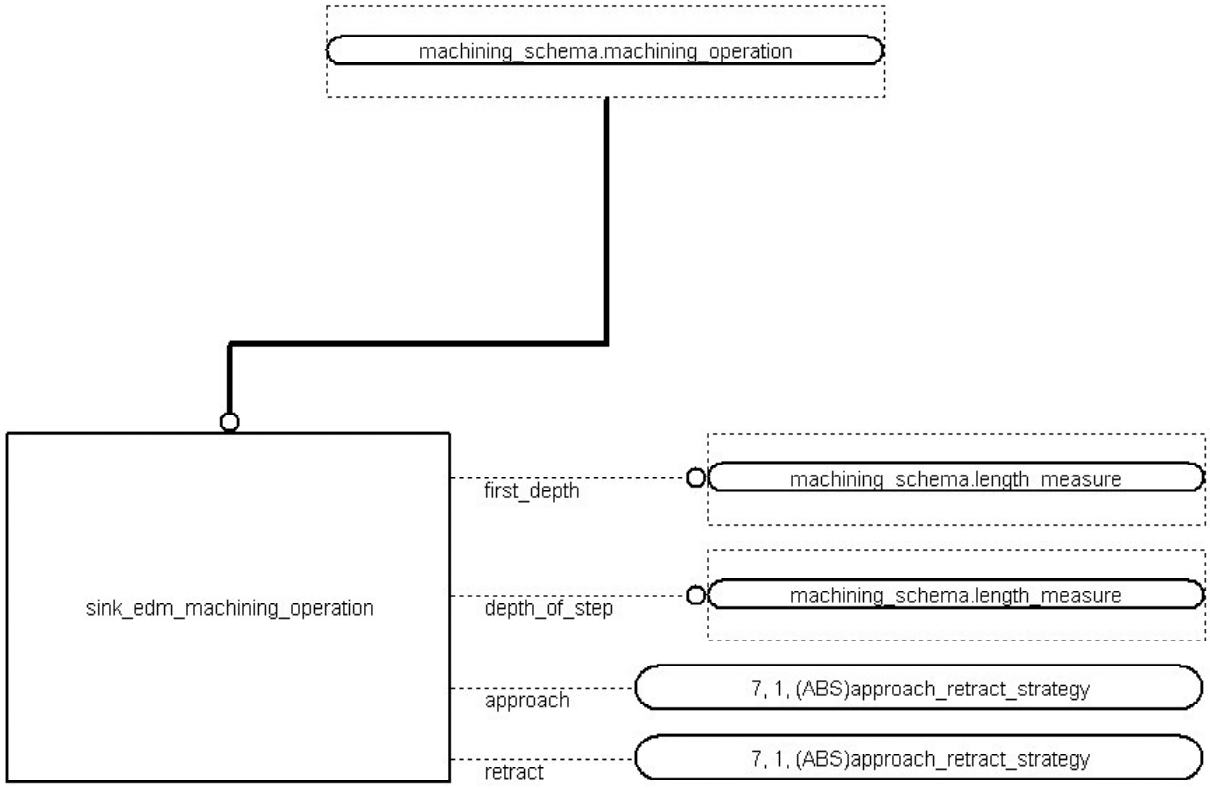


Figure B.3 — Express-G diagram 3

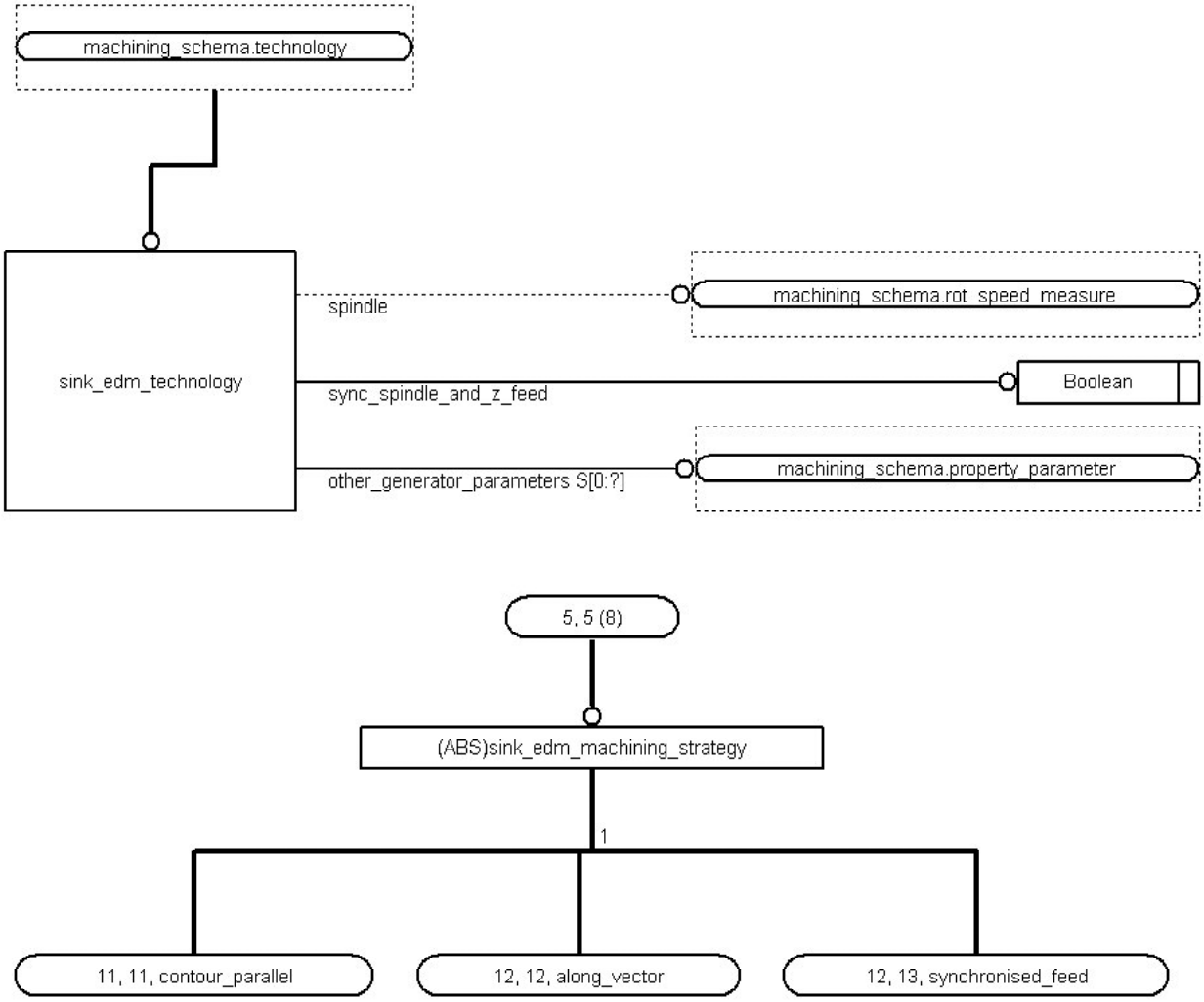


Figure B.4 — Express-G diagram 4

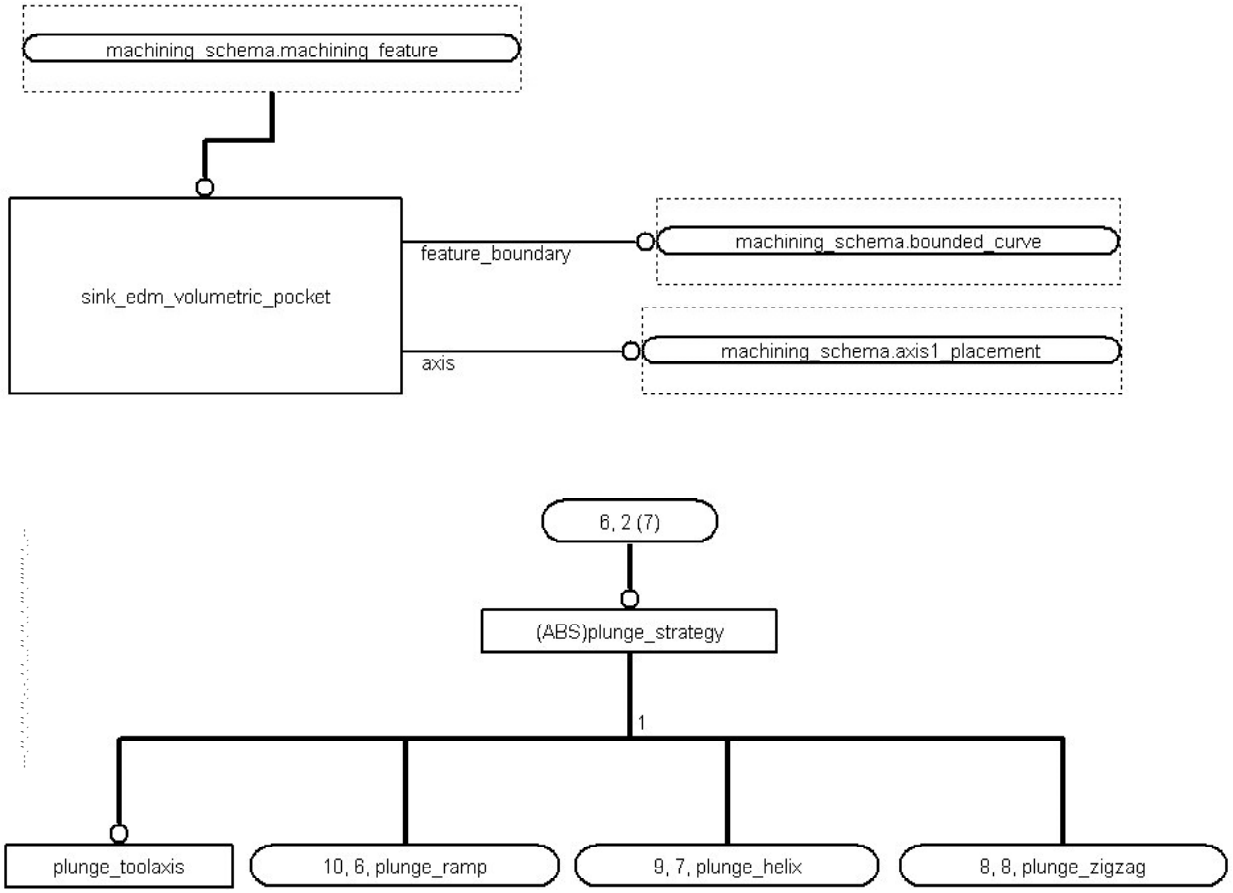


Figure B.5 — Express-G diagram 5

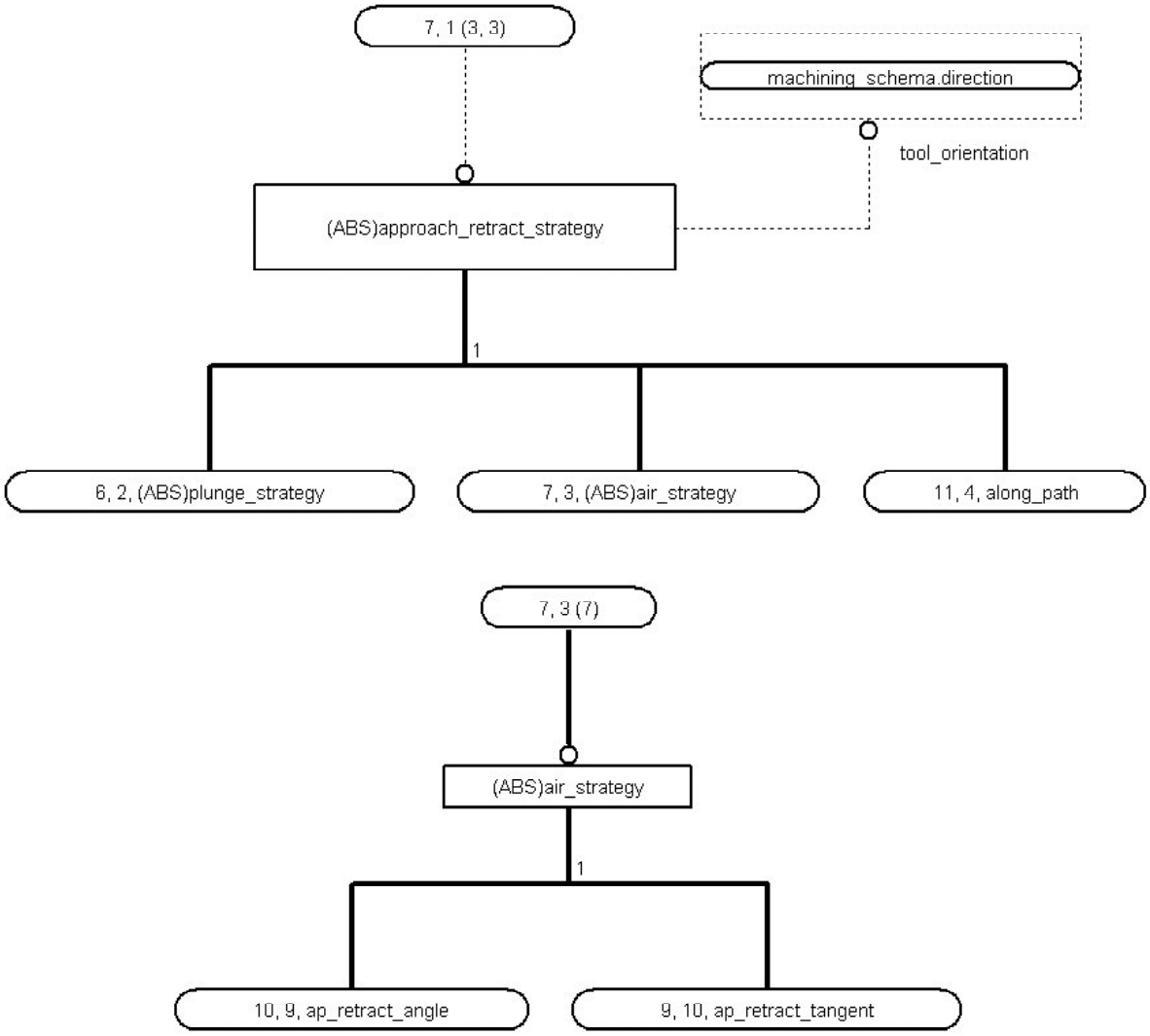


Figure B.6 — Express-G diagram 6

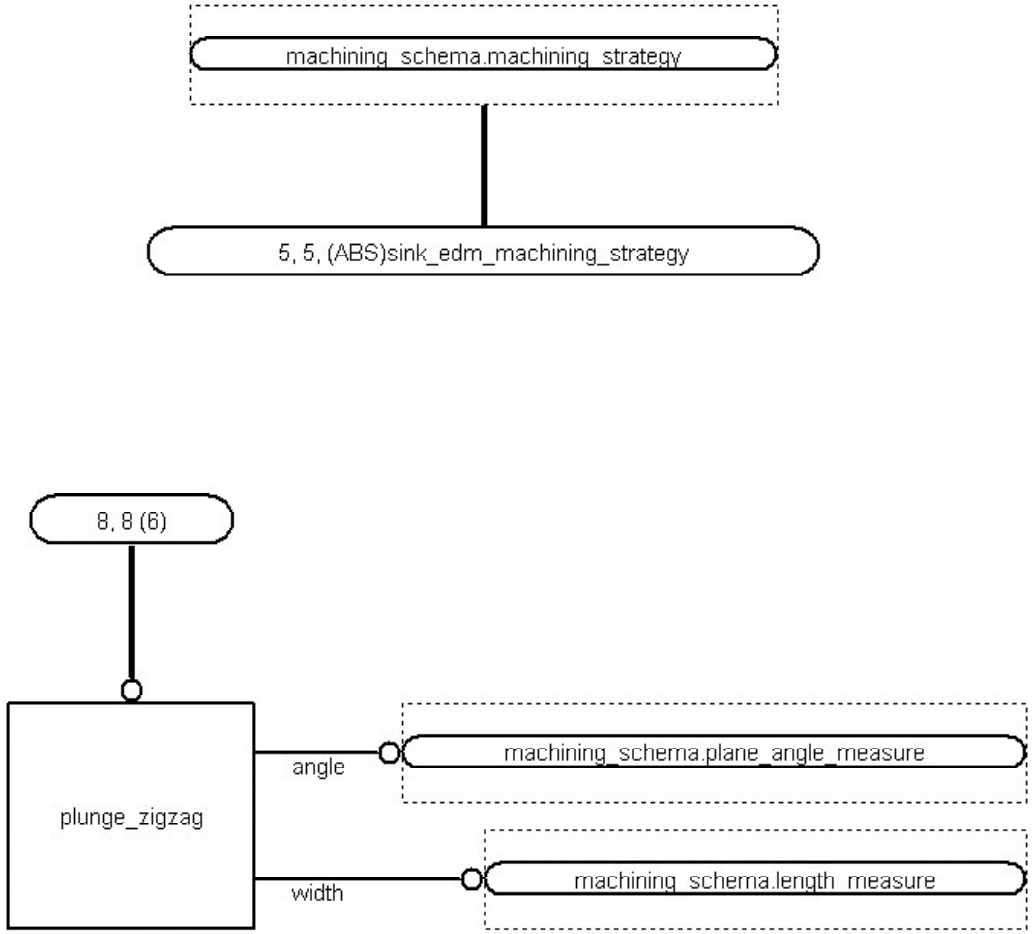


Figure B.7 — Express-G diagram 7

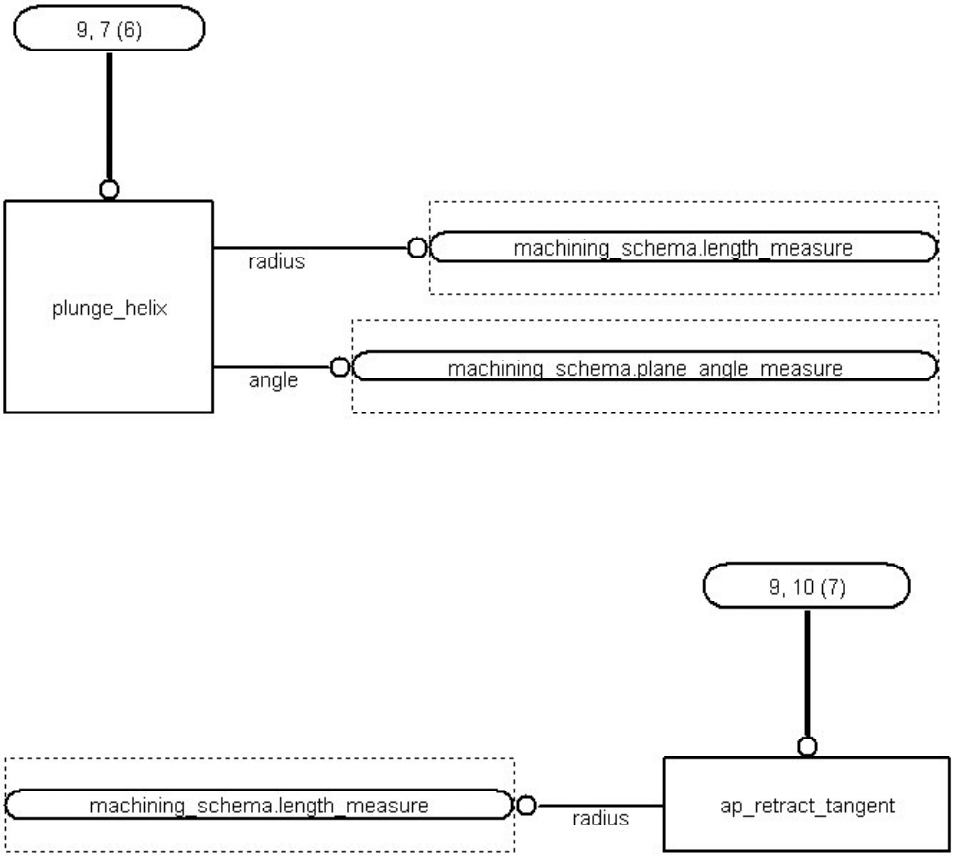


Figure B.8 — Express-G diagram 8

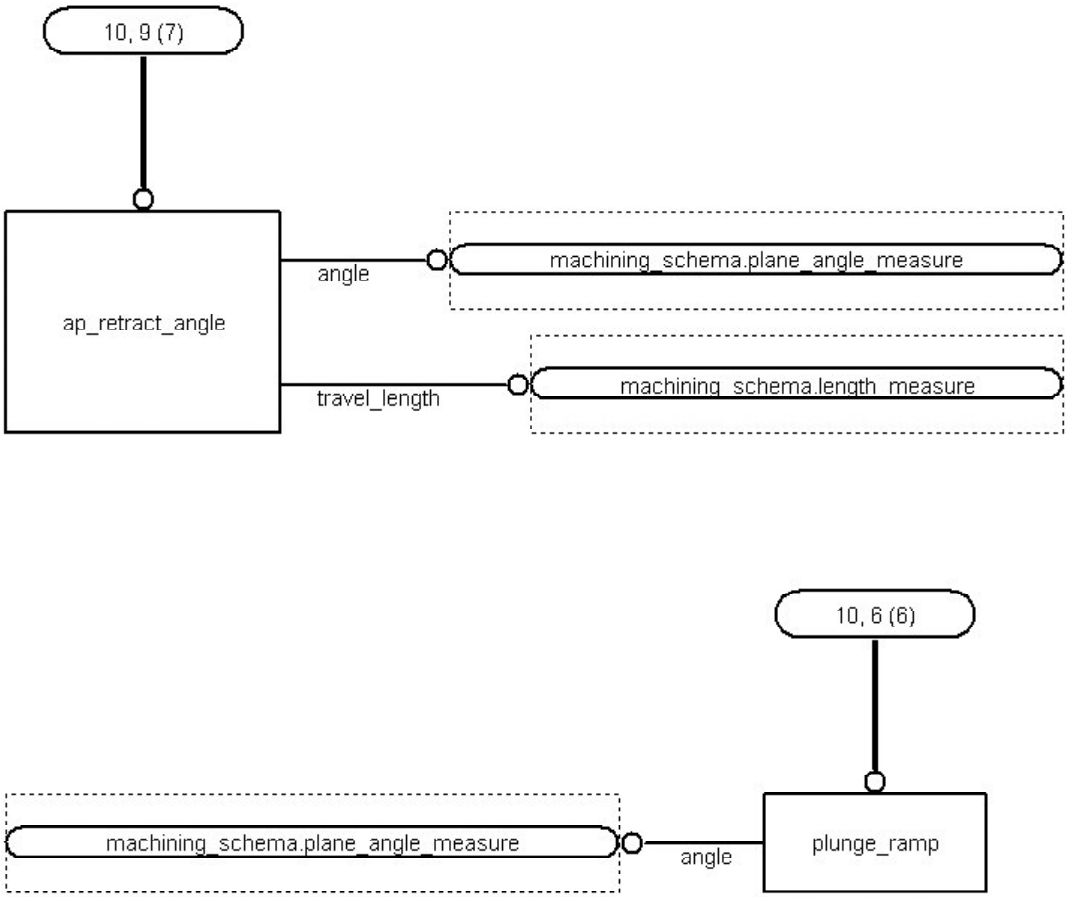


Figure B.9 — Express-G diagram 9

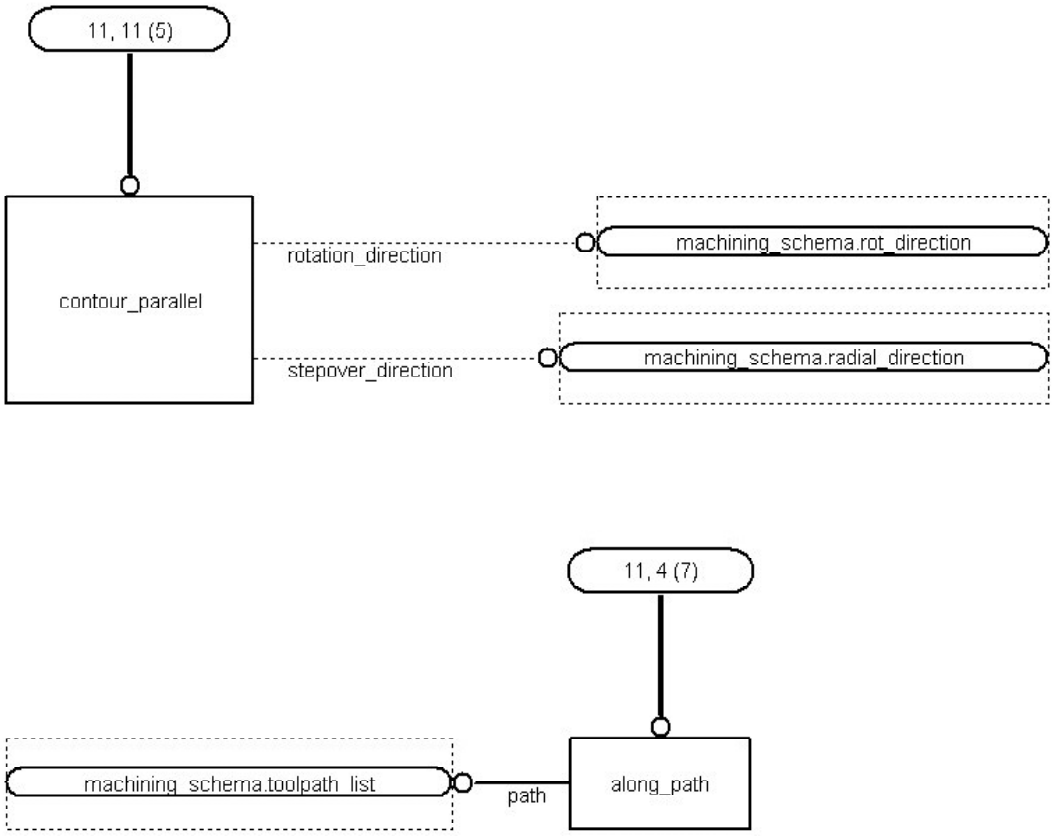
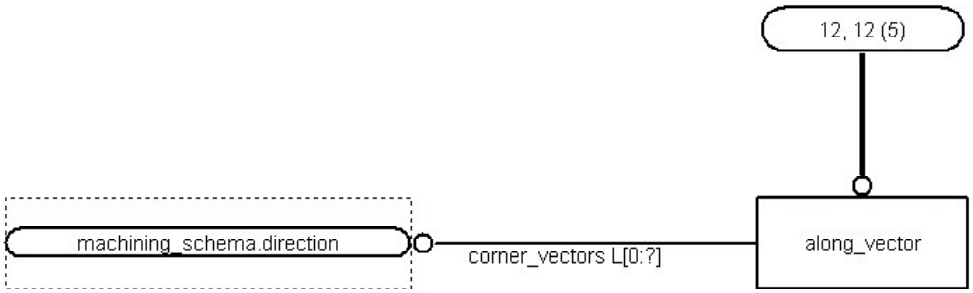


Figure B.10 — Express-G diagram 10



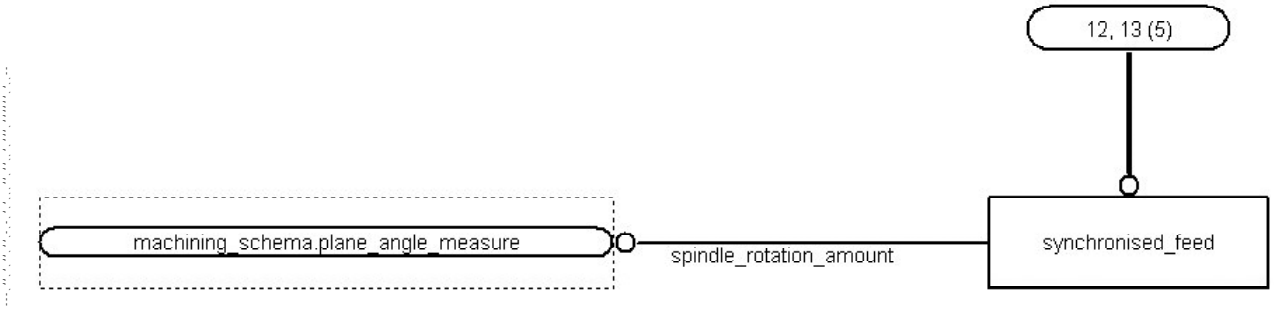


Figure B.11 — Express-G diagram 11

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