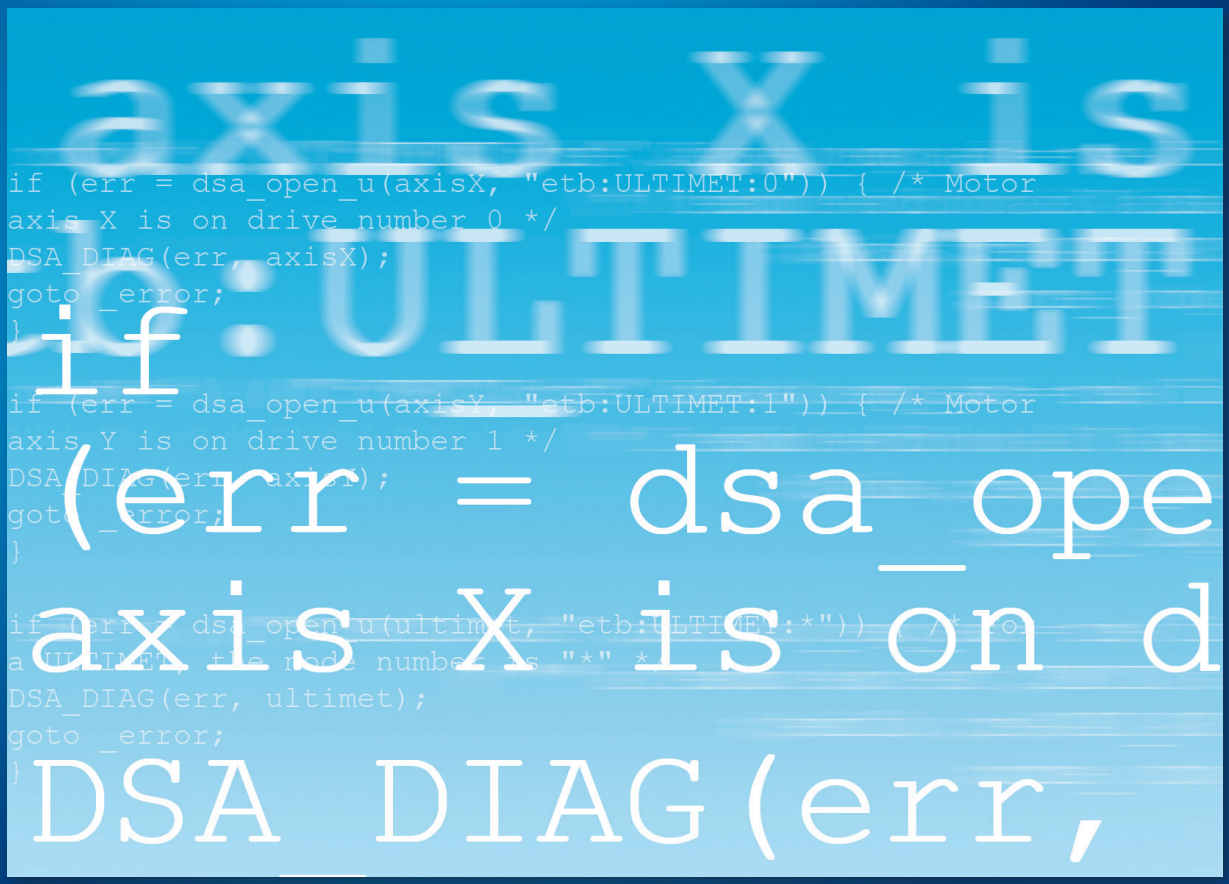


# EDI 4
# (ETEL Device Interface)

## User's Manual

Version M

ETEL

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# Table of contents

# Record of revisions:

| Document revisions | | |
|---|---|---|
| **Version** | **Date** | **Main modifications** |
| Ver A | 25.04.13 | First version |
| Ver B | 05.05.14 | Updated version:<br>- New EDI4 package (from EDI 4.10A) |
| Ver C | 17.12.14 | Updated version:<br>- New EDI4 package (from EDI 4.12A) |
| Ver D | 27.04.15 | Updated version:<br>- New EDI4 package (from EDI 4.13A) |
| Ver E | 30.06.16 | Updated version:<br>- New EDI4 package (from EDI 4.15A) |
| Ver F | 06.12.16 | Updated version:<br>- New EDI4 package (from EDI 4.16A) |
| Ver G | 25.10.17 | Updated version:<br>- New EDI4 package (from EDI 4.17A)<br>- New boolean type (refer to §3.7) |
| Ver H | 29.11.18 | Updated version:<br>- New EDI4 package (from EDI 4.20A) |
| Ver I | 29.05.19 | Updated version:<br>- New EDI4 package (from EDI 4.21A) |
| Ver J | 05.11.19 | Updated version:<br>- New EDI4 package (from EDI 4.22A) |
| Ver K | 18.09.20 | Updated version:<br>- New EDI4 package (from EDI 4.23A) |
| Ver L | 25.02.21 | Updated version:<br>- New EDI4 package (from EDI 4.24A) |
| Ver M | 24.09.21 | Updated version:<br>- New EDI4 package (from EDI 4.25A) |

# Documentation concerning the EDI4:

- **EDI4** **EDI4 principle & operation**
- **HTML Reference Manual** **File list & data structure in html.bat**

**Caution:** **As the HTML documentation is generated for each EDI4 release, it is the only up-to-date reference manual.**

**All functions present in the "HTML Reference Manual" mentioned under 'Internal use only' are available for the use but are neither documented nor officially supported by ETEL support.**

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Igor Pavlov

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Author: Adam Dunkels adam@sics.se

# 1 Introduction

## 1.1 Acronyms

| Abbreviation | Definition |
|---|---|
| API | Application Program Interface |
| DLL | Dynamic Link Library |
| EDI | ETEL Device Interface |
| ISO | International Organization for Standardization |
| URL | Uniform Resource Locator |
| CSM | Customer Software Module (ULTIMET ADVANCED embedded user application based on EDI) |
| ESM | ETEL Software Module (ULTIMET ADVANCED module integrated in firmware) |
| SHM | Shared memory (communication between Customer Software Module and ULTIMET ADVANCED firmware) |

**Remark:** The updates between two successive versions are highlighted with a modification stroke in the margin of the manual.

## 1.2 Glossary

The following terms are constantly used in this manual. It is essential to know these definitions before reading this manual.

**AccurET** ETEL position controller.

**AccurET-family** Devices belonging to the AccurET family and communicating through TransnET (AccurET and UltimET Light or ULTIMET ADVANCED).

**API** Application Programming Interface: a set of software functions to have access to a system.

**Device** Can be a position controller (i.e. AccurET), a motion controller (i.e. UltimET Light or ULTIMET ADVANCED).

**DLL** «Dynamic Link Library». A .dll file contains one or several functions compiled, linked, and stored separately from the processes using them. The operating system maps the DLLs into the address space of the process when this process starts up or as they are called, while it is running. The process then executes the functions in the DLL.

**Drive** Equivalent to an AccurET position controller.

**EDI4.xx** Set of libraries supporting AccurET-family products, **but not the DSC-family and DSB-families.**

**Increments** ETEL's devices use a large number of physical quantities (position, speed, acceleration, force, time, electric current,...). These quantities are represented by 32 or 64-bit integers or floats, with units specific to the devices (UPI, USI,...). These units are called 'increments', hence the representation by increments' term used to represent the physical quantities.

**IRQ** Interrupt Request.

**ISO units** International system of units used to express the physical quantities. The basic units are m(meter), s (second), kg (kilogram), A (Ampere) and K (Kelvin). There are also their derivatives: m/s, $m/s^2$, $m/s^3$, N (Newton) = kg * $m/s^2$, W (Watt) = N * m/s, V (Volt) = W/A,...

**Remark:** For EDI, the temperature is always given in °C (Celsius) and the angular positions in turns.

**ISR** Interrupt Service Routine.

| | |
|---|---|
| **Master** | Refers to an UltimET motion controller in the context of the TransnET communication bus. |
| **Motion controller** | ETEL device that is able to control several position controllers (e.g. UltimET Light or ULTIMET ADVANCED motion controllers). |
| **OS** | Operating System. |
| **Object** | Refers to the definition widely used in the object-oriented programming. In C language, an object is nothing more than a structure containing a series of information (a classical example of a C object is the FILE structure of the standard library). |
| **Position controller** | ETEL device capable of controlling the position of an axis or axes (e.g. AccurET position controllers). |
| **RTV** | Real-Time Value. |
| **Slave** | Refers to an AccurET position controller in the context of the TransnET communication bus. |
| **TransnET** | Very high speed proprietary communication bus used to exchange information between the AccurETs and between AccurETs and UltimET. |
| **UltimET** | Generic term referring to UltimET Light or ULTIMET ADVANCED motion controllers. |
| **UltimET Light** | Refers to UltimET Light PCI, PCIe or TCP-IP products motions controllers. |
| **ULTIMET ADVANCED** | Refers to ULTIMET ADVANCED motion controller. |

## 1.3 Presentation of this manual

### 1.3.1 Intended readers

It is assumed the user is familiar with software programming, in particular the C language. Software design and architecture aspects must be mastered by the developer intending to use this DLL interface. In particular integrating a DLL into a software project should not be an issue.

Also the user must be familiar with ETEL position controllers and their usage as described in the corresponding "Operation and Software Manual". If the application requires a motion controller, the developer must refer to the corresponding "User's Manual" to understand how to use it.

### 1.3.2 Contents

This document presents all the libraries of the EDI package with emphasis on the DSA library. This library is the only one that is necessary to program the controllers from a PC. The other libraries are mainly used by the DSA library itself.

The next chapter describes the general package including its structure, supported operating systems, communication buses and file description.

The chapters that follow are ordered in pretty much the same way as one would go about developing an application using ETEL controllers. They detail how to use the library by referring to an example that is the same throughout the different chapters.

Throughout the example, the basic and most common operations will be reviewed. The complete list of operations provided by the package can be found in the **"HTML Reference Manual"** organized by feature.

The appendices include:
- Table containing for each controller command the corresponding DSA function, when it exists;
- Similar table containing for each device register the corresponding access functions, when they exist;
- Description of the error output;
- Description of the examples provided, other than the one analyzed throughout this manual;
- Description of the changes required to upgrade an application from EDI3xx to EDI4.xx.

# 2 Package features

## 2.1 Presentation

The ETEL Device Interface (EDI) is a set of libraries which enable the communication with ETEL position and motion controllers to access their functionalities. ETEL began to develop EDI in 1997. Four major versions have been developed, but the table below only includes information about the two most recent ones (EDI3.xx and EDI4.xx).

| EDI version | First release | DSC family | AccurET family | Development environment | EDI documentation |
|---|---|---|---|---|---|
| EDI3.xx | 3.00A (17.03.2009) | ✓ | ✓ | Visual Studio 2005 | From EDI-user-c.pdf |
| EDI4.xx | 4.01A (03.06.2013) | | ✓ | Visual Studio 2010 until 4.16A<br>Visual Studio 2015 until 4.22A<br>Visual Studio 2019 from 4.23A | From EDI4-User-VerA.pdf |

**Remark:** Refer to §15.2 for more information about the changes between EDI3.xx and EDI4.xx.

These libraries constitute an API (Application Program Interface) allowing the user to:
- Manage the communication with the controllers through the many existing communication buses, e.g. PCI/PCIe, TCP/IP, USB and Shared Memory (SHM).
- Access all the functionalities of ETEL controllers through an homogeneous interface, whatever the product and firmware version.
- Manage the conversion of the products' internal units (increments) in order to enable the user to work with conventional units (ISO).

These libraries are totally developed in C and can be used from other common programming languages, such as C++, and C#. There is a DLL to be used from C/C++ applications and a class library for C# .NET framework version 4.8.

Most of the applications call the DSA high level library, which in turn calls the other libraries of the EDI package. This library is able to manage the latest position and motion controllers.

There is a `readme.doc` file that gives the installation and compilation guidelines for the supported Operating Systems, as well as the list of files that are used and where they can be found.

## 2.2 Supported Operating Systems

The EDI set of libraries includes support for the following operating systems:
- Windows 10 Enterprise and
- RTX64 4.0 (64-bit).

**Remark:** EDI may run on other Windows and RTX operating system versions. However, the qualification of the EDI libraries has been realized under the conditions listed in the qualification environment table presented below. ETEL cannot guarantee full technical support for issues occurring under different operating system conditions.
ETEL does not support operating systems that are no longer supported by their respective vendors.
The PCIe interface of the ULTIMET ADVANCED motion controller is not supported on the RTX operating system.

| EDI Qualification Environment | | |
|---|---|---|
| Windows and RTX 64-bit | Operating System | RTX 64 4.0 (2-core) / Windows 10 Entreprise LTSC 64-bit (2-core) |
| | Processor Type | Intel® Core™ i7-7700 CPU @ 3.60 GHz |
| | System memory (RAM) | 16 GB |
| | EDI development environment | Visual Studio 2019 |
| | Application type | 64-bit application |

Special RTX recommendation: from EDI-4.10A, it is advised to configure RTX to request its memory from local memory pool. Refer to §14 for RTX configuration.

## 2.3 DLL (Dynamic Link Library)

The EDI package for Windows is a set of dynamic link libraries commonly known as DLL.

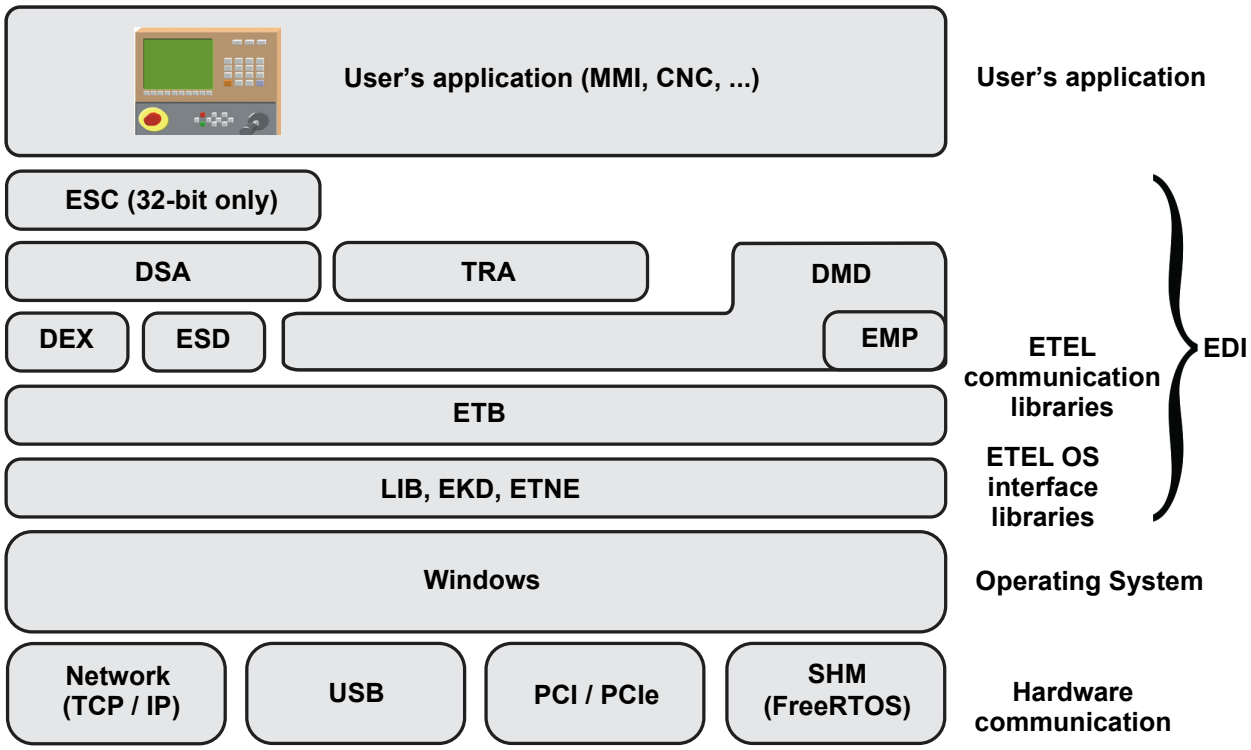
This kind of library is a standard for Windows and all programmers are used to deal with it. Actually, all the Windows' libraries are in this format and all the compilers available for Windows use this kind of libraries. So, DLLs are characterized by:

- Being a Windows standard;
- Their format is known to all compilers;
- They are dynamically linked, which allows them to be modified or updated without requiring recompilation of the applications using them.

To use the EDI package with Windows it is important to correctly understand the functioning of a DLL. Please refer to the manuals of your compiler to know in detail how the DLLs work and how the compiler is able to manage them. Be careful to understand where the DLLs have to be stored and where the application accesses them.

## 2.4 Package structure

The EDI package is in fact a collection of several libraries. However, the API for programming ETEL controllers is provided entirely by the DSA library. The other libraries are only used by the DSA top-level library and the developer does not need to access them directly.




For reference, here follows an explanation of the functionality provided by each one of these libraries:

| | |
|---|---|
| **ESC** | • Allows the compilation as well as the download and upload of a Sequence of the AccurET family. This library makes uses of a help library named assert40c.dll and is only available for 32-bit Operating Systems. |
| **DSA** | • Manages a single device, device group and interpolation device group objects;<br>• Generic functions for using all the functionality of the ETEL devices;<br>• Performs conversions between the device internal units (increments) and ISO units;<br>• Transparent to communication configuration;<br>• Manages devices on several communication buses at the same time;<br>• Specific functions to set and get the main device registers;<br>• Specific functions to execute most commands used by the devices;<br>• Asynchronous and synchronous functions. |
| **TRA** | • Manages the translation between the ETEL language (terminal commands) and the ETCOM records internally used by the controllers. |

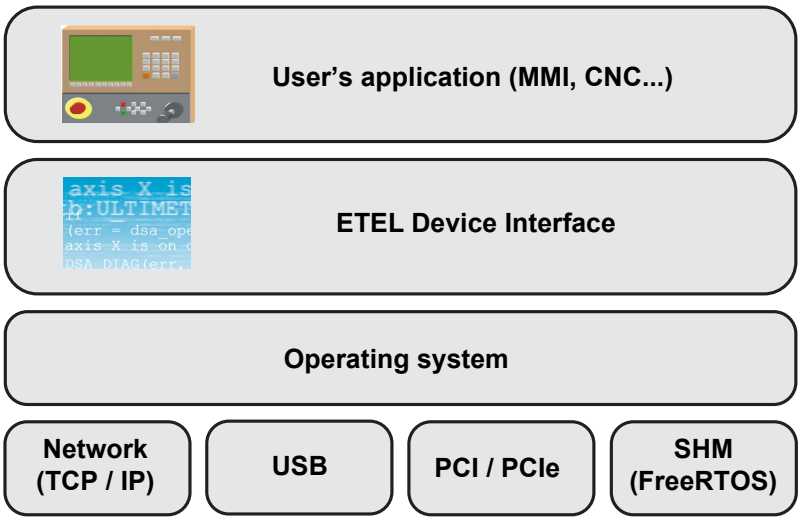
| | |
|---|---|
| **DMD** | • Manages meta-information objects;<br>• Stores min / max and default values for each register;<br>• Stores the list of spaces / indexes and subindexes available;<br>• Translates error codes / status / commands and aliases;<br>• Directly generated from the position controller database;<br>• Stores information for each device and firmware version. |
| **DEX** | • Allows exporting and importing Time-based (Scope), Frequency-based (Identification), Mapping and Scaling data to or from a file. |
| **ESD** | • Allows downloading a pre-compiled Sequence file. |
| **EMP** | • Parses XML metadata files. |
| **ETB** | • Manages the communication buses and logical ports;<br>• Handles the PCI/PCIe, USB and TCP/IP transparently;<br>• Handles the normal and boot communications;<br>• Handles the status update (refer to §7)<br>• Multiple logical port message queuing;<br>• Registering of event handlers (callback). |
| **LIB and EKD** | • Help libraries for hardware and operating system specific accesses. |
| **ETNE** | • Allows communication to the ETEL ETND deamon which is a process acting as a TCP/IP server. By running this process, it is possible for another network user to connect to ETEL controllers' local hardware. |

## 2.5 Main characteristics

The main characteristics of the software are:
- Implemented in ANSI C;
- Can be used from C, C++ and C# (refer to §2.1 for further details);
- Common source files for multiple platforms and Operating Systems;
- C++ wrapper classes included in header files;
- Thread-safe implementation;
- Object-oriented architecture.

## 2.6 Supported communication buses

### 2.6.1 Description




At the moment, the EDI package supports the following communication buses:

| Communication bus | ETEL product |
|---|---|
| PCI / PCIe | UltimET Light PCI, UltimET Light PCIe and ULTIMET ADVANCED PCIe |
| TCP/IP | AccurET, UltimET Light TCP/IP and ULTIMET ADVANCED TCP/IP |
| USB | AccurET |
| SHM | ULTIMET ADVANCED (Customer Software Module) |

UltimET Light PCIe is supported since EDI 4.11A. This board is MSI (Message Signal Interrupt) capable. To

use the MSI capability of this board, the UltimET PCI driver 11.1.0 or higher must be installed. If another driver is used, the MSI capability will not be enabled. Caution must be taken when installing the UltimET 11.1.0 driver.

ULTIMET ADVANCED PCIe is supported since EDI 4.22A. The same driver as the UltimET Light PCI/PCIe can be used, but it must be the driver delivered with the EDI 4.22 package or higher. Please refer to the UltimET PCI/PCIe Technical Note available in the documentation folder of the EDI and ComET packages or the corresponding "UltimET motion controller User's Manual".

**Remark:** The PCIe interface of the ULTIMET ADVANCED motion controller is not supported on the RTX operating system.

With the package comes an ETEL network process called «ETND», which is a daemon running on a remote machine. This distant machine is connected to the controller system via any of the other aforementioned buses. The application can connect to this remote «ETND» on a distant machine via a TCP/IP and have access to the remotely connected controllers.

**Restrictions:**
Only one process can be connected to a specific bus at the same time. The ETND/ETNE mechanism if the user wants to have several processes connected to the same hardware through the same bus. Please refer to the ETND-ETNE Technical Note for further information.

## 2.7 Versions numbering

All the ETEL software programs are identified with a version numbering as follow:

<digit 1>.<digit 2><digit 3><alphabetical character 1>

For example, a version number can be: 1.00A, 2.00D, 3.15B, etc. Each EDI package and library have their own version number. There is no direct link between the package and the individual libraries' version numbers. For the libraries, the first digit (<digit1>), representing the major version index of the version number, is present followed by a 0 in the file name of this library. To know the exact version of a library, open Windows Explorer and right click on the library file to select 'Properties'. To get the general EDI Package version, the DSA library provides the function `dsa_get_edi_version()`.

## 2.8 Files for Windows

For each library, there are several files necessary for the compilation and the execution of the code. To run EDI, the following files are used:

| | |
|---|---|
| dsa40.h | Header file necessary during the compilation |
| dsa40c.lib | Static library necessary during linking |
| dsa40c.dll, tra40c.dll, etb40c.dll, dmd40c.dll, emp40cd.dll, esd40c.dll, ekd40c.dll, (or ekd40_32c.dll if you are running a 32 bits application on Windows 64 bits OS), lib40c.dll, dex40c.dll | Dynamic link library necessary during execution |
| esc40c.dll, assert40c.dll | Dynamic link library necessary to compile an ETEL sequence (32-bit only) |
| etne40c.dll | Dynamic link library necessary to allow TCP/IP connection through ETND daemon |
| FTBUSUI.dll, FTD2XX.dll | Dynamic link library necessary to connect through USB |
| wdapi910.dll, wdapi1021.dll (or wdapi1021_32.dll if you are running a 32-bit application on Windows 64-bit OS) wdapi1110.dll (or wdapi1110_32.dll if you are running a 32-bit application on Windows 64-bit OS) | Dynamic link library necessary to connect to UltimET PCI/PCIe |

The debug versions, necessary during the development, are added to these files:

| | |
|---|---|
| dsa40cd.lib | Static library, debug version |
| dsa40cd.dll, tra40cd.dll, etb40cd.dll, dmd40cd.dll, emp40cd.dll, esd40cd.dll, ekd40cd.dll, (or ekd40_32c.dll if you are running a 32 bits application on Windows 64 bits OS), lib40cd.dll, dex40cd.dll | Dynamic link library, debug version |
| esc40cd.dll, assert40cd.dll | Dynamic link library necessary to compile an ETEL sequence (32-bit only) |
| etne40cd.dll | Dynamic link library necessary to allow TCP/IP connection through ETND daemon |

| | |
|---|---|
| wdapi910.dll, wdapi1021.dll (or wdapi1021_32.dll if you are running a 32-bit application on Windows 64 bits OS) wdapi1110.dll (or wdapi1110_32.dll if you are running a 32-bit application on Windows 64 bits OS) | Dynamic link library necessary to connect to UltimET PCI/PCIe |

The files contain the name of the library followed by a number which represents the first digit of the version number. One or several letters enable the differentiation of the implementation types.

The .lib files are simple interfaces between the application and the DLL. Their size is then relatively small because the code of the functions is stored in the DLL file. These files are given in the COFF format for Visual Studio 2019 C++.

For the libraries other than DSA, the files are more or less the same. These libraries are internally used by the DSA library or for special applications.

**Remark:** ETEL does not provide any support concerning the use of other libraries such as TRA, DMD, ETB, ESC, ETNE, EKD, LIB, ESD, EMP and DEX.

# 3 General guidelines for programming with the EDI package

## 3.1 Object oriented

The DSA library as all the other libraries of the EDI package, is totally implemented in C and follows the object-oriented philosophy. The work is done with objects represented by C structures. Hence, an object corresponds to each device, and all the functions concerning this device receive a pointer to this object (this structure) as parameter. The content of the structure is not visible to the user.

This is a similar approach to the functions of the standard C library which give access to files. Here also, an object (FILE structure) is created for each file the user wants to manage and all the functions doing an operation on a file receive as parameter the pointer to this object. It is the case of fprintf(), which receives as first parameter the pointer on the FILE structure.

To have access to a position controller, a pointer on the `DSA_DRIVE` object must be first created as follows:

```
DSA_DRIVE *drive1 = NULL;
```

It is important to assign this pointer to the NULL value. To avoid wrong manipulations of the pointer, the library refuses to create an object if the pointer is not NULL.

Once the pointer declared, the object must be created and the pointer affected. This is done as follows:

```
err = dsa_create_drive(&drive1);
```

As mentioned above, most of the DSA functions return an integer which represents the error code. To detect a possible error, the creation of a drive object can be done as follows:

```
DSA_DRIVE *drive1 = NULL;
int err;

err = dsa_create_drive(&drive1);
if (err != 0) {
  printf("cannot create drive object\n");
  exit(1);
}
```

The creation of an object, necessary for the communication with the UltimET, is done in a similar way:

```
DSA_MASTER *UltimET = NULL;
int err;

err = dsa_create_master(&UltimET);
if (err != 0) {
  printf("cannot create UltimET object\n");
  exit(1);
}
```

## 3.2 Groups

In the previous section, the first parameter of each DSA library function represents the device on which the user wants to do the operation. In practice, this parameter is a pointer to an object which includes all the information of the device in question.

However, the user often needs to send a command or do an operation on several controllers at the same time. This is also the case when the user wants to start synchronized movements. For that purpose, the DSA library has the possibility to create groups of devices. The user can then perform operations on these groups instead of performing them on an individual device.

The DSA library enables the definition of the following groups:

| Group | Type | Description | Product |
|---|---|---|---|
| Device group | DSA_DEVICE_GROUP | Group of several position or motion controllers of the same family. | AccurET, UltimET |
| Drive group | DSA_DRIVE_GROUP | Group of several position controllers of the same family. | AccurET |
| UltimET group | DSA_MASTER_GROUP | Group of several motion controllers of the same family. | UltimET |
| Interpolation group | DSA_IPOL_GROUP | Group of several controllers with its motion controller which generate interpolated movements with the controllers of the same family. | AccurET, UltimET |

To create a group, the process is similar to the one used to create a single device. A pointer to the object corresponding to the desired group must be first created:

```
DSA_DRIVE_GROUP *group1 = NULL;
```

Like for the drive and master objects, the pointer must be assigned to NULL before creating the group object. Then, the following function must be called:

```
err = dsa_create_drive_group(&group1, 2);
```

Compared to the creation of a drive, the creation of a group requires an extra parameter which is the number of devices that the user wants to assign to the group. It is in a way the size of the group which is equal to 2 in the above example.

Once the group created, the devices belonging to it must be assigned as follows:

```
err = dsa_add_group_item(group1, drive1);
err = dsa_add_group_item(group1, drive2);
```

To do so, both `drive1` and `drive2` objects must have been created before.
Instead of allocating a device, it is possible to assign another group. For example, the following group can be created:

```
dsa_create_drive_group(&group2, 2);
dsa_add_group_item(group2, drive3);
dsa_add_group_item(group2, group1);
```

In the above example, a group of position controllers (`DSA_DRIVE_GROUP`) has been created. Therefore, only `DSA_DRIVE, DSA_DRIVE_GROUP`, or the `DSA_IPOL_GROUP` objects can be assigned to it. If the user wants to include the UltimET in a group, the `DSA_DEVICE_GROUP` group type must be created.
A group of position controllers can include position controllers which are not on the same communication bus. On the other hand, in a `DSA_IPOL_GROUP`, the position controllers are only accessible via the same UltimET which means that they must be connected to the same TransnET (refer to the "UltimET Light or ULTIMET ADVANCED User's Manual" for more details about the interpolation group).
In most cases, a group can be used exactly like a device. It is then possible to use a group as the first parameter of the DSA functions as in the following example, where the «power on» command is sent to all position controllers of group 1:

```
err = dsa_power_on_s(group1, ...);
```

A `DSA_IPOL_GROUP` can also be used where a `DSA_DEVICE_GROUP` or `DSA_DRIVE_GROUP` can, as follows:

```
DSA_IPOL_GROUP *igroup = NULL;
dsa_create_ipol_group(&igroup, 2);
dsa_add_group_item(igroup, drive3);
dsa_add_group_item(igroup, group1);
err = dsa_power_on_s(igroup, ...); /*send power on to drive 1, 2, and 3*/
```

But, a `DSA_DEVICE_GROUP` cannot be used everywhere as a `DSA_IPOL_GROUP` can. The function starting the interpolation mode only accepts a `DSA_IPOL_GROUP` as parameter:

```
dsa_ipol_begin_s(igroup, ...); /*but not dsa_ipol_begin_s(group1,...)*/
```

Also, it is not possible to read a register on a group and so the following example is invalid:

```
err = dsa_get_register_s(group1,...);    /* WRONG */
```

See §3.3 for more details about the hierarchy of the different objects and which type of object is accepted by each DSA library function.

### 3.2.1 Gantry

ETEL provides several ways to define a GANTRY:

- **Gantry level 2:**

This is the most convenient way to use a gantry (refer to the "AccurET Operation & Software Manual"). In this mode, the gantry management is done by the AccurET itself. Of course, the 2 axes of the gantry must be the two axes of the same AccurET controller.
In this level, the user can define and open communication only on a single `DSA_DRIVE`, which must be the gantry master. Of course, it is possible to open the communication on the slave, if the user wants to monitor some registers of the slave.

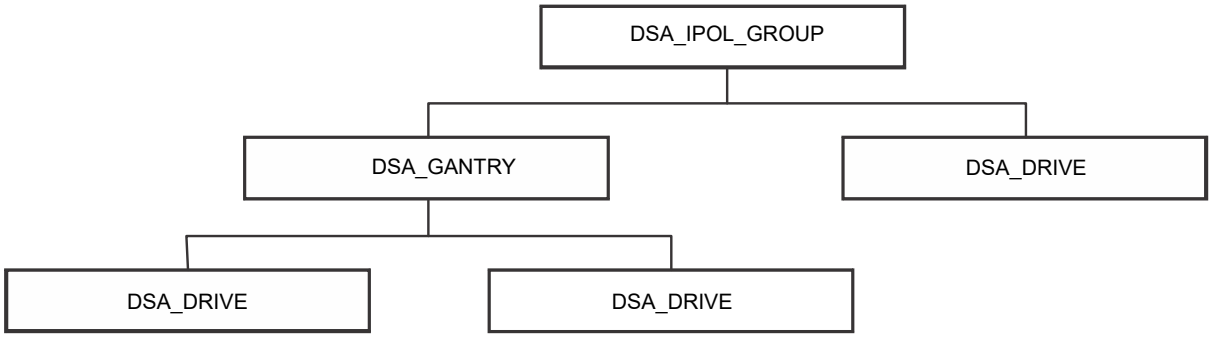
- **Gantry level 1:**

In this level, the user has to define and open the communication with the 2 axes of the gantry. Moreover, the user should define an EDI `DSA_GANTRY` object, which is, in fact, a group of these 2 axes. The commands should be sent using this `DSA_GANTRY` group, especially for the "Homing" command. In this gantry level, the homing procedure is handled by the UltimET. Inside EDI, the `dsa_start_homing_s/a` function will redirect the homing to UltimET if the device parameter is a `DSA_GANTRY`.

- **Group of group**

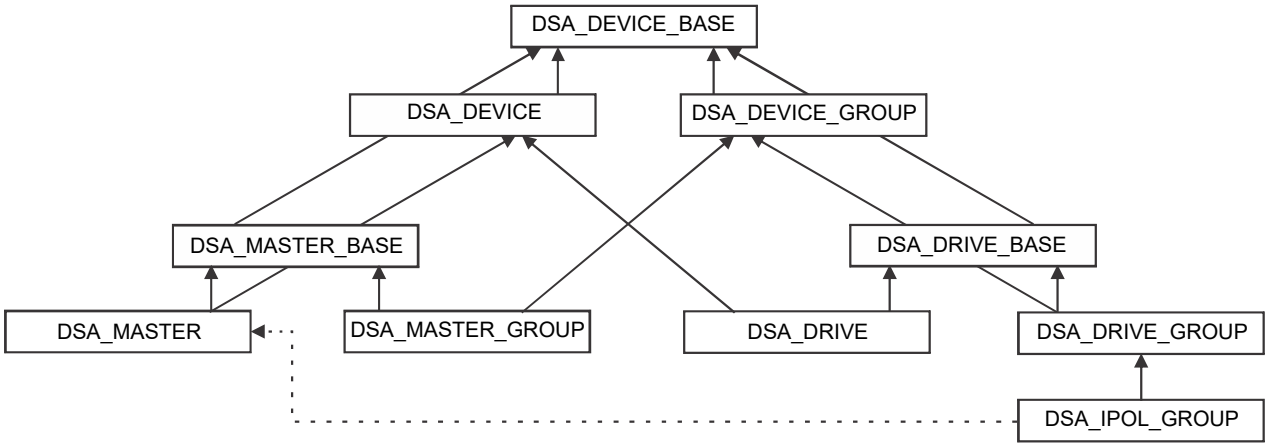
EDI can handle a group of groups as long as they are on the same bus. This is especially useful to make interpolation between a single axis and the 2 axes of a gantry in level 1. In this case, the user must define:

- 3 `DSA_DRIVE` (the single axis and the 2 axes of the gantry);
- 1 `DSA_GANTRY` (which is a group of 2 axes), filled with the 2 axes of the gantry;
- 1 `DSA_IPOL_GROUP` filled with the `DSA_GANTRY` object and the single axis.




The `DSA_IPOL_GROUP` can then be used on all EDI interpolation functions.

## 3.3 Inheritance




As seen previously, the DSA library functions have always, as first parameter, an object which represents a device or group of devices. Nevertheless, it is not possible to do all operations on any object.

For example, the power of a position controller can be switched on and off, but it is not possible to do it with an UltimET. The `dsa_power_on_s()` will hence accept the objects of `DSA_DRIVE` and `DSA_DRIVE_GROUP` type, but not the `DSA_MASTER` type.

Similarly, reading of a register can only be done on one device at the same time. The `dsa_get_register_...()` function will then accept the objects of the type `DSA_DRIVE` and `DSA_MASTER` but not the `DSA_DRIVE_GROUP` type.

The objects of the DSA library are organized in a hierarchy which defines the relations of heritage commonly used in oriented-object programming. This hierarchy is illustrated above.

On the above figure, the `DSA_DRIVE` object inherits the `DSA_DEVICE` object which means that the `DSA_DRIVE` «is» a `DSA_DEVICE` or in other words that the `DSA_DRIVE` can be used instead of a `DSA_DEVICE`. If a DSA function accepts a `DSA_DEVICE` as parameter, it will automatically accept a `DSA_DRIVE` too, which is the case for the `dsa_get_register_...()`.

From these relations of heritage and the prototype of the function, it is easy to know which objects are supported.

## 3.4 Functions

There are two types of functions provided in the EDI package: those that return when the execution of the feature it implements is finished (these are called synchronous functions) and those that return immediately without waiting for the task they have started to terminate (these are called asynchronous functions). Usually, for each function implementing a specific feature, the two type (synchronous and asynchronous) are available. They can be easily identified by the appending letters on their respective names:

- **_s** for synchronous functions
- **_a** for asynchronous functions

For example, to switch the power on, one can either use the `dsa_power_on_`**`s`**`(...)` or the `dsa_power_on_`**`a`**`(...)` function, depending on whether if it is intended that the execution flow in the application waits for the end of the «power on» or not, in order to do other things in the meantime.

The first parameter of each function is always the `DSA_DRIVE` or `DSA_MASTER` object which represents the device on which the operation will be executed.

### 3.4.1 Synchronous functions and timeouts

These functions are called by the user and their execution ends once the respective operation is finished.

For example, when the `dsa_get_register_..._s()` function is called, it asks the device for the value of a register and waits for the reply. Once the device has returned the value of the corresponding register, the function exits.

The synchronous functions put on hold the execution of the program until its operation is concluded. It stops the user from doing another things before the current one is finished. A way of bypassing this is to use multiple threads or resorting to asynchronous functions (see §3.4.2).

In the DSA library, the synchronous functions are identified by a '**_s**' affix on their name and by a 'timeout' parameter which is always the last one. The timeout is the maximum time allowed for the operation to finish. This time is always expressed in milliseconds. To use the synchronous version of the «power on» function, one would write:

```
if (err = dsa_power_on_s(drive, 10000)){
   DSA_EXT_DIAG(err, drive);
   goto _error;
}
```

The call of a function ends when the task is finished or when the timeout has been reached. In the above example, the function ends when the motor is switched on and the control part (regulation) is activated, or when the process takes 10 seconds (in this case, the function returns an error).

For operations where the execution time does not depend on the position controller configuration or on the application, the default timeout can be used by passing the `DSA_DEF_TIMEOUT` (which will be explained later on).

The 'timeout' parameter allows the limitation of the maximum time that the function uses to terminate its task. After this time, if the task has not yet finished, the function ends by returning the `DSA_ETIMEOUT` error.

If the user does not want a timeout, which means there is no time limit to for the synchronous function to execute, the INFINITE value can be assigned to the timeout parameter.

The functions such as `dsa_wait_movement_s()` need a time of execution which depends on the user's application. For functions like these, the use of the default timeout does not make sense.

**Remark:** As EDI is thread-safe, the user can design a multi-threaded application, each thread using EDI's synchronous functions. This can result in a kind of asynchronous application. However, there is a limit. For each synchronous function, EDI uses an internal synchronous event. The total number of synchronous events is limited to 50.

## 3.4.2 Asynchronous functions and callbacks

During the development of an application, we mainly use synchronous functions. Nevertheless, in a few cases the use of synchronous functions is not ideal or requires the use of multiple threads. For example, the user wants to monitor the status of a position controller and at the same time wait for the end of a movement. In this case, the use of asynchronous functions can be useful. As mentioned above, the synchronous functions naming end with '_s' and the last parameter is called 'timeout'. There is an equivalent asynchronous function for every synchronous function. Their name ends with an '**_a**' instead of '**_s**' and the last parameter is a pointer to a function and a generic pointer (`void *`) instead of a timeout. For example, here is how to power a motor using the asynchronous version of the implementing function:

```
DSA_CALLBACK do_something_on_poweron_end(DSA_DEVICE_BASE *dev, int err,
                                         void *param);
long[4] params;
...
if (err = dsa_power_on_a(drive,do_something_on_poweron_end,params)) {
   DSA_EXT_DIAG(err, drive);
   goto _error;
}
```

The asynchronous functions start an operation and exit without waiting for the end. Their execution is then really fast. After having started the operation, the user can execute other operations without having to use multiple threads.

When the user calls an asynchronous function, a handler must be provided as parameter which is a pointer to a function often called 'callback'. This function is called by a single thread within the library once the operation is finished.

For example, if the user calls the `dsa_get_register_..._a()` function, it exits before the value of the register is actually returned by the device. Once the value returned, the library calls the callback function, passing the returned register value as parameter.

Besides the handler, the user has the 'param' parameter that can be used at his discretion. This parameter is not interpreted by the library and is passed to the callback function when it is called.

Depending on the EDI function used, different callback types must be used. The different types are:

- `DSA_HANDLER: void callback(DSA_DEVICE_BASE *dev, int err, void *param)`

Must be used on DSA functions which do not return any values like:

```
dsa_power_on_a(DSA_DRIVE_BASE *grp, DSA_HANDLER handler, void *param)
```

- `DSA_INT_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, int val);`

Must be used on DSA functions which return a single int value like:

```
dsa_get_warning_code_a(DSA_DEVICE *dev, int kind, DSA_INT_HANDLER handler,
                       void *param);
```

- `DSA_LONG_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, long val);`

Must be used on DSA functions which return a single int value like:

```
dsa_get_register_int32_a(DSA_DEVICE *dev, int typ, unsigned idx, int sidx,
                         int kind, DSA_LONG_HANDLER handler, void *param);
```

- `DSA_EINT64_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, eint64 val);`

Must be used on DSA functions which return a integer 64 bits value like:

```
dsa_get_register_int64_a(DSA_DEVICE *dev, int typ, unsigned idx, int sidx,
                         int kind, DSA_INT64_HANDLER handler, void
                         *param);
```

- `DSA_DWORD_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, dword val);`

Must be used on DSA functions which return a dword value like:

```
dsa_get_profile_limit_mode_a(DSA_DRIVE *obj, int kind, DSA_DWORD_HANDLER
                             handler, void *param);
```

- `DSA_FLOAT_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, float val);`

Must be used on DSA functions which return a single float value like:

```
dsa_get_register_float32_a(DSA_DEVICE *dev, int typ, unsigned idx, int
                           sidx, int kind, DSA_FLOAT_HANDLER handler, void
                           *param);
```

- `DSA_DOUBLE_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, double val);`

Must be used on DSA functions which return a single double value like:

```
dsa_get_pl_proportional_gain_a(DSA_DRIVE *obj, int kind, DSA_DOUBLE_HANDLER
                               handler, void *param);
```

- `DSA_STATUS_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, const DSA_STATUS *status);`

Must be used on DSA functions which return a `DSA_STATUS` parameter like:

```
dsa_wait_status_equal_a(DSA_DEVICE *drv, DSA_STATUS *mask, DSA_STATUS *ref,
                        DSA_STATUS_HANDLER handler, void *param);
```

- `DSA_2INT_HANDLER: void callback(DSA_DEVICE *dev, int err, void *param, int val1, int val2);`

Must be used on DSA functions which return 2 integer 32 bits values like:

```
dsa_quick_register_int32_request_a(DSA_DEVICE *dev, int typ1, unsigned
                                   idx1, int sidx1, long *val1, int typ2,
```

```
                                    unsigned idx2, int sidx2, long *val2,
                                    dword *rx_time, DSA_2INT_HANDLER
                                    handler, void *param);
```

- `DSA_PROGRESS: void callback (const char *text, void *puser);`

Must be used on DSA functions which call progress callback like:

```
      dsa_system_configuration_backup (const char *zip_file_name, int nb_url,
                                       const char* urls[], dword flag, dword
                                       optional_block_type_mask, DSA_PROGRESS
                                       progress_fct, void *puser);
```

**Remark:** EDI callback functions are called by a single internal EDI thread. Therefore, the user callback functions should be as short as possible, avoiding to block the EDI callback mechanism.

Each pending callback uses an internal asynchronous event. The total number of asynchronous events is limited to 50. Therefore, the user should avoid having more than 50 pending asynchronous functions.

### 3.4.3 Generic functions

All actions that can be done on a device resume to the following three basic operations:
- Sending a command with zero, one or several parameters;
- Setting the value of a register;
- Reading the value of a register.

On top of these three basic operations, there is the status management which will be detailed in §7.

Most of the operations available for the user from the DSA library are special cases of one of these three basic operations. It means that through these three operations it is possible to have access to all the available functionalities in a device. It is for this reason that the DSA library has a set of functions - termed *generic* - for doing these three operations. In fact, there are more than three, not only because there are synchronous and asynchronous versions of each, but also because there are different functions depending on the number and type of the parameters of the commands and depending on whether the value of a given register is wanted in ISO or controller units. Refer to the **"HTML Reference Manual"** for the complete list.

However, the generic functions can be cumbersome to use as they require to know exactly the command's syntax and parameters or the registers that need to be set to implement an operation. Therefore, the EDI package provides functions that implement the specific operation without having to know which command to send or register to read/write. These are called specific functions (refer to next section) and they exist for every operation performed frequently on ETEL devices.

Generic functions remain useful to access the functionalities for which there is not (yet) a specific function available. For example, the DSA library does not have any function to reset the position controller (RSD). To do execute this action, the user has to use a generic function.

**Remark:** ETEL reserves the right to modify the command number and register number. Specific EDI functions will handle these changes and make them transparent for the user. However, when using generic functions, the user will have to adapt the code to these changes, making it more difficult to maintain. Therefore, ETEL does not recommend the use of generic functions unless strictly necessary.

### 3.4.4 Specific functions

Operations can be executed on the devices once an associated object has been created and the communication established. Specific functions implement the most often used operations.

**Remark:** The contents of EDI4.xx was revised and old functions to access controllers of the DSB/DSC families have been removed. Refer to §15.1 for a list of these functions.

For example, to switch on the position controller, the following function must be called:

```
err = dsa_power_on_s(drive1, 10000);
if (err != 0) {
```

```
    printf("problems during power on\n");
    exit(1);
}
```

The first parameter of each function is always the `DSA_DRIVE` or `DSA_MASTER` object which represents the device on which the operation will be executed. The last parameter is always the 'timeout', which represents the maximum time which allowed to complete the operation. This time is always expressed in milliseconds.

The function exits when the operation is finished or when the timeout has elapsed. In the above example, the function exist when the motor is switched on and the control part (regulation) is activated or when the process takes 10 seconds. In this case, the function returns an error.

For operations where the execution time does not depend on the position controller configuration or on the application, the default timeout can be used by giving the `DSA_DEF_TIMEOUT` (which will be explained later on).

Other functions may require more parameters. For example, it is the case for the function which starts a movement, which also requires as input the target point. Here is an example on how a movement can start with a target point at 0.32 meter from the origin point:

```
err = dsa_set_target_position_s(drive1, 0, 0.32, DSA_DEF_TIMEOUT);
if (err != 0) {
   printf("cannot start movement\n");
   exit(1);
}
```

In this example, the movements are specified relative to the software position limits set on the position controller (corresponding to parameters KL34 and KL35 on the AccurET family). So, it is necessary to read these position limits first. This is quite a common operation, so there are specific functions available for this:

```
err = dsa_get_min_soft_position_limit_s(axisX,&pos_min,
                                        DSA_GET_CURRENT,
                                        DSA_DEF_TIMEOUT);
err = dsa_get_max_soft_position_limit_s(axisX, &pos_max,
                                        DSA_GET_CURRENT,
                                        DSA_DEF_TIMEOUT);
```

A list of the available functions is provide in the appendix (see §15.1). If the user is used to program Sequences in the ETEL language or is familiar with the commands on the ETEL terminal, it is easy to find the correspondence between these commands and the functions of the DSA library.

Here are some examples of specific functions:

- `dsa_reset_error_ex_s(drive1, 123, DSA_DEF_TIMEOUT);`
- `dsa_power_on_s(drive1, 10000);`
- `dsa_homing_start_s(drive1, 10000);`
- `dsa_wait_movement_s(drive1, 60000);`
- `dsa_set_target_position(drive1, 0, 0.5, DSA_DEF_TIMEOUT);`

## 3.5 Error management

In general, each function of the EDI package returns an integer (int) which represents the error code. If the operation ends with success, the function returns 0, otherwise it returns the number of the error represented by a negative number.

The possible error code are defined by a series of #define stored in dsa40.h header file. For the DSA library the possible error codes are as follows:

| #define | Error code | Comment |
|---|---|---|
| DSA_E_TRAJ_CALCULATION_0 | -380 | Error Trajectory calculation 0 |
| DSA_E_TRAJ_CALCULATION_1 | -381 | Error Trajectory calculation 1 |
| DSA_E_TRAJ_CALCULATION_2 | -382 | Error Trajectory calculation 2 |
| DSA_E_TRAJ_CALCULATION_3 | -383 | Error Trajectory calculation 3 |
| DSA_E_TRAJ_CALCULATION_4 | -384 | Error Trajectory calculation 4 |
| DSA_E_TRAJ_CALCULATION_5 | -385 | Error Trajectory calculation 5 |
| DSA_E_TRAJ_CALCULATION_6 | -386 | Error Trajectory calculation 6 |
| DSA_E_TRAJ_CALCULATION_7 | -387 | Error Trajectory calculation 7 |
| DSA_E_TRAJ_CALCULATION_8 | -388 | Error Trajectory calculation 8 |
| DSA_E_TRAJ_CALCULATION_9 | -389 | Error Trajectory calculation 9 |
| DSA_EACQDEVINUSE | -337 | One of the device is already doing an acquisition |
| DSA_EACQNOTPOSSIBLE | -336 | Drives must be connected with TransnET |
| DSA_EAXESRECOVER | -309 | TransnET established but axes not recovered |
| DSA_EBADCOMPRESSTOOL | -303 | Unhandled compress tool |
| DSA_EBADDRIVER | -328 | Wrong version of the installed device driver |
| DSA_EBADDRVVER | -325 | A drive with a bad version has been detected |
| DSA_EBADIPOLGRP | -327 | The ipol group is not correctly defined |
| DSA_EBADLIBRARY | -333 | Function of external library not found |
| DSA_EBADPARAM | -322 | One of the parameter is not valid |
| DSA_EBADSEQVERSION | -338 | The sequence version is not correct |
| DSA_EBADSTATE | -324 | This operation is not allowed in this state |
| DSA_EBUSERROR | -313 | The underlaying etel-bus is not working fine |
| DSA_EBUSRESET | -314 | The underlaying etel-bus in performing a reset operation |
| DSA_ECANCEL | -319 | The transaction has been canceled |
| DSA_ECFGCOMPFILE | -339 | File has been compiled for a different axes configuration |
| DSA_ECONVERT | -317 | A parameter exceeded the permitted range |
| DSA_EDRVERROR | -311 | Drive in error |
| DSA_EDRVFAILED | -323 | The drive does not operate properly |
| DSA_EEQUATION | -340 | Equation cannot be resolved |
| DSA_EFLUSH | -341 | Flush communication timeout |
| DSA_EINTERNAL | -316 | Some internal error in the etel software |
| DSA_EMAPNOTACTIVATED | -335 | Mapping cannot be activated by the device |
| DSA_EMETAHEADER | -300 | Bad metadata header format |
| DSA_EMETAHEADERVER | -301 | Bad metadata header version |
| DSA_EMETAPARSER | -304 | Metadata parsing error |
| DSA_ENOACK | -312 | No acknowledge from the drive |
| DSA_ENODRIVE | -320 | The specified drive does not respond |
| DSA_ENOFREESLOT | -330 | No free slot available |
| DSA_ENOFWINPOOL | -305 | Firmware not found in FW pool |
| DSA_ENOLIBRARY | -332 | External library not found |
| DSA_ENOTIMPLEMENTED | -326 | The specified operation is not implemented |
| DSA_EOBSOLETE | -329 | Function is obsolete |
| DSA_EOPENPORT | -321 | The specified port cannot be open |
| DSA_ERTVREADSYNCRO | -331 | RTV read synchronization error |
| DSA_ERTVWRITESYNCRO | -307 | RTV write synchronization error |
| DSA_ESYNTAX | -334 | Mapping file syntax error |
| DSA_ESYSTEM | -315 | Some system resource return an error |
| DSA_ETIMEOUT | -310 | A timeout has occurred |
| DSA_ETRANS | -318 | A transaction error has occurred |
| DSA_ETRANSNET | -308 | TransnET is not established in imparted time |

| #define | Error code | Comment |
|---|---|---|
| DSA_EUNZIP | -302 | Unable to unzip metadata buffer |
| DSA_EUPLOADFILE | -306 | MD5 of uploaded file does not fit MD5 of original |
| DSA_EWFP | -342 | Communication not opened (device in WaitForProgram) |

It is the developer's responsibility to verify these error codes and react in consequence. Good programming practice recommend for each error code to be tested and reacted upon.
The DSA library offers a means of error diagnostic with its `DSA_EXT_DIAG()` macro:

```
int err;
...
if (err = dsa_power_on_s(...)) {
   DSA_EXT_DIAG(err, drv);
   goto _error;
}
```

The `DSA_EXT_DIAG` macro prints on the standard output an error message, the status of the device at the time of the error and the call stack trace (with line numbers) of the part of the execution performed by the EDI package up until the error occurred. This output can be used by the developer to identify the source of a problem. It also gives in depth detailed information on the context and the whereabouts of the source of error which is a very important help to ETEL when supporting a user development. Developers are therefore strongly encouraged to use this call to be able to benefit from an efficient support from ETEL.

**Remark:** ETEL's support team requires detailed diagnosis information for any issues that are reported.

A detailed description of the meaning of the information outputed by `DSA_EXT_DIAG()` is given in appendix §15.3. The output of `DSA_EXT_DIAG` is the standard output. If the user application does not redirect its standard output or if the standard output is not visible, it is advised to use `DSA_EXT_SDIAG` or even `DSA_EXT_FDIAG` to store the error message.

The user can also test the smooth operation of a DSA function in a more classical way, but less efficient:

```
int err;
...
err = dsa_power_on_s(...);
if (err == 0)
   printf ("power on done.\n");
else if (err == DSA_ETIMEOUT)
   printf("timeout error.\n");
else
   printf("error %d during power on.\n", err);
...
```

The DSA library also offers a function which enables the conversion of an error code into a text error message in the form of a string of characters. Here is the prototype:

```
const char *dsa_translate_error(int code);
```

Here is an example of a way to process the return code using this function:

```
int err;
...
err = dsa_power_on_s(...);
if (err) {
   printf("ERROR %d : %s\n", err, dsa_translate_error(err));
   exit(err);
}
printf("power on done.\n");
...
```

## 3.6 Memory management

A safe application should be able to run for several days, weeks and even months. One of the well known issues is called memory fragmentation. This problem occurs when dynamic memory is continuously allocated and deallocated. To avoid this problem, it is advised to divide the application in 3 phases:

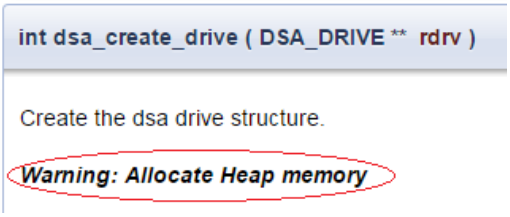
### 3.6.1 Initialization phase

The initialization phase is done only once at the startup of the application:
- Handle the system configuration (download firmware, sequences, registers…).
- Create the required objects (`dsa_create_drive`, `dsa_create_master`, `dsa_create_acquisition` …).
- Open the communication (`dsa_open_u`…).

=> Dynamic allocation allowed.

### 3.6.2 Processing phase

The processing phase is generally a loop executing the real job of the application (can run for several months!).
- Check in HTML documentation that none of the used functions allocates memory.




=> Dynamic allocation forbidden.

### 3.6.3 End phase

The end phase is done once just before the application exits:
- Close the communication (`dsa_close`).
- Destroy the objects (`dsa_destroy`, `dsa_destroy_acquisition`...).

=> Free dynamically allocated resources.

This way, dynamic memory allocation is controlled and no fragmentation occurs. Keep also in mind that dynamic memory allocation can be hidden, especially when using a high level language like C#.

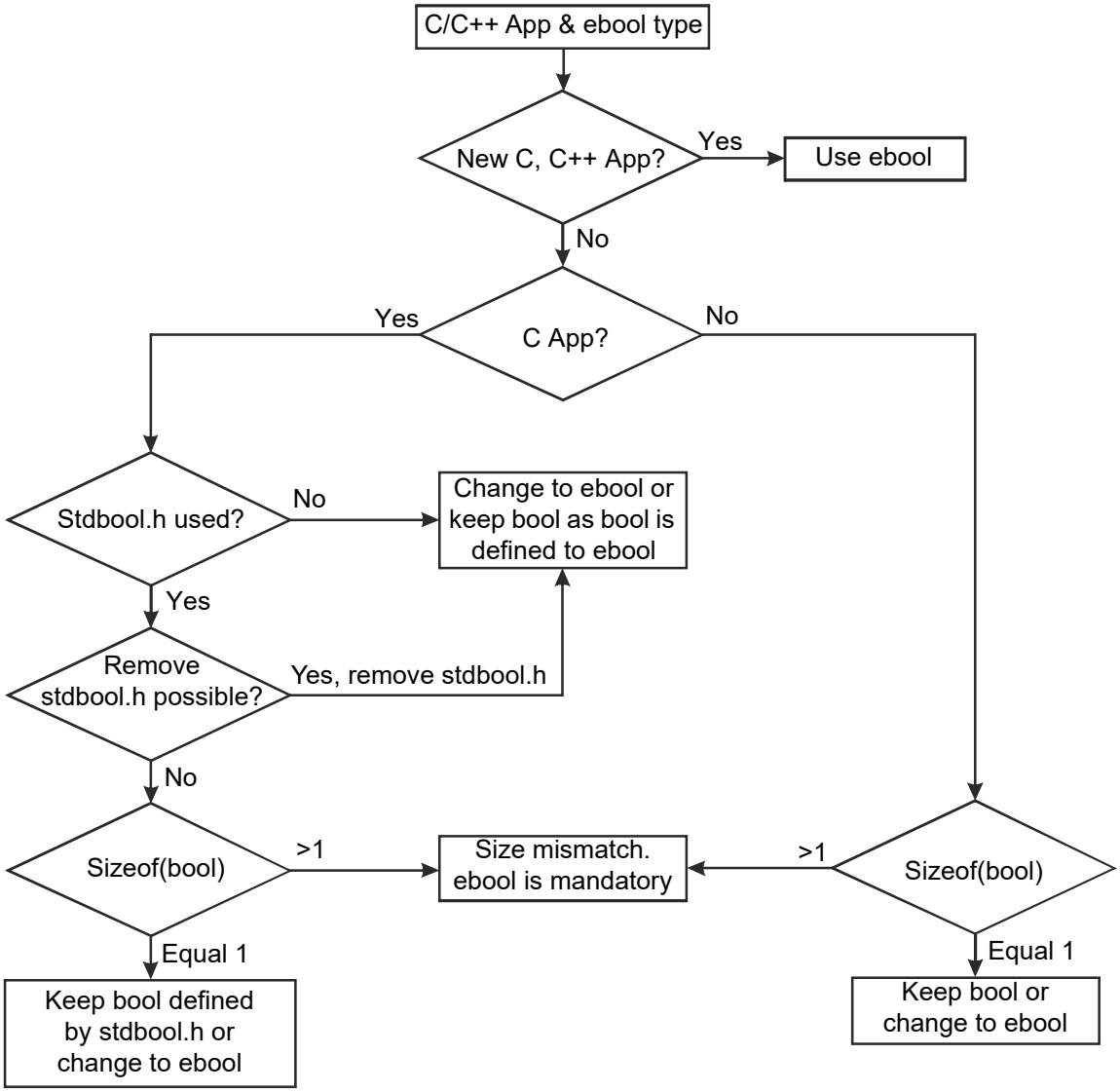
## 3.7 Boolean type: ebool

Since the release of EDI 4.17A, a new Boolean type is defined named ebool. This type corresponds to an unsigned char with a size of 1 byte.

In the standard for C++ programming language, the boolean type is defined but the sizeof(bool) could be equal or bigger (≥) to 1 byte depending on the C++ compiler that is used. For C language, the boolean type is present from C99 version and is defined through "stdbool.h". As for C++ language, the sizeof(bool) could be equal or bigger (≥) to 1 byte.

Therefore, it is recommended for EDI C/C++ user applications to use the ebool type for any variables of boolean type to avoid any risks linked to size mismatch between C/C++ compilers.

For the C# language, the sizeof(bool) is equal to 1 byte, so there is no risk of size mismatch.



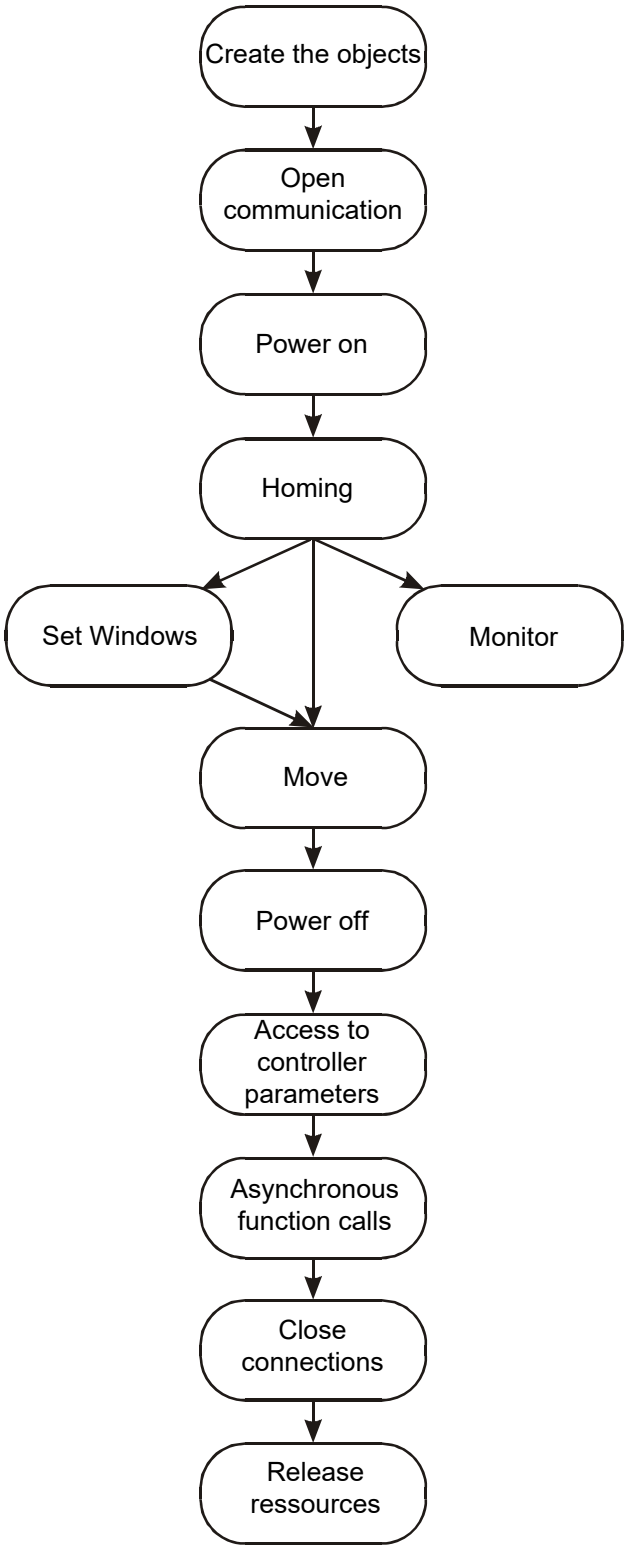
# 4 Application startup

## 4.1 Presentation of the general example

The example is given in C as it is a common general basis for programmers and other languages as well.

This example aims at using the library to control two axes concurrently via an UltimET.

EDI Application Example Synopsis




The system commissioning aspects are **outside** the scope of this example, mainly because they are beyond the scope of the DLL itself. Hence the example does **not** cover:

- Downloading firmware onto the UltimET and the position controllers (although there is an example showing how to do it);
- Setting of the position controllers;
- Commissioning can be done through ComET software.

A first set of actions aims at getting the position controllers in an operational state which entails:

- Establishing the communication with the UltimET and the position controllers connected to it (§4.5);
- Powering up the position controllers (§4.6);
- Performing the homing procedure on each position controller (§4.7).

The next set deals with making movements on each axis by first describing how to set precision windows (§5.2), and then actually specifying and starting the movement (§5.3 and §5.4). The movements will be controlled by the UltimET which will execute them in interpolated mode.

In a more elaborate step, one thread will be created to monitor the current position (§6) of the motors. The monitoring thread will show the current position of each motor every 100ms. Another thread will loop indefinitely waiting for a user input: the space bar will immediately stop the movement and set one of the controller's digital outputs.

Additional features will be described in:
- §11 for 'Access to controller parameters';
- §12 for 'Asynchronous function calls';

Finally, it will be shown how to power off the position controllers (§4.6).

## 4.2 Prerequisites

The first step in using an ETEL controller is to tune its position and other regulation algorithms. This is done prior to programming any functional behavior via ETEL's commissioning tool ComET and is outside the scope of this documentation. It is considered henceforth that these operations have been carried out successfully. They are a necessary prerequisite to start testing a software application developed with the EDI package.

## 4.3 Application initialization steps

From a purely programming point of view, there are a couple of header files to be included at the beginning of source code of this example:

- some standard libraries:

```
#include <stdio.h>          /* standard I/O library*/
#include <stdlib.h>         /* standard general purpose library*/
#include <ctype.h>          /* standard character conversion library*/
#include <math.h>
```

- the platform specific header for the thread management library:

```
#include <process.h>        /* standard multithreading library*/
```

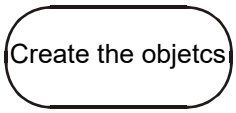
- the EDI top level library header (version 4.x):

```
#include <dsa40.h>
#include <dmd40.h>
```

Also, most functions of the library return an error code or 0 if no error occurred. A variable is needed to store the last error. The error codes are negative values, ranging from -399 to -300 for the dsa40 library:

```
int err = 1;                /* initialized to a value that is NOT */
                            /* returned by the library functions  */
```

## 4.4 Creating the objects




As an illustration of the creation of objects and for the needs of the example, the objects representing the controllers and the UltimET must be created.

A pointer to a `DSA_DRIVE` object for each position controller must be defined. This hidden object is defined in the dsa40 library. It is not required to access the members of this object directly, but this object has to be passed to various dsa library functions. The pointer must be initialized to NULL before calling the «create drive» function, otherwise this function will fail.

```
DSA_DRIVE *axisX = NULL;
DSA_DRIVE *axisY = NULL;
```

The same goes for the object representing the UltimET:

```
DSA_MASTER *UltimET = NULL;
```

Once the pointers have been declared, the actual objects themselves have to be created and initialized:

```
/* Create the drive and UltimET objects. */
if (err = dsa_create_drive(&axisX)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
if (err = dsa_create_drive(&axisY)) {
   DSA_EXT_DIAG(err, axisY);
```

```
    goto _error;
  }
  if (err = dsa_create_master(&UltimET)) {
    DSA_EXT_DIAG(err, UltimET);
    goto _error;
  }
```

When the UltimET manages interpolated movements, the commands must be sent to what is called an interpolation group. This interpolation group can be used like a normal device group. All position controllers within this group can also be interpolated. For this, a pointer to a `DSA_IPOL_GROUP` (like a `DSA_DRIVE_GROUP`) object mus be defined. This object can be considered as an array containing `DSA_DRIVE` objects. The client can set, change and retrieve the different devices belonging to this object through some access functions.

Like the `DSA_DRIVE`, thus group pointer must be initialized to NULL before calling the created group function, otherwise this function will fail.

```
DSA_IPOL_GROUP *igrp = NULL;
```

To create the interpolation group object the size for the group must be provided and cannot be changed afterwards.

```
if (err = dsa_create_ipol_group(&igrp, 2)) {
  DSA_EXT_DIAG(err, igrp);
  goto _error;
}
```

In this example, two position controllers are assigned to this group by calling the function `dsa_add_group_item()` that requires two arguments: the group and the position controller to assign.

```
if (err = dsa_add_group_item(igrp, axisX)) {
  DSA_EXT_DIAG(err, axisX);
  goto _error;
}
if (err = dsa_add_group_item(igrp, axisY)) {
  DSA_EXT_DIAG(err, axisY);
  goto _error;
}
```

Associate the UltimET to the interpolation group. When an interpolated movement on a group of axes is required, the dsa40 library will use the UltimET associated with the group.

```
if (err = dsa_set_master(igrp, UltimET)) {
  DSA_EXT_DIAG(err, igrp);
  goto _error;
}
```

The next step consists of opening the communication channels.

## 4.5 Establishing the communication


Once the device objects have been created, a physical device must be associated with it. The communication bus used to communicate with the position controller, as well as the physical address of the position controller (axis number) must be indicated. This is usually done by the `dsa_open_u` function, which takes the URL of the position controller as the parameter. The URL identifies the protocol used, the communication bus type and characteristics and the corresponding physical axis used. The only protocol recognized by ETEL's EDI package is the proprietary ETB (ETEL Bus) protocol. Hence all URLs used for referencing ETEL devices take the following form:

"**etb**:<bus type>:<axis>"

As a simple example, if we want the position controller `axisX` object to correspond to the axis 12 which is connected to the USB port of the PC, the communication would be established using the following call:

```
err = dsa_open_u(axisX, "etb:usb:12");
```

This function will first open the communication bus on the condition that it is not already opened and then will store the axis number in the `axisX` object. The second parameter is the character string representing the URL.

The general syntax for ETEL URLs is described hereunder:

URL = "**etb** : <communication bus> : <axis number>"

<axis number> is either

an integer, ranging from 0 to 62 for the AccurET family (the axis number is set via the controller's dip switches or using the AXI command; refer to the corresponding "AccurET Operation & Software Manual" for further information);

or «*» to designate the UltimET.

<communication bus> is a string describing the bus used and depends on the type of bus.
The following table describes the syntax of <communication bus>.

| Bus type | Syntax | Description |
|---|---|---|
| UltimET Light TCP/IP<br>ULTIMET ADVANCED TCP/IP<br>ETND | ETN://<ip-address> :<port>[,<flags>] | Remote access via TCP/IP to :<br>- UltimET Light TCP/IP<br>- ULTIMET ADVANCED TCP/IP<br>- ETND deamon<br><ip-address> : the IP address of the device or the host running ETND (localhost or 127.0.0.1 can be used)<br><port>: The IP port to use :<br>- UltimET Light : 1129,1128,1127<br>- ULTIMET ADVANCED : 1129 (2 connection available)<br>- ETND : depends on the port.properties file present in the directory where ETND is launched. Use the port xxx specified in line port.n.accept.0.driver=ETN:xxx<br>UltimET Light TCP/IP available flags (optional):<br>- T=<keep-alive><br>- x<br>ULTIMET ADVANCED TCP/IP available flags (optional):<br>- T=<keep-alive><br>- x<br>ETND available flags (optional):<br>- T=<keep-alive> |
| UltimET Light PCI/PCIe | ULTIMET [DEVIDX=n][,<flags>] | Direct access to UltimET Light PCI/PCIe<br>DEVIDX=<n> : (optional)<br>- In the case where several UltimET Light are present in the PC, this allow to specify which UltimET must be opened. First UltimET Light is specified with n=0. The order depends of the PCI/PCIe slots numbering.<br>available flags (optional):<br>- r<br>- x |
| ULTIMET ADVANCED PCI/PCIe | UA [DEVIDX=n][,<flags>] | Direct access to ULTIMET ADVANCED PCIe<br>DEVIDX=<n> : (optional)<br>- In the case where several ULTIMET ADVANCED are present in the PC, this allow to specify which ULTIMET ADVANCED must be opened. First ULTIMET ADVANCED is specified with n=0. The order depends of the PCI/PCIe slots numbering.<br>available flags (optional):<br>- x |

| Bus type | Syntax | Description |
|---|---|---|
| USB | USB | Opening communication on USB will open all ETEL devices connected through USB to the PC. EDI will act as a master. But be aware that the:<br>- devices will not be synchronized as they are when using a motion controller.<br>- each devices must have a unique axis number |

Flags explanations:

- T=<keep-alive>
  keep-alive is a number of 500ms packets
  The communication between EDI and Device is kept by sending records each <keep alive> ms. Both EDI & device checks the communication activity and if it detects that after 3 times the <keep alive> time no record is transmitted, it will generate an error and disconnect.
  Setting -1 as keep-alive will disable the check
- x
  Reset all Connected AccurET: All devices present on TransnET are rebooted.
- r
  Reset UltimET: the UltimET processor is resetted and firmware restarted.

Below are some examples of commonly used URLs:

etb:ETN://172.22.7.200:1149:12 => used to open a communication with controller 12 connected to a computer whose IP address is 172.22.7.200 and that is connected to the controllers network via port 1149. The communication between the remote computer and the controller's network for port 1149 will be described in the port.properties of that computer.

etb:ULTIMET,r:* => used to open and reset communication with an UltimET Light PCI/PCIe itself.

etb:ULTIMET:23 => used to open communication with an AccurET controller 23, using the TransnET connected to an UltimET Light in a PCI slot.

etb:USB:2 => used to open communication with an AccurET controller 2, using USB.

etb:ETN://172.22.10.112:1129,T=-1:0 => used to open a communication with controller 0 using TransnET connected to an UltimET TCP/IP whose IP address is 172.22.10.112. The port 1129 is used. T=-1 allows the user to disable keep-alive handshaking between PC and UltimET. This handshaking has been implemented to check the link presence between the PC and the UltimET TCP/IP. Every 10 seconds, a message is sent by EDI to the UltimET. If the UltimET does not receive this message after 3x10 seconds, it falls into error 1603.

etb:UA DEVIDX=1, T=10000 => used to open communication with ULTIMET ADVANCED PCIe. The keep alive is set to 10 seconds, which means that each 10 seconds, a record is sent by EDI to ULTIMET ADVANCED to keep communication alive. If the PC application crashed, ULTIMET ADVANCED will fall in error after 3x10 seconds and will automatically close the connection. If ULTIMET ADVANCED crashed, EDI will close the communication after 30 seconds. Each command sent will then return a `DSA_EBUSSTATE` error.

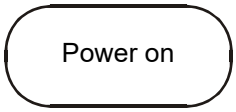
In our example, the following lines explain how to establish the communication. Note that the example is opening communication through an UltimET Light PCI/PCIe. If instead, the communication should be established with an UltimET Light TCP/IP, ULTIMET ADVANCED PCIe or TCP/IP, only the specified URL should be modified, with the rest of the example remaining the same:

```
if (err = dsa_open_u(axisX, "etb:UltimET:0")) {
  DSA_EXT_DIAG(err, axisX);
  goto _error;
}
if (err = dsa_open_u(axisY, "etb:UltimET:1")) {
  DSA_EXT_DIAG(err, axisY);
```

```
    goto _error;
  }
  if (err = dsa_open_u(UltimET, "etb:UltimET:*")) {
    DSA_EXT_DIAG(err, UltimET);
    goto _error;
  }
```

**Remark:** When opening communication with several devices, it is mandatory to use the same URL for each device (except the axis number). For example, if URL etb:UltimET,rx:* is used to open communication with UltimET Light, the URL etb:UltimET,rx:0 must be used to open communication with AccurET axis 0.

## 4.6 Powering on (and off)




Different devices take different time to boot up completely. This means that in a system that includes different types of devices (for e.g. position controllers and a motion controller), some devices will be ready while others have not yet finished booting. This can have the effect of putting in error a device that expects another to be ready, but indeed has not yet finished booting. This is why, when all devices have finished booting, it is recommended to start the application by a general «reset error» command:

```
if (err = dsa_reset_error_ex_s(igrp, 123, DSA_DEF_TIMEOUT)) {
  DSA_EXT_DIAG(err, igrp);
  goto _error;
}
```

Now, commands can be sent to the controllers. The first thing to do is to put the position controller in power on state. This is done via the `dsa_power_on_s` command. It is the equivalent to the controller's `PWR=1` command.

The affix "_s" on the function's name indicates that this is a «synchronous» function. Synchronous functions wait until the end of the operation before returning. All synchronous functions have a timeout parameter as the last parameter. This parameter orders the function to return with a timeout error (`DSA_ETIMEOUT`) if no response comes from the position controller before the end of the specified timeout. This lack of response usually indicates an error in the application, or could result from bad position controller parameters. An appropriate timeout value depends on the application and the command issued. For e.g. in the «power on» case, less than 1 second could be appropriate if the phasing initialization is based on current pulses (K90 = 1), but more than 5 seconds could be required if the phasing initialization is based on constant current (K90 = 2).

This can be done in one of two ways:

- Either switch the power on in each motor individually:

```
if (err = dsa_power_on_s(axisX, 10000)) {
  DSA_EXT_DIAG(err, axisX);
  goto _error;
}
if (err = dsa_power_on_s(axisY, 10000)) {
  DSA_EXT_DIAG(err, axisY);
  goto _error;
}
```

- Or, since there is a group object (primarily for interpolation purposes, but it can also be used anywhere a group is expected), send the command to the group in general, the DLL taking upon itself the responsibility of dispatching it to all the members of the group:

```
if (err = dsa_power_on_s(igrp, 10000)) {
  DSA_EXT_DIAG(err, igrp);
  goto _error;
}
```

Powering off is just as simple as:

```
if (err = dsa_power_off_s(igrp, 10000)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

## 4.7 Homing


The next step in the preparation of the controllers and motors for operation consists on performing the homing procedure in order to find the reference for the motor's absolute position. Once again, this can be done on each axis individually:

```
if (err = dsa_homing_start_s(axisX, 10000)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
if (err = dsa_homing_start_s(axisY, 10000)) {
   DSA_EXT_DIAG(err, axisY);
   goto _error;
}
```

or on the group as a whole:

```
if (err = dsa_homing_start_s(igrp, 10000)) {
   DSA_EXT_DIAG(err, axisY);
   goto _error;
}
```

`dsa_homing_start_s()` is the equivalent of the controller's `IND` command.

This function «only» starts the homing procedure. Before other movements can be executed, the homing procedure must have terminated. So, to wait until the homing is concluded, proceed as follows:

```
if (err = dsa_wait_movement_s(igrp, 60000)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

**Remark:** Be sure to use a `DSA_GANTRY` object when working with a Gantry in 'Level 1'. In this special case, EDI will forward the homing procedure to the UltimET.

# 5 Movements

## 5.1 Introduction to the example's trajectory

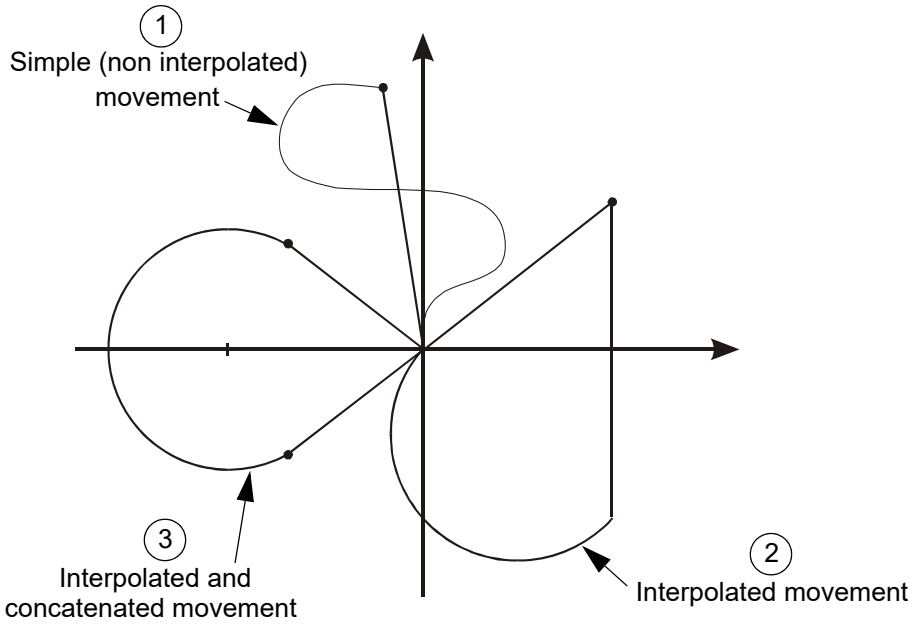
In our example, to make sure the movement never exceeds the limits and that a proper error is generated on the position controller in case this occurs, the coordinates of the positions are always given with reference to the minimum and maximum position limits. These are stored on the controller's parameters KL34 and KL35 for the AccurET-family and can be read as follows:

```
#define AXIS_NB_X 0
#define AXIS_NB_Y 1

double pos_min[2], pos_max[2];

if (err = dsa_get_min_soft_position_limit_s(axisX, &pos_min[AXIS_NB_X],
                                            DSA_GET_CURRENT, DSA_DEF_TIMEOUT)) {
  DSA_EXT_DIAG(err, axisX);
  goto _error;
}
if (err = dsa_get_max_soft_position_limit_s(axisX, &pos_max[AXIS_NB_X],
                                            DSA_GET_CURRENT, DSA_DEF_TIMEOUT)) {
  DSA_EXT_DIAG(err, axisX);
  goto _error;
}
```

The same is repeated for the other axis, storing the available range of motion in a variable to be used later:

```
double range_of_motion[2];
range_of_motion[AXIS_NB_X] = pos_max[AXIS_NB_X] - pos_min[AXIS_NB_X];
range_of_motion[AXIS_NB_Y] = pos_max[AXIS_NB_Y] - pos_min[AXIS_NB_Y];
```

In our example the motors will move so that the toolpoint executes the trajectory depicted next:



## 5.2 Defining the position windows

Set Windows

To ensure that the movement complies with the application's requirements, there are several windows that have to be (or can be) defined, depending on what type of requirement is governing the application. For example, for a position driven application, the user might want to constrain the tracking error, and/or the position settling time, and/or the precision of the target position.

The EDI package provides several specific functions for this purpose:

- `dsa_set_following_error_window_s` sets the tracking error limit (position controller parameter K30)
- `dsa_set_position_window_time_s` defines the minimum time during which the position must be within given bounds of the target position for it to be considered reached (position controller parameter K38).
- `dsa_set_position_window_s` sets the acceptable error on the real position (position controller parameter K39) compared to the target position.

Usually, these parameters are set at the position controller's level when integrating the system, but some applications may need to change, for example, the tracking error detection limit depending on an operating mode. This could be done as follows:

```
long axisX_trackingErrorLimit =...;
long axisY_trackingErrorLimit =...;
if (err = dsa_set_following_error_window_s(axisX, axisX_trackingErrorLimit,
                                           DSA_DEF_TIMEOUT)) {
  DSA_EXT_DIAG(err, axisX);
  goto _error
}
if err = dsa_set_following_error_window_s(axisY, axisY_trackingErrorLimit,
                                          DSA_DEF_TIMEOUT)) {
  DSA_EXT_DIAG(err, axisY);
  goto _error
}
```

## 5.3 Simple (non interpolated) movements

Move

### 5.3.1 Defining the movement profile

As described in the "AccurET's Operation & Software Manual", the movement can be controlled in a variety of ways depending on its operating mode: force reference, speed reference, external reference or position reference. The controller's mode (position controller parameter K61) is initialized at startup, but can be modified using `dsa_set_drive_control_mode_a()`. Refer to the "**HTML Reference Manual**" for the details of this function.

When in position controlled mode, which is the default mode, the movement can be defined by means of a set of specific functions. In the other operating modes, the movement must be defined using the generic functions (refer to §10.2 for more information).

A position controlled movement can be defined by up to four parameters. One usually sets at least the target position (refer to §5.3.2); the speed, acceleration and jerk time describing the movement profile can also be modified.

To set the movement speed:

```
double profileSpeed = 0.1; /* m/s or t/s for rotary motors */
if (err = dsa_set_profile_velocity_s(axisX,0, profileSpeed, DSA_DEF_TIMEOUT)) {
  DSA_EXT_DIAG(err, axisX);
  goto _error;
}
```

To set the movement acceleration:

```
double profileAcc = 10.0; /* m/s^2 or t/s^2 for rotary motors*/
if (err = dsa_set_profile_acceleration_s(axisX, 0, profileAcc,
                                         DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
```

To set the movement jerk time:

```
double jerkTime = 0.01; /* seconds */
if (err = dsa_set_jerk_time_s(axisX, 0, jerkTime, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
```

### 5.3.2 Starting

Making a single position controller simply go to a given position is quite straightforward. To move to a random position within the bounds of the motor stroke:

```
double position =
pos_min[AXIS_NB_X]+(rand()*(range_of_motion[AXIS_NB_X]) / RAND_MAX;
if (err = dsa_set_target_position_s(axisX, 0, position, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
```

and then wait until the movement is finished:

```
if (err = dsa_wait_movement_s(axisX, 60000)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
```

The `dsa_set_target_position_s`() is the equivalent to the controller's `POS` command. It sets the value of the target position and starts the movement.

A special note must be made for the second parameter («0» in the above example). The function takes a subindex parameter as its second argument. If a zero is written in the subindex, like above, the movement will start immediately. A value of 1 to 3 in the subindex just prepares the movement, which will then start with the "new set point" command:

```
if (err = dsa_new_setpoint_s(axisX, preparedsIndex, flags ,DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
```

Note that this function takes a group as first parameter. Indeed preparing movements at different subindices and using the `dsa_new_setpoint_s` function is meaningful when several position controllers need to start simultaneously. With TransnET, as in this example, all position controllers are synchronized together. In this case, the movements start exactly at the same time (within one microsecond).

The third param is a mask and should contain the logical sum of all the following constants, specifying which information must be fetched from the buffer. The constants include (refer to the **"HTML Reference Manual"** for complete range of values):

- `DSA_STA_POS`: use the target position of the given buffer;
- `DSA_STA_SPD`: use the profile velocity of the given buffer;
- `DSA_STA_ACC`: use the profile acceleration of the given buffer;
- `DSA_STA_JRK`: use the profile jerk of the given buffer.

For example, if subindex 2 was used to store the new target position and movement profile speed, then, to start the movement we would write:

```
if (err = dsa_new_setpoint_s(igrp, 2, DSA_STA_POS | DSA_STA_SPD,
                             DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

## 5.4 Interpolated movements


In this example, there are two axes and an UltimET, so it is possible to perform interpolated movements.

Interpolated movements are defined by high level commands that are sent to the UltimET which interprets them to generate the set points for each individual position controller making up the interpolation group in order to execute the specified trajectory.

To start making interpolated movements, it is required to to enter into the «interpolated» mode using the `dsa_ipol_begin_s()` function. Once in this mode, one must use the interpolation functions on the position controllers belonging to the interpolation group. They begin with `dsa_ipol_...()`. It is no longer possible to set a target position using `dsa_set_target_position_s()` on a given axis. To do so, it is required to to leave the interpolation mode using the `dsa_ipol_end_s()` function.

Interpolated mode functions allow to specify geometric definitions of the trajectory, such as executing a line, a circle and so on. Refer to the "**HTML Reference Manual**" for the full list of available functions. The current position when entering the interpolation mode is used as reference point for all subsequent movement definitions. When leaving the interpolation mode, the reference reverts to what was defined before.

So, to enter interpolation mode, use:

```
if (err = dsa_ipol_begin_s(igrp, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

**Remark:** Initiating the interpolation mode changes the reference point for the position. Whereas before, all positions were relative to the encoder reference mark, once in interpolation mode, the reference point used is the position where the system was when the `dsa_ipol_begin_s()` function was executed. So all coordinates given in interpolated mode are relative to the position at the start of the interpolation mode.

### 5.4.1 Defining the movement profile

Then, in this mode, it is the maximum tangential speed (in m/s) and accelerations (in $m/s^2$) that must be defined.

To set the tangential speed of the trajectory:

```
if (err = dsa_ipol_tan_velocity_s(igrp, 0.05, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

To set the tangential acceleration of the trajectory:

```
if (err = dsa_ipol_tan_acceleration_s(igrp, 0.1, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

To set the tangential deceleration of the trajectory:

```
if (err = dsa_ipol_tan_deceleration_s(igrp, 0.1, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

Now we are ready to make our system move.

### 5.4.2 Executing movements

At this point one can, for example, start the trajectory with a linear segment. The following function defines and starts the movement from the previous end of segment and stops the system at the end of the specified segment.

To specify the coordinates of the end point of the segment:

```
double endPointX = range_of_motion[AXIS_NB_X]/4.0;
double endPointY = range_of_motion[AXIS_NB_Y]/4.0;
```

And to actually go from the end position of the previous segment to the specified end position:

```
if (err = dsa_ipol_line_2d_s(igrp, endPointX, endPointY, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

After this other lines can be specified by other calls to the same function:

```
endPointX = range_of_motion[AXIS_NB_X] / 4.0;
endPointY = -range_of_motion[AXIS_NB_Y] / 4.0;
if (err = dsa_ipol_line_2d_s(igrp,endPointX, endPointY, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

or draw a portion of a circle with calls like:

to define the center point of the arc:

```
double centerX = range_of_motion[AXIS_NB_X]/8.0;  /* X of center of arc */
double centerY = -range_of_motion[AXIS_NB_X]/8.0; /* Y of center of arc */
```

to define end point of the arc:

```
double arcendX = 0.0; /* X coordinate of end point of arc (return to center)*/
double arcendY = 0.0; /* Y coordinate of end point of arc (return to center)*/
```

and to execute the movement:

```
if (err = dsa_ipol_circle_cw_c2d_s(igrp, arcendX, arcendY, centerX, centerY,
                                   DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

which will draw an arc ending at the position given by the 2nd and 3rd parameters, centered on the point with the coordinates given by the 4th and 5th parameters (remember, all with respect to the point at which the system was when entering the interpolation mode) and moving in the clockwise direction.

## 5.5 Interpolated and concatenated movements

Up to now the system would have stopped at the end of each segment. To make a continuous movement, it is necessary to start the concatenation of the segments as follows:

```
if (err = dsa_ipol_begin_concatenation_s(igrp, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

But, this function should only be executed **after** the first segment has started, to inform the trajectory generator to look ahead for the next segment.

With the concatenation enabled, all segments are processed at constant speed, without stopping between segments. This means that when the interpolator processes one segment, it does not decrease the speed at the end of the segment. It jumps to the next segment without a speed change. The following calls will generate a movement along a trajectory at a constant speed:

```
double endPointX = -range_of_motion[AXIS_NB_X]/8.0;
double endPointY = range_of_motion[AXIS_NB_Y]/8.0;

if (err = dsa_ipol_line_2d_s(igrp,
                             endPointX,    /* Segment end X */
                             endPointY,    /* Segment end Y */
                             DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
if (err = dsa_ipol_begin_concatenation_s(igrp, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
if (err = dsa_ipol_circle_ccw_c2d_s(
                           igrp,
                           endPointX,                        /* Arc end X */
                           -endPointY,                       /* Arc end Y */
                           -range_of_motion[AXIS_NB_X]/4.0, /* Arc center X */
                           0.0,                              /* Arc center Y */
                           DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
if (err = dsa_ipol_line_2d_s(igrp,
                             0.0,
                             0.0, /* return to interpolation mode origin */
                             DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

Of course, in this mode, one must take care of not introducing angles in the trajectory to avoid damaging the mechanical system.

Once the concatenated segments section is terminated, it is possible to revert to individual segments, in between which the UltimET will drive the system to a stop and a restart:

```
if (err = dsa_ipol_end_concatenation_s(igrp, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

When the system no longer needs to perform interpolated movements, the interpolation mode is exited by calling:

```
if (err = dsa_ipol_wait_movement_s(igrp, 60000)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

to wait for all segment to be finished, and then:

```
if (err = dsa_ipol_end_s(igrp, DSA_DEF_TIMEOUT)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

to leave the interpolation mode and come back to the previous reference system.

# 6 Monitoring data

Move

In this section, it will be shown how to read data in a cycle from the controllers. The example will monitor the motor's position and the position controller's status, which are two of the quite common monitoring requirements.

To get feedback data on a regular basis, it is usual to create a specific thread to handle the data. Creating a thread is system and language dependent. On Windows and in C, a thread is created as follows:

```
if (_beginthread(display_thread, 0, igrp) <= 0) {
  err = DSA_ESYSTEM;
  printf("ERROR in file %s, at line %s %s\n",_FILE_,_LINE_,
        dsa_translate_edi_error(err));
  goto _error;
}
```

Notice here a slightly different way to handle the error code. This is because `_beginthread` is a C library call that does not return known EDI error codes. So if there is a system error creating the thread, it is translated into an EDI system error and processed for display.

`_beginthread()` is an operation made available by `<process.h>`. The tasks the thread will do are implemented by the function passed as first parameter, i.e. `display_thread()`. This function will be called by the thread with the third parameter of `_beginthread` as its own parameter; here a pointer to our group of position controllers.

Let's now see what `display_thread()` does.

First, the access to the position controllers must be renewed, which is done with the help of the drive group passed as parameter to the function:

```
DSA_DRIVE_GROUP *grp = (DSA_DRIVE_GROUP *)param; /* get group from paramter*/
DSA_DRIVE *drv[2]; /* create local drive objects*/
for (i = 0; i < 2; i++) {
  if (err = dsa_get_group_item(grp, i, &drv[i])) {
    DSA_EXT_DIAG(err, drv[i]);
    goto _error;
  }
}
```

The task is an infinite loop that will be stopped when the system terminates the whole process after it has come to its end. Every 100ms, the loop will read the position controller status and the actual position for display. Before the position controller status can be read, as it is a DSA object, it must be initialized using the appropriate function. The position controller status is kept up-to-date in the process memory by the DSA library because it is very frequently needed. Therefore, reading the controller's status is a very efficient operation that does not degrade the overall performance of the user's application.

```
for(;;) {
  double pos[2];

DSA_STATUS status[2]= {{sizeof(DSA_STATUS)},{sizeof(DSA_STATUS)}};
for (i = 0; i < 2; i++) {
  int err;
  if (err = dsa_get_status(drv[i], &status[i])) {
    DSA_EXT_DIAG(err, drv[i]);
    goto _error;
  }
}
for (i = 0; i < 2; i++) {
```

```
      int err;
      if (err = dsa_get_position_actual_value_ex_s(drv[i], 0, &pos[i],
                                                   DSA_GET_CURRENT,
                                                   DSA_DEF_TIMEOUT)){
        DSA_EXT_DIAG(err, drv[i]);
        goto _error;
      }
    }
    /*
    * We can now print the status string on the display.
    */
    printf("%04d: ", ++counter);
    for (i = 0; i < 2; i++) {
      printf("AXIS %d: %c%c%c/%4.4fmm", i,
             status[i].drive.moving ? 'M' : '-',
             status[i].drive.warning ? 'W' : '-',
             status[i].drive.error ? 'E' : '-',
             pos[i] * 1.0E3);
      printf((i == 0) ? ", " : "\r");
    }

    /* wait 100ms: system dependent call */
    { extern_stdcall Sleep(int); Sleep(100); }

  }/*end endless loop*/
```

# 7 Status handling

## 7.1 Principle

Each ETEL's device has a set of information which allows the user to know which is the state of the device. This information is represented by a bit field. Each bit corresponds to a state (power on, error, warning, movement,...). The value of the bit shows if the device is or is not in this state.

Some of the states found on most ETEL devices, include:

| | |
|---|---|
| Present | Shows if the device is present (active) |
| Warning | Shows if a warning appeared on the device |
| Error | Shows if the device is in error |
| Moving | Shows if the movement is in progress |
| In_window | Shows if the motor is in position, in the given window |
| Sequence | Shows if the sequence is running |
| Trace | Shows if the acquisition of a trace is in progress |
| User 0 | At the user's disposal |
| ... | |
| User 16 | |

The main special feature of the status is its automatic update in real time. Indeed, because the status information needs to be queried often in applications, the DSA library maintains an up-to-date real-time value of the status of each position controller connected to the bus. Therefore, the status access functions do not generate any communication over the bus and are, thus, not time consuming (i.e. these functions can be called frequently without degrading the overall performance of the application).

The user has functions allowing to wait for a device to be in a given state. Thus, the user can be informed of a status change without polling the status.

Here is the list of the available functions:

| | |
|---|---|
| dsa_get_status | Returns the status of the device |
| dsa_grp_get_and_status | Applies a bitwise AND on status of all devices of device group and returns it |
| dsa_grp_get_or_status | Applies a bitwise OR on status of all devices of device group and returns it |
| dsa_wait_status_equal_s() / _a() | Waits for a device to be in a given state |
| dsa_wait_status_not_equal_s() / _a() | Waits for a device to quit a given state |
| dsa_grp_wait_and_status_equal_s() / _a() | Waits for all the devices of a group to be in a given state |
| dsa_grp_wait_and_status_not_equal_s() / _a() | Waits for all the devices of a group to leave a given state |
| dsa_grp_wait_or_status_equal_s() / _a() | Waits for one of the devices of a group to be in a given state |
| dsa_grp_wait_or_status_not_equal_s() / _a() | Waits for one of devices of a group to leave a given state |
| dsa_cancel_status_wait | Unblocks all status waiting for specified device. The callbacks of asynchronous wait will be called |
| dsa_grp_cancel_status_wait | Unblocks all status waiting for specified device group. The callbacks of asynchronous wait will be called |

## 7.2 Working with DSA_STATUS

The DSA_STATUS is a union of the following members:

```
typedef union DSA_STATUS {
  int size;                          /**< The size of this structure */
  DsaStatusSWMode sw;                /**< Status for SW1/SW2 access. Use only
                                     when status is got from
                                     Dsa_get_status_drom_drive. Allow access to
                                     homing and init bit field */
  DsaStatusRawMode raw;              /**< Status for raw access. Use carefully.
                                     Compatibility not granted along EDI
                                     versions */
  DsaStatusDriveBitMode drive;       /**< Status for drive bit access */
  DsaStatusDsmaxBitMode dsmax;       /**< Status for dsmax bit access */
  DsaStatusUltimETBitMode ultimet;   /**< Status for UltimET bit access */
  DsaStatusUltimETBitMode master;    /**< Status for UltimET bit access */
} DSA_STATUS;
```

Depending on how the status is read, the user has to access the structure using the corresponding sub-structure. There are several EDI functions which can be used to read the status:

- **The functions accessing the internal realtime status of EDI:**

```
dsa_get_status(DSA_DEVICE *dev, DSA_STATUS *status)
dsa_grp_get_and_status(DSA_DEVICE_GROUP *grp, DSA_STATUS *status)
dsa_grp_get_or_status(DSA_DEVICE_GROUP *grp, DSA_STATUS *status)
dsa_gantry_get_and_status(DSA_GANTRY *gantry, DSA_STATUS *status)
dsa_gantry_get_or_status(DSA_GANTRY *gantry, DSA_STATUS *status)
```

These functions (without timeout parameter) are accessing the internal status of EDI. For reminder, EDI gets and stores in real-time the status of each connected device using M63. Executing these functions **does not generate any communication** between EDI and the device and this is why they do not require any timeout parameter.

When using these functions, the user has to access the read status using one of the following DSA_STATUS member:

```
typedef union DSA_STATUS {
  int size;                          /**< The size of this structure */
  DsaStatusSWMode sw;                /**< Status for SW1/SW2 access. Use only
                                     when status is got from
                                     dsa_get_status_drom_drive. Allow access to
                                     homing and init bit field */
  DsaStatusRawMode raw;              /**< Status for raw access. Use carefully.
                                     Compatibility not granted along EDI
                                     versions */
  DsaStatusDriveBitMode drive;       /**< Status for drive bit access */
  DsaStatusDsmaxBitMode dsmax;       /**< Status for dsmax bit access */
  DsaStatusUltimETBitMode ultimet;   /**< Status for UltimET bit access */
  DsaStatusUltimETBitMode master;    /**< Status for UltimET bit access */
} DSA_STATUS;
```

Use the DsaStatusDriveBitMode drive member if the specified device is an AccurET.
Use the DsaStatusUltimETBitMode ultimet (or master) member if the specified device is an UltimET.
The DsaStatusDsmaxBitMode dsmax has been kept for compatibility reasons but does not have all usable status bits defined.

- **The function accessing the detailed status of the drive:**

```
dsa_get_status_from_drive(DSA_DEVICE *dev, DSA_STATUS *status, long timeout)
```

This function (with a timeout parameter) is reading the status of the AccurET. They are reading the M60 and M61 registers. Therefore, executing these functions **generates communication** between EDI and the device and this is why they have a timeout parameter.

When using this function, the user has to access the read status using the following `DSA_STATUS` member:

```
typedef union DSA_STATUS {
  int size;                          /**< The size of this structure */
  DsaStatusSWMode sw;                /**< Status for SW1/SW2 access. Use only
                                     when status is got from
                                     dsa_get_status_drom_drive. Allow access to
                                     homing and init bit field */
  DsaStatusRawMode raw;              /**< Status for raw access. Use carefully.
                                     Compatibility not granted along EDI
                                     versions */
  DsaStatusDriveBitMode drive;       /**< Status for drive bit access */
  DsaStatusDsmaxBitMode dsmax;       /**< Status for dsmax bit access */
  DsaStatusUltimETBitMode ultimet;   /**< Status for UltimET bit access */
  DsaStatusUltimETBitMode master;    /**< Status for UltimET bit access */
} DSA_STATUS;
```

It is interesting to use this function on an AccurET (not on an UltimET). If you look at the sub-structure definitions, you can see that DsaStatusSWMode member has 2 interesting bits defined:

`init_done`: The initialization procedure has been done
`homing_done`: The homing procedure has been done

These 2 bits are not present in M63. As the EDI real-time status mechanism is done using M63, these bits are not defined in the other sub-structure. **Therefore, you should NOT access the `DSA_STATUS` using the DsaStatusSWMode member when the status is retrieved using `dsa_get_status` function, because some bits are not up-to-date.**

There are 3 ways of initializing the `DSA_STATUS` structure:

- `DSA_STATUS st = {sizeof(DSA_STATUS)};`
  Be carefull, on some OS (like QNX6), this way of initialization does not set the other structure members to 0 (on these kinds of OS, the second method is preferred, especially when it is requested to have the other members set to 0).

- `DSA_STATUS st;`
  `DSA_INIT_STATUS(st);` From EDI-4.11A ONLY

- `DSA_STATUS st;`
  `memset(&st, 0, sizeof(st)); st.size = sizeof(st);`

Here is a reading example of the status:

```
int err;
DSA_STATUS status= {sizeof(DSA_STATUS)};/* very important ! */

...

err = dsa_get_status(drive1, &status);
if (err != 0) {
  printf("I cannot get the drive status : %s\n",
  dsa_translate_error(err));
}

if (status.drive.moving)
  printf("The drive is moving\n");
else
  printf("The drive is stoped\n");
```

In this example, the user has to set the size field of the structure. Given that the status of a position controller si being queried, the status bits can be accessed via the 'drive' structure.

Here is an example where the application waits for the end of a movement by using the waiting on the status:

```
DSA_STATUS mask = {sizeof(DSA_STATUS)};
DSA_STATUS ref = {sizeof(DSA_STATUS)};

...

/* start a movement */
dsa_set_target_position_s(drive1, 0, 1.0, DSA_DEF_TIMEOUT);

/* wait for the end of the movement
* this code is equivalent to dsa_wait_movement_s(drive1, 20000) */
mask.drive.moving = 1;
dsa_wait_status_equal_s(drive1, &mask, &ref, NULL, 20000);
```

In this example, the user waits for the movement to be finished (i.e. 'moving' bit is equal to 0). It must be specified that the user waits for the 'moving' bit to be equal to 0. This is why there are a mask ('mask' variable) and a reference ('ref' variable). In the mask, the bits on which the waiting is done are set to 1. In the example, it is the 'moving' bit. The values the user is waiting for are set in the reference. In the example, the value is equal to 0.

In the mask, all bits except the 'moving' bit must be equal to 0. It is done thanks to the `sizeof(DSA_STATUS)`, which initializes to the first member of the structure and the other members to zero. The 'ref' variable is also set to 0 by this function even if it is not necessary. Only the value of the 'moving' bit is interesting in this variable. The size fields of both structures must be correctly initialized.

In the following example, the user monitors the position controller to determine if it is in error mode or not. To do so, an asynchronous wait is used on the error bit of the status:

```
void DSA_CALLBACK err_handler(DSA_DEVICE *dev, int err,
                              void *param, const DSA_STATUS *status)
{
  printf("ERROR ON THE DRIVE !\n");
}

int main()
{
  DSA_STATUS mask = {sizeof(DSA_STATUS)};
  DSA_STATUS ref = {sizeof(DSA_STATUS)};

  DSA_DRIVE *drive1 = NULL;
  /* create and open the drive */
  dsa_create(&drive1);
  dsa_open_u(drive1,...);

  /* wait for an error - the program do not block here */
  mask.drive.error = 1;
  ref.drive.error = 1;
  dsa_wait_status_equal_a(drive1, mask, ref, err_handler, NULL);

  /* execute movements */
  dsa_set_target_position_s(drive1,...);
  ...

  /* close and destroy */
  dsa_close(drive1);
  dsa_destroy(&drive1);
}
```

## 7.3 Performances

The status are the fastest way for a device to give a Boolean type information to the PC. This information can be a change of state, an event taking place or any other information. The user can use part of the status to for its own purposes.

The routing of these status must be carefully done. The processing at the PC level is realized by interrupt. A task of the PC can be awakened by a status change. Thus, all the waits on the status do not use the time of the CPU.

Each device has a large number of Boolean information which are often stored in the M60, M61 and M63 monitoring registers. The status do not provide all the information, but only those that require a fast routing to the PC. For example, there is a bit (number 2) of M60 which indicates if the position controller has done the homing or not. This information is obviously useful, but it does not require to be know in real time, therefore, it is not include in EDI's status. If the user wants to know this information, it can be simply request to the position controller the value of M60 using the `dsa_get_status_from_drive_s` function, and access this bit using DsaStatusSWMode member of `DSA_STATUS`.

The status are updated every TransnET cycle time. The motion controller receives an update of the status at this rate (but because some position controllers have a slower status update cycle time, the motion controller will receive during several TransnET cycles the same status value for these position controllers). Each time it detects a change of status, the motion controller informs the PC. Thus, the PC is informed of a status change at the same rate as the motion controller, but is often limited by the performances of the Windows OS.

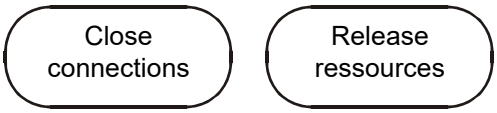
If the performances of the PC do not allow it to monitor the evolution of the status, certain changes of these status can pass undetected at the PC level. For example, if a very short movement is done, the 'moving' bit of the status will be equal to 1 during a very short time. This change can pass unnoticed by the PC and this bit would be considered equal to 1 at all times.

On the other hand, the PC will be always informed of the last state available. If the user wants to wait for the end of the movement, he has to wait for the 'moving' bit to be equal to 0. It is true whatever the performances of the PC. The waiting functions on the status do not wait for a change of state (edge detection) but simply wait for a given state (level detection).

## 7.4 User status

Among the bits of the status, 16 of them are at the user's disposal. At the PC level, these bits are managed exactly like the others. Thus, the user can read them and wait for them to be in a particular state thanks to the functions described above. At the device level, several other features, such as error, in window, interpolation marks, K177 user status parameter modify the state of these bits. See the "User's Manual" of the related device to know how these interact.

# 8 Terminating the application




Application termination operations take place in the reverse order of those described in §4 which correspond to creating the objects and establishing the communication.

These two functions allocate resources. During the creation of an object or a group, memory is allocated. When establishing the communication, for e.g. the use of the USB port, the interrupt IRQ or other resources specific to the communication bus are assigned as well. These resources must be released as soon as there are not used any more. It is recommended to do it just before exiting the application.

The `dsa_close()` function closes the communication and the `dsa_destroy()` function destroys an object or a group. Closing the communication must be done before the destroying the object.

Firstly, the connections must be closed:

- connection to the UltimET:

```
if (err = dsa_close(UltimET)) {
   DSA_EXT_DIAG(err, UltimET);
   goto _error;
}
```

- connections to both position controllers:

```
if (err = dsa_close(axisX)) {
   DSA_EXT_DIAG(err, drv);
   goto _error;
}
if (err = dsa_close(axisY)) {
   DSA_EXT_DIAG(err, drv);
   goto _error;
}
```

Then, just like the objects were created at the beginning of the application, the memory allocated to them must be released:

- group object:

```
if (err = dsa_destroy(&igrp)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
```

- UltimET object:

```
if (err = dsa_destroy(&UltimET)) {
   DSA_EXT_DIAG(err, UltimET);
   goto _error;
}
```

- and the drive objects

```
if (err = dsa_destroy(&axisX)) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
if (err = dsa_destroy(&axisY)) {
   DSA_EXT_DIAG(err, axisY);
   goto _error;
}
```

# 9 Recommended proper reaction to error detection

Code is more maintainable if all error processing is done in the same location. This is why, in the above examples, function call error handling has always referred to a goto label, where all error processing is performed.

Of course, one drawback of a single common error handler is that it needs to identify where the error was originated and what is the state of the program. This might make more code to write, but once validated, it usually ends up making the software easier to maintain.

The group object of drives, if it is a valid pointer, can first be destroyed; it is no longer of any use. The group, drive, UltimET pointers can be invalid if the `dsa_create_...` functions have failed (or not been called!) or that some memory has been corrupted.

```
if (dsa_is_valid_drive_group(igrp))
   dsa_destroy(&igrp);
```

The same has to be done with the motion controller and the position controllers. For each position controller, if the object pointer is valid, first check if the communicate is still working in order to stop all movements, power off the controller and finally close the communication. Afterwards, the object itself can be destroyed:

```
if(dsa_is_valid_drive(axisX)) {
   /* Is the communication open? */
   ebool open = 0;
   dsa_is_open(axisX, &open);
   if (open) {
      /* Stop movements. */
      dsa_quick_stop_s(axisX, DSA_QS_PROGRAMMED_DEC,
                       DSA_QS_BYPASS | DSA_QS_STOP_SEQUENCE, DSA_DEF_TIMEOUT);

      /* When the motor has stopped, a power off is done. */
      dsa_wait_movement_s(axisX, 60000);
      dsa_power_off_s(axisX, 60000);

      /* Close the connection. */
      dsa_close(axisX);
   }

   /* Finally, release the associated resources to the OS. */
   dsa_destroy(axisX);
}
```

The same must be done for the other axis. The UltimET also has to be shut down:

```
if(dsa_is_valid_master(UltimET)) {
   /* Is the UltimET open ? */
   ebool open = 0;
   dsa_is_open(UltimET, &open);
   if (open) {
      /* Close the connection */
      dsa_close(UltimET);
   }
   /* And finally, release all resources to the OS. */
   dsa_destroy(&UltimET);
}
```

**Remark:** The dsa_destroy function requires as parameter the address of the pointer to the object (`&axisX`, `&axisY` and `&UltimET`) and not the pointers themselves (`axisX`, `axisY` and `UltimET`). In this way, once the object is destroyed, its address is assigned to NULL.

# 10 Units and unit conversions

## 10.1 Specific functions

In this type of function, the parameters representing a physical quantity are always given in ISO units. For example, in the `dsa_set_target_position()`, the linear position is given in meter. According to the motor type (rotary or linear) and the quantity (position, speed, time...), the value will be given with the following unit. By using specific functions, EDI will automatically have access to the correct parameter depending on the family of the accessed device.

| Quantity | Linear motor | Rotary motor |
|---|---|---|
| Position | m | Turns |
| Speed | m/s | Turns/s |
| Acceleration | $m/s^2$ | $Turns/s^2$ |
| Jerk time | s | |
| Time | s | |
| Current | A | |
| Temperature | °C | |

## 10.2 Generic functions

As seen previously, the parameters of the functions representing a physical quantity are always given in ISO unit like meter, second, ampere, etc... On the other hand, ETEL devices work with internal units called «increments». Here is a table illustrating the differences between these two types of units:

| | ISO units | Increments |
|---|---|---|
| Coding | Floating point 64 bits | 32 or 64 bits integer or float |
| Reference | Normalized | Depending on the device's parameters |
| Names | meter [m], second [s], ampere [A],... | UPI, USI, DPI,... |
| Use | Application level | Device level |

To set a register in increment using the generic functions, the user needs to know the register-type and register-index in order to use the adequate function:

| | DSA function |
|---|---|
| Set register containing 32-bit integer increments | dsa_set_register_int32_... |
| Set register containing 64-bit integer increments | dsa_set _register_int64_... |
| Set register containing 32-bit float increments | dsa_set_register_float32_... |
| Set register containing 64-bit float increments | dsa_set_register_float64_... |

To set a register in ISO using the generic functions, EDI will automatically detect the accessed register and convert ISO double parameter into the correct increment type.

| | DSA function |
|---|---|
| Set register using ISO value | dsa_set_iso_register_... |

When using the specific functions, the DSA library does automatically the necessary unit conversions and send to the devices the quantities in increments. On the other hand, when the generic functions are used, the user can choose between the use of increments or ISO units. If the ISO unit is chosen, the user must specify the name of corresponding unit in the device so that the DSA library does the appropriate conversion.

Here are some examples:

**Example 1:**

- The user wants to modify the K39 register of a position controller
- K39 represents the in-window position of a linear motor
- This quantity in increments (in the position controller) is given in UPI
- This quantity in ISO units is given in meters [m]

The allocation of this register in increments is done in the following way:

```
err = dsa_set_register_int32_s(
    drive1,                    /* grp: destination device */
    2,                         /* typ: 2 = K register */
    39,                        /* idx: register index */
    0,                         /* sidx: register sub-index */
    1000,                      /* value: register value in UPI */
    DSA_DEF_TIMEOUT            /* timeout: default timeout */
);
```

or

To set a register in increment using the generic functions, the user needs to know the corresponding register-type and register-index to use the adequate function:

```
err = dsa_set_register_int32_s(
   drive1,                     /* destination device*/
   DMD_TYP_PPK,                /* typ 2 = K register */
   39,                         /* register index */
   0,                          /* register sub-index*/
   1000,                       /* value: register value in UPI*/
   DSA_DEF_TIMEOUT             /* default timeout*/
);
```

The appointment of this register in ISO units is done in the following way:

```
err = dsa_set_iso_register_s(
    drive1,                    /* grp: destination device */
    2,                         /* typ: 2 = K register */
    39,                        /* idx: register index */
    0,                         /* sidx: register sub-index */
    0.0001,                    /* value: register value in [m] */
    DMD_CONV_UPI,              /* conv: drive unit (UPI) */
    DSA_DEF_TIMEOUT            /* timeout: default timeout */
);
```

To set a register specifying the ISO value, the user must specify which conversion function number to use. Here follows a list of available conversion function number:

| Values (#define) | Device's unit | Description | Condition |
|---|---|---|---|
| DMD_CONV_AVI | AVI | Analog voltage: +/-8192 inc => -/+10V | Deprecated |
| DMD_CONV_AVI12BIT | AVI12BIT | Analog voltage: +/-2048 inc => -/+10V | Deprecated |
| DMD_CONV_AVI16BIT | AVI16BIT | Analog voltage: +/-32767 inc => -/+10V | Deprecated |
| DMD_CONV_AVI16BITINV | AVI16BITINV | Analog voltage: +/-32767 inc => +/-10V | |
| DMD_CONV_BIT0 | BIT0 | 2^0 = 1 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT10 | BIT10 | 2^10 = 1024 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT11 | BIT11 | 2^11 = 2048 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT11_ENCODER | BIT11_ENCODER | Analog encoder signal amplitude in volt (11 bit) | |
| DMD_CONV_BIT11P2 | BIT11P2 | Analog encoder (11 bit) | |

| Values (#define) | Device's unit | Description | Condition |
|---|---|---|---|
| DMD_CONV_BIT15 | BIT15 | 2^15 = 32768 correspond to 1.0 | |
| DMD_CONV_BIT15_ENCODER | BIT15_ENCODER | Analog encoder signal amplitude in volt (15 bit) | |
| DMD_CONV_BIT15P2 | BIT15P2 | Analog encoder (15 bits) | Deprecated |
| DMD_CONV_BIT24 | BIT24 | 2^24 = 256*65536 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT31 | BIT31 | 2^31 = 32768*65536 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT5 | BIT5 | 2^5 = 32 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT8 | BIT8 | 2^8 = 256 correspond to 1.0 | Deprecated |
| DMD_CONV_BIT9 | BIT9 | 2^9 = 512 correspond to 1.0 | Deprecated |
| DMD_CONV_BOOL | BOOL | Boolean value | |
| DMD_CONV_C13 | C13 | Current 13bit range | Deprecated |
| DMD_CONV_C14 | C14 | Current 14bit range | Deprecated |
| DMD_CONV_C29 | C29 | Current 29bit range | |
| DMD_CONV_CLTI | CLTI | Current loop time increment (cti) | Deprecated |
| DMD_CONV_CTI | CTI | Current loop time increment (41us) | Deprecated |
| DMD_CONV_CTRL_CUR2 | CTRL_CUR2 | Controller i^2*t, dissipation value | |
| DMD_CONV_CTRL_CUR2T | CTRL_CUR2T | Controller i^2*t, integration value | |
| DMD_CONV_CUR | CUR | Current | |
| DMD_CONV_CUR_NM | CUR_NM | Current in Newton meter | Deprecated |
| DMD_CONV_CUR2 | CUR2 | i^2, dissipation value | |
| DMD_CONV_CUR2PHYSICAL | CUR2PHYSICAL | Cur2 using M82:1 | |
| DMD_CONV_CUR2T | CUR2T | i^2*t, integration value | |
| DMD_CONV_CUR2T_V2 | CUR2T_V2 | i^2*t, integration value | |
| DMD_CONV_CUR2TPHYSICAL | CUR2TPHYSICAL | cur2t using M82:1 | |
| DMD_CONV_CURPHYSICAL | CURPHYSICAL | dci factor using M82:1 | |
| DMD_CONV_DAI | DAI | Drive acceleration increment | |
| DMD_CONV_DPI | DPI | Drive position increment | |
| DMD_CONV_DPI2 | DPI2 | Drive position increment (secondary encoder) | |
| DMD_CONV_DPI3 | DPI3 | Drive position increment (auxiliary encoder) | |
| DMD_CONV_DPIPHYSICAL | DPIPHYSICAL | dpi without Mimo conversion (MF500) | Deprecated |
| DMD_CONV_DSI | DSI | Drive speed increment | |
| DMD_CONV_DWORD | DWORD | Double word value without conversion | |
| DMD_CONV_ENCOFF | ENCOFF | 11bit with 2048 offset | Deprecated |
| DMD_CONV_EXP10 | EXP10 | Ten power factor | Deprecated |
| DMD_CONV_FLOAT | FLOAT | Float value | |
| DMD_CONV_FREF_FCTRL | FREF_FCTRL | Force ref of force control (conv 1:1) | |
| DMD_CONV_FTI | FTI | Fast time increment (125us-166us) | |
| DMD_CONV_HSTI | HSTI | Half slow time increment | Deprecated |
| DMD_CONV_INT | INT | Integer value without conversion | |
| DMD_CONV_IP_ADDRESS | IP_ADDRESS | ip address type | |
| DMD_CONV_ISO_POS | ISO_POS | Increment register in ISO (position) (m or t 1:1) | |
| DMD_CONV_K1 | K1 | Position loop proportional gain | |
| DMD_CONV_K10 | K10 | 1st order filter in s. | Deprecated |
| DMD_CONV_K1031 | K1031 | Per cent unit, 100% => 3133 | Deprecated |
| DMD_CONV_K14 | K14 | Dual encoder speed loop output (DSC) | Deprecated |
| DMD_CONV_K2 | K2 | Position loop speed feedback gain | |
| DMD_CONV_K20 | K20 | Position loop speed ffwd gain | |
| DMD_CONV_K20_DSB | K20_DSB | Position loop speed ffwd gain (DSB) | Deprecated |
| DMD_CONV_K21 | K21 | Position loop acceleration ffwd gain | |
| DMD_CONV_K21_DSB | K21_DSB | Position loop acceleration ffwd gain (DSB) | Deprecated |
| DMD_CONV_K23 | K23 | Commutation phase advance factor | |
| DMD_CONV_K23_ACCURET | K23_ACCURET | Back EMF compensation | |

| Values (#define) | Device's unit | Description | Condition |
|---|---|---|---|
| DMD_CONV_K239 | K239 | motor Kt factor in mN(m)/A | |
| DMD_CONV_K4 | K4 | Position loop integrator gain | |
| DMD_CONV_K5 | K5 | Position loop anti-windup gain | |
| DMD_CONV_K75 | K75 | Encoder multiple index distance | |
| DMD_CONV_K8 | K8 | Position loop speed filter (DSC) | Deprecated |
| DMD_CONV_K80 | K80 | cl prop gain delta[1/A] | |
| DMD_CONV_K80_VHP | K80_VHP | cl prop gain delta[V/A] | |
| DMD_CONV_K80_VHPPHYSICAL | K80_VHPPHYSICAL | K80_VHP using M82:1 | |
| DMD_CONV_K80PHYSICAL | K80PHYSICAL | K80 using M82:1 | Deprecated |
| DMD_CONV_K81 | K81 | cl prop integrator delta[1/(A*s)] | |
| DMD_CONV_K81_VHP | K81_VHP | cl prop gain delta[V/(A*s)] | |
| DMD_CONV_K81_VHPPHYSICAL | K81_VHPPHYSICAL | K81_VHP using M82:1 | |
| DMD_CONV_K81PHYSICAL | K81PHYSICAL | K81 using M81:1 | Deprecated |
| DMD_CONV_K82 | K82 | Filter time, T = [cti] * ((2^n)-1) | Deprecated |
| DMD_CONV_K9 | K9 | 1st order filter in pl | Deprecated |
| DMD_CONV_K94 | K94 | Time in 2x current loop increment | Deprecated |
| DMD_CONV_K95 | K95 | Current rate for k95 | Deprecated |
| DMD_CONV_K96 | K96 | Phase rate for k96 | Deprecated |
| DMD_CONV_KDF_FCTRL | KDF_FCTRL | Force loop derivative gain | |
| DMD_CONV_KF22 | KF22 | Jerk feedforward | |
| DMD_CONV_KF256 | KF256 | Kt/M for Init small movement 2 | |
| DMD_CONV_KFLOAT | KFLOAT | Float value for K parameters | |
| DMD_CONV_KIF_FCTRL | KIF_FCTRL | Integrator gain for the force loop | |
| DMD_CONV_KPF_FCTRL | KPF_FCTRL | Force loop proportional gain | |
| DMD_CONV_KT_MOTOR | KT_MOTOR | KT motor | |
| DMD_CONV_LONG | LONG | Long integer value without conversion | |
| DMD_CONV_M16 | M16 | Jerk value | |
| DMD_CONV_M242 | M242 | Quartz frequency in Hz | |
| DMD_CONV_M29 | M29 | Per cent unit, 100% => M229 | |
| DMD_CONV_M82 | M82 | Current limit in 10 mA units | |
| DMD_CONV_MASS_ACC_FFWD | MASS_ACC_FFWD | Mass for acceleration feed forward | Deprecated |
| DMD_CONV_MASS_ACC_FFWD2 | MASS_ACC_FFWD2 | Mass for acceleration feed forward | |
| DMD_CONV_MF89 | MF89 | Magnetic period for Init small movement 2 | |
| DMD_CONV_MLTI | MLTI | Manager loop time increment (mlti) | |
| DMD_CONV_MSEC | MSEC | Milliseconds | |
| DMD_CONV_PER_100 | PER_100 | Per cent unit, 100% => 1.0 | |
| DMD_CONV_PER_1000 | PER_1000 | Per thousand unit | |
| DMD_CONV_PH11 | PH11 | 2^11 = 2048 correspond to 360 degrees | |
| DMD_CONV_PH12 | PH12 | 2^12 = 4096 correspond to 360 degrees | Deprecated |
| DMD_CONV_PH28 | PH28 | 2^28 = 65536*4096 correspond to 360 degrees | Deprecated |
| DMD_CONV_PLTI | PLTI | Position loop time increment (fti) | |
| DMD_CONV_PLTI_INV | PLTI_INV | 1/plti (1/M244) | |
| DMD_CONV_POLE_FREQ | POLE_FREQ | Filter pole frequency in Herz | |
| DMD_CONV_QZTIME | QZTIME | Interrupt time in sec = inc / m242 | |
| DMD_CONV_SEC | SEC | Seconds (1:1) | |
| DMD_CONV_SPEC2F | SPEC2F | Filter time, T = [fti] * ((2^n)-1) | Deprecated |
| DMD_CONV_STI | STI | Slow time increment (500us-2ms) | |
| DMD_CONV_STRING | STRING | Packed string value | |
| DMD_CONV_TEMP | TEMP | 2^0 = 1 correspond to 1.0 | |
| DMD_CONV_TTI | TTI | Minimum time base TransnET (25us) | |
| DMD_CONV_UAI | UAI | Acceleration, user acceleration increment | |

| Values (#define) | Device's unit | Description | Condition |
|---|---|---|---|
| DMD_CONV_UFAI | UFAI | User friendly acceleration increment | |
| DMD_CONV_UFPI | UFPI | User friendly position increment | |
| DMD_CONV_UFSI | UFSI | User friendly speed increment | |
| DMD_CONV_UFTI | UFTI | User friendly time increment | |
| DMD_CONV_UPI | UPI | User position increment | |
| DMD_CONV_UPI2 | UPI2 | User position increment (dual encoder) | |
| DMD_CONV_UPI3 | UPI3 | User position increment (auxiliary encoder) | Deprecated |
| DMD_CONV_USI | USI | User speed increment | |
| DMD_CONV_VOLT | VOLT | 2^0 = 1 correspond to 1.0 | |
| DMD_CONV_VOLT100 | VOLT100 | (2^0)/100 = 1 correspond to 1.0 | |

The specific functions request ISO parameters values. However, in certain cases, the user might be interested in converting increments to ISO or vice-versa. For these cases, EDI provides some functions allowing to convert increments to/from ISO:

```
dsa_convert_int32_to_iso(DSA_DEVICE *dev, double *iso, long inc, int conv);
dsa_convert_int64_to_iso(DSA_DEVICE *dev, double *iso, eint64 inc, int conv);
dsa_convert_float32_to_iso(DSA_DEVICE *dev, double *iso, float inc, int conv);
dsa_convert_float64_to_iso(DSA_DEVICE *dev, double *iso, double inc, int conv);
dsa_convert_int32_from_iso(DSA_DEVICE *dev, long *inc, double iso, int conv);
dsa_convert_int64_from_iso(DSA_DEVICE *dev, eint64 *inc, double iso, int conv);
dsa_convert_float32_from_iso(DSA_DEVICE *dev, float *inc, double iso, int
                             conv);
dsa_convert_float64_from_iso(DSA_DEVICE *dev, double *inc, double iso, int
                             conv);
```

The conv parameter represents the conversion which must be used. The corresponding conversion of a register can be retrieved using:

- the DMD function: `dmd_get_register_convert(DMD *dmd, int typ, unsigned idx, int sidx)`
- the DSA macro: `DSA_REG_CONV(registerTyp, registerIndex, registerSidx);`

Some conversions are not considered as ISO conversion. Then, before calling the conversion function, it is advised to check if the conversion is an ISO conversion using the function `dmd_is_double_conv(int conv)`. Otherwise, calling the conversion function will return a `DSA_EBADPARAM ERROR`.

Here is the list of the conversion functions which are not ISO conversion:

```
DMD_CONV_DWORD
DMD_CONV_BOOL
DMD_CONV_INT
DMD_CONV_LONG
DMD_CONV_STRING
DMD_CONV_FLOAT
DMD_CONV_ADDRESS
```

Almost all ISO conversions can be represented by a single factor. Then, the register increments can easily be converted into ISO using this factor.

The DSA function `dsa_get_inc_to_iso_factor(DSA_DEVICE *dev, int conv, double *factor)` allows to retrieve this factor. However, some ISO conversions **cannot** be represented by a factor. In this case, calling `dsa_get_inc_to_iso_factor` function will return a `DSA_ECONVERT` error.

Here is the list of the ISO conversions which cannot be represented by a factor:

| | |
|---|---|
| `DMD_CONV_KFLOAT` | (K256, K257, K258, k259, k260, k261, K262, k263, k264, K265, K266, K267, K268, MF92, MF93, MF94 |
| `DMD_CONV_POLE_FREQ` | (KF12) |
| `DMD_CONV_EXP10` | (Obsolete) |
| `DMD_CONV_SPEC2F` | (Obsolete) |

| | |
|---|---|
| DMD_CONV_ENCOFF | (Obsolete) |
| DMD_CONV_BIT11P2 | (M43) |
| DMD_CONV_BIT15P2 | (Obsolete) |
| DMD_CONV_K82 | (Obsolete) |

Therefore, for these ISO conversions, the EDI functions "dsa_convert_..._to/from_iso" **must** be used if the user wants to do the conversions from increments to ISO.

To use the #define's values, the 'dmd40.h' file must be included at the beginning of the source file as follows:

```
#include <dmd40.h>
```

The unit of a parameter is then represented by an integer assigned to the 'conv' parameter of the generic functions. This number represents the ID of the unit in question.

To know the unit of a register or the unit of a command's parameter, that is to say the value to give to the 'conv' parameter, three methods are available:

- Check in the "Operation & Software manual" of the device in question, the 'units conversion' chapter. Thanks to the name of the unit given in this chapter and the defines written above, the value of the 'conv' parameter can be found.
- Use the dsa_get_register_...() function. If the 'kind' parameter is assigned to DSA_GET_CONV_FACTOR, this function returns in the 'val' parameter the unit of the register. This method cannot be used to know the unit of a command's parameters.
- Use the DSA_REG_CONV(typ, idx, sidx) macro which is replaced by the unit of the register specified in the parameters. The DSA_CMD_CONV(typ, idx, par) macro allows the same thing for the parameters of the commands. The values given by these macros are different from the #define ones or those given by dsa_get_register_...(). Their use and the result are identical.

## 10.3 System registers

System registers are the registers influencing ISO conversion factors. These registers are read and internally stored by EDI when the communication is opened. The ISO conversion functions will then use these internally stored value to fulfill ISO conversion. If the user modifies the value of a system register, then EDI must be forced to reload the system registers by calling the EDI dsa_reset() function.

Here is the list of system registers:

| Registers | Aliases | Description |
|---|---|---|
| C1 | | Manager mode |
| C8 | | Position loop time interrupt setting |
| C9 | | Manager loop time interrupt setting |
| C490 | | ZxT transfer matrix selection |
| K54 | PPOLE | Motor pair pole number |
| K55 | | Encoder position increment factor |
| K72 | | TTL filter length |
| K76 | | Dual Encoder Feedback mode |
| K77 | | Encoder interpolation shift value |
| K78 | | Regulator type |
| K79 | | Encoder type |
| K88 | | Current regulator mode |
| K89 | | Motor phase number and PWM frequency |
| K118 | | Encoder HSEI input filter |
| K239 | | Motor Kt factor |
| K240 | | Movement type conversion |
| K241 | | Encoder period |
| K242 | | Position multiplication factor |
| K243 | | Position division factor |

| Registers | Aliases | Description |
|---|---|---|
| K522 | | Ufpi multiplication factor |
| K523 | | Ufpi ten power |
| K524 | | Ufsi ten power |
| K525 | | Ufai ten power |
| K526 | | Ufti ten power |
| KF490 | | ZXT Conversion radius |
| KL55 | | Encoder position increment factor |
| M81 | | SAV and Reboot needed for ISO conversion |
| M82 | | Controller max current |
| M229 | | Max value of PWM counter |
| M239 | | Encoder period |
| M240 | | Movement type conversion |
| M241 | | Encoder interpolation factor |
| M242 | | UltimET Light quartz frequency [Hz] |
| M243 | CLTI | Controller current loop time factor |
| M244 | ULTI | UltimET Light interrupt time factor |
| M245 | MLTI | Controller manager loop time factor |
| MF82 | IMAXC | Controller max current |
| MF229 | | Output voltage conversion factor |
| MF500 | | Logical axes MIMO correction factor |
| MF510 | | ZXT FFW mass iso conversion |

# 11 Access to the controller parameters

Access to controller parameters

## 11.1 Sending commands

Some commands do not have a corresponding specific function and it is necessary to use the generic functions to send them to the controller. The user must pay attention to the fact that these functions are for Advanced and non-standard use (e.g. indirect addressing) and could lead to unexpected behavior. For further information, please contact ETEL's Support team.

Each device is able to execute a large number of commands which do all sorts of operations.

Each command has a number and none, one or several parameters. These parameters can belong to one of the following categories:

- Parameters with units: they represent physical quantities such as position, speed, time, etc. They can be given in increments or ISO units. In increments, they are coded in 32-bit or 64-bit integer or float values. In ISO units, they are coded in double precision floating point values.
- Parameters without units: they often represent non-physical quantities such as the axis number, the error number, a digital input/output state, etc... These quantities are coded in 32-bit integers.
- Special parameters: they represent position controller registers. This kind of parameters is not further developed in this "User's Manual".

Here are examples of commands that a position controller is able to execute:

| Command | ETEL syntax | Command number | Parameter number | Parameters type |
|---|---|---|---|---|
| Power on | PWR | 124 | 1 | Without unit |
| Emergency stop | HLO | 119 | 0 | Without unit |
| Set axis number | AXI | 109 | 2 | Without unit |
| Waiting time | WTT | 10 | 1 | With unit (physical quantity) |
| Reset | RSD | 88 | 1 | Without unit |

The DSA library has a set of functions which allows the user to send a command to a device. Among these functions, the user will choose one according to the number and the type of parameters of the command to send.

As commands can have several types of parameters, EDI defines only a subset of generic functions.

Here is the list of the available functions:

| Function which sends the command | Parameters type of the command to send |
|---|---|
| dsa_execute_command_s() | No parameter |
| dsa_execute_command_d_s() | One 32-bit integer parameter |
| dsa_execute_command_i_s() | One ISO parameter |
| dsa_execute_command_dd_s() | Two 32-bit integer parameters |
| dsa_execute_command_id_s() | Two parameters: the first in ISO and the second in 32-bit integer |
| dsa_execute_command_di_s() | Two parameters: the first in 32-bit integer and the second in ISO |
| dsa_execute_command_ii_s() | Two parameters in ISO |
| dsa_execute_command_x_s() | Any number and type of parameters |

If the user wants to send the command number 119 (HLO) to a position controller, the function to use is `dsa_execute_command_s()` as follows:

```
err = dsa_execute_command_s(
   axisX,                    /* grp: destination device */
   119                       /* cmd: number of the command */
   FALSE,                    /* fast: fast command */
```

```
   FALSE,                    /* ereport: report drive errors */
   DSA_DEF_TIMEOUT           /* timeout: by default */
);
```

In the same way, here is an example to send the command number 109 (AXI) with the parameters 1203 and 3:

```
err = dsa_execute_command_dd_s(
   axisX,                    /* grp: destination device */
   109,                      /* cmd: number of the command */
   0,                        /* typ1: type of the first parameter */
   1203,                     /* par1: first parameter */
   0,                        /* typ2: type of the second parameter */
   3,                        /* par2: second parameter */
   FALSE,                    /* fast: fast command */
   FALSE,                    /* ereport: report drive errors */
   DSA_DEF_TIMEOUT           /* timeout: by default */
);
```

Regarding the meaning of the different parameters, the first one is always the `DSA_DRIVE` or `DSA_MASTER` object which represents the device on which the operation will be executed. Among the last parameters, there is the 'timeout' with two other parameters. The remaining parameters depend on the number and the type of the command's parameters to send.

The following table shows all the parameters:

| Parameter | Name | Description |
|---|---|---|
| First parameter | grp | DSA_DRIVE or DSA_MASTER object |
| Parameter dependent on the number and the type of the command's parameters to send | typ | Always equal to 0 which means that the parameter is an immediate value. During the use of commands with special parameters, this parameter can have other values. |
| | par | Value of the parameter. It can be a long or a double type depending on whether the value is given in increments or ISO units. |
| | conv | Type of conversion to do. This parameter is only present when the parameter is used with the value given in ISO unit. See §10.1. |
| Last parameters | fast | Equal to TRUE if the command is fast. The fast commands have priority on the others. Only a few commands can be a fast command. In the majority of cases, this parameter must be equal to FALSE. |
| | ereport | If this parameter is equal to TRUE and the device which the command is sent to is in error, the function returns an error. It is then possible to detect if a device is in error or not. |
| | timeout | Maximum time of execution. |

The parameters of the `dsa_execute_command_x_s()` function are a little bit different. Actually, this function allows the user to send commands whose number of parameters is variable and/or type are different. First, the user must create a `DSA_COMMAND_PARAM` type array with a number of elements corresponding to the number of the command's parameters. Each element in that table must then be assigned with the type, the value and the conversion type of the corresponding parameter. Once the array is created and assigned, the `dsa_execute_command_x_s()` command must be called by passing the pointer and size of this array.

Here is an example where 1025 command (*ILINE=0, 0.28, 0.12, 0, 0) is sent to the UltimET:

```
DSA_COMMAND_PARAM params[ ] = {
   {0,0,0},{0,0,0},{0,0,0},{0,0,0},{0,0,0}
};

params[1].conv = DMD_CONV_UFPI;
params[1].val.d = 0.28;
params[2].conv = DMD_CONV_UFPI;
params[2].val.d = 0.12;

dsa_execute_command_x_s(UltimET, 1025, params, 5,
                        FALSE, FALSE, DSA_DEF_TIMEOUT);
```

Here is an example where command 61 (SMP command) (SMP.0=0, 12000L, 5000L, 0.05) is sent to a controller:

```
SMP.0 = 0, 12000L, 5000L, 0.05 sub-index, position in 64bits integer, speed in
64-bit integer, acc in ISO

DSA_COMMAND_PARAM param[4];
param[0].typ = DMD_TYP_IMMEDIATE_INT32;
param[0].conv = 0;
param[0].val.i = 0;

param[1].typ = DMD_TYP_IMMEDIATE_INT64;
param[1].conv = 0;
param[1].val.i64 = 12000;

param[2].typ = DMD_TYP_IMMEDIATE_INT64;
param[2].conv = 0;
param[2].val.i64 = 5000;

param[3].typ = DMD_TYP_IMMEDIATE_INT64;
param[3].conv = DMD_CONV_UAI;
param[1].val.d = 0.05;

dsa_execute_command_x(drive1, 61, params, 4, FALSE, FALSE, DSA_DEF_TIMEOUT);
```

## 11.2 Reading and writing of controller registers

Each device has several registers' types. The 16 types usually called are:

| Type | Name | Type number |
|---|---|---|
| 32-bits integer Parameters | K0, K1, K2,… | DMD_TYP_PPK_INT32 (2) or DMD_TYP_PPK |
| 32-bits float Parameters | KF0, KF1, KF2,… | DMD_TYP_PPK_FLOAT32 (34) |
| 64-bits integer Parameters | KL0, KL1, KL2,… | DMD_TYP_PPK_INT64 (66) |
| 64-bits float Parameters | KD0, KD1, KD2,… | DMD_TYP_PPK_FLOAT64 (98) |
| 32-bits integer Monitoring | M0, M1, M2,… | DMD_TYP_MONITOR_INT32 (3) or DMD_TYP_MONITOR |
| 32-bits float Monitoring | MF0, MF1, MF2,… | DMD_TYP_MONITOR_FLOAT32 (35) |
| 64-bits integer Monitoring | ML0, ML1, ML2,… | DMD_TYP_MONITOR_INT64 (67) |
| 64-bits float Monitoring | MD0, MD1, MD2,… | DMD_TYP_MONITOR_FLOAT64 (99) |
| 32-bits integer Common | C0, C1, C2,… | DMD_TYP_COMMON_INT32 (13) or DMD_TYP_COMMON |
| 32-bits float Common | CF0, CF1, CF2,… | DMD_TYP_COMMON_FLOAT32 (45) |
| 64-bits integer Common | CL0, CL1, CL2,… | DMD_TYP_COMMON_INT64 (77) |
| 64-bits float Common | CD0, CD1, CD2,… | DMD_TYP_COMMON_FLOAT64 (109) |
| 32-bits integer User | X0, X1, X2,… | DMD_TYP_USER_INT32 (1) or DMD_TYP_USER |
| 32-bits float User | XF0, XF1, XF2,… | DMD_TYP_USER_FLOAT32 (33) |
| 64-bits integer User | XL0, XL1, XL2,… | DMD_TYP_USER_INT64 (65) |
| 64-bits float User | XD0, XD1, XD2,… | DMD_TYP_USER_FLOAT64 (97) |
| 32-bits integer ESM(*) | W0,W1,W2,… | DMD_TYP_ESM_INT32(12) or DMD_TYP_ESM |
| 32-bits float ESM(*) | WF0,WF1,WF2,… | DMD_TYP_ESM_FLOAT32(44) |
| (64-bits integer ESM(*) | WL0,WL1,WL2,… | DMD_TYP_ESM_INT64(76) |
| 64-bits float ESM(*) | WD0,WD1,WD2,… | DMD_TYP_ESM_FLOAT64(108) |
| 32-bits integer ESM Monitor(*) | R0,R1,R2,… | DMD_TYP_ESM_MON_INT32(10) or DMD_TYP_ESM_MON |
| 32-bits float ESM Monitor(*) | RF0,RF1,RF2,… | DMD_TYP_ESM_MON_FLOAT32(42) |
| 64-bits integer ESM Monitor(*) | RL0,RL1,RL2,… | DMD_TYP_ESM_MON_INT64(74) |
| 64-bits float ESM Monitor(*) | RD0,RD1,RD2,… | DMD_TYP_ESM_MON_FLOAT64(106) |

(*) These registers are available on the ULTIMET ADVANCED motion controller with an ESM module. Refer to the "ULTIMET ADVANCED Motion Controller Operation and Software Manual" for further details.

The DSA library has a specific function to read and assign each register widely used. Furthermore, it offers 12 generic functions which are able to assign and read any register:

| Function | Description |
|---|---|
| dsa_get_register_int32_s() | Allows the reading of a integer 32-bits increment value of a register of corresponding increment type |
| dsa_get_register_float32_s() | Allows the reading of a float 32-bits increment value of a register of corresponding increment type |
| dsa_get_register_int64_s() | Allows the reading of a integer 64-bits increment value of a register of corresponding increment type |
| dsa_get_register_float64_s() | Allows the reading of a float 64-bits increment value of a register of corresponding increment type |
| dsa_get_iso_register_s() | Allows the reading of an ISO unit value of any register |
| dsa_set_register_int32_s() | Allows the setting of a integer 32-bits increment value of a register of corresponding increment type |
| dsa_set_register_float32_s() | Allows the setting of a float 32-bits increment value of a register of corresponding increment type |
| dsa_set_register_int64_s() | Allows the setting of a integer 64-bits increment value of a register of corresponding increment type |
| dsa_set_register_float64_s() | Allows the setting of a float 64-bits increment value of a register of corresponding increment type |
| dsa_set_iso_register_s() | Allows the setting of an ISO unit value of any register |

The following example assigns the X2:0 user variable with the value read in the M64:0 monitoring register:

```
long val;
err = dsa_get_register_int32_s(
   axisX,                    /* grp: destination device */
   3,                        /* typ: 3 = M monitoring register */
   64,                       /* idx: register index */
   0,                        /* sidx: register subindex */
   &val,                     /* value: register value */
   DSA_GET_CURRENT,          /* kind: actual device value */
   DSA_DEF_TIMEOUT           /* timeout: default timeout */
   );
err = dsa_set_register_int32_s(
   axisX,                    /* grp: destination device */
   1,                        /* typ: 1 = X user variable */
   2,                        /* idx: register index */
   0,                        /* sidx: register subindex */
   val,                      /* value: register value */
   DSA_DEF_TIMEOUT           /* timeout: default timeout */
   );
```

The following example is similar to the previous one but with ISO quantities. It reads the speed stored in the KL211:0 parameter, multiplies it by 10 and stores it again in the KL211:0 parameter. The KL211:0 parameter is in USI unit.

```
double speed; /* in m/s */
err = dsa_get_iso_register_s(
   axisX,                    /* grp: destination device */
   66,                       /* typ: 66 = KL parameter */
   211,                      /* idx: register index */
   0,                        /* sidx: register subindex */
   &speed,                   /* value: returned value */
   DMD_CONV_USI,             /* conv: drive unit (USI) */
   DSA_GET_CURRENT,          /* kind: actual device value */
   DSA_DEF_TIMEOUT           /* timeout: default timeout */
  );
err = dsa_set_iso_register_s(
   axisX,                    /* grp: destination device */
   66,                       /* typ: 66 = KL parameter */
   211,                      /* idx: register index */
   0,                        /* sidx: register subindex */
   speed * 10.0,             /* value: value to set */
   DMD_CONV_USI,             /* conv: drive unit (USI) */
   DSA_DEF_TIMEOUT           /* timeout: default timeout */
   );
```

## 11.3 Saving and resetting

The values of parameters that have been modified are not automatically save to the controller's flash (non-volatile) memory. This means that if a controller is reset, the parameters revert back to the values actually stored in the flash memory and all modifications are lost. To save the modified parameters to the controller's flash memory, the `dsa_save_parameters_s()` function must be executed (it is the equivalent of the SAV command).

Sending the SAV command to a device will cause it to temporarily loose communication and disappear from the network, just reappear later in error. It is possible that the device itself does not have time to acknowledge the SAV command before the communication is lost. Therefore, for this specific case, it is highly recommended not to verify the error code returned by the `dsa_save_parameters_s()` function, as it might be misleading.

The second parameter corresponds to one of the following constants:

| dsa_save_parameters_s() function 2nd parameter | Description |
|---|---|
| DSA_PARAM_SAVE_ALL | Save all information to the flash memory. |
| DSA_PARAM_SAVE_SEQ_LKT | Save Sequence and user look-up tables to the flash memory. |
| DSA_PARAM_SAVE_X_PARAMS | Save user (X) registers and parameters (K) to the flash memory. |
| DSA_PARAM_SAVE_K_C_E_X_PARAMS(*) | Save K, KL, KF, KD, C, CL, CF, CD, EL, X, XL, XF, XD parameters to flash memory. |
| DSA_PARAM_SAVE_K_PARAMS(*) | Save K, KL, KF, KD parameters to the flash memory. |
| DSA_PARAM_SAVE_C_PARAMS(*) | Save C, CL, CF, CD parameters to the flash memory. |
| DSA_PARAM_SAVE_X_PARAMS(*) | Save X, XL, XF, XD parameters to the flash memory. |
| DSA_PARAM_SAVE_L_PARAMS(*) | Save LD parameters to the flash memory. |
| DSA_PARAM_SAVE_SEQUENCES(*) | Save Sequences to the flash memory. |
| DSA_PARAM_SAVE_K_E_PARAMS(*) | Save K, KL, KF, KD, EL parameters to the flash memory. |
| DSA_PARAMS_SAVE_P_PARAMS(*) | Save P parameters to the flash memory. |
| DSA_PARAMS_SAVE_W_PARAM(**) | Save W parameters to the micro-SD memory. |

(*) Only on the AccurET family.
(**) Only on the ULTIMET ADVANCED with an ESM module.

As mentioned before, the SAV command will cause the device to temporarily disappear from the network and reappear in error. So, before issuing new commands, it is required to wait enough time until the device is present again:

```
{
   /* setup status masks */
      DSA_STATUS status_checkbits   = {sizeof(DSA_STATUS)}
      DSA_STATUS status_checkstates = {sizeof(DSA_STATUS)};

   status_checkbits.drive.present   = 1;
   status_checkstates.drive.present = 1;

   /* wait that the controllers are present */
   if (err = dsa_wait_status_equal_s(axisX, &status_checkbits,
                                     &status_checkstates, NULL, 20000)) {
      DSA_EXT_DIAG(err, axisX);
      goto _error;
   }
}
```

**Remark:** The SAV command takes quite some time to execute, hence the large timeout value for the last parameter of the function `dsa_wait_status_equal_s` in the example above.

For the new values of the modified parameters to be effectively taken into account, the controller must be reset. There is no specific function for the RSD (reset) command, so it must be sent with a generic function:

```
dsa_execute_command_d_s(
   axisX,                    /* grp: destination device */
   DMD_CMD_RESET_DRIVE,      /* cmd: constant number of the RSD command (88) */
   DMD_TYP_IMMEDIATE,        /* typ: the parameter to the command is a value*/
   255,                      /* par: the value always passed to RSD command*/
   FALSE,                    /* fast: 1 or true = fast command */
   FALSE,                    /* ereport: 1 or false do not report drive error */
   10000                     /* timeout: 10 secs */
 )
```

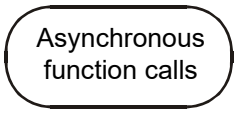
**Remark:** The RSD command also takes quite some time to be executed, hence the large timeout value for the last parameter of the function `dsa_execute_command_d_s` in the example above.

Also, because the controller resets, it does not have the time to send back the acknowledgement that the reset command was received and executed. This is why the call to `dsa_execute_command_d_s()` for the RSD command returns most of the time an error indicating an absence of command acknowledge. As for the SAV command, it is also recommended not to verify the error code returned by the RSD command, as it might be misleading.

The user must pay attention to the fact that if a motion controller is in the group of devices that is reset, the communication and the connection to that device (and hence all controllers downstream) will be lost. In that case, the communication must be re-established. The correct procedure is to first close the communication with all devices and then re-open it as follows:

```
/* Close communication.
* You don't need to destroy the objects; these will be used again when
* reopening the communication
*/
dsa_close(axisX);
dsa_close(axisY);
dsa_close(UltimET);

/* Reopen communication*/
if (err = dsa_open_u(axisX, "etb:UltimET:0")) {
   DSA_EXT_DIAG(err, axisX);
   goto _error;
}
if (err = dsa_open_u(axisY, "etb:UltimET:1")) {
   DSA_EXT_DIAG(err, axisY);
   goto _error;
}
if (err = dsa_open_u(UltimET, "etb:UltimET:*")) {
   DSA_EXT_DIAG(err, UltimET);
   goto _error;
}
```

# 12 Asynchronous function calls




This section illustrates how to use asynchronous functions. Before closing the communication and ending this example, the power will be switched back on once again, but this time asynchronously (which means the program will not at this point wait for the power on to finish). This is done using a similar function as at the beginning, but tending with **_a**. As explained before (refer to §3.4.2), asynchronous functions have the following form:

`operation_name`**`_a`**`(`*`device/group identifier, callback function, callback function user parameters`*`).`

So, in the present case, the call would look like this:

```
if (err = dsa_power_on_a(igrp, callback, (void*)1)) {
  DSA_EXT_DIAG(err, igrp);
  goto _error;
}
```

In the above call, the EDI library will start the power on (PWR.x=1) and return immediately. When the power on command finishes, the EDI library calls the function "callback" that was specified and passes it the value of 1 as user parameter.
The callback function must have the following syntax:

```
void callback(DSA_DEVICE_GROUP *grp, int err, void *param) {
... do something when the command - here "power on" - is finished.
}
```

The first parameter is the usual device or device group identifier.
The second is the error code that was returned by the command that was executed. Here, it is the error code of the "power on" command. Usually the callback function does something different depending on whether there was an error or not. In this example, it prints a different message.

The third parameter is what was specified as the third parameter of the asynchronous function call: "1". Hence, in this example, the callback function looks like this:

```
void callback(DSA_DEVICE_GROUP *grp, int err, void *param)
{
  /* The asynchronous function has terminated with an error */
  if (err) {
    asyncFunctionError = err;
    printf("\n-> callback function called with error %d and parameter %d\n",
    err,(int)(param));
  }
  /* The asynchronous function has terminated without error */
  else {
    asyncFunctionError = 0;
    printf("\n-> callback function called with parameter %d\n",
    (int)(param));
  }
  callbackCalled = 1;
}
```

The callback sets the global variable `asyncFunctionError` as a means to transfer the command error code back to the main program, which can then take the appropriate action. Notice also the last line, which sets a global variable to tell the main program that the function has been called. This is done here to allow displaying "*"s while the callback has not been called as follows:

```
callbackCalled = 0;
if (err = dsa_power_on_a(igrp, callback, (void*)1)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}
while (!callbackCalled) {
   printf("*");
   fflush(stdout);
   Sleep(100);
}
```

Somewhere amongst the "*"s, one of the messages "callback function called with error XXX and parameter 1" or "callback function called with parameter 1" will be displayed, depending on how the power on terminates.
Since there is an asynchronous function for every "normal" one, it is also possible to wait for the end of a movement using an asynchronous function. In the example, this is illustrated with a homing command (IND.x). The homing command is started as usual, but waiting for the end of the associated movement is performed with an asynchronous call:

```
if (err = dsa_homing_start_s(igrp, 10000)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}

/* Initialization of main thread - callback function synchronous variable */
callbackCalled = 0;
if (err = dsa_wait_movement_a(igrp, callback, (void*)2)) {
   DSA_EXT_DIAG(err, igrp);
   goto _error;
}

/* Wait for callback function to be called and finished*/
while (!callbackCalled) {
   printf("*");
   fflush(stdout);
   Sleep(100);
}

if (asyncFunctionError) {
   DSA_EXT_DIAG(asyncFunctionError, igrp);
   goto _error;
}
```

Here amongst the "*"s, one of the messages "callback function called with error XXX and parameter 2" or "callback function called with parameter 2" will be displayed, depending on how the homing terminates. Notice "2" is the difference with the previous message seen for the power on.

Notice also how the error code of the command can be processed as usual error codes using a global variable - `asyncFunctionError`, and the `DSA_EXT_DIAG` function.

# 13 Acquisition

ETEL's controllers can save information of internal registers under specific conditions which a user application can retrieve for the most various purposes. This whole process is known as acquisition and entails 3 actions:

- **Configuration**: the user application must configure which register(s) to acquire, how many samples at which sampling rate and, finally, when/how to start the acquisition (trigger conditions);
- **Acquisition**: once the trigger conditions are met, the controller starts to save the register's information over time up to the defined number of samples and at the defined sampling frequency;
- **Upload**: once all samples have been saved, the data is ready to be uploaded from the controller to the user application.

**Remark:** During an acquisition the controller uses the Trace advanced register type (T register) to store the values of the basic register types K, M, X and C over time. A trace corresponds to a T register containing the values of the register selected for acquisition, sampled at the frequency set by the user and with the acquisition starting from the moment the trigger conditions, also set by the user, are valid. Refer to the "AccurET Modular Position Controller Operation & Software Manual" and the "UltimET Light / ULTIMET ADVANCED Motion Controller User's Manuals" for more information about register types.

ETEL's controllers support two acquisition modes:

- **Normal**: after configuring the acquisition, the user application instructs the controller to start the acquisition, waits for the controller to finish acquiring the data (trigger conditions must be valid and all points saved) and finally uploads the acquisition data. For acquiring more data, a new acquisition must be programmed.
- **Continuous**: for this mode there is no need for configuring the trigger conditions. As soon as the user application instructs the controller to start the acquisition, the data is continuously saved to a circular buffer. The user application must upload the traces fast enough from the controller to avoid overrunning already acquired samples (data loss). A few guidelines are provided in §13.3 for configuring correctly the continuous acquisition to avoid data loss (samples overrun on the circular buffer). In this mode, the acquisition is performed continuously until stopped without the need for reprogramming.

## 13.1 Acquisition synchronization

When configuring a single acquisition for retrieving data from multiple AccurET position controllers connected to the same TransnET bus (slaves), the acquisition is synchronized by the UltimET motion controller (master). It is not possible to realize a single acquisition to retrieve data from multiple AccurET position controllers that are not interconnect through the same TransnET bus. For such case, the user must configure multiple acquisitions, one for each controller. Also, for such case, as each controller has its own time reference because they are not interconnected through the TransnET bus, the acquired data is not synchronized between controllers (the exception being the acquisition on both axes of the same AccurET controller). If an UltimET motion controller is already used to synchronize an acquisition, it is not possible to configure another acquisition using the same UltimET controller as master.

## 13.2 EDI programming: Normal Acquisition

**Remark:** For details about the EDI acquisition functions, please refer to the corresponding HTML documentation included in the EDI package.

### 13.2.1 Creating an acquisition

EDI provides the `DSA_ACQUISITION` object which the user must use for programming an acquisition. When creating this object, the user specifies which devices take part of the acquisition, namely:

- Devices which will acquire data;
- Devices which will act as trigger;
- Devices which will synchronize the acquisition (e.g. UltimET motion controller).

The EDI function for creating an acquisition object uses dynamic memory allocation. The continuous usage of dynamic memory allocation is not recommended because of memory fragmentation and performance degradation, in particular for real-time applications. Thus, it is recommended to create the acquisition objects

altogether when starting the application and destroy them just before exiting the application.

```
int dsa_create_acquisition(DSA_ACQUISITION **acq, DSA_DEVICE_BASE *dev)
```

### 13.2.2 Reserving an acquisition

An acquisition object must be reserved before it can be used. It is at this particular moment that EDI actually verifies if every device specified at object creation is not already taking part on another reserved acquisition. From a programming point of view, realizing this check earlier when creating the acquisition object would be too constraining considering the recommendation for creating acquisition objects altogether at application startup. With this mechanism of reservation, a user can create all the acquisition objects as recommended and reserve them in a need to use basis.

```
int dsa_acquisition_reserve(DSA_ACQUISITION *acq)
```

### 13.2.3 Configuring an acquisition

Once created and reserved, the acquisition object can be configured by specifying:

1. Which device registers must be acquired:
```
int dsa_acquisition_config_trace(DSA_ACQUISITION *acq, DSA_DEVICE_BASE *dev,
                                 int trace_idx, int typ, int idx, int sidx)
```

2. Which device and event act as a trigger:
```
int dsa_acquisition_config_immediate_trigger(DSA_ACQUISITION *acq,
                                             DSA_DEVICE_BASE *dev)

int dsa_acquisition_config_begin_of_movement_trigger(DSA_ACQUISITION *acq,
                                                     DSA_DEVICE_BASE *dev,
                                                     int ipol_grp, double delay)

int dsa_acquisition_config_end_of_movement_trigger(DSA_ACQUISITION *acq,
                                                   DSA_DEVICE_BASE *dev,
                                                   int ipol_grp, double delay)

int dsa_acquisition_config_position_trigger(DSA_ACQUISITION *acq,
                                            DSA_DEVICE_BASE dev,
                                            int edge, double position,
                                            int conv, double delay)

int dsa_acquisition_config_position_int64_trigger(DSA_ACQUISITION *acq,
                                                  DSA_DEVICE_BASE *dev,
                                                  int edge, eint64 inc_position,
                                                  double delay)

int dsa_acquisition_config_trace_idx_trigger(DSA_ACQUISITION *acq,
                                             DSA_DEVICE_BASE *dev,
                                             int edge, int trace_idx,
                                             double value,
                                             int conv, double delay)

int dsa_acquisition_config_trace_idx_int32_trigger(DSA_ACQUISITION *acq,
                                                   DSA_DEVICE_BASE *dev,
                                                   int edge, int trace_idx,
                                                   int value, double delay)
int dsa_acquisition_config_trace_idx_int64_trigger(DSA_ACQUISITION *acq,
                                                   DSA_DEVICE_BASE *dev,
                                                   int edge, int trace_idx,
```

```
                                                    eint64 inc_value, double delay)
int dsa_acquisition_config_trace_idx_float32_trigger(DSA_ACQUISITION *acq,
                                                     DSA_DEVICE_BASE *dev,
                                                     int edge, int trace_idx,
                                                     float inc_value,
                                                     double delay)

int dsa_acquisition_config_trace_idx_float64_trigger(DSA_ACQUISITION *acq,
                                                     DSA_DEVICE_BASE *dev,
                                                     int edge,
                                                     int trace_idx,
                                                     double inc_value,
                                                     double delay)

int dsa_acquisition_config_register_trigger(DSA_ACQUISITION *acq,
                                            DSA_DEVICE_BASE *dev,
                                            int edge, int typ, int idx, int sidx,
                                            double value, int conv, double delay)

int dsa_acquisition_config_register_int32_trigger(DSA_ACQUISITION *acq,
                                                  DSA_DEVICE_BASE *dev,
                                                  int edge, int typ, int idx,
                                                  int sidx, int inc_value,
                                                  double delay)

int dsa_acquisition_config_register_int64_trigger(DSA_ACQUISITION *acq,
                                                  DSA_DEVICE_BASE *dev,
                                                  int edge, int typ, int idx,
                                                  int sidx, eint64 inc_value,
                                                  double delay)

int dsa_acquisition_config_register_float32_trigger(DSA_ACQUISITION *acq,
                                                    DSA_DEVICE_BASE *dev,
                                                    int edge,
                                                    int typ, int idx, int sidx,
                                                    float inc_value,
                                                    double delay)

int dsa_acquisition_config_register_float64_trigger(DSA_ACQUISITION *acq,
                                                    DSA_DEVICE_BASE *dev,
                                                    int edge,int typ, int idx,
                                                    int sidx,
                                                    double inc_value,
                                                    double delay)

int dsa_acquisition_config_int32_bit_field_state_trigger(DSA_ACQUISITION *acq,
                                                         DSA_DEVICE_BASE *dev,
                                                         int typ, int idx,
                                                         int sidx,
                                                         dword low_state_mask,
                                                         dword high_state_mask,
                                                         double delay)

int dsa_acquisition_config_int64_bit_field_state_trigger(DSA_ACQUISITION *acq,
                                                         DSA_DEVICE_BASE *dev,
                                                         int typ, int idx,
                                                         int sidx,
```

```
                                                    eint64 low_state_mask,
                                                    eint64 high_state_mask,
                                                    double delay)

  int dsa_acquisition_config_int32_bit_field_change_trigger(DSA_ACQUISITION *acq,
                                                     DSA_DEVICE_BASE *dev,
                                                     int typ, int idx,
                                                     int sidx,
                                                     dword rising_edge_mask,
                                                     dword falling_edge_mask,
                                                     double delay)

int dsa_acquisition_config_int64_bit_field_change_trigger(DSA_ACQUISITION *acq,
                                                    DSA_DEVICE_BASE *dev,
                                                    int typ, int idx,
                                                    int sidx,
                                                    eint64 rising_edge_mask,
                                                    eint64 falling_edge_mask,
                                                    double delay)
```

3. How many acquisition points, which sampling frequency or acquisition duration:

```
  int dsa_acquisition_config_with_nb_points_and_total_time(DSA_ACQUISITION *acq,
                                                     int nb_points,
                                                     double total_time,
                                                     int synchro_mode)

  int dsa_acquisition_config_with_nb_points_and_sampling_time(DSA_ACQUISITION*acq,
                                                     int nb_points,
                                                     double sampling_time,
                                                     int synchro_mode)

  int dsa_acquisition_config_with_sampling_time_and_total_time(DSA_ACQUISITION *acq,
                                                     double sampling_time,
                                                     double total_time,
                                                     int synchro_mode)
```

The `synchro_mode` argument in the above functions plays an important role on the definition of the acquisition, as it defines which adjustments EDI introduces to the acquisition configuration concerning the sampling frequency and acquisition duration. It is important to note that:

- In an AccurET position controller, the sampling frequency can be 20 kHz or 2.5 kHz depending on the register;
- In the UltimET motion controller, the sampling frequency is 10 kHz.

The options available for the `synchro_mode` argument are:

- `DSA_ACQUISITION_SYNCHRO_MODE_NONE`

EDI freezes the number of acquisition points specified.

(for the EDI function `dsa_acquisition_config_with_sampling_time_and_total_time` the number of points is obtained using the formula `total_time / sampling_time`).

EDI first computes the possible sampling frequency given the type of data to acquire and device:

| AccurET | | UltimET | Highest sampling rate |
|---|---|---|---|
| # traces @ 20 kHz | # traces @ 2.5 kHz | # traces @ 10 kHz | |
| ≥ 1 | X | 0 | 20 kHz |
| X | X | ≥ 1 | 10 kHz |
| 0 | All | 0 | 2.5 kHz |

X: no matter

The final sampling frequency is computed to obtain a multiple of this highest value which best fits the specified sampling time. The acquisition duration is then re-computed using this frequency and the specified number of acquisition points.

- `DSA_ACQUISITION_SYNCHRO_MODE_COMMON_STI`

EDI freezes the number of acquisition points specified.

(for the EDI function `dsa_acquisition_config_with_sampling_time_and_total_time` the number of points is obtained by using the formula `total_time / sampling_time`).

EDI first computes the lowest possible sampling frequency given the type of data to acquire and device:

| AccurET | | UltimET | Lowest sampling rate |
|---|---|---|---|
| # traces @ 20 kHz | # traces @ 2.5 kHz | # traces @ 10 kHz | |
| All | 0 | 0 | 20 kHz |
| 0 | 0 | All | 10 kHz |
| All | 0 | ≥ 1 | 10 kHz |
| X | ≥ 1 | X | 2.5 kHz |

X: no matter

The final sampling frequency is computed to obtain a multiple of this lowest value which best fits the specified sampling time. The acquisition duration is then re-computed using this frequency and the specified number of acquisition points.

- `DSA_ACQUISITION_SYNCHRO_MODE_MIN_STI`

EDI freezes the number of acquisition points specified.

(for the EDI function `dsa_acquisition_config_with_sampling_time_and_total_time` the number of points is obtained by using the formula `total_time / sampling_time`).

In this specific case, EDI ignores the other arguments. It simply computes the highest possible sampling frequency given the type of data to acquire and device:

| AccurET | | UltimET | Highest sampling rate |
|---|---|---|---|
| # traces @ 20 kHz | # traces @ 2.5 kHz | # traces @ 10 kHz | |
| ≥ 1 | X | X | 20 kHz |
| 0 | X | ≥ 1 | 10 kHz |
| 0 | All | 0 | 2.5 kHz |

X: no matter

And, the acquisition duration is then computed using this highest sampling frequency.

### 13.2.4 Initiating an acquisition

It is now the moment to start the acquisition. Once an acquisition has started, the device(s) specified for acquiring data will wait until the trigger conditions on the trigger device are valid before saving the data. When the trigger conditions are met, the device(s) starts to save the data. The user application should wait until the device(s) have finished saving all the data before uploading. Therefore, EDI provides two methods for initiating an acquisition:

- Synchronous method

The EDI function is blocked until the devices have finished saving the data (or a specified timeout has elapsed).

```
int dsa_acquisition_acquire_s(DSA_ACQUISITION *acq, int timeout)
```

- Asynchronous method

The EDI function returns immediately without waiting, while allowing to specify a user callback which will be called when the device(s) have finished saving the data. On the Windows operating system, it is possible to set up to 5 simultaneous asynchronous acquisitions.

```
int dsa_acquisition_acquire_a(DSA_ACQUISITION *acq, DSA_HANDLER handler,
                              void *param)
```

### 13.2.5 Verifying an acquisition frequency parameters computed by EDI

Before uploading the data, it might be interesting to check the actual number of acquired points, acquisition duration and sampling frequency used. Indeed, as explained before, the acquisition frequency parameters can be adjusted by EDI in the case the user specifies settings that are not actually feasible. The following functions can be used to retrieve the acquisition frequency parameters used for the acquisition.

```
int dsa_acquisition_get_real_total_time(DSA_ACQUISITION *acq,
                                        double *real_total_time)

int dsa_acquisition_get_real_nb_points(DSA_ACQUISITION *acq, int
                                       *real_nb_points)

int dsa_acquisition_get_real_sampling_time(DSA_ACQUISITION *acq,
                                           double *real_sampling_time)

dsa_acquisition_get_trace_real_nb_points(DSA_ACQUISITION *acq, DSA_DEVICE
                                         *dev,int trace_idx, int
                                         *real_nb_points)
```

### 13.2.6 Uploading acquired points

Once the data has been saved, the user can perform the upload in ISO or increments units.

```
int dsa_acquisition_upload_trace(DSA_ACQUISITION *acq, DSA_DEVICE *dev,
                                 int trace_idx, int table_size, double
times[],double traces[], int conv)

int dsa_acquisition_upload_int32_trace(DSA_ACQUISITION *acq, DSA_DEVICE *dev,
                                       int trace_idx, int table_size,
                                       double times[], int traces[])

int dsa_acquisition_upload_int64_trace(DSA_ACQUISITION *acq, DSA_DEVICE *dev,
                                       int trace_idx, int table_size,
                                       double times[], eint64 traces[])

int dsa_acquisition_upload_float32_trace(DSA_ACQUISITION *acq, DSA_DEVICE
                                         *dev,int trace_idx, int table_size,
                                         double times[], float traces[])

int dsa_acquisition_upload_float64_trace(DSA_ACQUISITION *acq, DSA_DEVICE
                                         *dev,int trace_idx, int table_size,
                                         double times[], double traces[])
```

### 13.2.7 Un-reserving an acquisition

Once the uploading is completed, the user can un-reserve the acquisition object. Although not mandatory, it is recommended to do so when several acquisition objects have been created, so that another acquisition object can be reserved, configured and used without conflicts.

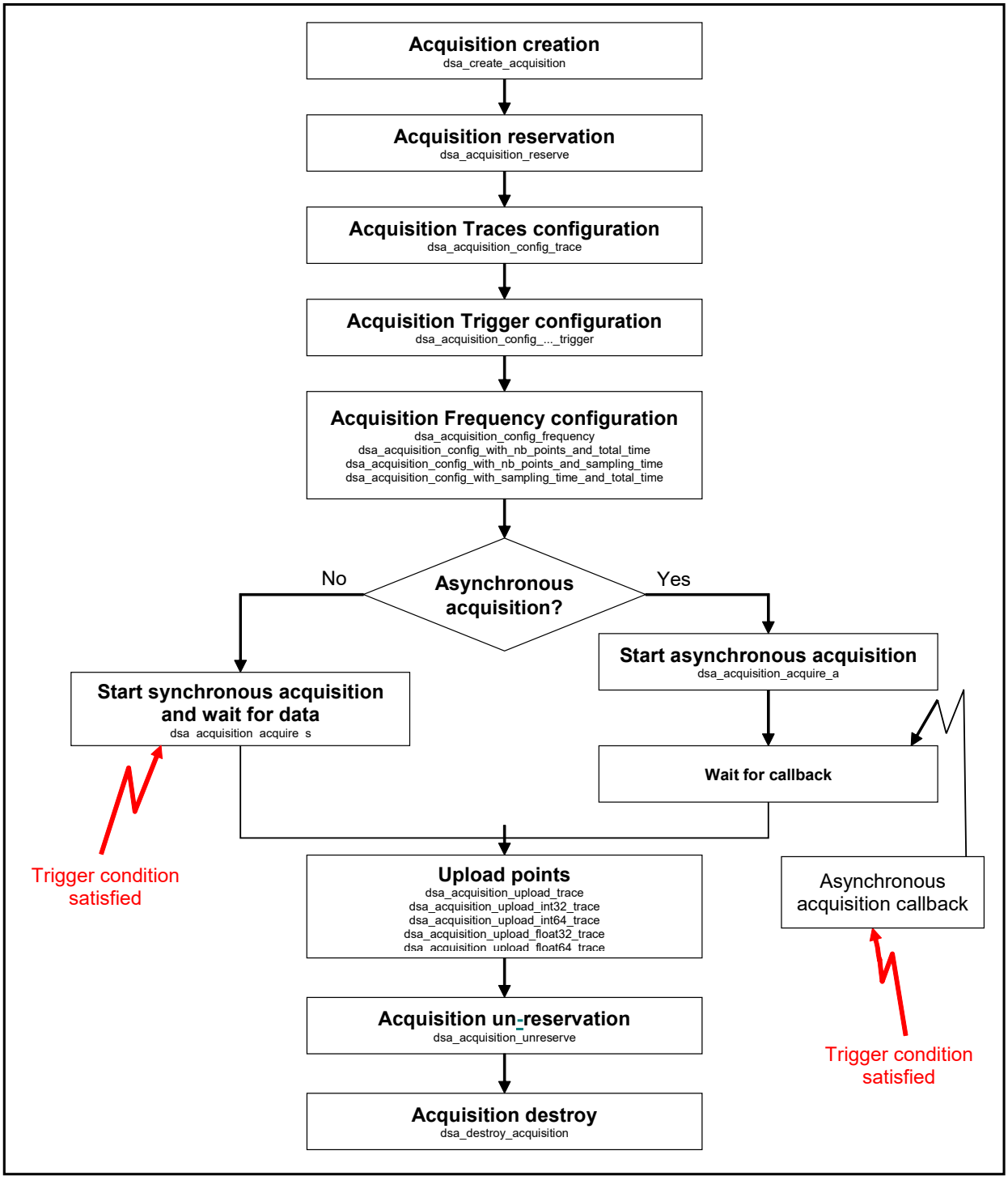
```
int dsa_acquisition_unreserve(DSA_ACQUISITION *acq)
```

### 13.2.8 Destroying an acquisition object

Finally, the acquisition object can be destroyed if the user application does not need it anymore. Be aware that this will free the dynamically allocated memory. If creation and destruction of acquisition objects is done continuously, it will create memory fragmentation.

```
int dsa_destroy_acquisition(DSA_ACQUISITION **acq)
```

A programming example of a normal acquisition is provided with the EDI package. Here is a flowchart depicting the normal acquisition process.



## 13.3 EDI programming: Continuous Acquisition

For this acquisition mode, creating and configuring traces is done using the same EDI functions as for the normal acquisition mode. The main difference is that this acquisition mode is not associated to a trigger. Therefore, the acquisition will start as soon as the start function is executed.

### 13.3.1 Creating an acquisition

The same object as for normal acquisition (`DSA_ACQUISITION`) can be used. Again, when creating this object, the user specifies which devices take part of the acquisition, namely:

- Devices which will acquire data;
- Devices which will synchronize the acquisition (e.g. UltimET motion controller).

The EDI function for creating an acquisition object uses dynamic memory allocation. The continuous usage of dynamic memory allocation is not recommended because of memory fragmentation and performance degradation, in particular for real-time applications. Thus, it is recommended to create the acquisition objects altogether when starting the application and destroy them just before exiting the application.

```
int dsa_create_acquisition(DSA_ACQUISITION **acq, DSA_DEVICE_BASE *dev)
```

### 13.3.2 Reserving an acquisition

An acquisition object must be reserved before it can be used. It is at this particular moment that EDI actually verifies if every device specified at object creation is not already taking part on another reserved acquisition. From a programming point of view, realizing this check earlier when creating the acquisition object would be too constraining considering the recommendation for creating acquisition objects altogether at application startup. With this mechanism of reservation, a user can create all the acquisition objects as recommended and reserve them in a need to use basis.

```
int dsa_acquisition_reserve(DSA_ACQUISITION *acq)
```

### 13.3.3 Configuring an acquisition

Once created and reserved, the acquisition object can be configured by specifying:

1. Which device registers must be acquired.

```
int dsa_acquisition_config_trace(DSA_ACQUISITION *acq, DSA_DEVICE_BASE *dev,
                                 int trace_idx, int typint idx, int sidx)
```

2. Size of the device's circular buffer and the acquisition sampling time

By default, the circular buffer's size is set to the maximum corresponding to 16384 acquisition points.

```
int dsa_acquisition_continuous_config(DSA_ACQUISITION *acq,
                                      int rolling_buffer_size,
                                      double sampling_time)
```

### 13.3.4 Initiating an acquisition

It is now the moment to start the continuous acquisition.

```
int dsa_acquisition_continuous_acquire(DSA_ACQUISITION *acq)
```

This function just starts the continuous acquisition and exits immediately.

### 13.3.5 Waiting for acquisition points

As mentioned before, as soon as the user application initiates an acquisition, the data is continuously saved to a circular buffer. On the one hand, the user application must wait until enough points have been saved before initiating the upload. On the other hand, the user application must upload the traces fast enough to avoid overrunning already acquired samples (data loss).

There are two methods available for waiting for available points:

- **Polling method**

The user polls the device for the number of points already acquired and when sufficient data is available, starts the uploading. The following function returns the number of available points:

```
int dsa_acquisition_continuous_get_nb_available_values(DSA_ACQUISITION *acq,
                                                       int *nb_data)
```

- **Waiting method**

EDI provides functions for waiting until the specified number of points has been stored in the circular buffer:

```
int dsa_acquisition_continuous_wait_available_values_s(DSA_ACQUISITION *acq,
                                                       int nb_available_values,
                                                       long timeout)

int dsa_acquisition_continuous_wait_available_values_a(DSA_ACQUISITION *acq,
                                                       int nb_available_values,
                                                       DSA_HANDLER handler,
                                                       void *param)
```

### 13.3.6 Uploading acquired points

Once data is available, the user application can upload the points using one of the following functions. Note that it is mandatory to upload the same number of points as it was specified in the waiting functions described before. Furthermore, the size of the arrays provided to the must sufficient to store the uploaded points.

```
int dsa_acquisition_continuous_upload_int32_trace(DSA_ACQUISITION *acq,
                                                  DSA_DEVICE *dev, int trace_idx,
                                                  Int nb_available_values,
                                                  double times[], int traces[])

int dsa_acquisition_continuous_upload_int64_trace(DSA_ACQUISITION *acq,
                                                  DSA_DEVICE *dev, int trace_idx,
                                                  int nb_available_values,
                                                  double times[], eint64
traces[])

int dsa_acquisition_continuous_upload_float32_trace(DSA_ACQUISITION *acq,
                                                    DSA_DEVICE *dev, int trace_idx,
                                                    int nb_available_values,
                                                    double times[],float traces[])

int dsa_acquisition_continuous_upload_float64_trace(DSA_ACQUISITION *acq,
                                                    DSA_DEVICE *dev,
                                                    int trace_idx,
                                                    int nb_available_values,
                                                    double times[],
                                                    double traces[])
```

```
int dsa_acquisition_continuous_upload_trace(DSA_ACQUISITION *acq, DSA_DEVICE *dev,
                                            int trace_idx,
                                            int nb_available_values,
                                            double times[], double traces[],
                                            int conv)
```

### 13.3.7 Checking integrity of the uploaded data

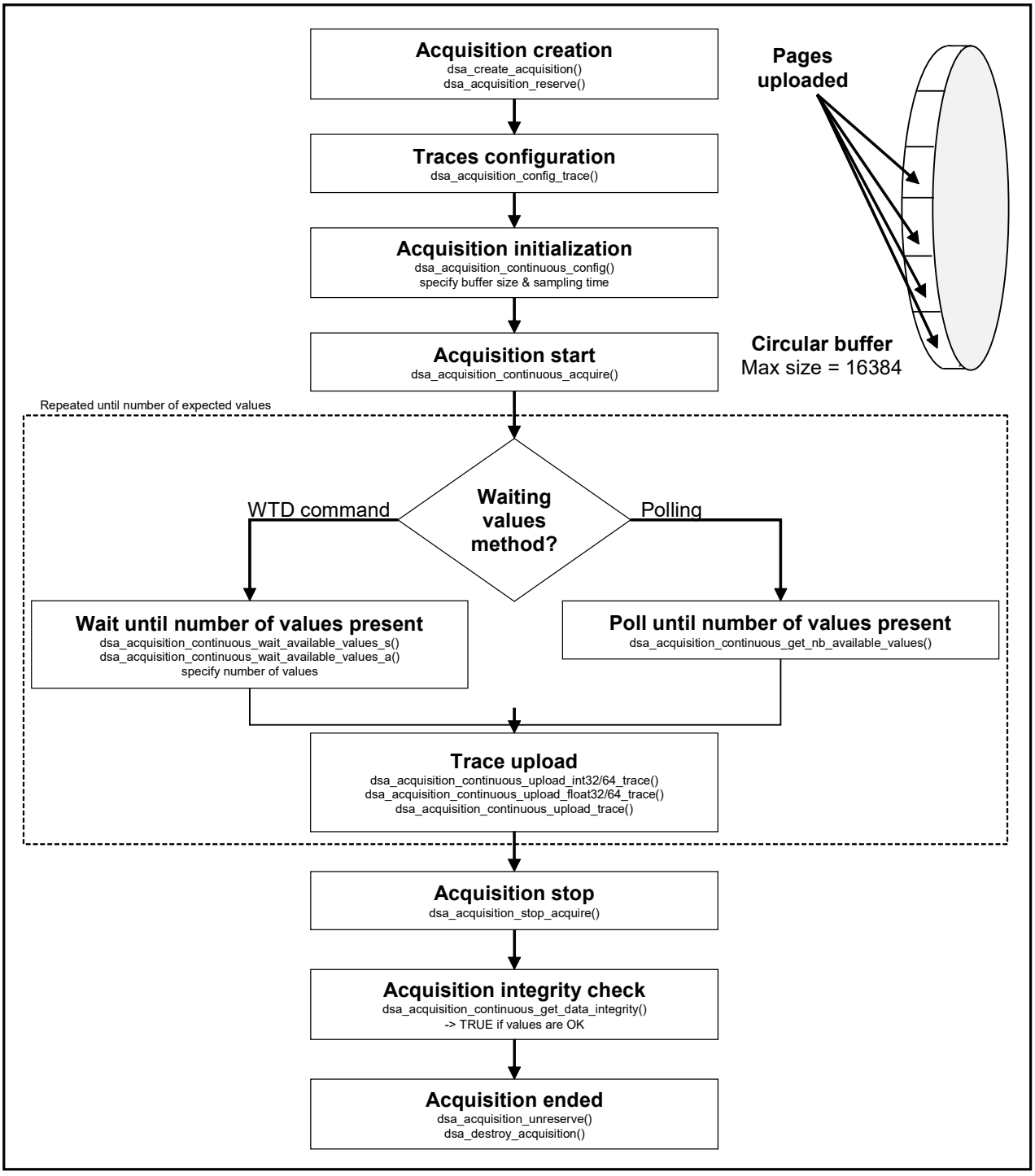
If the user application is not sufficiently fast to upload the traces from the controller, it could occur that newer samples overwrite older samples in the circular buffer, corresponding effectively to data loss. The user can verify the data integrity with the following function:

```
int dsa_acquisition_continuous_get_data_integrity(DSA_ACQUISITION *acq,
                                                  ebool *integrity_guaranteed)
```

The next section will provide guidelines for configuring correctly the continuous acquisition to avoid data loss (samples overrun on the circular buffer).

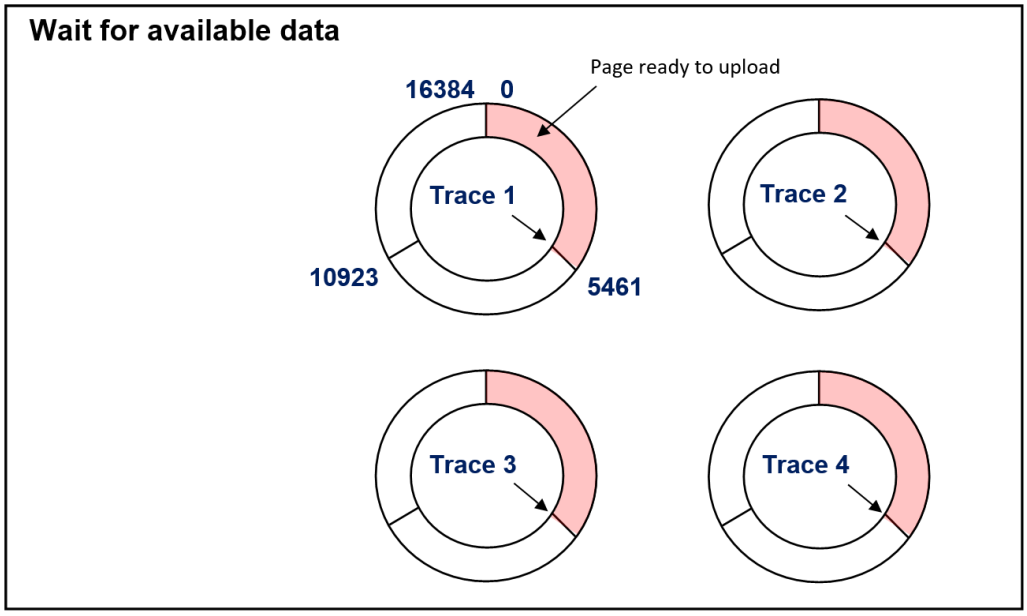
### 13.3.8 Guidelines for configuring a continuous acquisition

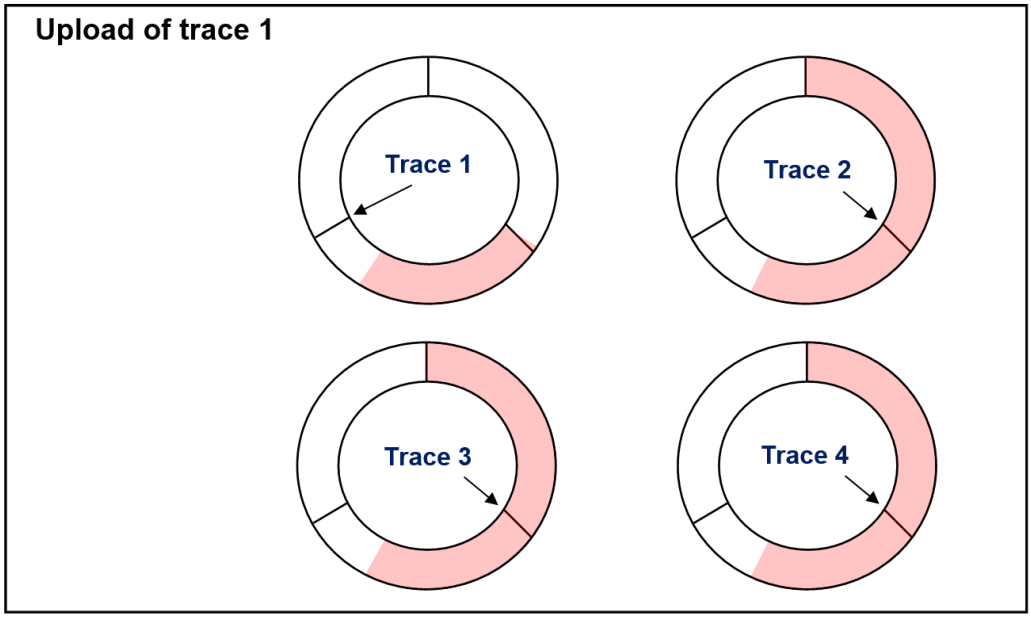
The flowchart below depicts the continuous acquisition process:

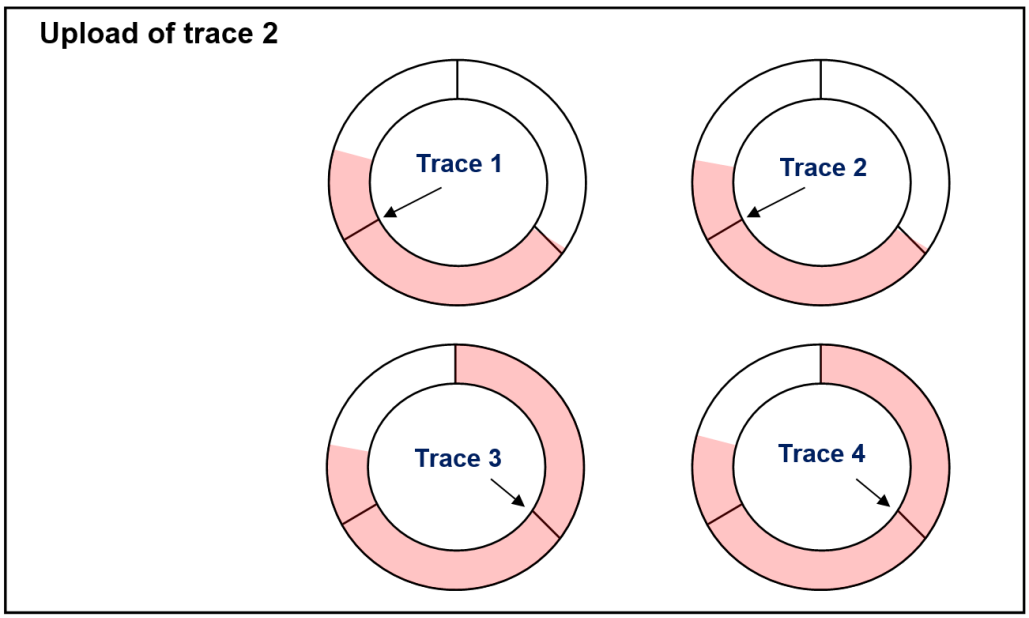


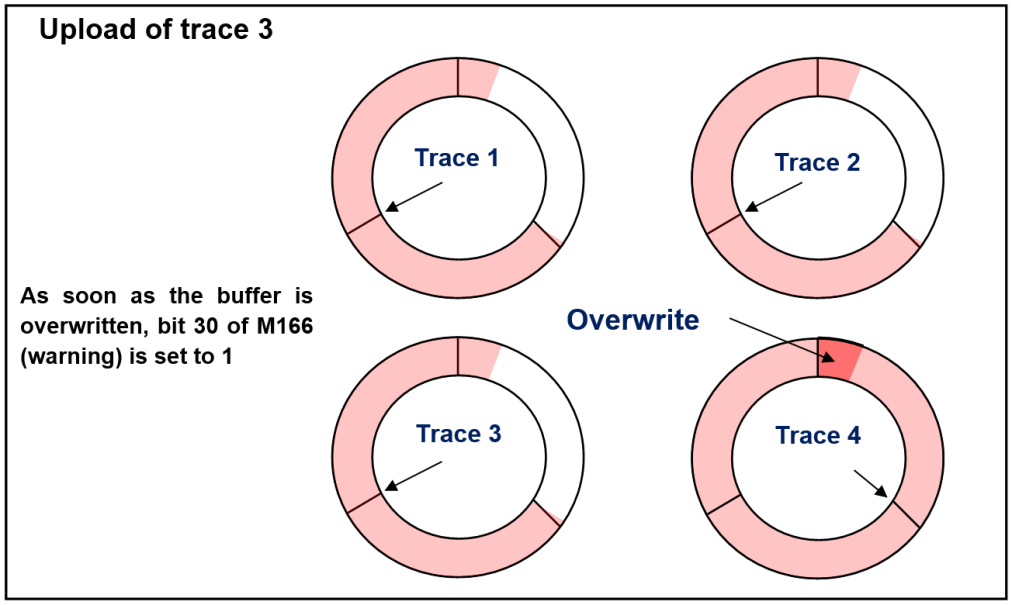

The critical aspect of a continuous acquisition is to find the correct configuration to avoid the overwriting of data in the circular buffer.

Example of an upload not sufficiently fast:
- 4 traces (i.e. 4 circular buffers).
- Maximum buffer size (= 16384 points).
- Waiting for 1/3 of the buffer's size for available data.


Wait for available data
Page ready to upload
16384
0
10923
5461
Trace 1
Trace 2
Trace 3
Trace 4


Upload of trace 1
Trace 1
Trace 2
Trace 3
Trace 4


Upload of trace 2
Trace 1
Trace 2
Trace 3
Trace 4



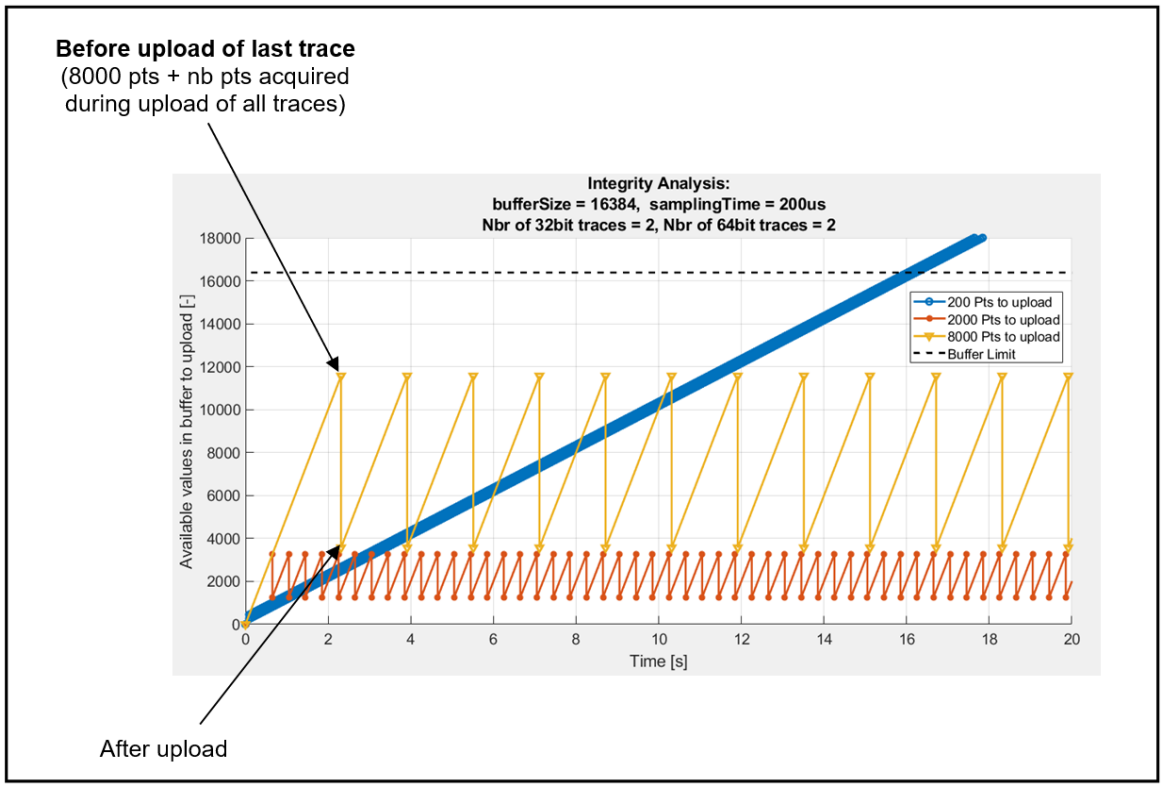

### *13.3.8.1 Theoretical analysis*

The following factors impact the behavior of the continuous acquisition:

1. Hardware and software configuration (PC and Operating System performance, in particular for the upload time and the storage media used for storing the uploaded data).
2. Number of traces.
3. Buffer size (usually it is set to its maximum of 16384 points).
4. Sampling time.
5. Number of points to wait for before uploading (NBPU).

Usually, the requirements of the application determine the three first factors. The only factors the user can tweak are the **sampling time** and **NBPU**. Therefore, the goal of the tuning is to determine the best values for these settings.

The following graph shows the theoretical behavior of a system with a fixed sampling time and different NPBU.



#### *13.3.8.2 Tuning guidelines*

Follow these guidelines to configure a continuous acquisition:

1. Define the Hardware/Software configuration (PC type, Operating System…).
2. Define the device(s) registers which must be acquired.
3. Define if a continuous acquisition is really necessary or if it can be replaced by a "long" normal acquisition.
4. Define the maximum allowed acquisition sampling time. The longer the sampling time, more time will the application have to upload the traces.
5. Measure the time the application needs to upload and save all traces of n points ((NBPU). Build a graph for different values of n.
6. Define a sampling time and a NPBU which best respects the following rule:
   **Time to upload and save all traces of NBPU points each < sampling time * NBPU**
7. Validate the configuration with the final real using EDI continuous acquisition functions.

**Remark:** If following these guidelines it is not possible to find a configuration for the continuous acquisition, the requirements of the application must be revised (refer to points 1. and 2. of the above listing).

# 14 Real-time applications

Some EDI-based applications need to comply with strict timing requirements. For addressing such use cases, EDI includes support for the RTX real-time operating system. Refer to §2.2 for information about the supported operating systems.
To efficiently execute an EDI-based program on RTX it is necessary to setup a specific RTX subsystem. The next section explains how to configure RTX for obtaining the best real-time performances.

However, it is wrong to assume that running such programs on a real-time operating system is for itself sufficient for achieving the level of performance required by certain applications, particularly if the timing requirements are extremely tight (measured in the microsecond scale). Indeed, in such cases the architecture of the software plays an equally important role and cannot be disregarded. This chapter provides a few useful guidelines on how to design a real-time program based on EDI.

Finally, this chapter concludes with a programming example of an EDI-based real-time application.

**Remark:** The PCIe interface of the ULTIMET ADVANCED motion controller is not supported on the RTX operating system.

## 14.1 RTX subsystem configuration

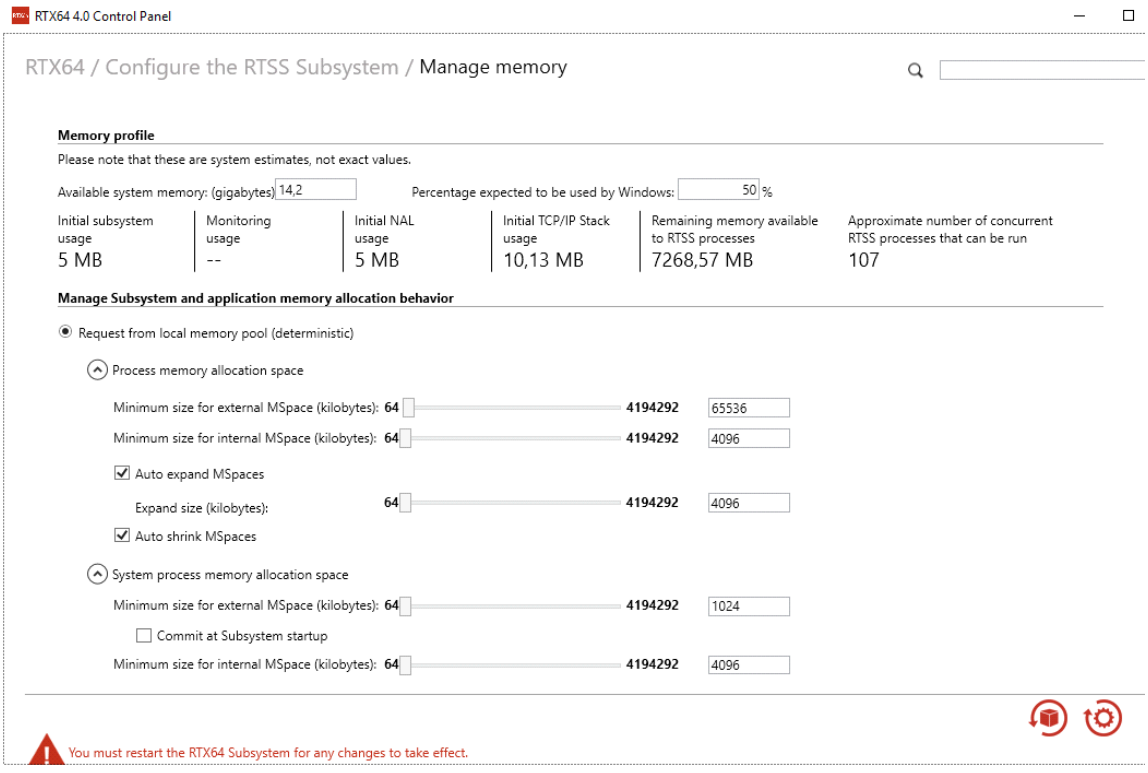
Except for the changes described next, the RTX subsystem default configuration can be used.

### 14.1.1 Memory Allocation Behavior

It is recommended to configure carefully the memory allocation behavior. Check RTX documentation about memory configuration. A balance must be found between the number of RTSS processes and the available memory. When using EDI, at least 256MB should be reserved for external MSSpace.

- Select the option **Request from local memory pool** (deterministic);
- Set the **Local memory pool size (kilobytes)** to 65536;
- Select the option Auto expand and set the Expand size (kilobytes) to 1024;
- Select the option Auto Shrink.

The figure below depicts such settings.

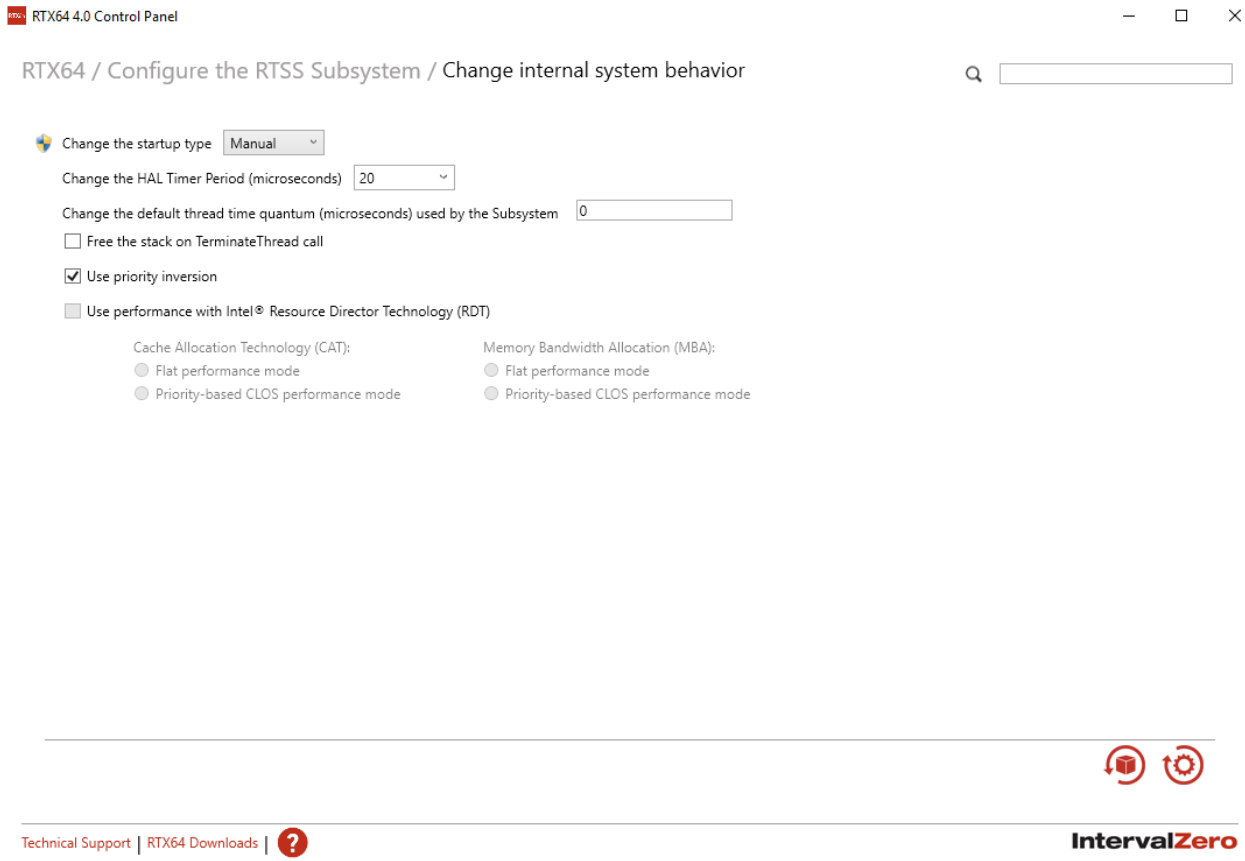



With this setting, the dynamic allocation of memory uses RTX's internal memory pool which is requisitioned from Windows at startup. This renders the creation of EDI objects much faster.

### 14.1.2 Internal System Behavior

It is recommended to configure the internal system behavior as follows:

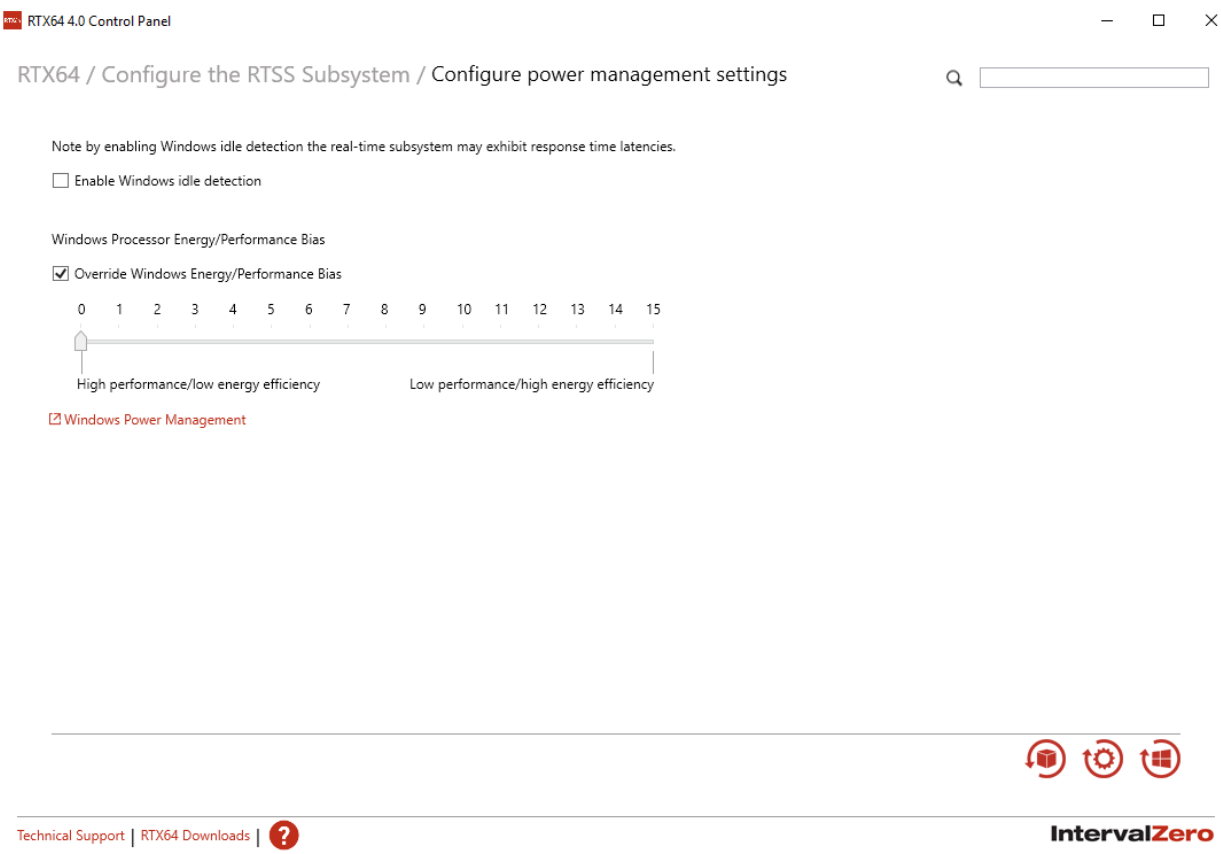
- Select the **Manual** option from the **Change the startup type** drop-down list;
- **Change the HAL timer Period (microseconds)** to 20 (IntervalZero recommends this value for applications that need to be very responsive to interrupts);
- **Change the default thread quantum (microseconds) used by the Subsystem** to 0 (zero);
- Unselect the option **Free the stack on TerminateThread call**;
- Select the option **Use priority inversion**.




### 14.1.3 Power management

It is recommended to configure the power management as follows:

- Select the Override Windows Energy/Performance Bias;
- Place the slide completely to the left (High performance/low energy efficiency)




## 14.2 RTX application

Before designing a real-time application, it is important to identify the different tasks it should realize and categorize these according to the following notions.

### 14.2.1 Non-real time

When the reaction time of the application (or task) to events is not critical and does not impact the proper execution of the process for which the machine is intended.

### 14.2.2 Real-time

An application (or task) that works in real-time can still afford execution latencies and non-determinism without jeopardizing system operation, eventually just degrading it marginally. The latencies experienced are usually in the range of a few hundreds of microsecond up to a few milliseconds.

### 14.2.3 Hard real-time

A hard real-time application (or task) must really comply with the timing execution requirements otherwise the system fails to operate. Tasks are typically executed cyclically at 10 kHz, with acceptable latencies up to a few tenths of microsecond.

A classic example of a hard real-time application is one where the trajectory generation is not done at the Controller level; instead it is the host PC that computes the trajectory setpoints for performing application specific motion profiles. The successive position setpoints composing the trajectory are then transmitted to the Controller(s) in a timely manner (typically one setpoint every 100 µs) to achieve the desired dynamic motion. Missing a setpoint or delaying it too much degrades the trajectory accuracy, possibly even triggering a tracking error on the Controller(s).

#### 14.2.3.1 Cyclic interrupt user callback function

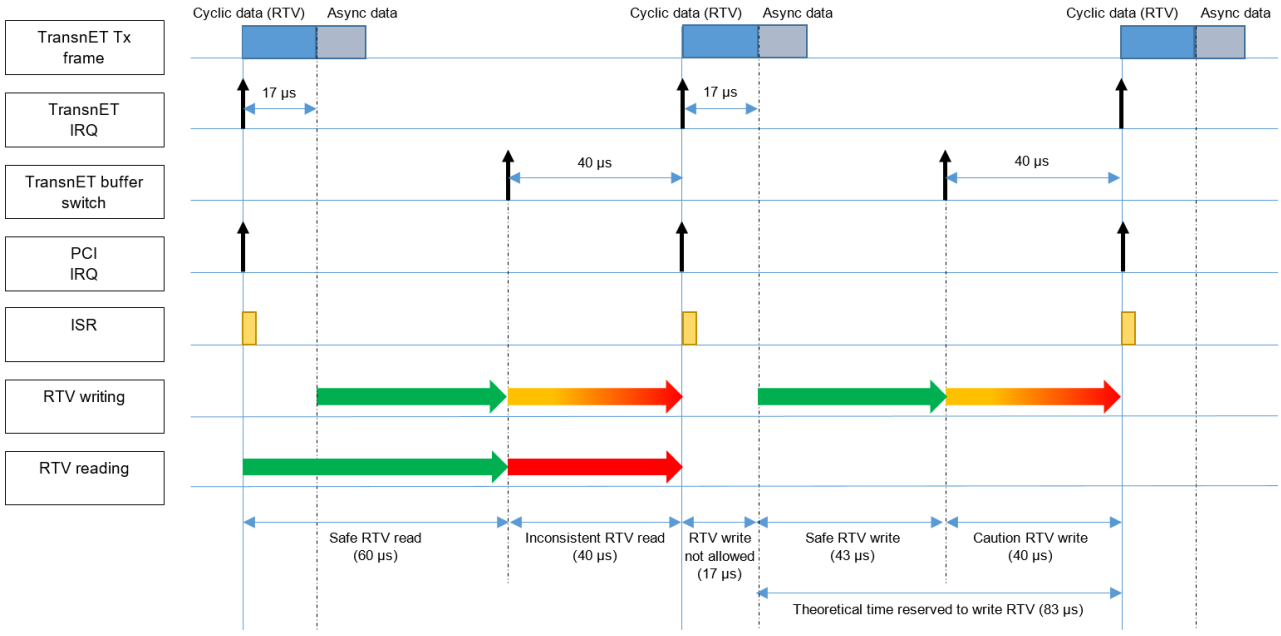
To realize the hard real-time application described above configure an UltimET motion controller to generate a PCI/PCIe cyclic interrupt (IRQ) synchronized with the TransnET cycle (10 kHz) and attach a user callback function (refer to §14.4 for the programming details). In the user callback function, send the previously computed trajectory setpoints to the Controller(s) using the real-time values (RTV) mechanism (refer to the "UltimET Light User Manual" for information about RTVs). Finally, the Controller(s) will drive the axis to the target setpoint using its internal position control loop.

The following timing diagram depicts the execution of the different elements involved on this transaction. The TransnET cycle represents the time reference. The UltimET motion controller generates a PCI/PCIe IRQ synchronized with the TransnET cycle. The RTX operating system reacts to this IRQ executing the ISR routine, which in turn triggers the IST task (refer to §14.3.3 for further information about these tasks). The IST task analyzes the root cause of the IRQ and executes the user callback function in the case of a cyclic IRQ.

**Remark:** The PCI/PCIe IRQ generation can be offset with respect to the TransnET IRQ, by chunks of 30 ns (refer to §14.3.4 and §14.4.3.1 for further information).

To ensure optimal real-time execution, the host PC must respect certain time constraints when writing/reading RTVs:

- RTVs must be written after the cyclic data of the current TransnET frame is dispatched (≥17 µs) and before the start of the next TransnET cycle.
- RTVs must be read before the TransnET buffer switch is executed (≤ 60 µs) to ensure that the values received are indeed valid.




TransnET IRQ, Operating System and user callback timing (theory)

#### 14.2.3.2 Execution latencies

It is important to understand that in a real system there are always latencies and some non-determinism on the execution of a program, even when using a real-time operating system like RTX. It is not possible to provide an exact value to quantify these latencies because it depends on many different factors like for e.g., the hardware being used (chipset, processor, how many and which devices are plugged, which interfaces are used, etc.) and the software (how many tasks are running, their priorities, is there a lot of context switch, how the code is optimized, etc.). But, as an order of magnitude, it can be said that it typically varies from a few to some tenths of microsecond.

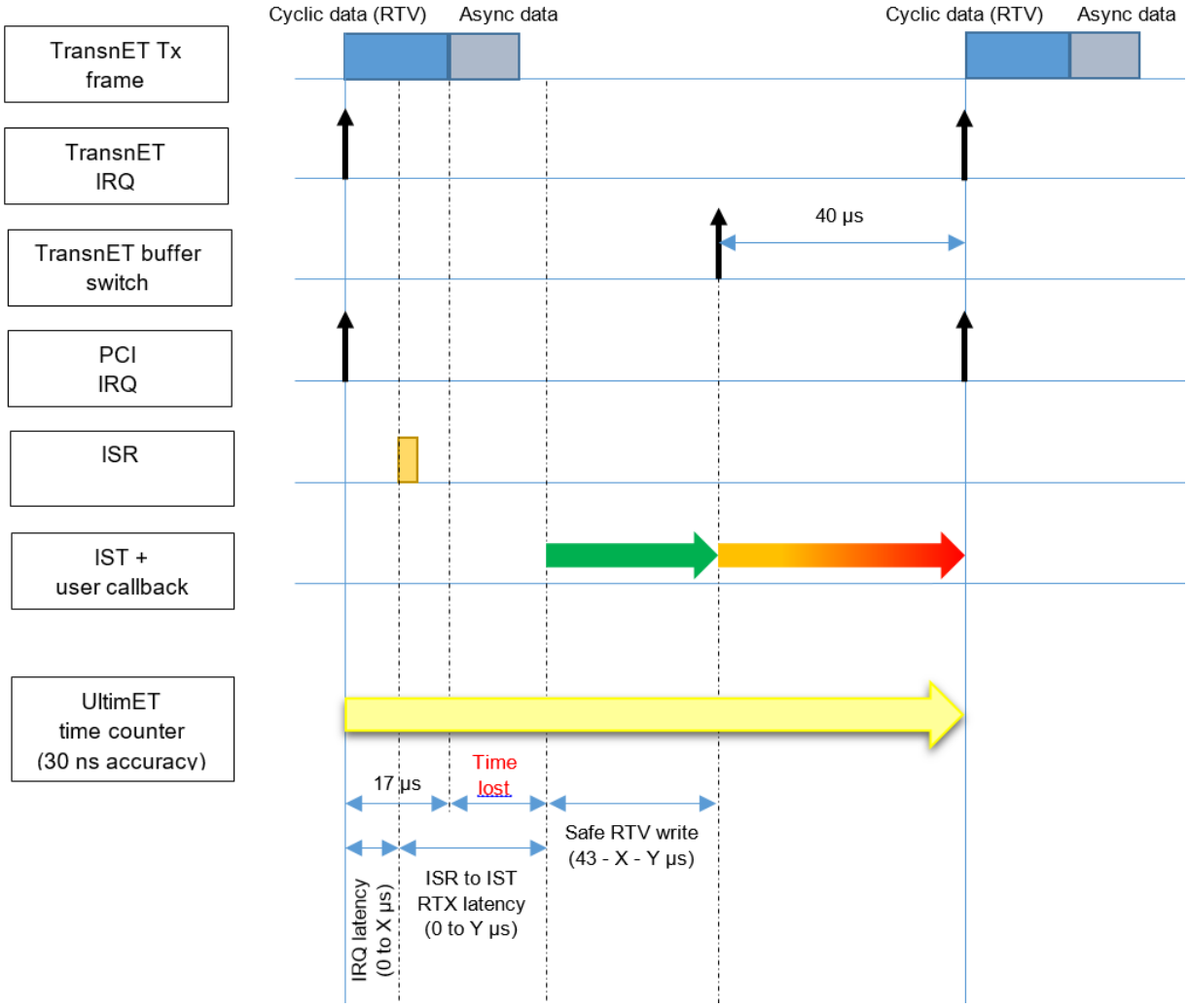
Of course, for hard real-time applications, it is important to take these additional delays into account, as to better optimize the application to comply with the timings constraints presented above for writing and reading RTVs.

One of the following methods can be used:

- **Polling**
  UltimET PCI/PCIe includes a precise time counter which keeps track of the time elapsed (in chunks of 30 ns) since the PCI/PCIe IRQ was generated and it is reset at every new IRQ. This counter can be polled in a loop until it reaches 17 µs. From this point on, RTVs can be safely written. If the latencies accumulated up to the execution of the user callback function are greater than 17 µs, the loop is not executed and the RTVs are written immediately. On the other hand, if these latencies are less than 17 µs, this approach is not very efficient since the loop execution is blocking the CPU, preventing it from executing other tasks.

- **Offset the PCI/PCIe interrupt generation with respect to TransnET**
  The alternative to the inefficient polling is to directly offset the PCI/PCIe IRQ generation with respect to TransnET IRQ by just the right amount to ensure that when the user callback function is executed, the RTVs can be written immediately. So, understanding the latencies experienced by the system is important to determine the "optimal and safe" offset to set.

The next timing diagram depicts the latencies inherent to the system. It is clear the effect of these latencies on "narrowing" the time interval available for safely writing the RTVs.




TransnET IRQ, Operating System and user callback timing in reality

## 14.3 Application design guidelines

### 14.3.1 Dynamic memory allocation

EDI functions can be grouped into 3 categories:

- Functions realizing dynamic memory allocation.
- Functions realizing dynamic memory deallocation.
- All other functions.

An application should be designed to avoid repetitive dynamic memory allocation/deallocation, as this will lead to memory fragmentation and, eventually, failure. Please refer to §3.6 for further information.

**Remark:** To avoid memory fragmentation it is recommended to allocate all the memory required only once at program startup and deallocate when no longer required just before program exit. Refer to EDI's HTML documentation to determine if a specific EDI function realizes dynamic memory allocation/deallocation.

### 14.3.2 Communication with the Controllers

As a rule of thumb, optimize the communication with the Controllers. This can be accomplished in several ways. For example, if different parts of the application need to frequently monitor various Controllers' registers, the best is to create a single task which polls regularly for the required registers and stores them in a memory pool where the other tasks can access. Another example is the use of the RTV functionality (refer to §14.4.3.1 or "UltimET Light User Manual" for further information).

Furthermore, it is highly recommended to reduce the communication with the Controllers to the strict minimum during the phases of execution where the hard real-time capability must be ensured. Therefore, the following actions should be avoided:

- Sending commands.
- Reading/Writing registers (use the RTV mechanism instead).
- Triggering Status Change. Although, it is not possible to stop all Status Change for occurring (for e.g. Status Change due to errors, warnings, as well as moving or in position status bit changes cannot be avoided), their occurrence can be nevertheless reduced. Keep in mind that running Sequences can also trigger Status Change and User Status Change should be avoided as well.

### 14.3.3 Task priority

The real-time sections of an application should be assigned to a task with higher priority. Adjusting the priority of tasks should be done with extreme caution: a task with high priority can starve the operating system if it never waits for the availability of resources.

EDI (RTX) creates several internal tasks:

- **IST**: this task is called by the RTX operating system at each PCI/PCIe IRQ (via the ISR routine). EDI sets the priority level for this task to the highest possible (127). The user cannot modify it. This task is also responsible for calling the user callback function (if one has been configured). Please refer to §14.4.3.1 for further information.
- **ETB**: this task manages the communication with the Controllers. More specifically, it handles *Command Acknowledgements and Status Changes*. By default, the priority level is set to 126. The user can modify it, but it is not recommended (reducing the priority level degrades the communication performance with the Controllers).
- **DSA asynchronous command management**: this task handles the *Command Acknowledgements* of all asynchronous commands (*dsa_..._a* functions). By default, the priority level is set to 108. The user can modify it, but it is not recommended (reducing the priority level degrades the performance of the asynchronous communication with the Controllers).
- **DSA asynchronous acquisition management**: EDI creates five additional tasks for handling asynchronous acquisitions. The priority level of these tasks is set to 100. The user cannot modify it.

**Remark:** The user can create additional tasks required by the application. But, it is important to consider the priority level set for these tasks. Tasks with a very high priority (≥ 100) can impact negatively the behavior of EDI.

### 14.3.4 Tuning the User callback

As mentioned before, the UltimET motion controller can be configured to delay the PCI/PCIe IRQ generation with respect to the TransnET cycle. With this feature, the execution of the user callback function can be tuned to start at the right moment to optimize the writing of RTVs.

Follow this procedure to optimize the application:

- Find the minimum time at which the user callback function is executed with respect to the PCI/PCIe IRQ:

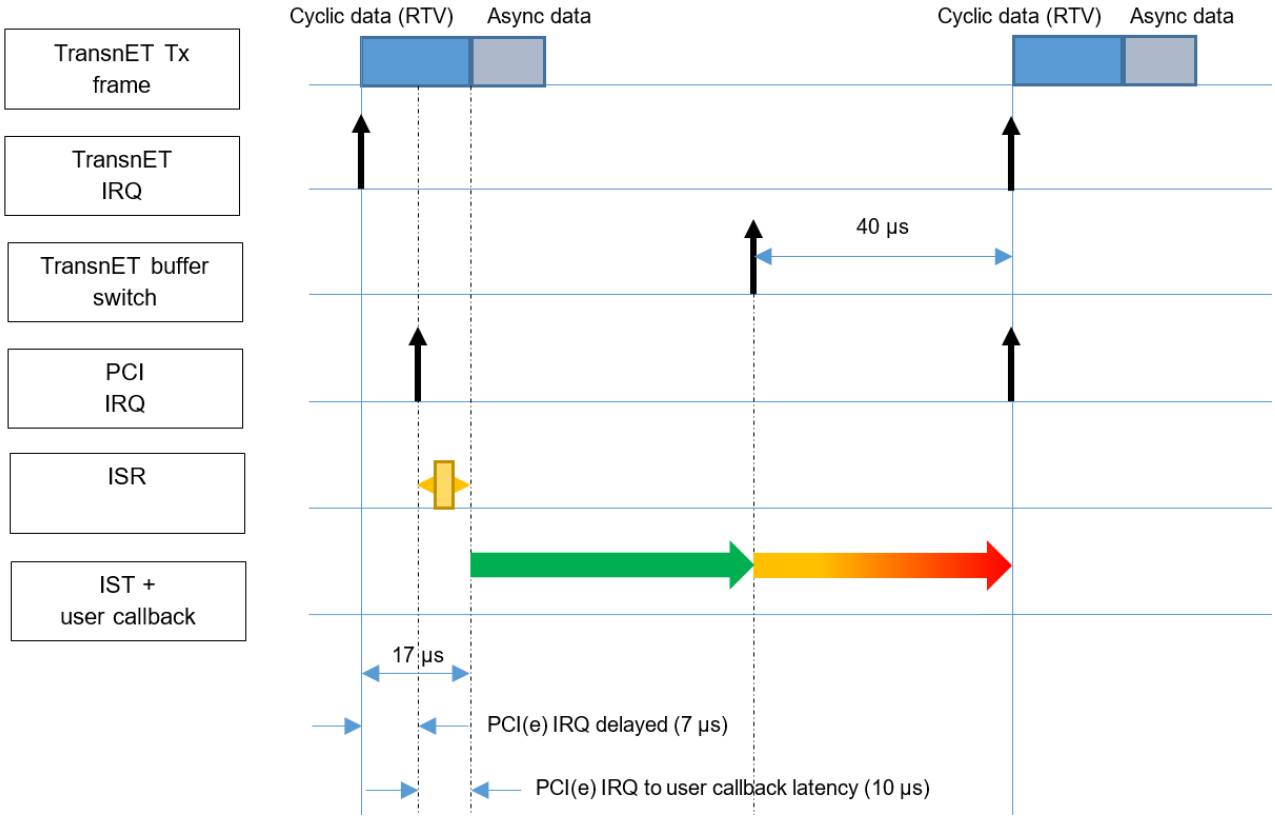
- Modify the user callback function to read the value of the UltimET's time counter when entering the function.
- Configure the PCI/PCIe IRQ with a delay of 0 µs with respect to the TransnET cycle and run the application for several minutes. When running always keep track of the absolute lowest counter value with the variable `minCallbackStart`.

- If `minCallbackStart ≤ 17 µs`, configure PCI/PCIe IRQ generation delay for the value `delay = 17 µs – minCallbackStart`.
- In the user callback function, before writing the RTV, poll in a loop the UltimET's time counter until it reaches `delay`.

In fact, the polling loop should never wait because the user callback actually starts at:

```
User callback start time = delay + minCallbackStart
                         = 17 µs – minCallbackStart + minCallbackStart
                         = 17 µs
```

The following timing diagram depicts the example where `minCallbackStart` is measured at 10 µs, so the PCI/PCIe IRQ generation offset is set to 7 µs (= 17 µs – 10 µs).



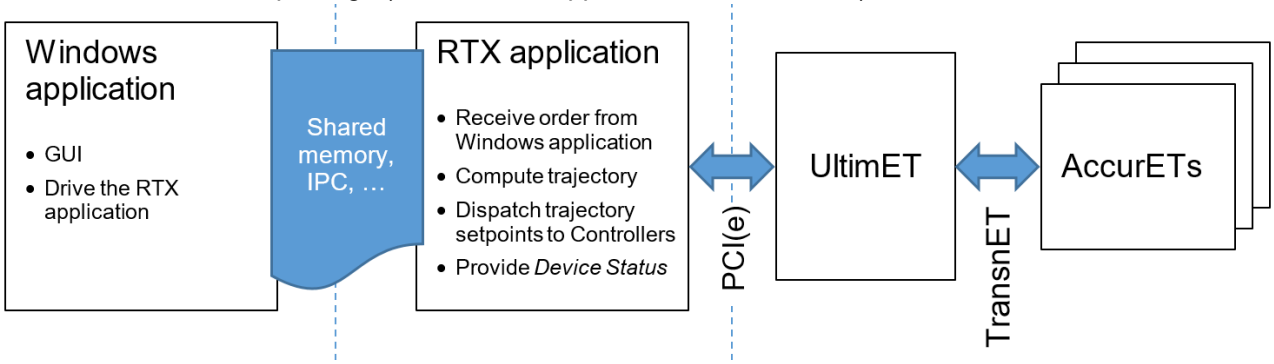

**Remark:** If it is also intended to read RTVs **before** writing RTVs, this procedure is not suited. Instead, remove the delay for generating the PCI/PCIe IRQ and first read the RTVs when executing the user callback function. Then, do a polling loop of the UltimET's time counter to check if 17 µs have elapsed before writing the RTVs.

### 14.3.5 Synchronization objects

The user callback function should execute as fast as possible and never overflow to the next IRQ cycle. Therefore, the use of synchronization objects like semaphore or mutexes is highly disapproved. The risk is that a low priority task owns the synchronization object, blocking the execution of the user callback function.

## 14.4 Example

This section includes an example of a RTX real-time application based on EDI. The source code is provided with the EDI distribution package (the Windows application is not included).




### 14.4.1 Specification

This application must create a circle trajectory and store the [X, Y] positions in a 2D array in a shared memory. The trajectory setpoints must be dispatched to the Controller in real-time at a rate of 10 kHz. The Controller must drive two motors, one for each axis.

In return, the application must receive the Controller status and position of the axes.

**Remark:** In a real implementation, the trajectory setpoints would normally be pre-computed by the Windows application and shared with the RTX application. The RTX application would then dispatch the setpoints to the Controllers in real-time. Similarly, the status and position information would be displayed in the Windows application GUI. In this example, and for the sake of simplificity, both of these tasks are realized by the RTX application.

### 14.4.2 Design

As explained before when designing a real-time application, it is important to identify the different tasks it should realize and categorize these according to:
- Non real-time;
- Real-time; and
- Hard real-time.

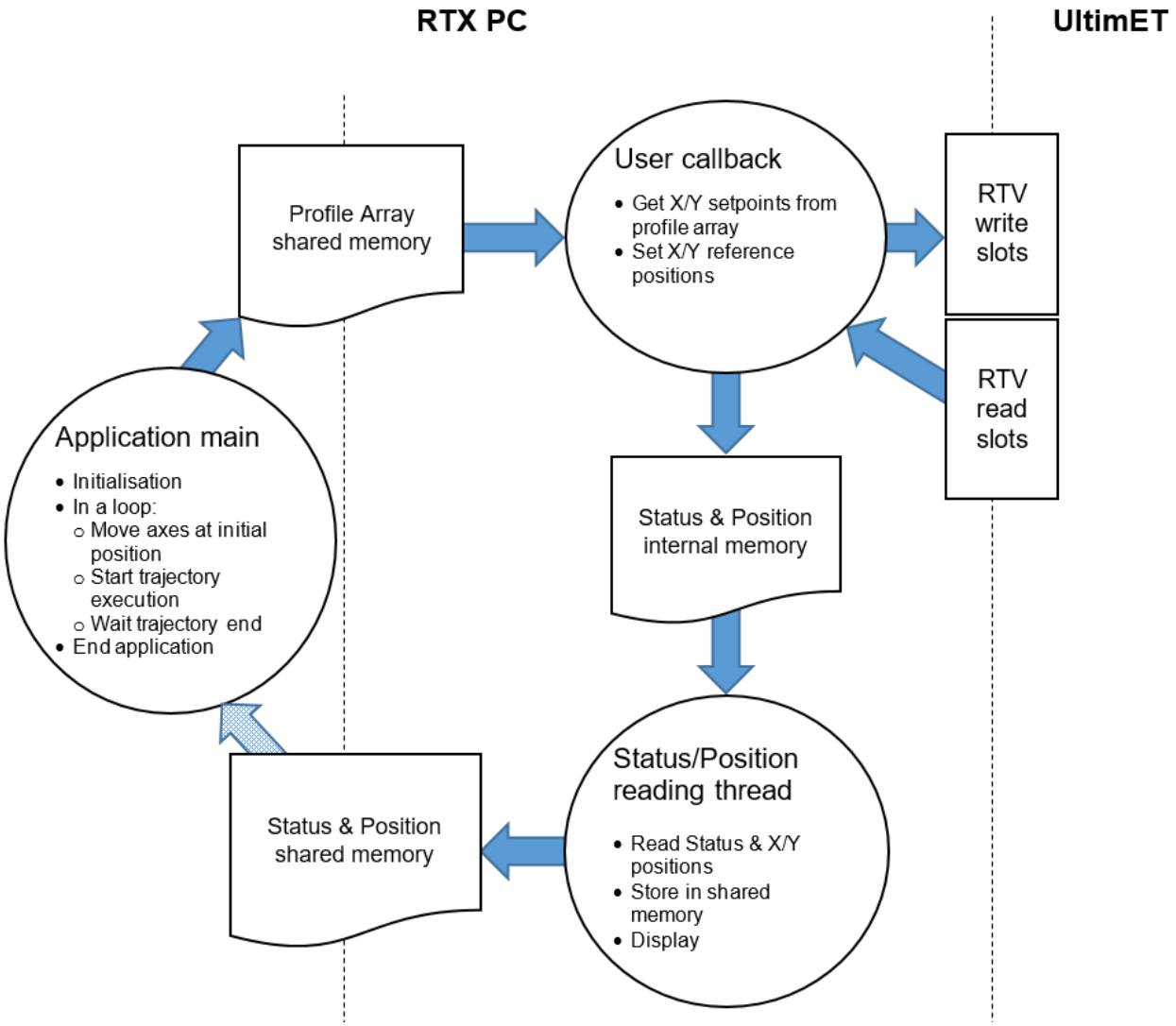
For this example, the non real-time tasks are mostly linked to the initialization of the application (memory allocation, Controllers reconfiguration, axes power up, etc.) and cleaning up before exiting (axes power down, memory deallocation, etc.).

The reception of Controller status and position axes are considered real-time tasks. The information must be handled regularly, but the application can cope with longer and less deterministic delays without jeopardizing system operation.

Finally, the hard real-time portion comprises the dispatching of the trajectory setpoints to the Controller. This information has to be provided regularly and deterministically to the Controller at the rate of 10 kHz.

In a nutshell, this example explains how to:
- Set an AccurET controller in a mode to accept external position references.
- Create (and destroy) real-time objects and how to read and write them.
- Setup a cyclic IRQ and user callback function at the required frequency.
- Write and read RTVs at the right moment.

The diagram below gives an overview of the implementation.




## 14.4.3 Programming

This application is spread over 3 modules:
- Real-time management.
- Status management.
- Application main.

### *14.4.3.1 Real-time management*

This module includes all functions related to the real-time execution:
- Creation of the real-time objects.
- Computation of the trajectory setpoints.
- User callback.
- Enabling/Disabling the execution of the real-time trajectory.

**Creation of real-time objects**

EDI provides two levels to interface real-time objects:

**DSA High level interface: DSA_RTV_DATA**

With this set of functions, creating an object reserves 1 or 2 slots from the master (UltimET) and links the slots to the specified device register. Specifying 64-bit registers will automatically reserve 2x 32-bit slots from the master. The register to which the object is linked defines then the type of the object: integer 64-bit, integer 32- bit, float 64-bit, float 32-bit.

It is possible to create a `DSA_RTV_DATA` object for reading. In this case the device register value is provided in the real-time TransnET slot. Reading the object reads the value from the real-time slot.


It is possible to create a `DSA_RTV_DATA` object for writing. In this case writing the object writes the value in the real-time TransnET slot which is assigned to device register.


**DSA Low level interface: DSA_RTV_SLOT**

With this set of functions, creating an object reserves slot(s) from the master (UltimET). This interface provides functions to create 32-bit or 64-bit slots.

The object can be manually linked to a device register of the corresponding type. Then, reading or writing `DSA_RTV_SLOT` objects provide the same functionalities as `DSA_RTV_DATA` objects.

Both interfaces provide functions to read an array of objects. The only restriction is that the array must contain objects of same type.

An ETB low-level function allows to read or write an array of 32-bit slots. This function can be used when there a mix of 64- bit and 32-bit real-time objects or a mix of integer and floating real-time objects. This allow to read or write all slots in a single call, which is much more efficient than reading/writing the different RTV types sequentially.

A drawback of this function is that one must know the slot numbers that are used and build the 32-bit slot values. In the case of 64-bit values, one must also know which 32-bit slot number corresponds to most significant DWORD and which corresponds to less significant DWORD in order to reconstruct the value.

This application example will use:

- DSA low level functions to initialize the RTVs containing the position setpoint of the X (`XReference`) and Y (`YReference`) axes. The AccurET controller will use these as reference positions.
- DSA high level functions to initialize the position feedback and status RTVs (`XFeedback`, `YFeedback`, `XStatus` and `YStatus`). These RTVs are linked to register values.
- ETB low-level function to read and write RTVs in the user callback function because it is more efficient. For this reason it is necessary to retrieve the raw slot numbers from the created objects.

Creating `XReference` and `YReference` real-time objects (EDI low-level interface):

```
//Create a slot into which the user callback write the reference position on X
if ((err = dsa_get_64bit_rtv0_slot(devices->master, &xReference))) {
   DSA_EXT_DIAG(err, devices->master);
   goto _error;
}
//Retrieve the low layer slot numbers to be able to use low-level ETB write
//function
if ((err = dsa_get_64bit_rtv_slot_nr(xReference,
                                     &writeSlotNbs[X_REFERENCE_LSL_SLOT_IDX],
                                     &writeSlotNbs[X_REFERENCE_MSL_SLOT_IDX]))) {
   DSA_EXT_DIAG(err, devices->master);
```

```
    goto _error;
}
//Create a slot into which the user callback write the reference position on Y
if ((err = dsa_get_64bit_rtv0_slot(devices->master, &yReference))) {
    DSA_EXT_DIAG(err, devices->master);
    goto _error;
}
//Retrieve the low layer slot numbers to be able to use low-level ETB write
//function
if ((err = dsa_get_64bit_rtv_slot_nr(yReference,
                                     &writeSlotNbs[Y_REFERENCE_LSL_SLOT_IDX],
                                     &writeSlotNbs[Y_REFERENCE_MSL_SLOT_IDX]))) {
    DSA_EXT_DIAG(err, devices->master);
    goto _error;
}
```

Creating `XFeedback`, `YFeedback`, `XStatus` and `YStatus` real-time objects (EDI high-level interface):

```
//Create a slot and link it to ML0 (position feedback) of axis X
//User callback reads this slot and put the read value in internal memory
if ((err = dsa_create_rtv_read(devices->x, DMD_TYP_MONITOR_INT64, 0, 0, &xFeedback))) {
    DSA_EXT_DIAG(err, devices->x);
    goto _error;
}
//Retrieve the underlaying slot object to be able to retrive the low layer slot number
if ((err = dsa_get_rtv_slot_of_rtv(xFeedback, &helpSlot))) {
    DSA_EXT_DIAG(err, devices->x);
    goto _error;
}
//Retrieve the low layer slot numbers to be able to use low-level ETB write function
if ((err = dsa_get_64bit_rtv_slot_nr(helpSlot, &readSlotNbs[X_FEEDBACK_LSL_SLOT_IDX],
                                     &readSlotNbs[X_FEEDBACK_MSL_SLOT_IDX]))) {
    DSA_EXT_DIAG(err, devices->x);
    goto _error;
}

//Create a slot and link it to ML0 (position feedback) of axis Y
//User callback reads this slot and put the read value in internal memory
if ((err = dsa_create_rtv_read(devices->y, DMD_TYP_MONITOR_INT64, 0, 0, &yFeedback))) {
    DSA_EXT_DIAG(err, devices->y);
    goto _error;
}
//Retrieve the underlaying slot object to be able to retrive the low layer slot number
if ((err = dsa_get_rtv_slot_of_rtv(yFeedback, &helpSlot))) {
    DSA_EXT_DIAG(err, devices->y);
    goto _error;
}
//Retrieve the low layer slot numbers to be able to use low-level ETB write function
if ((err = dsa_get_64bit_rtv_slot_nr(helpSlot, &readSlotNbs[Y_FEEDBACK_LSL_SLOT_IDX],
                                     &readSlotNbs[Y_FEEDBACK_MSL_SLOT_IDX]))) {
    DSA_EXT_DIAG(err, devices->y);
    goto _error;
}

//Create a slot and link it to M63 (status) of axis X
//User callback reads this slot and put the read value in internal memory
if ((err = dsa_create_rtv_read(devices->x, DMD_TYP_MONITOR_INT32, 63, 0, &xStatus))) {
    DSA_EXT_DIAG(err, devices->x);
    goto _error;
}
//Retrieve the underlaying slot object to be able to retrive the low layer slot number
if ((err = dsa_get_rtv_slot_of_rtv(xStatus, &helpSlot))) {
    DSA_EXT_DIAG(err, devices->master);
    goto _error;
}
```

```
//Retrieve the low layer slot numbers to be able to use low-level ETB write function
if ((err = dsa_get_32bit_rtv_slot_nr(helpSlot, &readSlotNbs[X_STATUS_SLOT_IDX]))) {
   DSA_EXT_DIAG(err, devices->master);
   goto _error;
}

//Create a slot and link it to M63 (status) of axis Y
//User callback reads this slot and put the read value in internal memory
if ((err = dsa_create_rtv_read(devices->y, DMD_TYP_MONITOR_INT32, 63, 0, &yStatus))) {
   DSA_EXT_DIAG(err, devices->y);
   goto _error;
}
//Retrieve the underlaying slot object to be able to retrive the low layer slot number
if ((err = dsa_get_rtv_slot_of_rtv(yStatus, &helpSlot))) {
   DSA_EXT_DIAG(err, devices->master);
   goto _error;
}

//Retrieve the low layer slot numbers to be able to use low-level ETB write function
if ((err = dsa_get_32bit_rtv_slot_nr(helpSlot, &readSlotNbs[Y_STATUS_SLOT_IDX]))) {
   DSA_EXT_DIAG(err, devices->master);
   goto _error;
}
```

**Computation of trajectory setpoints**

The trajectory generated in this example is a simple circle. The corresponding X and Y positions are stored in a 2D table. The table size depends on the rate at which the application sends the setpoints to the Controller (for an update rate of 10 kHz, i.e. 1 setpoint every 100 µs, a total of 25000 setpoints are stored).

**Remark:** The trajectory computation is included in the source code that is provided with the EDI distribution package.

**User callback**

For this application example, the AccurET controller must be configured for the external position reference mode (ITP = 1). In this mode, the position reference is not given by the Controller's internal setpoint generator, but comes from a register which can be updated via RTV. In the user callback, the successive trajectory setpoints are written to the corresponding RTV slots that will update the Controller's position reference register.

The user callback executes two main tasks:
- Reads the RTVs containing the status and position measurements of the Controller.
- Writes to the RTVs the trajectory setpoints to update the Controller's position reference.

The first task is always executed at each cycle, while the second one is only executed when the main application has enabled it.

As presented in sections §14.2.3.1 and §14.2.3.2, RTVs must be read before 60 µs and written after 17 µs. Therefore, the user callback first reads the RTVs, then prepares the values to be written to the RTVs and waits until the time counter reaches 17 µs before writing them.

The user callback is also able to generate errors and signal these to the main application. These are the errors which are detected:

```
RTV_READ_SYNCHRO_ERROR = -1,          // The callback has read real-time values not in
                                      // imparted time

CALLBACK_DURATION_EXCEEDED = -2,      // The callback duration has exceeded the imparted
                                      // time and is no
```

```
//-----------------------------------------------------------------------------
// This is the function which will be called at each PCI IRQ. The devices have prealably
// set in ITP mode 1 (position reference provided by RTV slots)
// This function:
// - read the RTV values containing the devices status and devices actual position.
// - get the next trajectory's point to go to
// - if requested by min application
//      - waits for the time where writing RTV values are safe (17 us after TransnET IRQ)
//       - write the RTV values in the programmed slots.
// - store the read RTV values (status & actual position) in internal memory
// - compute the callback duration to allow generating an error if the duration exceeds
// the imparted time
// - compute the minimal callback start time to allow to fine tune the callback timing
// Refer to EDI4 RTX realtime application documentation
// - if an error is detected (read real-time values not done in imparted time, or
// callback duration exceeded), it generates an event signaling the error to the main
// application
//-----------------------------------------------------------------------------

static void _user_callback(DSA_MASTER *master, int nr,
                           int nb_read, DSA_RTV_DATA **read_rtv,
                           int nb_write, DSA_RTV_DATA **write_rtv, ETB *etb)
{
   int read_err = 0;
   int write_err = 0;
   S_POINT p;
   eint64 start_time_us, callback_duration_us;//Used to compute the duration
                                       //of the callback with OS time function
   double fpga_start_time_us;          //Used to compute the minimal start time
                                       //of the callback allowing a fine tuning

   //get the start time of callback (from PCI IRQ).
   //This take ~2 us and should be removed once callback has been fine tuned
   fpga_start_time_us = _get_FPGA_time(etb) * FPGA_TIME_TO_US;

   //get the start time using OS timing
   start_time_us = _get_time_us();

   //Compute the minimal start time (for fine tuning of callback
   if (realtime_callback_min_start_time_us > fpga_start_time_us)
   realtime_callback_min_start_time_us = fpga_start_time_us;

   //Read the real-time values containing status and position feedbacks.
   //Calling the function returns
   //an error if the reading cannot be done in the same TransnET cycle
   read_err = etb_read_slot_array(etb, NB_32BITS_READ_SLOTS, readSlotNbs, readSlotValps);

   //If required by main application, execute the trajectory
   if (trajectory.execute) {
      if (_get_next_point(&p) == -1) {
         trajectory.execute = FALSE;
         _trig_trajectory_end();
      }
      else {
         //Prepare the array of real-time values
         writeSlotVals[X_REFERENCE_LSL_SLOT_IDX] = LOWDWORD64(p.xi);
         writeSlotVals[X_REFERENCE_MSL_SLOT_IDX] = HIGHDWORD64(p.xi);
         writeSlotVals[Y_REFERENCE_LSL_SLOT_IDX] = LOWDWORD64(p.yi);
         writeSlotVals[Y_REFERENCE_MSL_SLOT_IDX] = HIGHDWORD64(p.yi);
         //Wait that the correct time to write the real-time values
         _wait_transnet_write_time(etb, 17 - USER_CALLBACK_DELAY);
         //Writes the real-time values
         etb_write_slot_array(etb, NB_32BITS_WRITE_SLOTS, writeSlotNbs,
         writeSlotVals);
      }

   }
```

```
   //No read error has been detected
   if (!read_err) {
      status_internal_update(readSlotVals[X_STATUS_SLOT_IDX],
readSlotVals[Y_STATUS_SLOT_IDX],
      readSlotVals[X_FEEDBACK_LSL_SLOT_IDX],
      readSlotVals[X_FEEDBACK_MSL_SLOT_IDX],
      readSlotVals[Y_FEEDBACK_LSL_SLOT_IDX],
      readSlotVals[Y_FEEDBACK_MSL_SLOT_IDX]);
   }
   //A read error has been detected => signal it to main application
   else {
      trajectory.execute = FALSE;
      trajectory.callback_error = RTV_READ_SYNCHRO_ERROR;
      _trig_callback_error();
   }
   //Compute the duration of the callback and generate an error if the imparted time is
   //exceeded
   callback_duration_us = _get_time_us() - start_time_us;
   if (callback_duration_us > USER_CALLBACK_RATE_US) {
      trajectory.execute = FALSE;
      trajectory.callback_error = CALLBACK_DURATION_EXCEEDED;
      _trig_callback_error();
   }
   return;

}
```

**User callback start and stop**

The user callback is enabled using the EDI function `dsa_start_delayed_rtv_handler`, which also configures the UltimET motion controller to generate a PCI/PCIe IRQ at a defined frequency and offset with respect to TransnET's IRQ.
The user must ensure that the execution of user callback does not overflow to the next cycle. Theoretically, the user callback execution could last up to 100 µs, but this is not possible because of the various latencies. ETEL recommends measuring the system latencies to determine the maximum execution duration feasible, applying a safety margin. Also, the user should monitor the time spent in the user callback and generate an error if it overflows the specified maximum.

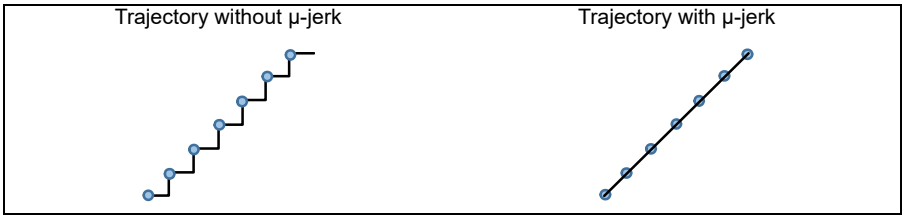
```
//-----------------------------------------------------------------------------------------
// Start the realtime callback
// The realtime callback is set with:
// - a delay of 0 (PCI IRQ not delayed from TransnET IRQ)
// - a frequency which depends of the OS:
//   RTX: 10 KHz (1 point each 100 us (TransnET frequency)
//   Windows: 40 Hz (1 point each 25 ms
// The realtime callback waits for the synchronization flag to execute the
// trajectory
// After this function, the callback will only read the RTV values and store them
// in internal memory
// The application will start the trajectory execution once the devices will be
// set in
// ITP=1 (position reference mode)
//-----------------------------------------------------------------------------------------
int realtime_callback_start()
{
   int err = 0;
   ETB *etb = NULL;
   if ((err = dsa_get_etb_bus(devices->master, &etb))) {
      DSA_DIAG(err, devices->master);
      goto _error;
   }
   printf("Start user callback\n");
   trajectory.execute = FALSE;
   trajectory.callback_error = NO_CALLBACK_ERROR;
```

```
   if ((err = dsa_start_delayed_rtv_handler(devices->master, 0,
(int)(USER_CALLBACK_RATE_US / 100.0),
                                            USER_CALLBACK_DELAY, _user_callback, 0,
                                            NULL, 0, NULL,
                                            etb))) {
      DSA_DIAG(err, devices->master);
      goto _error;
   }
_error:
   return err;
}

//-----------------------------------------------------------------------------
// Stop the real-time callback
//-----------------------------------------------------------------------------
int realtime_callback_stop()
{
   int err = 0;
   printf("Stop user callback\n");

   trajectory.execute = FALSE;
   if ((err = dsa_stop_rtv_handler(devices->master, 0))) {
      DSA_DIAG(err, devices->master);
      goto _error;
   }
_error:
   return err;
}
```

**Enabling and disabling the real-time trajectory execution**

Before it can enable the dispatching of trajectory setpoints to the Controller, the application must realize the following initialization steps:

- Move the axes to the first trajectory setpoint.
- Initialize the RTV with this first position to avoid a too big position step leading to a tracking error when the Controller's external position reference mode is enabled.
- Set the Controller's µ-jerk to linearize the position between two setpoints. The µ-jerk must be set equal to the duration between two setpoints (i.e. 100 µs).




- Enable the Controller's external position reference mode.

Finally, set the flag to enable the user callback to dispatch a trajectory setpoint per cycle.

```
//-----------------------------------------------------------------------------
// Start the realtime trajectory execution
// - Program the micro jerk of the devices. The micro jerk is set to the callback rate.
//   This forces the device to linearize the position between provided trajectory points
// - Initialize the reference realtime value slots with the first point of the trajectory.
//   This is requested, the axes would take their reference position from realtime value /
/ slot as soon as they would be set in ITP=1
// - Set the devices in ITP=1 mode (position reference from specified RTV slot)
// - Start the trajectory execution by setting the flag which tells the real-time callback
//   to send the trajectory points
//-----------------------------------------------------------------------------
int realtime_trajectory_start()
{
   int err = 0;
```

```
    S_POINT* initial_position = realtime_trajectory_get_initial_position();
    ETB *etb = NULL;

    printf("Start real-time trajectory\n");

    if ((err = devices_set_micro_jerk(USER_CALLBACK_RATE_US / 1000000.0))) {
       goto _error;
    }
    if ((err = dsa_get_etb_bus(devices->master, &etb))) {
       DSA_EXT_DIAG(err, devices->master);
       goto _error;
    }

    writeSlotVals[X_REFERENCE_LSL_SLOT_IDX] = LOWDWORD64(initial_position->xi);
    writeSlotVals[X_REFERENCE_MSL_SLOT_IDX] = HIGHDWORD64(initial_position->xi);
    writeSlotVals[Y_REFERENCE_LSL_SLOT_IDX] = LOWDWORD64(initial_position->yi);
    writeSlotVals[Y_REFERENCE_MSL_SLOT_IDX] = HIGHDWORD64(initial_position->yi);
    if ((err = etb_write_slot_array(etb, NB_32BITS_WRITE_SLOTS, writeSlotNbs,
writeSlotVals))) {
       ETB_ETCOM_DIAG(err, NULL, 0);
       goto _error;
    }
    if ((err = devices_enable_itp_mode(writeSlotNbs[X_REFERENCE_LSL_SLOT_IDX],
writeSlotNbs[X_REFERENCE_MSL_SLOT_IDX],
                                       writeSlotNbs[Y_REFERENCE_LSL_SLOT_IDX],
                                       writeSlotNbs[Y_REFERENCE_MSL_SLOT_IDX]))) {
        goto _error;
    }
    trajectory.execute = TRUE;
_error:
    return err;
}
```

To disable the trajectory execution, the application must:

- Unset the flag disabling the dispatch of trajectory setpoints from the user callback.
- Disable the Controller's external position reference mode.
- Reset the Controller's µ-jerk.

```
//-----------------------------------------------------------------------------------------
// Stop the realtime trajectory execution:
// - Reset the flag avoiding the real-time callback to send trajectory points
// - Disable position reference mode of the devices (ITP=0)
// - Set micro jerk to 0
//-----------------------------------------------------------------------------------------
int realtime_trajectory_stop()
{
   int err = 0;
   printf("Stop real-time trajectory\n");
   trajectory.execute = FALSE;

   if ((err = devices_disable_itp_mode())) {
      goto _error;
   }
   if ((err = devices_set_micro_jerk(0))) {
      goto _error;
   }

_error:
   return err;
}
```

#### *14.4.3.2 Status management*

This module contains the functions for managing the Controller's status and position feedback information which is collected by the user callback function and stored in an internal memory.

A low priority status handling task reads regularly this internal memory, converts the position measurements into ISO units and stores the data in a shared memory. Once finished, the task sets an event signaling that the shared memory has been updated and displays the status on the console.

**Remark:** In a real use case, the Windows application would get the status information from the shared memory and display it on the GUI.

**Creating and starting the status task**

```
//-----------------------------------------------------------------------------------------
// The function executed by status thread.
// This function:
// - get the devices position feedback (stored by realtime task in INCREMENT) and convert
// them in ISO
// - get the devices status (stored by realtime task)
// - write these values in shared memory which will be read and displayed by main
// application
// - In this example, we display the status in this task.
// - In a "normal" application, this should be done in a Windows task displaying this on
// a nice windows panel. Therefore, the shared memory is protected by a Critical section
// allowing this.
// Moreover, the update of the shared memory is signaled by an event which the windows
// application could wait for. In our example, nobody waits for this event.
//-----------------------------------------------------------------------------------------
static int _status_thread_fct(void *params)
{
   S_DEVICES *devices = (S_DEVICES *)params;
   int err = 0;
   double xIsoFeedback;
   double yIsoFeedback;
   dword xStatus;
   dword yStatus;
   while (!stop) {
   if ((err = dsa_convert_int64_to_iso(devices->x, &xIsoFeedback,
internal_status.feedback.xi,          DMD_CONV_UPI))) {
      DSA_DIAG(err, devices->x);
      goto _error;
   }
   if ((err = dsa_convert_int64_to_iso(devices->y, &yIsoFeedback,
internal_status.feedback.yi,          DMD_CONV_UPI))) {
      DSA_DIAG(err, devices->y);
      goto _error;
   }
   xStatus = internal_status.xStatus;
   yStatus = internal_status.yStatus;
   //Write data to shared memory
   CRITICAL_ENTER(status_shm);
   status_shm.xFeedback = xIsoFeedback;
   status_shm.yFeedback = yIsoFeedback;
   status_shm.xStatus = xStatus;
   status_shm.yStatus = yStatus;
   CRITICAL_LEAVE(status_shm);
   //Signal that the shared memory has been updated
   AUTOEVENT_SET(status_shm.updated);
   _status_display();
   SLEEP(500);
   }
_error:
   return err;
}

//-----------------------------------------------------------------------------------------
// Start the status thread
//-----------------------------------------------------------------------------------------
int status_thread_start(S_DEVICES *devices)
```

```
{
   printf("Start status thread\n");
   memset(&internal_status, 0, sizeof(internal_status));
   memset(&status_shm, 0, sizeof(status_shm));
   CRITICAL_INIT(status_shm);
   AUTOEVENT_INIT(status_shm.updated, FALSE);

   THREAD_INIT_AND_NAME_PRIO(status_thread, "Status Thr", status_thread_fct,
                             (void*)devices,EDI_THREAD_PRIORITY_IDLE);
   if (status_thread == THREAD_INVALID) {
      printf("Unable to create Status thread\n");
      return -1;
   }
   return 0;
}
```

#### *14.4.3.3 Application main*

The main function executes:

- Initialization: creation of device objects, opening communication and initialization of Controllers (reset errors, power on, homing…).
- Initiating the user callback.
- Initiating the status task.
- In a loop (fixed number of iterations)
    - Enabling the real-time trajectory execution.
    - Waiting for the user callback to complete the trajectory execution.
    - Disabling the trajectory execution.
- After executing all iterations or in case an error is detected, closing communication, stopping all tasks and destroying all objects.

```
//---------------------------------------------------------------------------------------
// main
// - Initialize the devices and real-time object
// - start a status thread which will display the status & position of the axes
// - Execute the real-time trajectory curve several times
//---------------------------------------------------------------------------------------
int main(void)
{
   int err;
   int i;
   ebool waiting;
   S_DEVICES *devices;
   printf("-----------------------------------------------------------------\n");
   printf("--- ETEL realtime application demo   ------------------------\n");
   printf("-----------------------------------------------------------------\n");
   if ((err = devices_create())) {
      goto _error;
   }
   if ((err = devices_open())) {
      goto _error;
   }
   if ((err = devices_init())) {
      goto _error;
   }
   devices = devices_get_object();
   if ((err = realtime_create(devices))) {
      goto _error;
   }
   if ((err = realtime_callback_start())) {
      goto _error;
   }
   if ((err = status_thread_start(devices))) {
      goto _error;
   }
   for (i = 0; i < NB_LOOP; i++) {
      if ((err = _start_trajectory_execution())) {
```

```
            goto _error;
         }
         waiting = TRUE;
         while (waiting) {
            switch (_wait_events()) {
               case TRAJECTORY_ERROR:
                  printf("Trajectory error %d\n", realtime_callback_get_error_nb());
                  if ((err = _stop_trajectory_execution())) {
                     goto _error;
                  }
                  waiting = FALSE;
                  break;
               case TRAJECTORY_FINISHED:
                  printf("Trajectory successfully ended\n");
                  if ((err = _stop_trajectory_execution())) {
                     goto _error;
                  }
                  printf("Main go to take a small nap...\n");
                  SLEEP(5000);
                  waiting = FALSE;
                  break;
               default:
                  printf("Event Wait error\n");
                  err = -1;
                  waiting = FALSE;
                  break;
            }
         }
      }

_error:
   _stop_trajectory_execution();
   realtime_callback_stop();
   status_thread_stop();
   realtime_destroy();
   devices_close();
   devices_destroy();
   if (err)
      printf("Ended with error %d\n", err);
   else
      printf("Ended successfully\n");

}
```

# 15 Appendixes

## 15.1 DSA library functions

### 15.1.1 Functions to send commands

| ETEL syntax | Command number | EDI function |
|---|---|---|
| ASG | 235 | |
| ASM | 230 | |
| ASP | 234 | |
| ASR | 231 | dsa_free_all_transnET_slots_s |
| | | dsa_unassign_slot_to_register_a |
| | | dsa_unassign_slot_to_register_s |
| | | dsa_assign_slot_to_register_s |
| | | dsa_assign_slot_to_register_a |
| ASS | 252 | |
| ASW | 232 | dsa_assign_register_to_slot_s |
| | | dsa_free_all_transnET_slots_s |
| | | dsa_unassign_register_to_slot_a |
| | | dsa_unassign_register_to_slot_s |
| | | dsa_assign_register_to_slot_a |
| AUT | 150 | |
| AXI | 109 | |
| BRK | 70 | dsa_quick_stop_s |
| | | dsa_quick_stop_a |
| CAL | 68 | |
| CEC | 58 | |
| CFGPGFIX | 310 | |
| CFGPGMOD | 311 | |
| CFGTRIGEXTPOS | 312 | |
| CH_BIT_REG32 | 90 | dsa_modify_bits_int32_register_s |
| | | dsa_modify_bits_int32_register_a |
| CHKDISTGRT | 563 | |
| CHKMD5 | 510 | |
| CHKMD5SWAP | 512 | |
| CLRWAIT | 180 | |
| CLX | 17 | |
| CSH | 21 | |
| CTFOFF | 301 | |
| CTFON | 300 | |
| CTFRTV | 302 | |
| CWS | 522 | |
| DEV_REMAP | 505 | |
| DEV_TRAP_CLEAN_ALL | 501 | |
| DEV_TRAP_INSERT | 500 | |
| DEV_TRAP_SNIPPET_SELECT | 503 | |
| DEV_TRAP_WIND_EVENT | 502 | |
| DEV_UNLOCK | 504 | |
| DEV_WRITE | 506 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| DFC | 241 | |
| DFCLD | 210 | |
| DIAGNOSE | 499 | |
| DIS | 82 | |
| DTC | 250 | |
| DWN | 42 | |
| DWNFW | 216 | |
| ECAT_ASW | 229 | |
| ECAT_ITP | 117 | |
| EDF | 239 | |
| EIOMAXURST | 755 | dsa_externalIO_reset_max_update_time_s |
| EIOSTA | 750 | dsa_externalIO_set_enable_cyclic_update_s |
| EIOWDEN | 720 | dsa_externalIO_enable_watchdog_s |
| | | dsa_externalIO_disable_watchdog_s |
| EIOWDSTP | 721 | dsa_externalIO_stop_watchdog_s |
| EIOWDTIME | 722 | dsa_externalIO_set_watchdog_time_s |
| END | 0 | dsa_stop_sequence_a |
| | | dsa_stop_sequence_in_thread_s |
| | | dsa_stop_sequence_in_thread_a |
| | | dsa_stop_customer_software_module_function_s |
| | | dsa_stop_sequence_s |
| | | dsa_stop_customer_software_module_function_a |
| ERR | 80 | |
| ERRORAUX | 85 | |
| ESMLOAD | 221 | |
| ESMUNLOAD | 222 | |
| FCOFF | 301 | dsa_force_control_dual_axes_off_a |
| | | dsa_force_control_dual_axes_off_s |
| FCON | 300 | dsa_force_control_dual_axes_on_s |
| | | dsa_force_control_dual_axes_on_a |
| FCRTV | 302 | |
| FGA | 313 | |
| FLASH_EXEC | 507 | |
| FLT | 222 | |
| FORCE_LIMIT | 118 | |
| FREESLOT | 531 | dsa_free_32bit_rtv_slot |
| | | dsa_free_64bit_rtv_slot |
| | | dsa_free_all_transnET_slots_s |
| FWD | 520 | |
| GETDINS | 738 | dsa_localIO_get_digital_input_state_s |
| GETDOUT | 735 | dsa_localIO_get_digital_output_s |
| GETEAINCS | 746 | dsa_externalIO_get_analog_input_converted_data_state_s |
| GETEAINRS | 745 | dsa_externalIO_get_analog_input_raw_data_state_s |
| GETEAOUTC | 741 | dsa_externalIO_get_analog_output_converted_data_s |
| GETEAOUTCS | 743 | dsa_externalIO_get_analog_output_converted_data_state_s |
| GETEAOUTR | 740 | dsa_externalIO_get_analog_output_raw_data_s |
| GETEAOUTRS | 742 | dsa_externalIO_get_analog_output_raw_data_state_s |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| GETEDINS | 765 | dsa_externalIO_get_digital_input_state_s |
| GETEDOUT | 760 | dsa_externalIO_get_digital_output_s |
| GETEDOUTS | 764 | dsa_externalIO_get_digital_output_state_s |
| GETEREG | 726 | dsa_externalIO_get_modbus_register_s |
| GETMDINS | 734 | dsa_localIO_get_masked_digital_input_state_s |
| GETMDOUT | 732 | dsa_localIO_get_masked_digital_output_s |
| GETMEDINS | 758 | dsa_externalIO_get_masked_digital_input_state_s |
| GETMEDOUT | 757 | dsa_externalIO_get_masked_digital_output_s |
| GETMEDOUTS | 766 | dsa_externalIO_get_masked_digital_output_state_s |
| GETSLOT | 530 | dsa_get_64bit_rtv0_slot |
| | | dsa_get_32bit_rtv0_slot |
| GFD | 229 | |
| GFS | 228 | dsa_upload_firmware_file_s |
| | | dsa_upload_log_file_s |
| | | dsa_upload_parameter_file_s |
| | | dsa_upload_zipped_log_file_s |
| | | dsa_upload_encrypted_log_file_s |
| | | dsa_upload_file_s |
| GGA | 312 | |
| GLFI | 215 | |
| GZFS | 218 | |
| HLB | 121 | dsa_ipol_quick_stop_s |
| | | dsa_quick_stop_a |
| | | dsa_quick_stop_s |
| | | dsa_ipol_quick_stop_a |
| HLO | 119 | dsa_quick_stop_s |
| | | dsa_quick_stop_a |
| HLT | 120 | dsa_quick_stop_a |
| | | dsa_ipol_quick_stop_s |
| | | dsa_ipol_quick_stop_a |
| | | dsa_quick_stop_s |
| IABSCOORDS | 556 | dsa_ipol_abs_coords_a |
| | | dsa_ipol_abs_coords_s |
| IABSMODE | 555 | dsa_ipol_set_abs_mode_a |
| | | dsa_ipol_set_abs_mode_s |
| IBEGIN | 553 | dsa_ipol_begin_a |
| | | dsa_ipol_begin_s |
| IBRK | 653 | dsa_ipol_quick_stop_s |
| | | dsa_ipol_quick_stop_a |
| ICCW | 1041 | dsa_ipol_circle_ccw_c2d_a |
| | | dsa_ipol_circle_ccw_c2d_s |
| ICCWR | 1027 | dsa_ipol_circle_ccw_r2d_a |
| | | dsa_ipol_circle_ccw_r2d_s |
| ICLRB | 657 | dsa_ipol_clear_buffer_s |
| | | dsa_ipol_clear_buffer_a |
| ICONC | 1030 | dsa_ipol_begin_concatenation_s |
| | | dsa_ipol_begin_concatenation_a |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| ICONT | 654 | dsa_ipol_continue_a |
| | | dsa_ipol_continue_s |
| ICW | 1040 | dsa_ipol_circle_cw_c2d_a |
| | | dsa_ipol_circle_cw_c2d_s |
| ICWR | 1026 | dsa_ipol_circle_cw_r2d_a |
| | | dsa_ipol_circle_cw_r2d_s |
| IEND | 554 | dsa_ipol_end_a |
| | | dsa_ipol_end_s |
| IEQ | 151 | |
| IGE | 156 | |
| IGT | 154 | |
| ILE | 155 | |
| ILINE | 1025 | dsa_ipol_line_a |
| | | dsa_ipol_line_2d_a |
| | | dsa_ipol_line_2d_s |
| | | dsa_ipol_line_s |
| ILKT | 1032 | dsa_ipol_lkt_a |
| | | dsa_ipol_lkt_s |
| ILOCK | 1044 | dsa_ipol_lock_a |
| | | dsa_ipol_lock_s |
| ILT | 153 | |
| IMARK | 1039 | dsa_ipol_mark_2param_s |
| | | dsa_ipol_mark_a |
| | | dsa_ipol_mark_2param_a |
| | | dsa_ipol_mark_s |
| IMRES | 1063 | |
| IMROT | 1056 | dsa_ipol_rotate_matrix_a |
| | | dsa_ipol_rotate_matrix_s |
| IMSCALE | 1055 | dsa_ipol_scale_matrix_2d_a |
| | | dsa_ipol_scale_matrix_2d_s |
| | | dsa_ipol_scale_matrix_a |
| | | dsa_ipol_scale_matrix_s |
| IMSHEAR | 1057 | dsa_ipol_shear_matrix_a |
| | | dsa_ipol_shear_matrix_s |
| IMTRANS | 1054 | dsa_ipol_translate_matrix_a |
| | | dsa_ipol_translate_matrix_2d_s |
| | | dsa_ipol_translate_matrix_2d_a |
| | | dsa_ipol_translate_matrix_s |
| INCONC | 1031 | dsa_ipol_end_concatenation_a |
| | | dsa_ipol_end_concatenation_s |
| IND | 45 | dsa_homing_start_s |
| | | dsa_homing_start_a |
| INE | 152 | |
| INI | 44 | |
| INS | 41 | |
| IOCFGRST | 595 | |
| IOIPOLTEST | 596 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| IOSHOWPINS | 597 | |
| IPT | 1045 | dsa_ipol_pt_a |
| | | dsa_ipol_pt_s |
| IPVT | 1028 | dsa_ipol_pvt_s |
| | | dsa_ipol_pvt_a |
| | | dsa_ipol_pvt_reg_typ_s |
| | | dsa_ipol_pvt_reg_typ_a |
| IPVTUPDATE | 662 | dsa_ipol_pvt_update_a |
| | | dsa_ipol_pvt_update_s |
| ISET | 552 | dsa_ipol_begin_s |
| | | dsa_ipol_begin_a |
| ISTP | 656 | dsa_ipol_quick_stop_a |
| | | dsa_ipol_quick_stop_s |
| ITACC | 1036 | dsa_ipol_tan_acceleration_s |
| | | dsa_ipol_tan_acceleration_a |
| ITANSPDMASK | 1074 | |
| ITDEC | 1037 | dsa_ipol_tan_deceleration_a |
| | | dsa_ipol_tan_deceleration_s |
| ITJRT | 1038 | dsa_ipol_tan_jerk_time_s |
| | | dsa_ipol_tan_jerk_time_a |
| ITP | 116 | |
| ITRIG | 1042 | |
| ITSPD | 1035 | dsa_ipol_tan_velocity_a |
| | | dsa_ipol_tan_velocity_s |
| IULINE | 1033 | dsa_ipol_uline_time_a |
| | | dsa_ipol_uline_s |
| | | dsa_ipol_uline_time_s |
| | | dsa_ipol_uline_2d_s |
| | | dsa_ipol_uline_2d_a |
| | | dsa_ipol_uline_time_2d_s |
| | | dsa_ipol_uline_time_2d_a |
| | | dsa_ipol_uline_a |
| IUNLOCK | 655 | dsa_ipol_unlock_s |
| | | dsa_ipol_unlock_a |
| IUNOCONC | 1052 | dsa_ipol_disable_uconcatenation_a |
| | | dsa_ipol_disable_uconcatenation_s |
| IURELATIVE | 1051 | dsa_ipol_set_urelative_mode_s |
| | | dsa_ipol_set_urelative_mode_a |
| IUSPDMASK | 1053 | dsa_ipol_uspeed_axis_mask_a |
| | | dsa_ipol_uspeed_axis_mask_s |
| IUSPEED | 1049 | dsa_ipol_uspeed_a |
| | | dsa_ipol_uspeed_s |
| IUTIME | 1050 | dsa_ipol_utime_s |
| | | dsa_ipol_utime_a |
| IWTT | 1029 | |
| JBC | 37 | |
| JBS | 36 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| JEQ | 137 | |
| JGT | 138 | |
| JLT | 136 | |
| JMP | 26 | dsa_execute_sequence_in_thread_s |
| | | dsa_execute_sequence_s |
| | | dsa_start_customer_software_module_function_a |
| | | dsa_execute_sequence_in_thread_a |
| | | dsa_start_customer_software_module_function_s |
| | | dsa_execute_sequence_a |
| JNE | 139 | |
| MAGCTRL | 160 | |
| MAM | 199 | |
| MCS | 200 | |
| MCT | 193 | |
| MD5_FSUM | 511 | |
| MD5_SUM | 510 | |
| MDA | 195 | |
| MDT | 192 | |
| MMF | 562 | |
| MMO | 194 | |
| MSI | 190 | |
| MSR | 196 | |
| MSV | 191 | |
| MTP | 197 | |
| MTU | 198 | |
| MVE | 60 | dsa_start_profiled_movement_ex_a |
| | | dsa_start_profiled_movement_s |
| | | dsa_start_profiled_movement_a |
| | | dsa_start_profiled_movement_ex_s |
| MVEDOF | 1539 | dsa_move_ndof_s |
| | | dsa_set_all_axes_motion_profile_data_and_move_s |
| MVETILT | 480 | dsa_start_tilt_movement_s |
| | | dsa_start_tilt_movement_a |
| NEW | 78 | dsa_default_parameters_a |
| | | dsa_default_parameters_s |
| NEWFC | 305 | dsa_force_control_new_s |
| | | dsa_force_control_new_a |
| | | dsa_force_control_new_ex1_s |
| | | dsa_force_control_new_ex2_s |
| | | dsa_force_control_new_ex2_a |
| | | dsa_force_control_new_ex1_a |
| NOG | 149 | |
| OFFSETAUX | 24 | |
| OFFSETSEC | 23 | |
| PARAMETERSWITCH | 1536 | dsa_activate_parameters_s |
| PBK | 221 | |
| PCT | 752 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| POP | 34 | |
| POSCAPT | 211 | |
| PTS | 76 | |
| PWR | 124 | dsa_quick_stop_a |
| | | dsa_power_on_a |
| | | dsa_quick_stop_s |
| | | dsa_power_on_s |
| | | dsa_power_off_a |
| | | dsa_power_off_s |
| PWR_MUL | 83 | |
| RCT | 754 | dsa_externalIO_reset_client_communication_s |
| READCYCLIC | 516 | |
| READJUSTPOS | 86 | |
| RES | 49 | dsa_load_parameters_a |
| | | dsa_load_parameters_s |
| RESETFC | 304 | dsa_force_control_reset_ex3_a |
| | | dsa_force_control_reset_ex3_s |
| | | dsa_force_control_reset_ex2_a |
| | | dsa_force_control_reset_ex2_s |
| | | dsa_force_control_reset_ex1_a |
| | | dsa_force_control_reset_ex1_s |
| | | dsa_force_control_reset_a |
| | | dsa_force_control_reset_s |
| RET | 69 | |
| RIC | 753 | dsa_externalIO_reset_io_cycle_count_s |
| RMF | 219 | dsa_remove_customer_software_module_s |
| | | dsa_remove_parameter_file_s |
| | | dsa_remove_etel_software_module_s |
| RMVE | 62 | dsa_start_relative_profiled_movement_a |
| | | dsa_start_relative_profiled_movement_ex_s |
| | | dsa_start_relative_profiled_movement_s |
| | | dsa_start_relative_profiled_movement_ex_a |
| RMVETILT | 481 | dsa_start_relative_tilt_movement_s |
| | | dsa_start_relative_tilt_movement_a |
| RSD | 88 | |
| RSH | 600 | |
| RST | 79 | dsa_reset_error_with_check_ex_a |
| | | dsa_reset_error_with_check_a |
| | | dsa_reset_error_with_check_ex_s |
| | | dsa_reset_error_with_check_s |
| | | dsa_reset_error_s |
| | | dsa_reset_error_ex_s |
| | | dsa_reset_error_ex_a |
| | | dsa_reset_error_a |
| RSTDOUT | 737 | dsa_localIO_reset_digital_output_s |
| RSTEDOUT | 762 | dsa_externalIO_reset_digital_output_s |
| RSU | 601 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| RTVDOUT | 229 | |
| RTVFFWD | 228 | |
| RTVQUIET | 227 | |
| SAF | 63 | dsa_set_advanced_filter_a |
| | | dsa_set_advanced_filter_s |
| SAFRX | 489 | dsa_set_rx_advanced_filter_s |
| | | dsa_set_rx_advanced_filter_a |
| SAFRY | 487 | dsa_set_tilt_advanced_filter_s |
| | | dsa_set_tilt_advanced_filter_a |
| | | dsa_set_ry_advanced_filter_a |
| | | dsa_set_ry_advanced_filter_s |
| SAV | 48 | dsa_save_parameters_a |
| | | dsa_save_parameters_s |
| SCI | 102 | |
| SDF | 240 | |
| SDP | 248 | |
| SDS | 245 | |
| SDSF | 226 | dsa_download_file_s |
| | | dsa_download_customer_software_module_s |
| SEQBKPALL | 142 | dsa_debug_sequence_enable_breakpoint_everywhere_s |
| | | dsa_debug_sequence_enable_breakpoint_everywhere_a |
| SEQBRKTHR | 143 | |
| SEQCONT | 140 | dsa_debug_sequence_continue_a |
| | | dsa_debug_sequence_continue_s |
| SEQDBGEND | 143 | |
| SEQENBKP | 141 | dsa_debug_sequence_enable_breakpoint_at_a |
| | | dsa_debug_sequence_enable_breakpoint_at_s |
| SET | 22 | dsa_set_user_position_s |
| | | dsa_set_user_position_a |
| SET_RANGE | 126 | |
| SETDOUT | 736 | dsa_localIO_set_digital_output_s |
| SETEAOUTC | 731 | dsa_externalIO_set_analog_output_converted_data_s |
| SETEAOUTR | 730 | dsa_externalIO_set_analog_output_raw_data_s |
| SETEDOUT | 761 | dsa_externalIO_set_digital_output_s |
| SETEREG | 725 | dsa_externalIO_set_modbus_register_s |
| SETFC | 303 | dsa_force_control_set_ex3_s |
| | | dsa_force_control_set_ex3_a |
| | | dsa_force_control_set_ex2_a |
| | | dsa_force_control_set_ex2_s |
| | | dsa_force_control_set_ex1_a |
| | | dsa_force_control_set_ex1_s |
| | | dsa_force_control_set_a |
| | | dsa_force_control_set_ex4_s |
| | | dsa_force_control_set_ex4_a |
| | | dsa_force_control_set_s |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| SETFCI | 306 | dsa_force_control_set_immediate_ex1_s |
| | | dsa_force_control_set_immediate_s |
| | | dsa_force_control_set_immediate_ex2_s |
| | | dsa_force_control_set_immediate_ex2_a |
| | | dsa_force_control_set_immediate_a |
| | | dsa_force_control_set_immediate_ex1_a |
| SETLOGLEVEL | 535 | |
| SETMDOUT | 733 | dsa_localIO_apply_mask_digital_output_s |
| SETMEDOUT | 763 | dsa_externalIO_apply_mask_digital_output_s |
| SETRTV | 532 | |
| SETTILT | 483 | dsa_set_tilt_user_position_a |
| | | dsa_set_tilt_user_position_s |
| SETVPAR | 1537 | dsa_set_vector_parameter_int64_s |
| | | dsa_set_vector_parameter_s |
| SETVPARM | 1538 | dsa_set_matrix_parameter_s |
| | | dsa_set_vector_parameter_mask_int64_s |
| | | dsa_set_matrix_parameter_int64_s |
| | | dsa_set_matrix_parameter_mask_s |
| | | dsa_set_matrix_parameter_mask_int64_s |
| | | dsa_set_vector_parameter_mask_s |
| SLS | 46 | dsa_search_limit_stroke_s |
| | | dsa_search_limit_stroke_a |
| SLT | 27 | |
| SMP | 61 | dsa_set_profiled_movement_ex_s |
| | | dsa_set_profiled_movement_s |
| | | dsa_set_profiled_movement_ex_a |
| | | dsa_set_profiled_movement_a |
| SMPDOF | 1540 | dsa_set_all_axes_motion_profile_data_s |
| SPG | 105 | |
| SPI2 | 220 | |
| SPIABORT | 579 | |
| SPIBURSTCFG | 586 | dsa_start_burst_transfer_s |
| | | dsa_start_burst_transfer_a |
| SPICON | 580 | dsa_SPI_connect_a |
| | | dsa_SPI_connect_s |
| SPICYCLICCFG | 585 | dsa_config_cyclic_transfer_s |
| | | dsa_config_cyclic_transfer_a |
| SPIDIS | 581 | dsa_SPI_disconnect_a |
| | | dsa_SPI_disconnect_s |
| SPIREAD | 582 | dsa_SPI_read_s |
| | | dsa_SPI_read_a |
| SPIRST | 589 | |
| SPIRW | 584 | dsa_SPI_read_write_s |
| | | dsa_SPI_read_write_a |
| SPIWRITE | 583 | dsa_SPI_write_s |
| | | dsa_SPI_write_a |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| SSR | 127 | dsa_set_several_iso_registers_a |
| | | dsa_set_several_iso_registers_s |
| | | dsa_set_several_registers_a |
| | | dsa_set_several_registers_s |
| STA | 25 | dsa_start_movement_s |
| | | dsa_change_setpoint_a |
| | | dsa_start_movement_a |
| | | dsa_change_setpoint_s |
| | | dsa_new_setpoint_s |
| | | dsa_new_setpoint_a |
| STARTBURST | 587 | dsa_start_burst_transfer_s |
| | | dsa_start_burst_transfer_a |
| STARTCSM | 224 | dsa_start_customer_software_module_a |
| | | dsa_start_customer_software_module_s |
| STARTCYCLIC | 590 | dsa_start_cyclic_transfer_handler |
| STE_ABS | 129 | dsa_step_motion_s |
| | | dsa_step_motion_a |
| STE_ADD | 114 | |
| STE_SUB | 115 | |
| STETILT_ABS | 484 | |
| STETILT_ADD | 485 | |
| STETILT_SUB | 486 | |
| STF | 244 | |
| STI | 33 | |
| STOPCSM | 225 | dsa_stop_customer_software_module_a |
| | | dsa_stop_customer_software_module_s |
| STOPCYCLIC | 591 | dsa_stop_cyclic_transfer_handler |
| STP | 18 | dsa_quick_stop_a |
| | | dsa_quick_stop_s |
| STR | 237 | |
| STV | 20 | dsa_set_parameters_version_s |
| | | dsa_set_parameters_version_a |
| SUF | 242 | |
| SUMAG | 239 | dsa_start_upload_memory_s |
| SUMETA | 253 | dsa_start_upload_metadata_s |
| SUP | 249 | dsa_start_upload_register_s |
| SUS | 246 | dsa_start_upload_sequence_s |
| | | dsa_upload_sequence_s |
| SUSF | 227 | dsa_upload_firmware_file_s |
| | | dsa_upload_parameter_file_s |
| | | dsa_upload_file_s |
| | | dsa_upload_encrypted_log_file_s |
| | | dsa_upload_zipped_log_file_s |
| | | dsa_upload_log_file_s |
| SUT | 247 | dsa_start_upload_trace_s |
| SUZSF | 217 | |
| TCPERR | 693 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| TEST | 767 | |
| TIMING | 110 | |
| TMA | 236 | |
| TNS | 77 | |
| TOUCHPROBE | 212 | |
| TRANCRC | 694 | |
| TRANSYNC | 695 | |
| TRE | 104 | dsa_trigger_disable_a |
| | | dsa_trigger_disable_s |
| | | dsa_trigger_enable_ex_a |
| | | dsa_trigger_enable_a |
| | | dsa_trigger_enable_s |
| | | dsa_trigger_enable_ex_s |
| TRESET | 540 | |
| TRF | 233 | |
| TRM | 103 | dsa_trigger_enable_s |
| | | dsa_trigger_disable_a |
| | | dsa_trigger_continuous_last_event_loaded_s |
| | | dsa_trigger_continuous_last_event_loaded_a |
| | | dsa_trigger_disable_s |
| | | dsa_trigger_enable_ex_a |
| | | dsa_trigger_enable_a |
| | | dsa_trigger_enable_ex_s |
| TRM2D | 108 | dsa_trigger2d_continuous_last_event_loaded_a |
| | | dsa_trigger2d_enable_ex_s |
| | | dsa_trigger2d_continuous_last_event_loaded_s |
| | | dsa_trigger2d_enable_s |
| | | dsa_trigger2d_enable_a |
| | | dsa_trigger2d_disable_a |
| | | dsa_trigger2d_disable_s |
| | | dsa_trigger2d_enable_ex_a |
| TRR | 106 | dsa_trigger_init_a |
| | | dsa_trigger_init_s |
| TRS | 107 | dsa_trigger_status_enable_a |
| | | dsa_trigger_status_disable_a |
| | | dsa_trigger_status_enable_s |
| | | dsa_trigger_status_disable_s |
| TST | 74 | |
| TTL_EMU | 185 | dsa_ttl_encoder_emulator_enable_s |
| | | dsa_ttl_encoder_emulator_enable_a |
| UATEST | 255 | |
| UDPERR | 692 | |
| UDS | 251 | dsa_upload_data_s |
| | | dsa_upload_sequence_s |
| UFC | 243 | |
| UGO | 220 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| UST | 30 | dsa_user_stretch_disable_s |
| | | dsa_user_stretch_enable_s |
| | | dsa_user_stretch_enable_a |
| | | dsa_user_stretch_disable_a |
| VALPOS | 130 | |
| WAB | 13 | |
| WAITBURST | 588 | dsa_start_burst_transfer_s |
| | | dsa_start_burst_transfer_a |
| WAITCSM | 238 | dsa_wait_customer_software_module_s |
| | | dsa_wait_customer_software_module_a |
| WBC | 54 | dsa_wait_bit_clear_a |
| | | dsa_wait_bit_clear_s |
| WBS | 55 | dsa_wait_bit_set_s |
| | | dsa_wait_bit_set_a |
| WPG | 53 | |
| WPL | 52 | |
| WRST | 81 | |
| WSBC | 515 | |
| WSBS | 514 | |
| WSG | 57 | dsa_wait_sgn_register_greater_a |
| | | dsa_wait_sgn_register_greater_s |
| WSL | 56 | dsa_wait_sgn_register_lower_s |
| | | dsa_wait_sgn_register_lower_a |
| WTD | 15 | dsa_acquisition_continuous_wait_available_values_s |
| | | dsa_acquisition_continuous_wait_available_values_a |
| WTF | 14 | dsa_force_control_wait_a |
| | | dsa_force_control_wait_s |
| WTK | 513 | dsa_ipol_wait_mark_a |
| | | dsa_ipol_wait_mark_s |
| WTM | 8 | dsa_wait_movement_s |
| | | dsa_wait_movement_a |
| WTP | 9 | dsa_wait_position_a |
| | | dsa_wait_position_s |
| WTS | 12 | |
| WTT | 10 | dsa_wait_time_s |
| | | dsa_wait_time_a |
| WTW | 11 | dsa_wait_window_a |
| | | dsa_wait_window_s |
| WTWZXT | 488 | dsa_wait_window_zxt_a |
| | | dsa_wait_window_zxt_s |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| XYY_ABS | 123 | dsa_set_iso_register_s |
| | | dsa_set_iso_register_a |
| | | dsa_set_register_int64_s |
| | | dsa_set_register_a |
| | | dsa_set_register_int32_s |
| | | dsa_set_register_float32_s |
| | | dsa_set_register_float64_s |
| | | dsa_set_register_s |
| | | dsa_set_register_int32_a |
| | | dsa_set_register_int64_a |
| | | dsa_set_register_float32_a |
| | | dsa_set_register_float64_a |
| XYY_ADD | 91 | |
| XYY_AND | 95 | dsa_register_int32_logical_and_s |
| | | dsa_register_int64_logical_and_a |
| | | dsa_register_int64_logical_and_s |
| | | dsa_register_int32_logical_and_a |
| XYY_AND_NOT | 97 | dsa_register_int32_logical_and_not_a |
| | | dsa_register_int64_logical_and_not_a |
| | | dsa_register_int64_logical_and_not_s |
| | | dsa_register_int32_logical_and_not_s |
| XYY_CONV | 122 | |
| XYY_DIV | 94 | |
| XYY_MODULO | 101 | |
| XYY_MUL | 93 | |
| XYY_NOT | 174 | |
| XYY_ORL | 96 | dsa_register_int32_logical_or_a |
| | | dsa_register_int64_logical_or_a |
| | | dsa_register_int64_logical_or_s |
| | | dsa_register_int32_logical_or_s |
| XYY_ORL_NOT | 98 | dsa_register_int64_logical_or_not_a |
| | | dsa_register_int32_logical_or_not_a |
| | | dsa_register_int64_logical_or_not_s |
| | | dsa_register_int32_logical_or_not_s |
| XYY_SET_MULTI | 125 | |
| XYY_SHL | 173 | |
| XYY_SHR | 172 | |
| XYY_SUB | 92 | |
| XYY_XOR | 99 | |
| XYY_XOR_NOT | 100 | |
| YLD | 205 | |

| ETEL syntax | Command number | EDI function |
|---|---|---|
| ZFT | 203 | dsa_sync_trace_force_trigger_s |
| | | dsa_sync_trace_force_trigger_a |
| | | dsa_acquisition_acquire_a |
| | | dsa_acquisition_acquire_s |
| | | dsa_acquisition_acquire_s |
| | | dsa_acquisition_continuous_acquire |
| | | dsa_sync_trace_enable_a |
| | | dsa_sync_trace_enable_s |
| | | dsa_acquisition_acquire_a |

### 15.1.2 Functions for the reading and the writing of the registers

| Registers | Alias | EDI read function | EDI write function |
|---|---|---|---|
| C107 or CF107 | | dsa_get_analog_output_s | dsa_set_analog_output_s |
| C30 | XSRT | dsa_get_mon_source_type_s | dsa_set_mon_source_type_s |
| C31 | XSRI | dsa_get_mon_source_index_s | dsa_set_mon_source_index_s |
| C359:1 | | dsa_trigger_get_fdout_mask_s | dsa_trigger_set_fdout_mask_s |
| C5 | FDOUT | dsa_get_fast_digital_output_s | dsa_set_fast_digital_output_s |
| C6 | XDOUT | dsa_get_x_digital_output_s | dsa_set_x_digital_output_s |
| C7:0 | | dsa_get_x_analog_output_1_s | dsa_set_x_analog_output_1_s |
| C7:1 | | dsa_get_x_analog_output_2_s | dsa_set_x_analog_output_2_s |
| C7:2 | | dsa_get_x_analog_output_3_s | dsa_set_x_analog_output_3_s |
| C7:3 | | dsa_get_x_analog_output_4_s | dsa_set_x_analog_output_4_s |
| K11 | | dsa_get_ttl_speed_filter_s | dsa_set_ttl_speed_filter_s |
| K164 | | dsa_get_syncro_start_timeout_s | dsa_set_syncro_start_timeout_s |
| K171 | DOUT | dsa_get_digital_output_s | dsa_set_digital_output_s |
| K190 | | dsa_force_control_get_default_force_duration_s | dsa_force_control_set_default_force_duration_s |
| K198 | | dsa_get_indirect_register_idx_s | dsa_set_indirect_register_idx_s |
| K201 | MMC | dsa_get_concatenated_mvt_s | dsa_set_concatenated_mvt_s |
| K202 | MMD | dsa_get_profile_type_s | dsa_set_profile_type_s |
| K203 | LTN | dsa_get_mvt_lkt_number_s | dsa_set_mvt_lkt_number_s |
| K204 | LTI | dsa_get_mvt_lkt_time_s | dsa_set_mvt_lkt_time_s |
| K213 | JRT | dsa_get_jerk_time_s | dsa_set_jerk_time_s |
| K220 | | dsa_get_ctrl_source_type_s | dsa_set_ctrl_source_type_s |
| K220:sidx | | dsa_get_ctrl_source_type_ex_s | dsa_set_ctrl_source_type_ex_s |
| K221 | | dsa_get_ctrl_source_index_s | dsa_set_ctrl_source_index_s |
| K221:sidx | | dsa_get_ctrl_source_index_ex_s | dsa_set_ctrl_source_index_ex_s |
| K223 | | dsa_get_ctrl_offset_s | dsa_set_ctrl_offset_s |
| K223:sidx | | dsa_get_ctrl_offset_ex_s | dsa_set_ctrl_offset_ex_s |
| K239 | | dsa_get_motor_kt_factor_s | dsa_set_motor_kt_factor_s |
| K30 | | dsa_get_following_error_window_s | dsa_set_following_error_window_s |
| K302 | | | dsa_force_control_set_enable_s |
| K31 | | dsa_get_velocity_error_limit_s | dsa_set_velocity_error_limit_s |
| K32 | | dsa_get_switch_limit_mode_s | dsa_set_switch_limit_mode_s |
| K320+(combi):0 | | dsa_trigger_get_combi_dout_mask_s | dsa_trigger_set_combi_dout_mask_s |
| K320+(combi):1 | | dsa_trigger_get_combi_fdout_mask_s | dsa_trigger_set_combi_fdout_mask_s |
| K320+(combi):3 | | dsa_trigger_get_combi_event_counter_group_s | dsa_trigger_set_combi_event_counter_group_s |
| K320+(combi):7 | | dsa_trigger_get_combi_user_status_mask_s | dsa_trigger_set_combi_user_status_mask_s |
| K33 | | dsa_get_enable_input_mode_s | dsa_set_enable_input_mode_s |
| K336 | | dsa_trigger_get_position_type_s | dsa_trigger_set_position_type_s |

| Registers | Alias | EDI read function | EDI write function |
|---|---|---|---|
| K337:0 | | dsa_trigger_get_continuous_nb_free_event_s | dsa_trigger_set_continuous_nb_free_event_s |
| K337:1 | | dsa_trigger_get_continuous_user_status_bit_s | dsa_trigger_set_continuous_user_status_bit_s |
| K338 | | dsa_trigger2d_get_box_tolerance_increment_s | dsa_trigger2d_set_box_tolerance_increment_s |
| K338 | | dsa_trigger2d_get_box_tolerance_s | dsa_trigger2d_set_box_tolerance_increment_s |
| K339:(pulse_-generator) | | dsa_trigger_get_pulse_generator_period_s | dsa_trigger_set_pulse_generator_period_s |
| K340+(pulse_-generator):0 | | dsa_trigger_get_pulse_generator_dout_mask_s | dsa_trigger_set_pulse_generator_dout_mask_s |
| K340+(pulse_-generator):1 | | dsa_trigger_get_pulse_generator_fdout_mask_s | dsa_trigger_set_pulse_generator_fdout_mask_s |
| K342:(pulse_-generator) | | dsa_trigger_get_pulse_generator_delay_s | dsa_trigger_set_pulse_generator_delay_s |
| K343:(pulse_-generator) | | dsa_trigger_get_pulse_generator_pulse_width_s | dsa_trigger_set_pulse_generator_pulse_width_s |
| K344:(pulse_-generator) | | dsa_trigger_get_pulse_generator_interval_s | dsa_trigger_set_pulse_generator_interval_s |
| K345:(pulse_-generator) | | dsa_trigger_get_pulse_generator_number_s | dsa_trigger_set_pulse_generator_number_s |
| K347 | | dsa_trigger_get_missed_event_detection_time-out_s | dsa_trigger_set_missed_event_detection_time-out_s |
| K348 | | dsa_trigger_get_missed_event_detection_toler-ance_increment_s | dsa_trigger_set_missed_event_detection_toler-ance_increment_s |
| K348 | | dsa_trigger_get_missed_event_detection_toler-ance_s | dsa_trigger_set_missed_event_detection_toler-ance_increment_s |
| K349 | | dsa_trigger_get_missed_event_detection_action_s | dsa_trigger_set_missed_event_detection_ac-tion_s |
| K353:(trigger_-feature) | | dsa_trigger_get_source_register_type_s | dsa_trigger_set_source_register_type_s |
| K354:(trigger_-feature) | | dsa_trigger_get_source_register_idx_s | dsa_trigger_set_source_register_idx_s |
| K355:(trigger_-feature) | | dsa_trigger_get_source_register_sidx_s | dsa_trigger_set_source_register_sidx_s |
| K356:(trigger_-feature) | | dsa_trigger_get_source_register_axis_s | dsa_trigger_set_source_register_axis_s |
| K357:0 | | dsa_get_error_dout_mask_s | dsa_set_error_dout_mask_s |
| K357:1 | | dsa_get_error_fdout_mask_s | dsa_set_error_fdout_mask_s |
| K359 | | dsa_trigger_get_dout_mask_s | dsa_trigger_set_dout_mask_s |
| K36 | MODESL | dsa_get_profile_limit_mode_s | dsa_set_profile_limit_mode_s |
| K360 | | dsa_trigger_get_position_mean_filter_s | dsa_trigger_set_position_mean_filter_s |
| K360:1 | | dsa_trigger_get_position_compensation_s | dsa_trigger_set_position_compensation_s |
| K38 | TIMEW | dsa_get_position_window_time_s | dsa_set_position_window_time_s |
| K39 | POSW | dsa_get_position_window_s | dsa_set_position_window_s |
| K40 | HMODE | dsa_get_homing_method_s | dsa_set_homing_method_s |
| K52 | | dsa_get_homing_fine_tuning_mode_s | dsa_set_homing_fine_tuning_mode_s |
| K53 | | dsa_get_homing_fine_tuning_value_s | dsa_set_homing_fine_tuning_value_s |
| K530 | ISPDRATE | | dsa_ipol_set_velocity_rate_s |
| K56 | | dsa_get_motor_phase_correction_s | dsa_set_motor_phase_correction_s |
| K61 | | dsa_get_drive_control_mode_s | dsa_set_drive_control_mode_s |
| K66 | | dsa_get_display_mode_s | dsa_set_display_mode_s |
| K68 | | dsa_get_encoder_inversion_s | dsa_set_encoder_inversion_s |
| K7 | | dsa_get_pl_integrator_mode_s | dsa_set_pl_integrator_mode_s |
| K70 | | dsa_get_encoder_phase_1_offset_s | dsa_set_encoder_phase_1_offset_s |
| K700 | ILKTCAM | | dsa_ipol_set_lkt_speed_ratio_s |
| K71 | | dsa_get_encoder_phase_2_offset_s | dsa_set_encoder_phase_2_offset_s |
| K710 | ILKTCYCLIC | | dsa_ipol_set_lkt_cyclic_mode_s |

| Registers | Alias | EDI read function | EDI write function |
|---|---|---|---|
| K711 | ILKTREL | | dsa_ipol_set_lkt_relative_mode_s |
| K75 | | dsa_get_encoder_index_distance_s | dsa_set_encoder_index_distance_s |
| K90 | | dsa_get_init_mode_s | dsa_set_init_mode_s |
| K93 | | dsa_get_init_final_phase_s | dsa_set_init_final_phase_s |
| K94 | | dsa_get_init_time_s | dsa_set_init_time_s |
| K97 | | dsa_get_init_initial_phase_s | dsa_set_init_initial_phase_s |
| KF1 | KPP | dsa_get_pl_proportional_gain_s | dsa_set_pl_proportional_gain_s |
| KF1 or KF61 | | dsa_get_pl_proportional_gain_ex_s | dsa_set_pl_proportional_gain_ex_s |
| KF191 | | dsa_force_control_get_default_force_range_s | dsa_force_control_set_default_force_range_s |
| KF2 | KDP | dsa_get_pl_speed_feedback_gain_s | dsa_set_pl_speed_feedback_gain_s |
| KF2 or KF62 | | dsa_get_pl_speed_feedback_gain_ex_s | dsa_set_pl_speed_feedback_gain_ex_s |
| KF205 | CAM | dsa_get_came_value_s | dsa_set_came_value_s |
| KF21 | KAFFP | dsa_get_pl_acc_feedforward_gain_s | dsa_set_pl_acc_feedforward_gain_s |
| KF224 | | dsa_get_ctrl_gain_s | dsa_set_ctrl_gain_s |
| KF224:sidx | | dsa_get_ctrl_gain_ex_s | dsa_set_ctrl_gain_ex_s |
| KF339:(pulse_-generator) | | dsa_trigger_get_pulse_generator_period_coeff_s | dsa_trigger_set_pulse_generator_period_coeff_s |
| KF342:(pulse_-generator) | | dsa_trigger_get_pulse_generator_delay_coeff_s | dsa_trigger_set_pulse_generator_delay_coeff_s |
| KF343:(pulse_-generator) | | dsa_trigger_get_pulse_generator_pulse_width_co-eff_s | dsa_trigger_set_pulse_generator_-pulse_width_coeff_s |
| KF360 | | dsa_trigger_get_time_compensation_s | dsa_trigger_set_time_compensation_s |
| KF4 | KIP | dsa_get_pl_integrator_gain_s | dsa_set_pl_integrator_gain_s |
| KF4 or KF64 | | dsa_get_pl_integrator_gain_ex_s | dsa_set_pl_integrator_gain_ex_s |
| KF44 | | dsa_get_homing_current_limit_s | dsa_set_homing_current_limit_s |
| KF5 | KAWP | dsa_get_pl_anti_windup_gain_s | dsa_set_pl_anti_windup_gain_s |
| KF6 | | dsa_get_pl_integrator_limitation_s | dsa_set_pl_integrator_limitation_s |
| KF60 | IPEAK | dsa_get_software_current_limit_s | dsa_set_software_current_limit_s |
| KF72 | | dsa_get_encoder_phase_1_factor_s | dsa_set_encoder_phase_1_factor_s |
| KF73 | | dsa_get_encoder_phase_2_factor_s | dsa_set_encoder_phase_2_factor_s |
| KF80 | KPC | dsa_get_cl_proportional_gain_s | dsa_set_cl_proportional_gain_s |
| KF81 | KIC | dsa_get_cl_integrator_gain_s | dsa_set_cl_integrator_gain_s |
| KF83 | | dsa_get_cl_current_limit_s | dsa_set_cl_current_limit_s |
| KF84 | | dsa_get_cl_i2t_current_limit_s | dsa_set_cl_i2t_current_limit_s |
| KF85 | | dsa_get_cl_i2t_time_limit_s | dsa_set_cl_i2t_time_limit_s |
| KF91 | | dsa_get_init_pulse_level_s | dsa_set_init_pulse_level_s |
| KF92 | | dsa_get_init_max_current_s | dsa_set_init_max_current_s |
| KL206 | BRKDEC | dsa_get_brake_deceleration_s | dsa_set_brake_deceleration_s |
| KL210:depth | | dsa_get_target_position_s | dsa_set_target_position_from_register_s |
| KL211 | SPD | dsa_get_profile_velocity_s | dsa_set_profile_velocity_s |
| KL212 | ACC | dsa_get_profile_acceleration_s | dsa_set_profile_acceleration_s |
| KL27 | | dsa_get_max_position_range_limit_s | dsa_set_max_position_range_limit_s |
| KL34 | MINSL | dsa_get_min_soft_position_limit_s | dsa_set_min_soft_position_limit_s |
| KL35 | MAXSL | dsa_get_max_soft_position_limit_s | dsa_set_max_soft_position_limit_s |
| KL41 | HSPD | dsa_get_homing_zero_speed_s | dsa_set_homing_zero_speed_s |
| KL42 | HACC | dsa_get_homing_acceleration_s | dsa_set_homing_acceleration_s |
| KL43 | | dsa_get_homing_following_limit_s | dsa_set_homing_following_limit_s |
| KL45 | HOFFS | dsa_get_home_offset_s | dsa_set_home_offset_s |
| KL46 | | dsa_get_homing_fixed_mvt_s | dsa_set_homing_fixed_mvt_s |
| KL47 | | dsa_get_homing_switch_mvt_s | dsa_set_homing_switch_mvt_s |
| KL48 | | dsa_get_homing_index_mvt_s | dsa_set_homing_index_mvt_s |
| M10 | | dsa_get_velocity_demand_value_s | |

| Registers | Alias | EDI read function | EDI write function |
|---|---|---|---|
| M11 | | dsa_get_velocity_actual_value_s | |
| M14 | | dsa_get_acc_demand_value_s | |
| M140 | | dsa_get_drive_fuse_status_s | |
| M2 | | dsa_get_position_ctrl_error_s | |
| M2:sub_axis | | dsa_get_position_ctrl_error_ex_s | |
| M25 | | dsa_get_cl_lkt_phase_1_s | |
| M25:1 | | dsa_get_cl_lkt_phase_2_s | |
| M25:2 | | dsa_get_cl_lkt_phase_3_s | |
| M282:what | | dsa_get_parameters_version_s | |
| M3 | | dsa_get_position_max_error_s | |
| M345:(pulse_-generator) | | dsa_trigger_get_pulse_generator_sent_pulse_number_s | |
| M346 | | dsa_trigger_get_treated_event_number_s | |
| M349 | | dsa_trigger_get_nb_free_event_s | |
| M350 | | dsa_trigger_get_first_free_event_index_s | |
| M351 | | dsa_trigger_get_treated_event_number_per_group_s | |
| M395 | | dsa_force_control_get_force_duration_s | |
| M40 | SINENC | dsa_get_encoder_sine_signal_s | |
| M41 | COSENC | dsa_get_encoder_cosine_signal_s | |
| M449 or M524 | | dsa_get_nb_available_slots_s | |
| M475 / M470 | | dsa_get_sequence_code_usage_s | |
| M476 / M471 | | dsa_get_sequence_data_usage_s | |
| M477 / M472 | | dsa_get_sequence_source_usage_s | |
| M48 | | dsa_get_encoder_hall_dig_signal_s | |
| M50 | DIN | dsa_get_digital_input_s | |
| M52 | FDIN | dsa_get_fast_digital_input_s | |
| M55 | XDIN | dsa_get_x_digital_input_s | |
| M56:0 | | dsa_get_x_analog_input_1_s | |
| M56:1 | | dsa_get_x_analog_input_2_s | |
| M56:2 | | dsa_get_x_analog_input_3_s | |
| M56:3 | | dsa_get_x_analog_input_4_s | |
| M60 | SD1 | dsa_get_drive_status_1_s | |
| M61 | SD2 | dsa_get_drive_status_2_s | |
| M64 | ERRCD | dsa_get_error_text | |
| M64 | ERRCD | dsa_gantry_get_error_code | |
| M64 | ERRCD | dsa_get_error_code_s | |
| M66 | WARNCD | dsa_get_warning_code_s | |
| M66 | WARNCD | dsa_get_warning_text | |
| M67 | SEQNBP | dsa_debug_sequence_get_nb_breakpoints_s | |
| M77 | SEQTHRBKD | dsa_debug_sequence_get_break_thread_nb_s | |
| M87 | | dsa_get_axis_number_s | |
| M90 | CTEMP | dsa_get_drive_temperature_s | |
| M95 | | dsa_get_drive_display_s | |
| M96 | | dsa_get_drive_sequence_line_s | |
| MF20 | RCUR1 | dsa_get_cl_current_phase_1_s | |
| MF21 | RCUR2 | dsa_get_cl_current_phase_2_s | |
| MF22 | RCUR3 | dsa_get_cl_current_phase_3_s | |
| MF30 | TIQ | dsa_get_cl_demand_value_s | |
| MF31 | RIQ | dsa_get_cl_actual_value_s | |
| MF395 | | dsa_force_control_get_force_range_s | |

| Registers | Alias | EDI read function | EDI write function |
|---|---|---|---|
| MF51 | AIN | dsa_get_analog_input_s | |
| MF67 | | dsa_get_cl_i2t_value_s | |
| ML434 | | dsa_get_min_user_soft_position_limit_s | |
| ML435 | | dsa_get_max_user_soft_position_limit_s | |
| ML6 | | dsa_get_position_demand_value_s | |
| ML6:sub_axis | | dsa_get_position_demand_value_ex_s | |
| ML7 | | dsa_get_position_actual_value_s | |
| ML7:sub_axis | | dsa_get_position_actual_value_ex_s | |

## 15.2 Main programming changes when passing from EDI3.xx to EDI4.xx

### 15.2.1 All files including EDI header files must include new version of header files

| EDI3.xx | EDI4.xx |
|---|---|
| #include<etne20.h> | #include <etne40.h> |
| #include<tra20.h> | #include <tra40.h> |
| #include<dsa30.h> | #include <dsa40.h> |
| #include<etb20.h> | #include <etb40.h> |
| #include<dmd20.h> | #include <dmd40.h> |
| #include<ekd20.h> | #include <ekd40.h> |
| #include<lib20.h> | #include <lib40.h> |
| #include<esc10.h> | #include<esc40.h> |

### 15.2.2 The application must be linked with new version of library files

| EDI3.xx | EDI4.xx |
|---|---|
| -L etne20c.lib | -L etne40c.lib |
| -L tra20c.lib | -L tra40c.lib |
| -L dsa30c.lib | -L dsa40c.lib |
| -L etb20c.lib | -L etb40c.lib |
| -L dmd20c.lib | -L dmd40c.lib |
| -L ekd20c.lib | -L ekd40c.lib |
| -L lib20c.lib | -L lib40c.lib |
| -L esd10c.lib | -L esd40c.lib |
| -L esc10c.lib | -L esc40c.lib (available for 32-bits application only)<br>-L emp40c.lib (from EDI4.10A) |

### 15.2.3 EDI obsolete functions

#### *15.2.3.1 Register and functionality remove*

EDI, especially DSA library, provides a huge amount of specific functions. EDI4.xx does not support old DSA, DSB and DSC devices anymore. Some specific functions were designed to access DSA/DSB/DSC specific registers. These functions are no more available:

| Obsolete functions due to register or functionality remove |
|---|
| dsa_set_trace_mode_mvt_s/a |
| dsa_set_trace_mode_pos_s/a |
| dsa_set_trace_mode_dev_s/a |
| dsa_set_trace_mode_iso_s /a |
| dsa_set_trace_mode_immediate_s/a |
| dsa_trace_acquisition_s/a |
| dsa_ipol_reset_s/a |
| dsa_wait_window_user_channel_s/a |

| Obsolete functions due to register or functionality remove |
|---|
| dsa_wait_movement_user_channel_s/a |
| dsa_wait_time_user_channel_s/a |
| dsa_wait_position_user_channel_s/a |
| dsa_wait_sgn_register_greater_user_channel_s/a |
| dsa_wait_sgn_register_lower_user_channel_s/a |
| dsa_wait_bit_set_user_channel_s/a |
| dsa_wait_bit_clear_user_channel_s/a |
| dsa_get_rtm_mon |
| dsa_init_rtm_fct |
| dsa_start_rtm |
| dsa_stop_rtm |
| dsa_edit_sequence_s/a |
| dsa_exit_sequence_s/a |
| dsa_can_command_1_s/a |
| dsa_can_command_2_s/a |
| dsa_get_ebl_baudrate_s/a |
| dsa_get_drive_fuse_checking_s/a |
| dsa_get_motor_temp_checking_s/a |
| dsa_get_interrupt_mask_1_s/a |
| dsa_get_interrupt_mask_2_s/a |
| dsa_get_indirect_axis_number_s/a |
| dsa_get_indirect_register_sidx_s/a |
| dsa_get_daisy_chain_number_s/a |
| dsa_get_drive_mask_value_s/a |
| dsa_get_irq_drive_status_1_s/a |
| dsa_get_irq_drive_status_2_s/a |
| dsa_get_ack_drive_status_1_s/a |
| dsa_get_ack_drive_status_2_s/a |
| dsa_get_irq_pending_axis_mask_s/a |
| dsa_get_encoder_phase_3_factor_s/a |
| dsa_get_encoder_phase_3_offset_s/a |
| dsa_get_encoder_index_signal_s/a |
| dsa_get_encoder_hall_1_signal_s/a |
| dsa_get_encoder_hall_2_signal_s/a |
| dsa_get_encoder_hall_3_signal_s/a |
| dsa_get_apr_input_filter_s/a |
| dsa_get_cl_regen_mode_s/a |
| dsa_get_pdr_step_value_s/a |
| dsa_get_ctrl_shift_factor_s/a |
| dsa_get_ref_demand_value_s/a |
| dsa_get_drive_control_mask_s/a |
| dsa_get_cl_output_filter_s/a |
| dsa_get_cl_input_filter_s/a |
| dsa_get_cl_phase_advance_factor_s/a |
| dsa_get_cl_phase_advance_shift_s/a |
| dsa_get_pl_speed_feedfwd_gain_s/a |
| dsa_get_pl_force_feedback_gain_1_s/a |
| dsa_get_pl_force_feedback_gain_2_s/a |
| dsa_get_pl_output_filter_s/a |
| dsa_get_pl_speed_filter_s/a |
| dsa_get_ttl_special_filter_s/a |
| dsa_get_init_current_rate_s/a |
| dsa_get_init_phase_rate_s/a |
| dsa_get_end_velocity_s/a |
| dsa_get_profile_deceleration_s/a |
| dsa_get_min_position_range_limit_s/a |
| dsa_get_max_profile_velocity_s/a |
| dsa_get_max_acceleration_s/a |
| dsa_get_acc_actual_value_s/a |

| Obsolete functions due to register or functionality remove |
|---|
| dsa_get_io_error_event_mask_s/a |
| dsa_get_syncro_input_mask_s/a |
| dsa_get_syncro_input_value_s/a |
| dsa_get_syncro_output_mask_s/a |
| dsa_get_syncro_output_value_s/a |
| dsa_get_x_analog_gain_s/a |
| dsa_get_x_analog_offset_s/a |
| dsa_get_can_feedback_1_s/a |
| dsa_get_can_feedback_2_s/a |
| dsa_get_mon_dest_index_s/a |
| dsa_get_mon_gain_s/a |
| dsa_get_mon_offset_s/a |
| dsa_get_trigger_map_offset_s/a |
| dsa_get_trigger_map_size_s/a |
| dsa_get_trigger_io_mask_s/a |
| dsa_get_trigger_irq_mask_s/a |
| dsa_get_realtime_enabled_global_s/a |
| dsa_get_realtime_valid_mask_s/a |
| dsa_get_realtime_enabled_mask_s/a |
| dsa_get_realtime_pending_mask_s/a |
| dsa_set_ebl_baudrate_s/a |
| dsa_set_drive_fuse_checking_s/a |
| dsa_set_motor_temp_checking_s/a |
| dsa_set_interrupt_mask_1_s/a |
| dsa_set_interrupt_mask_2_s/a |
| dsa_set_indirect_axis_number_s/a |
| dsa_set_indirect_register_sidx_s/a |
| dsa_set_encoder_phase_3_factor_s/a |
| dsa_set_encoder_phase_3_offset_s/a |
| dsa_set_apr_input_filter_s/a |
| dsa_set_cl_regen_mode_s/a |
| dsa_set_pdr_step_value_s/a |
| dsa_set_ctrl_shift_factor_s/a |
| dsa_set_cl_output_filter_s/a |
| dsa_set_cl_input_filter_s/a |
| dsa_set_cl_phase_advance_factor_s/a |
| dsa_set_cl_phase_advance_shift_s/a |
| dsa_set_pl_speed_feedfwd_gain_s/a |
| dsa_set_pl_force_feedback_gain_1_s/a |
| dsa_set_pl_force_feedback_gain_2_s/a |
| dsa_set_pl_output_filter_s/a |
| dsa_set_pl_speed_filter_s/a |
| dsa_set_ttl_special_filter_s/a |
| dsa_set_init_current_rate_s/a |
| dsa_set_init_phase_rate_s/a |
| dsa_set_end_velocity_s/a |
| dsa_set_profile_deceleration_s/a |
| dsa_set_min_position_range_limit_s/a |
| dsa_set_max_profile_velocity_s/a |
| dsa_set_max_acceleration_s/a |
| dsa_set_io_error_event_mask_s/a |
| dsa_set_syncro_input_mask_s/a |
| dsa_set_syncro_input_value_s/a |
| dsa_set_syncro_output_mask_s/a |
| dsa_set_syncro_output_value_s/a |
| dsa_set_x_analog_gain_s/a |
| dsa_set_x_analog_offset_s/a |
| dsa_set_mon_dest_index_s/a |
| dsa_set_mon_gain_s/a |

| Obsolete functions due to register or functionality remove |
|---|
| dsa_set_mon_offset_s/a |
| dsa_set_trigger_map_offset_s/a |
| dsa_set_trigger_map_size_s/a |
| dsa_set_trigger_io_mask_s/a |
| dsa_set_trigger_irq_mask_s/a |
| dsa_set_realtime_enabled_global_s/a |
| dsa_set_realtime_valid_mask_s/a |
| dsa_set_realtime_pending_mask_s/a |
| etb_get_baudrate |
| etb_multi_send |
| etb_start_rtm |
| etb_stop_rtm |
| etb_init_rtm_fct |
| etb_get_rtm_mon |
| etb_link_error |
| etb_irq_watchdog |
| etb_get_bus_counters |
| etb_add_rt_handler |
| etb_remove_rt_handler |
| etb_auto_number |
| etb_activate_download |
| etb_start_download_file |
| etb_start_upload_file |
| etb_etcom_multi_send |
| etb_etcom_start_download_file |
| etb_etcom_start_upload_file |

#### *15.2.3.2 Axis addressing*

DSC and AccurET families differ concerning axis addressing:
- DSC family allows 32 axes, where DSMAX has number 31.
- AccurET family allows 64 axes, where UltimET has number 63.

EDI functions with parameters allowing axis addressing have been doubled in EDI3.xx (for e.g. `dsa_get_etb_axis` was dedicated to DSC family and returned an axis number 0 and 31, while `dsa_etcom_get_etb_axis` was dedicated to AccurET family and returned an axis number 0 and 63). As EDI4.xx does not support DSC any more, the DSC dedicated functions addressing axis have been removed:

| Obsolete functions due to DSC family axis addressing |
|---|
| dsa_open_e |
| dsa_open_ef |
| dsa_get_etb_axis |
| dsa_create_auto_e |
| etb_get_baudrate |
| etb_multi_send |
| etb_get_drv_present |
| etb_get_drv_status |
| etb_get_drv_info |
| etb_get_ext_info |
| etb_diag |
| etb_sdiag |
| etb_fdiag |
| etb_putm |
| etb_putr |
| etb_getm |
| etb_getr |
| etb_start_download |
| etb_start_upload |
| etb_download_firmware |

| Obsolete functions due to DSC family axis addressing |
|---|
| tra_upload_register_stream_e |
| tra_download_register_stream_e |
| tra_download_register_stream_e2 |
| tra_upload_limited_register_stream_e |
| tra_send_direct_stream_e |
| tra_get_axis_mask_e |
| tra_set_axis_mask_e |
| tra_set_preference_axis_mask |
| tra_get_preference_axis_mask |

#### *15.2.3.3 Record accessing*

DSC and AccurET families differ concerning the record used on the communication protocol:
- DSC family uses ETBREC fixed size record.
- AccurET family uses ETCOM variable length record.

As EDI3.xx supports both DSC and ETEL products, some functions allowing management of records have been implemented. The functions for the old ETBREC record have been removed:

| Obsolete functions due to DSC-family ETBREC record |
|---|
| tra_translate_cmd_to_ascii |
| tra_translate_cmd_to_ascii_ex |
| tra_translate_cmd_from_ascii |
| tra_translate_cmd_from_ascii_ex |
| tra_translate_rqs_to_ascii |
| tra_translate_rqs_to_ascii_ex |
| tra_get_iso_converter |
| tra_set_iso_converter |
| etb_etcom_to_recs |
| etb_recs_to_etcom |

#### *15.2.3.4 NON ANSI functions*

Some non ANSI functions have been removed. These are the functions returning a whole structure content. These are especially the functions allowing the initialization of a structure:

| Obsolete non ANSI functions |
|---|
| dsa_init_status |
| dsa_init_info |
| dsa_init_x_info |
| dsa_init_vector |
| dsa_init_vector_typ |
| dsa_init_rtm |
| etb_init_drv_info |
| etb_init_timeouts |
| etb_init_ext_info |
| etb_init_drv_status |
| etb_init_rec_param |
| etb_init_counters |
| etb_init_bus_status |
| etb_init_svr_info |
| etb_activate_status |
| etb_init_master_info |

The call to these functions can be replaced by:

**Example:**

```
DSA_STATUS status = dsa_init_status();
```

replaced by

```
DSA_STATUS status = {sizeof(DSA_STATUS)};
```

#### 15.2.3.5 Functions managing special ETEL devices

A special ETEL device called 'gp_module' was developed. This device was a special 'TEB' device. All functions accessing this device have been removed:

| Obsolete 'GP_MODULE' special device functions |
|---|
| dsa_create_gp_module |
| dsa_create_gp_module_group |
| dsa_is_valid_gp_module |
| dsa_is_valid_gp_module_group |
| dsa_is_valid_gp_module_base |

#### 15.2.3.6 Special functions accessing 'DSMAX'

Some functions accessing DSMAX must be used in EDI3.xx to access UltimET as well. These functions have been renamed into '...MASTER...', providing a more generic name. To allow portability between EDI3.xx and EDI4.xx, the old functions name still exists, but will be removed in the future:

| Obsolete 'DSMAX' functions | |
|---|---|
| dsa_create_dsmax | dsa_create_master |
| dsa_create_ dsmax _group | dsa_create_ master _group |
| dsa_is_valid_ dsmax | dsa_is_valid_master |
| dsa_is_valid_dsmax _group | dsa_is_valid_master _group |
| dsa_is_valid_dsmax_base | dsa_is_valid_master_base |
| dsa_set_dsmax | dsa_set_master |
| dsa_get_dsmax | dsa_get_master |

| Obsolete 'DSMAX' objects | |
|---|---|
| DSA_DSMAX | DSA_MASTER |
| DSA_DSMAX_GROUP | DSA_MASTER_GROUP |
| DSA_DSMAX_BASE | DSA_MASTER_BASE |

#### 15.2.3.7 Function allowing old ETEL sequence translation/download/upload

The ETEL Sequences on DSC family were interpreted by the controller. These Sequences were saved into S registers of the controller. The functions, allowing translation, download and upload of such Sequences into S registers have been removed:

| Obsolete ETEL sequence translation/download/upload |
|---|
| tra_is_valid_sequence_traductor |
| tra_create_sequence_traductor_o |
| tra_create_sequence_traductor_o2 |
| tra_clear_sequence_drive_map |
| tra_setup_sequence_drive_map |
| tra_etcom_setup_sequence_drive_map |
| tra_is_valid_sequence_traductor_e |
| tra_create_sequence_traductor_e |
| tra_download_sequence_stream_e |
| tra_upload_sequence_stream_e |
| tra_get_sequence_line_e |

## 15.3 Diagnostic (DSA_EXT_DIAG()) output description

DSA_DIAG() outputs a mixture of valuable information meant in part for the developer of the application, and in part for the ETEL DLL customer support should that be necessary. The output of DSA_EXT_DIAG is the standard output. If the user application does not redirect its standard output or if the standard output is not visible, it is advised to use DSA_EXT_SDIAG or even DSA_EXT_FDIAG to store the error message.

The layout of the output comes in three parts:

- The first line is very important for the application developer, because it provides a report on the state of the application: communication status and drive status. With this line and knowledge of the application and the system, the user should be able to identify the source of the problem in a large majority of the cases.
- The following lines constitutes the calling stack trace and is primarily meant for ETEL Support. It gives precise information on the execution flow (file name, function called and line number) that led to the error. It is for this piece of information that it is strongly recommended to systematically call DSA_EXT_DIAG() after each operation used from the EDI package. **This information will be requested by ETEL's Support team anytime a problem is reported.**
- The last line is a summarizing error message

### 15.3.1 Example 1

Programming example:

```
DSA_DRIVE *drv1 = NULL;
int err = 0;
if (err = dsa_create_drive(drv1)) { //Should be &drv1
     DSA_EXT_DIAG(err, drv1);
     goto _error;
}
```

Output:

```
.\test1.c (11045) : ERROR -322 : bad parameter (EDI package 0x4238080)
stacktrace:
      X:\lib-edi\sw_dsa\v40\c\dsaopn.c (dsa_create_drive:645)
      ERROR -322 : bad parameter : NULL DSA_DRIVE pointer on pointer
```

In this case, the user passes the pointer to the object instead of the address. By calling dsa_create_drive function, EDI checks if the pointer is correct. If it is not the case, it returns a DSA_EBADPARAM error. DSA_EXT_DIAG is called by passing the pointer as parameter. DSA_EXT_DIAG prints out that the pointer is not valid.

### 15.3.2 Example 2

Programming example:

```
DSA_DRIVE *drv1 = NULL;
int err = 0;

if (err = dsa_create_drive(&drv1)) {
     DSA_EXT_DIAG(err, NULL);
     goto _error;
}
if (err = dsa_open_u(drv1, "etb:ULTIMET:2")) {
     DSA_EXT_DIAG(err, drv1);
     goto _error;
}
```

Output:

```
.\test1.c (11048) : ERROR -320 : no drive response (EDI package 0x4238080)
```

```
on unknown command 0 (record 0x0, timeout 0 ms)sent on axisMask 0x0
status device 2 (status 0xc)
     POWER ON: 0
     PRESENT: 0
     MOVING: 0
     IN WINDOW: 0
     SEQUENCE ON: 0
     ERROR: 0
     TRACE ON: 0
     SEQUENCE THREAD ON: 0
     WARNING: 0
     SAVE_POS: 0
     BREAKPOINT: 0
     USER-BITS: 0x0
stacktrace:
     X:\lib-edi\sw_dsa\v40\c\dsaopn.c (dsa_open_u:1241)
     X:\lib-edi\sw_dsa\v40\c\dsaopn.c (dsa_reset:1529)
     ERROR -320 : no drive response : Device not present on bus
```

In this case, the user tries to open an axis not present. The call to `dsa_open_u` function returns an error. `DSA_EXT_DIAG` prints out that axis 2 does not respond. The user can also see this by analyzing the printed out drive status (0x0 0x0).

### 15.3.3 Example 3

Programming example:

```
DSA_DRIVE *drv1 = NULL;
DSA_DRIVE *drv2 = NULL;
DSA_DRIVE_GROUP *grp = NULL;
int err = 0;

if (err = dsa_create_drive(&drv1)) {
   DSA_EXT_DIAG(err, NULL);
   goto _error;
}
if (err = dsa_create_drive(&drv2)) {
   DSA_EXT_DIAG(err, drv2);
   goto _error;
}
if (err = dsa_create_drive_group(&grp, 2)) {
   DSA_EXT_DIAG(err, grp);
   goto _error;
}
if (err = dsa_set_group_item(grp, 0, drv1)) {
   DSA_EXT_DIAG(err, drv1);
   goto _error;
}
if (err = dsa_set_group_item(grp, 1, drv2)) {
   DSA_EXT_DIAG(err, drv2);
   goto _error;
}
if (err = dsa_open_u(drv1, "etb:ULTIMET:0")) {
   DSA_EXT_DIAG(err, drv1);
   goto _error;
}
if (err = dsa_open_u(drv2, "etb:ULTIMET:1")) {
   DSA_EXT_DIAG(err, drv2);
   goto _error;
```

```
  }
  if (err = dsa_wait_time_s(grp, 5.0, 10)) {
    DSA_EXT_DIAG(err, grp);
    goto _error;
  }
```

Output:

```
.\test1.c (11067) : ERROR -310 : timeout error (EDI package 0x4238080)on command WTT
(record 0x20, timeout 10 ms) sent on axisMask 0x3
status device 0 (status 0xc)
  POWER ON: 0
  PRESENT: 1
  MOVING: 0
  IN WINDOW: 1
  SEQUENCE ON: 0
  ERROR: 1 (device-error 56: Time-out error in TransnET communication)
  TRACE ON: 0
  SEQUENCE THREAD ON: 0
  WARNING: 0
  SAVE_POS: 0
  BREAKPOINT: 0
  USER-BITS: 0x0
status device 1 (status 0xc)
  POWER ON: 0
  PRESENT: 1
  MOVING: 0
  IN WINDOW: 1
  SEQUENCE ON: 0
  ERROR: 1 (device-error 56: Time-out error in TransnET communication)
  TRACE ON: 0
  SEQUENCE THREAD ON: 0
  WARNING: 0
  SAVE_POS: 0
  BREAKPOINT: 0
  USER-BITS: 0x0
stacktrace:
  X:\lib-edi\sw_dsa\v40\c\dsawai.c (dsa_wait_time_s:174)
  X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_2c:902)
  X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_ncn:600)
  X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_ncx:441)
  X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_g1cxv:1022)
  X:\lib-edi\sw_dsa\v40\c\dsatrn.c (dsa_commit_sync_trans:205)
  X:\lib-edi\sw_dsa\v40\c\dsamsg.c (_dsa_wait_sync_event:922)
  ERROR -310 : timeout error : Event waiting timeout
  AxisMask 0x3
  Rec 0x20, Cmd 0xa, Timeout 10 [ms]
```

In this case, the user calls the WTT function with an EDI timeout of 10 ms. This follows to a `DSA_ETIMEOUT` error. `DSA_EXT_DIAG` is called passing the device group as parameter. `DSA_EXT_DIAG` prints out the error and the status of each drive present in the group.

### 15.3.4 Example 4

```
  DSA_DRIVE *drv1 = NULL;
  DSA_DRIVE *drv2 = NULL;
  int err = 0;
```

```
  if (err = dsa_create_drive(&drv1)) {
    DSA_EXT_DIAG(err, NULL);
    goto _error;
  }
  if (err = dsa_create_drive(&drv2)) {
    DSA_EXT_DIAG(err, drv2);
    goto _error;
  }
  if (err = dsa_open_u(drv1, "etb:ULTIMET:0")) {
    DSA_EXT_DIAG(err, drv1);
    goto _error;
  }
  if (err = dsa_open_u(drv2, "etb:ULTIMET:1")) {
    DSA_EXT_DIAG(err, drv2);
    goto _error;
  }
  if (err = dsa_power_on_s(drv1, 1000)) {
    DSA_EXT_DIAG(err, drv1);
    goto _error;
  }
  if (err = dsa_homing_start_s(drv1, 1000)) {
    DSA_EXT_DIAG(err, drv1);
    goto _error;
  }
```

Output:

```
.\test1.c (11056) : ERROR -311 : drive in error (EDI package 0x4238080)on command PWR
(record 0x20, timeout 1000 ms) sent on axisMask 0x1
status device 0 (status 0xc)
   POWER ON: 0
   PRESENT: 1
   MOVING: 0
   IN WINDOW: 1
   SEQUENCE ON: 0
   ERROR: 1 (device-error 56: Time-out error in TransnET communication)
   TRACE ON: 0
   SEQUENCE THREAD ON: 0
   WARNING: 0
   SAVE_POS: 0
   BREAKPOINT: 0
   USER-BITS: 0x0
stacktrace:
   X:\lib-edi\sw_dsa\v40\c\dsafct.c (dsa_power_on_s:405)
   X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_2c:902)
   X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_ncn:600)
   X:\lib-edi\sw_dsa\v40\c\dsasyn.c (_dsa_sync_cmd_ncx:561)
   X:\lib-edi\sw_dsa\v40\c\dsamsg.c (_dsa_wait_sync_event:918)
   ERROR -311 : drive in error : Event received with message error
   AxisMask 0x1
   Rec 0x20, Cmd 0x7c, Timeout 1000 [ms]
```

In this case, the user calls `dsa_homing_start` on a drive which is not powered on. This returns a `DSA_EDRVERR` error. `DSA_EXT_DIAG` prints out that the axis 0 cannot be homed because it is not powered on.

## 15.4 Description of the other examples in C

**Example1: acquisition\acquisition.c**

```
/*
* This simple demo program shows how to make acquisition, using ETEL EDI library set. This example will do
* an acquisition of one trace on two AccurET controllers connected to an UltimET.
*/

/*
* To run this demo without modification, you must have:
* - 2 linear motor and an AccurET properly configured.
* - an UltimET plugged in the PC
* - AccurET and UltimET connected through TransnET
*/
```

**Example2: compiler\compiler.c**

```
/*
* This simple demo program shows how to:
* - compile and download a Sequence into an AccurET.
* - upload a Sequence from an AccurET
*/

/*
* To run this demo without modification, you don't need to have a motor connected. You must have one or many
* AccurET(s) connected through USB or UltimET. The example allows to choose between several
* configurations
*/
```

**Example3: compiler\offline_compiler.c**

```
/*
* This simple demo program shows how to:
* - compile a sequence using an off-line compiler.
* - download the compiled Sequence into a device
*/

/*
* To run this demo without modification, you don't need to have a motor connected. You must have one or any
* AccurET(s) connected through USB or UltimET. The example allows to choose between several
* configurations
*/
```

**Example4: generic\sample_1.c**

```
/*
* This simple demo program shows how to make basic drive operations (power on, indexation, movement) on
* a single drive, using ETEL EDI library set.
* The program will send a power on and an indexation command, then move the motor near the two limits of
* the available range, go to the zero position again and power off the drive.
*/

/*
* To run this demo without modification, you must have:
* - a linear motor and an AccurET controller properly configured.
* - a USB connection between the drive and the PC.
* - the drive must have the axis number 0.
* - KL45 must be set to insure that position 0 is inside the valid range.
* - KL34 and KL35 must be set properly.
* If KL34 and KL35 aren't set properly, you can modify this code to set pos_min and pos_max manually.
*/
```

**Example5: generic\sample_2.c**

```
/* This second sample program extends sample_1.c and shows how to use the library to control multiple axes
* in once. It will move a x/y table to random positions.
*/

/*
* To run this demo without modification, you must have:
* - two linear motors with one AccurET controller configured.
* - a USB connection between the drive and the PC.
* - the drives must have the axes number 0 and 1.
* - KL45 must be set to insure that position 0 is inside the valid range.
* - KL34 and KL35 must be set properly.
*/
```

**Example6: generic\sample_3.c**

```
/*
* This third sample program extends sample_2.c and shows how to use multithreading with ETEL's DLLs. In
* this program, we will add a thread to monitor the current position of the drive and a thread for emergency stop.
* The monitoring thread will show the current position of both axes every 100ms, and the second thread will
* wait indefinitely for a command from the user: the space key will immediately stop the sequence, which will
* run indefinitely otherwise.
*/

/*
* To run this demo without modification, you must have:
* - two linear motors with one AccurET controller configured.
* - a USB connection between the drive and the PC.
* - the drives must have the axes number 0 and 1.
* - KL45 must be set to insure that position 0 is inside the valid range.
* - KL34 and KL35 must be set properly.
*/
```

**Example7: generic\sample_4.c**

```
/*
C example for upload / download of parameters in an UltimET.
The functions defined in this example are also valid for AccurET drives.
*/
```

**Example8: generic\sample_5.c**

```
/*
C example for download firmware into a DRIVE or an UltimET.
*/
```

**Example9: io\io1.c**

```
/*
* This sample program show how to set and get I/Os from UltimET.
*/

/*
* To run this demo without modification, you must have:
* - an UltimET PCI board plugged into your PC or
* - an UltimET TCP/IP connected to the network
*/
```

**Example10: mapping\mapping1.c**

```
/*
* This sample program shows how to:
*    -    download mapping file into a group of drives
*    -    upload data stored in a group of device into a mapping file
*    -    activate mapping of a group of drive
```

```
*    -    deactivate mapping of a group of drive
*    -    check mapping activity of a group of drive
*/

/*
* To run this demo without modification, you must have:
* - a PCI-UltimET board plugged into your PC
* - one or many AccurET(s) connected to UltimET through TransnET
* If you want to run this example without UltimET, you must change the URL It is advised to download first
* mapping files provided with the example before uploading data from drives. There are 2 mapping files
* provided with the example:
* - map2D.txt which is a correct mapping file downloadable into 2 AccurET number 0 and 1.
* - map3D.txt which is a correct mapping file downloadable into 3 AccurET number 0, 1 and 2.
*/
```

**Example11: mapping\scaling1.c**

```
/*
* This sample program shows how to
*    -    download scaling file into a drive
*    -    activate scaling of a drive
*    -    deactivate scaling of a drive
*    -    check scaling activity of a drive
*/
/*
* To run this demo without modification, you must have:
* - an AccurET connected to your PC, either by USB, TCP/IP or through an UltimET
* Just change the URL to fit the connection
* There is 1 scaling file provided with the example:
* - scaling.txt which is a correct scaling file downloadable into an AccurET number 0.
*/
```

**Example12: rtv\rtv1.c**

```
/*
* This sample program shows how to read real-time value on TransnET without irq synchronization, this means
* that the software will configure UltimET to put:
*        M50: Digital input
*        ML7: real position real-time value
*        MF31: Real force Iq measured of the AccurET into Real time slot on TransnET.
* The example will then read these value asynchronously.
*/
/*
* To run this demo without modification, you must have:
* - a PCI-UltimET board plugged into your PC
* - an AccurET device 0 connected to UltimET through TransnET
* - Eventually a connected and set motor
*/
```

**Example13: rtv\rtv2.c**

```
/*
* This sample program shows how to read real-time value on TransnET with irq synchronization, this means
* that the software will configure UltimET to put:
*        M50: Digital input
*        ML7: real position real-time value
*        MF31: Real force Iq measured of the AccurET into Real-time slot on TransnET.
* The example will then read these value synchronously when DSA_RTV_HANDLER will be called
*/
/*
* To run this demo without modification, you must have:
* - a PCI-UltimET board plugged into your PC
* - an AccurET device 0 connected to UltimET through TransnET
* - Eventually a connected and set motor
*/
```

**Example14: rtv\rtv3.c**

```
/*
* This sample program shows how to setup slave-to-slave communication using RTV.
* - Configure Axis 0 to put ML1 value into a slot
* - Configure Axis 1 to read slot value into ML450
* - Move Drive 0 and monitor ML450 of drive 1 during move
* This is an example. Slave to slave communication can be made without RTV if the two axes are part of the
* same AccurET
*/

/*
* To run this demo without modification, you must have:
* - a PCI-UltimET board plugged into your PC
* - an AccurET axis 0 connected to UltimET through TransnET with a connected and set motor
* - an AccurET axis 1 connected to UltimET through TransnET
*/
```

**Example15: stream\stream.c**

```
/*
* This sample program shows how to make "stream" transfer between PC and device. Stream transfer allows
* to write or read a large amount of data into/from the device. This type of transfer is mainly used when
* uploading traces or registers or when downloading firmwares.
* This sample allows the user to choose the communication bus and the connected devices. No tests are done
* concerning the validity of the registers' typ. For example, if is not possible to write M registers, but this
* example does no validity check
*/
```

**Example16: ultimet\ultimet_1.c**

```
/*
* This simple demo program shows how to make basic interpolated movements on a X-Y axes system using
* ETEL's EDI libraries and the UltimET motion controller. The program will switch the motors on, send an
* indexation command, make a simple movement, switch to the interpolation mode and interpolate a G-code
* movement.
*/

/*
* To run this demo without modification, you must have:
* - two linear motors with one AccurET controllers configured.
* - one UltimET Light PC, configured like this
* - a TransnET connection between the drives and the UltimET.
* - the drives must have the axis number 0 and 1.
* - KL45 must be set to insure that position 0 is inside the valid range.
* - KL34 and KL35 must be set properly.
*/
```

**Example17: ultimet\ultimet_2.c**

```
 /*
* This is a simple program that use the UltimET motion controller to perform an interpolated movement on a
* X-Y axes system with PVT commands. PVT means Position - Velocity - Time. A movement is defined by the
* position of the destination point (in x,y,z and theta coordinates), the velocity at the destination point, and the
* time to do the displacement.
*/

/*
* To run this demo without modification, you must have:
* - two linear motors with one AccurET controllers configured.
* - one UltimET Light PCI, configured like this
* - a TransnET connection between the drives and the UltimET.
* - the drives must have the axis number 0 and 1.
* - KL45 must be set to insure that position 0 is inside the valid range.
```

```
* - KL34 and KL35 must be set properly.
*/
```

**Example18: ultimet\ultimet_3.c**

```
/*
* This is a simple program that illustrates the working principle of the command 126.
* The aim of this function is to set in one block several values into X, XL, XF, XD or L registers. For X, XF and
* L registers, the maximum number of values is 127. For XL and XD registers, the maximum number of values
* is 100. It sets from a specified index at a fixed depth the values in the specified type of register.
* This command has to be sent by calling dsa_execute_command_x_s(). Please see the EDI HTML
* documentation for further explanations about this function.
* The number of parameters to send has to be equal to the number of effective values plus one. This additional
* parameter has to be first set to specify the type of register, the depth and the index used by the command.
*/

/*
* To run this demo without modification, you must have:
* - one UltimET Light PCI or an UltimET TCP/IP
*/
```

**Example 19: etne/etne_sample1.c**

```
/*
* This software is an example showing the way to implement the following things:
* 1) The way to open several connection on an UltimET PCI using ETNE server
* 2) How to use the new DSA_EXT_DIAG for extended diagnostic in case of error
*
* Remark: The EDI package must be greater or equal to 4.00A!!!
*/
```

**Example 20: trigger/trigger_sample1.c**

```
/*
* This example shows how to set a trigger using dsa specific functions.
*/
```

**Example 21: umeg\umeg.c (User's manual example)**

```
/*
*This is the example that is referred to in the “EDI User's Manual”.
*
* This examples aims at using the library to control two axes concurrently via an UltimET.
* The UltimET is an UltimET-PCI and the controllers are one AccurET 400.
* If an UltimET Light TCP/IP or UltimET Advanced is used, only the URL used when the communication is
* opened must be changed. The remainder of the example will run.
* A first set of actions aims at getting the drives in an operational state which entails:
* - establishing the communication with the UltimET and the drives connected to it
* - powering up the drives
* - performing the homing procedure on each drive.
*
* The next set deals with making movements on each axis by first describing how to set the limits and precision
* windows, and then actually specifying and starting the movement. The movements will be controlled by the
* UltimET which will execute them in interpolated mode. In a more elaborate step, one thread will be created
* to monitor the current position of the motors. The monitoring thread will show the current position of each
* motor every 100ms. Another will loop indefinitely waiting for a user input: the space bar will immediately stop
* the movement and set one of the controller’s digital outputs.
*
* Finally, it will be shown how to power off the drives.
*
* The last portion of the program covers error handling.
*
```

```
* To run this example without modification, you must have:
* - two linear motors and two ETEL position loop controllers set and tuned accordingly.
* - an UltimET Light PCI on a PCI slot of your PC.
* - a TransnET connection between the UltimET and the drives.
* - the drives must have the axis numbers 0 and 1.
* - the software position limits (KL34 and KL35) must have been set when setting the controllers otherwise
* these will be defaulted to zero and nothing will move.
*/
```

## 15.5 Deprecated functions

The table below lists the EDI deprecated C functions. Deprecated functions remain in the EDI package, they are functional, but not further improved.

ETEL S.A. strongly recommends against using these functions for the development of new applications, as they might be removed at the earliest in the next major or minor release.

### 15.5.1 C interface

| DLL | Deprecated function | Recommended alternative function |
|---|---|---|
| DSA | int dsa_change_setpoint_s/a | int dsa_new_setpoint_s/a |
| DSA | int dsa_start_profiled_movement_s/a | int dsa_start_profiled_movement_ex_s/a |
| DSA | Int dsa_start_relative_profiled_movement_s/a | int dsa_start_relative_profiled_movement_ex_s/a |
| DSA | int dsa_set_profiled_movement_s/a | int dsa_set_profiled_movement_ex_s/a |
| DSA | int dsa_set_register_s/a | int dsa_set_register_int32_s/a |
| DSA | int dsa_get_register_s/a | int dsa_get_register_int32_s/a |
| DSA | int dsa_set_array_s/a | int dsa_set_array_int32_s/a |
| DSA | int dsa_get_array_s/a | int dsa_get_array_int32_s/a |
| DSA | int dsa_create_dsmax | int dsa_create_master |
| DSA | int dsa_create_dsmax_group | int dsa_create_master_group |
| DSA | int dsa_set_dsmax | int dsa_set_master |
| DSA | int dsa_get_dsmax | int dsa_get_master |
| DSA | ebool dsa_is_valid_dsmax | ebool dsa_is_valid_master |
| DSA | ebool dsa_is_valid_dsmax_group | ebool dsa_is_valid_master_group |
| DSA | ebool dsa_is_valid_dsmax_base | ebool dsa_is_valid_master_base |
| DSA | int dsa_set_gate | N/A |
| DSA | int dsa_get_new_gate | N/A |
| DSA | int dsa_clear_gate | N/A |
| DSA | int dsa_convert_to_iso | int dsa_convert_int32_to_iso |
| DSA | int dsa_convert_from_iso | int dsa_convert_int32_from_iso |
| DSA | int dsa_diag | int dsa_ext_diag |
| DSA | int dsa_sdiag | int dsa_ext_sdiag |
| DSA | int dsa_fdiag | int dsa_ext_fdiag |
| DSA | int dsa_acquisition_config_trigger | int dsa_acquisition_config_immediate_trigger<br>(+ *other specific trigger functions*) |
| DSA | int dsa_acquisition_config_frequency | int dsa_acquisition_config_with_nb_points_and_total_time |
| DSA | int dsa_download_compiled_sequence_file | int dsa_download_compiled_sequence_file_ex |
| DSA | int dsa_quick_register_request_s/a | int dsa_quick_register_int32_request_s/a |
| DSA | int dsa_reset_error_s/a | int dsa_reset_error_ex_s/a |
| DSA | int dsa_reset_error_with_check_s/a | int dsa_reset_error_with_check_ex_s/a |
| DSA | int dsa_execute_sequence_s/a | int dsa_execute_sequence_in_thread_s/a |
| DSA | int dsa_stop_sequence_s/a | int dsa_stop_sequence_in_thread_s/a |
| DSA | int dsa_trigger_enable_s/a | int dsa_trigger_enable_ex_s/a |
| DSA | int dsa_trigger2d_enable_s/a | int dsa_trigger2d_enable_ex_s/a |

| DLL | Deprecated function | Recommended alternative function |
|---|---|---|
| DSA | int dsa_set_pl_speed_feedback_gain_s/a | int dsa_set_pl_speed_feedback_gain_ex_s/a |
| DSA | int dsa_get_pl_speed_feedback_gain_s/a | int dsa_get_pl_speed_feedback_gain_ex_s/a |
| DSA | int dsa_set_pl_proportional_gain_s/a | int dsa_set_pl_proportional_gain_ex_s/a |
| DSA | int dsa_get_pl_proportional_gain_s/a | int dsa_get_pl_proportional_gain_ex_s/a |
| DSA | int dsa_set_pl_integrator_gain_s/a | int dsa_set_pl_integrator_gain_ex_s/a |
| DSA | int dsa_get_pl_integrator_gain_s/a | int dsa_get_pl_integrator_gain_ex_s/a |
| DSA | int dsa_set_ctrl_source_index_s/a | int dsa_set_ctrl_source_index_ex_s/a |
| DSA | int dsa_get_ctrl_source_index_s/a | int dsa_get_ctrl_source_index_ex_s/a |
| DSA | int dsa_set_ctrl_source_type_s/a | int dsa_set_ctrl_source_type_ex_s/a |
| DSA | int dsa_get_ctrl_source_type_s/a | int dsa_get_ctrl_source_type_ex_s/a |
| DSA | int dsa_set_ctrl_offset_s/a | int dsa_set_ctrl_offset_ex_s/a |
| DSA | int dsa_get_ctrl_offset_s/a | int dsa_get_ctrl_offset_ex_s/a |
| DSA | int dsa_set_ctrl_gain_s/a | int dsa_set_ctrl_gain_ex_s/a |
| DSA | int dsa_get_ctrl_gain_s/a | int dsa_get_ctrl_gain_ex_s/a |
| DSA | int dsa_get_position_ctrl_error_s/a | int dsa_get_position_ctrl_error_ex_s/a |
| DSA | int dsa_get_position_demand_value_s/a | int dsa_get_position_demand_value_ex_s/a |
| DSA | int dsa_get_position_actual_value_s/a | int dsa_get_position_actual_value_ex_s/a |
| DSA | int dsa_force_control_set_s/a | int dsa_force_control_set_ex4_s/a |
| DSA | int dsa_force_control_set_ex1_s/a | int dsa_force_control_set_ex4_s/a |
| DSA | int dsa_force_control_set_ex2_s/a | int dsa_force_control_set_ex4_s/a |
| DSA | int dsa_force_control_set_ex3_s/a | int dsa_force_control_set_ex4_s/a |
| DSA | int dsa_force_control_reset_s/a | int dsa_force_control_reset_ex3_s/a |
| DSA | int dsa_force_control_reset_ex1_s/a | int dsa_force_control_reset_ex3_s/a |
| DSA | int dsa_force_control_reset_ex2_s/a | int dsa_force_control_reset_ex3_s/a |
| DSA | int dsa_force_control_new_s/a | int dsa_force_control_new_ex2_s/a |
| DSA | int dsa_force_control_new_ex1_s/a | int dsa_force_control_new_ex2_s/a |
| DSA | int dsa_force_control_set_immediate_s/a | int dsa_force_control_set_immediate_ex2_s/a |
| DSA | int dsa_force_control_set_immediate_ex1_s/a | int dsa_force_control_set_immediate_ex2_s/a |
| DSA | int dsa_start_upload_memory_s | N/A |
| DSA | int dsa_start_upload_sequence_s | int dsa_upload_sequence_s |
| ETB | int etb_etcom_start_download_ex | int etb_etcom_start_download_ex3 |
| ETB | int etb_etcom_start_download_ex2 | int etb_etcom_start_download_ex3 |
| ETB | int etb_etcom_download_firmware | int etb_etcom_download_firmware_ex |
| DMD | int dmd_get_register_min_value | int dmd_get_register_min_value_int32 |
| DMD | int dmd_get_register_max_value | int dmd_get_register_max_value_int32 |
| DMD | int dmd_get_register_default_value | int dmd_get_register_default_value_int32 |
| DMD | int dmd_get_parameter_min_value | int dmd_get_parameter_min_value_int32 |
| DMD | int dmd_get_parameter_max_value | int dmd_get_parameter_max_value_int32 |
| DMD | int dmd_get_parameter_default_value | int dmd_get_parameter_default_value_int32 |
| DMD | ebool dmd_is_command_deprecated | N/A |
| DMD | ebool dmd_is_command_waiting | N/A |
| DMD | ebool dmd_is_parameter_jump_target | N/A |
| DMD | ebool dmd_is_parameter_l_value | N/A |
| DMD | int dmd_get_enum_value | int dmd_get_enum_value_int32 |
| DMD | int dmd_get_enum_range | N/A |
| DMD | ebool dmd_is_enum_deprecated | N/A |
| TRA | int tra_receive_direct_cmd_e | nt tra_receive_direct_cmd_e_ex |

### 15.5.2 .NET interface

| Class | Deprecated method | Recommended alternative method |
|---|---|---|
| DsaDsmax | Class DsaDsmax | Class DsaMaster |
| DsaDsmaxGroup | Class DsaDsmaxGroup | Class DsaMasterGroup |
| DsaDrive, DsaDriveGroup | changeSetPoint | newSetPoint |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | setRegister | setRegisterInt32 |
| DsaDrive, DsaMaster | getRegister | getRegisterInt32 |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | setArray | setArrayInt32 |
| DsaDrive, DsaMaster | getArray | getArrayInt32 |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | getNewGate | N/A |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | setGate | N/A |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | clearGate | N/A |
| DsaDrive, DsaMaster | convertToIso | convertInt32ToIso |
| DsaDrive, DsaMaster | convertFromIso | convertInt32FromIso |
| DsaAcquisition | configTrigger | configImmediateTrigger<br>(+ *other specific trigger methods*) |
| DsaAcquisition | configFrequency | configWithNbPointsAndTotalTime |
| DsaDrive, DsaMaster | quickRegisterRequest | quickRegisterInt32Request |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | resetError | resetErrorEx |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | resetErrorWithCheck | resetErrorWithCheckEx |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | executeSequence | executeSequenceInThread |
| DsaDrive, DsaDriveGroup, DsaMaster, DsaMasterGroup | stopSequence | stopSequenceInThread |
| DsaDrive, DsaDriveGroup | enableTrigger | enableTriggerEx |
| DsaDrive, DsaDriveGroup | trigger2dEnable | trigger2dEnableEx |
| DsaDrive, DsaDriveGroup | setPLSpeedFeedbackGain | setPLSpeedFeedbackGainEx |
| DsaDrive | getPLSpeedFeedbackGain | getPLSpeedFeedbackGainEx |
| DsaDrive, DsaDriveGroup | setPLProportionalGain | setPLProportionalGainEx |
| DsaDrive | getPLProportionalGain | getPLProportionalGainEx |
| DsaDrive, DsaDriveGroup | setPLIntegratorGain | setPLIntegratorGainEx |
| DsaDrive | getPLIntegratorGain | getPLIntegratorGainEx |
| DsaDrive, DsaDriveGroup | setCtrlSourceType | setCtrlSourceTypeEx |
| DsaDrive | getCtrlSourceType | getCtrlSourceTypeEx |
| DsaDrive, DsaDriveGroup | setCtrlSourceIndex | setCtrlSourceIndexEx |
| DsaDrive | getCtrlSourceIndex | getCtrlSourceIndexEx |
| DsaDrive, DsaDriveGroup | setCtrlOffset | setCtrlOffsetEx |
| DsaDrive | getCtrlOffset | igetCtrlOffsetEx |
| DsaDrive, DsaDriveGroup | setCtrlGain | setCtrlGainEx |
| DsaDrive | getCtrlGain | getCtrlGainEx |
| DsaDrive | getPositionCtrlError | igetPositionCtrlErrorEx |
| DsaDrive | getPositionDemandValue | getPositionDemandValueEx |
| DsaDrive | getPositionActualValue | getPositionActualValueEx |
| DsaDrive, DsaMaster | startUploadSequence | uploadsequence |
| EtbBus | etcomStartDownload | etcomStartDownloadEx |
| EtbBus | etcomDownloadFirmware | etcomDownloadFirmwareEx |

| Class | Deprecated method | Recommended alternative method |
|---|---|---|
| DmdData | getRegisterMinValue | getRegisterMinValueInt32 |
| DmdData | getRegisterMaxValue | getRegisterMaxValueInt32 |
| DmdData | getRegisterDefaultValue | getRegisterdefaultValueInt32 |
| DmdData | getParameterMinValue | getParameterMinValueInt32 |
| DmdData | getParameterMaxValue | getParameterMaxValueInt32 |
| DmdData | getParameterDefaultValue | getParameterDefaultValueInt32 |
| DmdData | isCommandDeprecated | N/A |
| DmdData | isParameterJumpTarget | N/A |
| DmdData | isParameterLValue | N/A |
| DmdData | getEnumValue | getEnumValueInt32 |
| DmdData | getEnumRange | N/A |
| DmdData | isEnumDeprecated | N/A |
| DmdData | isRegisterDeprecated | N/A |

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