sat-nms MNC/NMS

Universal Device Driver

Reference Manual

Version 1.6 / 2014-07-11

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Introduction

This is the *Universal Device Driver Reference Manual* to the ***sat-nms*** M&C/VLC software. It mainly describes how to make the software interface to a certain type of equipment which is not included in the the ***sat-nms*** device driver library for some reason.

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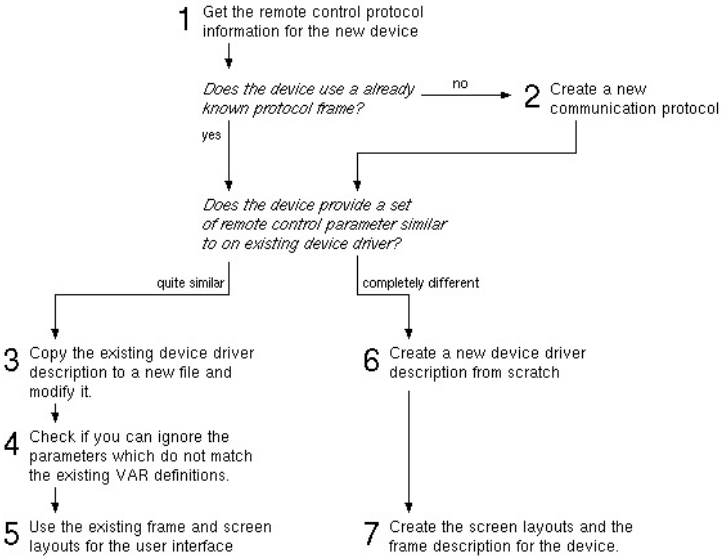
To make the ***sat-nms*** software support an additional device type, the software needs at least three components:

1. A low level communication protocol which handles the protocol frame including device addressing or checksum calculation.
2. A device driver which defines the parameters the operator may inspect or control at the device. The device driver also contains the I/O routines to exchange these parameters with the device.
3. Finally, there must be a standard user interface (the so called 'device oriented user interface') for the new device which lets an operator view or modify the device parameters.

With the ***sat-nms*** software, all three components from the physical M&C interface at the device up to the representation of parameters on the screen are configurable and extensible by the customer. The ***sat-nms*** software comes with library supporting a large number of devices. These files are at your's disposal to use them as templates or as ready made module for the device driver you need to develop.



The diagram above illustrates the first steps to the integration of a new device type into the ***sat-nms*** software. You are encouraged to use as much as possible of the existing protocol, driver and user interface definitions.

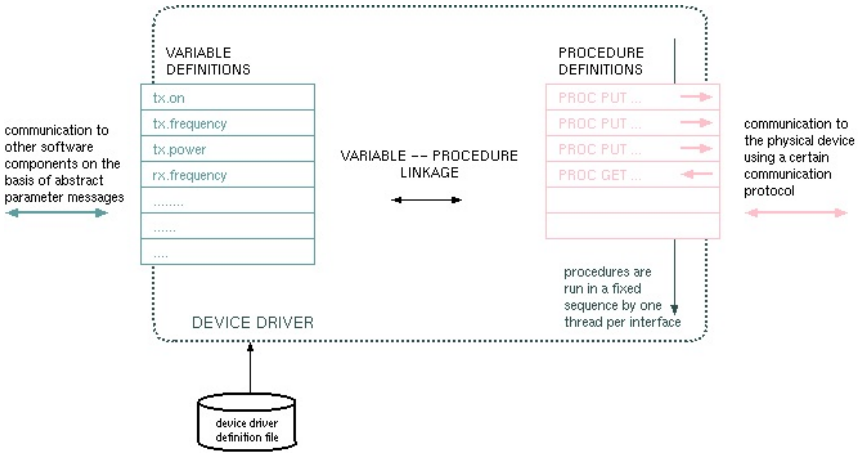
M&C / VLC device drivers

Device drivers in the M&C/VLC software translate abstract parameter settings which are represented by parameter messages into commands sent to the physical device and vice versa. The basic idea is to modularize the software in a way, that one device in a station setup can be replaced by another model, perhaps even by a model made by another vendor, simply by selecting another device driver.

The ***sat-nms*** M&C advances this concept by introducing a 'universal device driver' which is completely user configurable. The configurable device driver let's you write your own device drivers for device models which are not yet supported by the software. Most of the device drivers coming with the software are built on top of this configurable driver, so there are a lot of examples you can use as a template.

Understanding the device driver

The figure below illustrates the structure of a device driver built with the 'universal device driver'. The principal function, however, applies to 'hard coded' drivers, too.



To other software components (primarily to the user interface) the device driver interfaces by a list of variable definitions. On the other hand, a list of procedures does the 'real work', translating the abstract parameter values to physical command sequences. In between a function here called 'variable -- procedure linkage' defines which procedure is run to set or read a certain parameter.

With the universal device driver, all this is setup (compiled) during the program initialization from a text file which describes the device driver in special, but quite simple programming language. The following pages describe how variables, procedures and the protocol encapsulation work together.

Variables

Variables are the interface between the device driver and the other components of the software, specially the user interface. Each variable acts as an end point for a parameter message. It may receive messages -- which causes the driver to set this parameter at the physical device -- but also may send it's parameter message in order to tell the user interface about the actual setting of this parameter.

Inside, a variable separately stores two values: The value which recently has been commanded and the value which has been read from the device during the previous polling cycle. By managing these values separately, the device driver is able to check if a value has properly been set by the device. If you see messages like 'Parameter some.name set to X but reads Y' in the event log, then the parameter polling which followed a command returned a value different from the commanded one.

Procedures

Driver procedures actually perform the communication with the device to control. They operate the device as commanded and poll the equipment settings and state.

There are two types procedures a driver may define. A 'PUT' procedure sends one or more parameters to the physical device after coding them into the format the physical device expects. A 'GET' procedure sends a request to the device, reads the reply and decodes one or more variable values from the data received. A

procure never can be both, 'PUT' and 'GET' at the same time.

The device driver executes the defined procedures in an endless loop, called the polling cycle. But a procedure is not necessarily called in every cycle. If there is nothing to do for a particular procedure, it is skipped. To determine which procedure must be executed in a cycle, procedures are bound to variables. A procedure may be bound to one or more variables, however, there may me at most one 'PUT' and one 'GET' procedure referencing a variable.

A 'PUT' procedure is executed, if at least one of the variables it is bound to has received a new setting, e.g. from the user interface. For a 'GET' procedure the following conditions cause the procedure to be executed:

1. The device driver has established communication to the device after power-on or after a communication interruption.
2. The (individually defined) polling interval for at least one of the variables bound to this procedure has elapsed.
3. At least one of the variables bound to the procedure has been commanded to the device. The parameter must be read back for verification.

Protocol encapsulation

The ***sat-nms*** device driver concept encapsulates the protocol frame used for the communication with a device in a separate layer. This protocol layer describes which kind protocol frame has to be wrapped around the commands sent to a device. There are a number of important advantages with this concept:

- The protocol frame is automatically added to each command or request sent to the device. The other way round, the driver automatically strips of this 'envelope' from the data received from the device.
- A certain type of protocol frame needs to be programmed only once and may be used for several device drivers, if for example different devices from the same vendor use one and the same protocol definition.
- Some devices may be operated either by one or the other communication protocol. The protocol encapsulation allows easily to switch between the variants.

With the ***sat-nms*** software, new protocol definitions may be added to the software, simply by editing a text file for the new type of protocol frame which is needed.

If you are going to write a new device driver, you first should investigate if there is an existing protocol definition in the ***sat-nms*** library which can be used to serve the new device. If no protocol definition matches, the chapter 'Device communication protocols' describes to write a new protocol definition.

Writing a device driver

As mentioned above, device drivers are coded as simple text files. When the M&C program starts, it 'compiles' the device drivers needed for it's equipment setup to memory. Writing a device driver means editing such a text file and storing it at a place in the M&C/VLC computer where the M&C program searches for device drivers.

The ***sat-nms*** device driver language has been designed to be very easy to understand. If you have a look at the device driver files coming with the ***sat-nms*** software, you probably will understand most of this language after an hour or two.

A M&C or VLC system keeps all device drivers in a subdirectory called `drivers`. On a M&C system this is the directory `/home/mnc/drivers`, on a VLC the directory is called `/home/vlc/drivers`. The name of the device driver files consist of the driver name (usually something like 'Manufacturer-ModelNumber') followed by the extension `.device`.

If you are writing the device driver on a Linux based M&C or NMS computer, you may want to use the vi or gvim text editor for this. vi has been configured to colorize device driver files on these machines. Beside this, vi is a very powerful editor for programming tasks.

You also may copy device driver files to a MS-Windows based computer to edit them there. If you do this, you should consider the following:

- Device driver files are Unix based text files. Lines are terminated with a line-feed character only. Your favorite MS-Windows text editor may have problems to show these files.
- Unix / Linux is case sensitive with file names. Be sure that you don't mess up the case of characters in file name when you copy files between Unix and MS-Windows.

Starting from scratch

The following pages describe the 'hard way' to create a device driver from scratch. It is a good exercise to do this once for a simple driver. In practice however, in most cases you will use an existing driver as a template and modify this for your needs.

The basic steps to build a device driver from scratch are:

1. Naming the device driver
2. Selecting the communication protocol
3. Including the standard definitions file
4. Defining the driver variables
5. Adding the data exchange procedures

If you are reading this manual online, you may open the 'NDSatCom-KuBand-Upconverter' driver example in a separate window to watch this in parallel while you are reading the following pages.

General file format

The ***sat-nms*** device driver language has been designed to be very easy to understand. The syntax resembles the BASIC programming language in some aspects, however, the language is highly specialized for it's purpose. Here some basic definitions which help you to read or write device driver files:

- The device driver language is case sensitive for all identifiers and keywords.
- Whitespace (space characters, tabs, line breaks) separates words.
- Line breaks have no special termination function.
- All keywords (except the RPN commands) are in upper case letters.
- Comments in C/C++ style are recognized (both, '**/* ... */**' and '**// ...** ' comments).
- Identifiers (names for variables and tables) may consist of letters, digits and dots. They must start with a letter.

Beside the rules listed above, the device drivers provided by SatService GmbH follow some sort of coding/formatting convention:

- Each file starts with a comment block containing a short description and a change history.
- Identifiers always start with a lowercase letter. If a name consists of more than one word, the first letter of each following word is in upper case. Dots are used to group parameter functionally. Example: `mod.symbolRate`.
- Statements are indented four columns for each level.

Naming a device driver

To create a new device driver, the first step is to give the driver a name. The device drivers supplied by SatService GmbH all follow a 2 part naming scheme: '`VendorName-ModelDescription`'. A 'Radyne DM240' modulator e.g. appears as `Radyne-DM240` in the device driver list. This makes it easy for the person who configures the equipment setup of a M&C/VLC system to select the appropriate device drivers.

The name of the device driver appears at several places:

- It is used as part of the device driver file name.
- Exactly the same name should be defined as a initialized variable called 'info.type'. The online help function and the device preset directory selection of the user interface depend on this definition. Chapter 'Info variables' gives more information about this.
- The COMMENT statement also contains the device driver name.

The COMMENT statement

The text following the COMMENT statement is free field and principally may contain any information. The device drivers coming with the ***sat-nms*** software all follow a convention which defines the comment string as

```
Driver-name X.YY YYMMDD
```

where X is the major version number of the driver, YY the minor version number and YYMMDD the release date of this driver version. It is recommended that customer defined device driver follow this

scheme, too.

The comment statement in fact creates a hidden info-variable definition. This variable with the name 'info.driver' is initialized with the comment text. At the Info-page of the device oriented user interface you can view the comment text or the driver name /version / date respectively.

Example

```
COMMENT   "NDSatCom-KuBand-Upconverter 1.03 010809"
```

This example, taken from NDSatCom-KuBand-Upconverter device driver, identifies this driver as version 1.03, released at August, 9th, 2001.

Selecting a communication protocol

With the ***sat-nms*** software, the device communication protocol handles the low level communication between M&C/VLC and device. There are trivial protocols which simply put a newline character at the end of each message and more sophisticated ones dealing with start/end characters, checksums, device addresses and more.

The ***sat-nms*** software comes with a bunch of predefined protocol definitions. If none of these protocol definitions matches, the chapter 'Device communication protocols' describes to write your own protocol definition.

The communication protocol used for a certain device (for a certain serial interface, more exactly spoken) is defined with the equipment setup which you can configure a the graphical user interface. The device driver defines a preferred communication protocol. This means, in the device driver you state the communication protocol this driver is designed for. At the equipment setup screen of the software you still are able to choose a different protocol for a device of this type, however, you will be warned by the software. The preferred communication protocol for a device driver is defined with the PROTOCOL statement:

The protocol definition this statement refers to must exist in the `protocols` subdirectory of the software.

Example

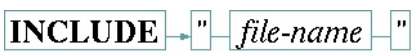
```
PROTOCOL  Miteq-MOD95
```

This example, taken from NDSatCom-KuBand-Upconverter device driver, defined the Miteq-MOD95 protocol as the preferred one for the driver.

File includes

ATTENTION: File including does not work when a device driver file gets interpreted by the *client* software, e.g. when a device preset shall be formatted along the device driver's parameter definitions. Variables defined in included files get not properly formatted in the device preset window. **For this reason it is recommended to use INCLUDE only for the standard includes as described in the example below!**

Device driver definition files may include other files. Frequently needed definitions may be encapsulated in included files which makes it easy to change these definitions at a central point. The syntax of the INCLUDE statement is:



The file name given in the INCLUDE statement is relative to the M&C software's home directory. With the ***sat-nms*** Software, there are two standard include files. Almost any driver provided by SatService GmbH includes one of these files. The files are named 'Standard.nc' and 'StandardBin.nc' respectively. They define the so called low level interface to the device and the fault flags which indicate a communication failure for the device.

Example

```
INCLUDE   "drivers/Standard.dotinc"
```

This includes the standard ***sat-nms*** include file for driver which use a text based communication protocol. The file is located in the 'drivers' subdirectory which is one level below the M&C software's home directory.

Defining variables

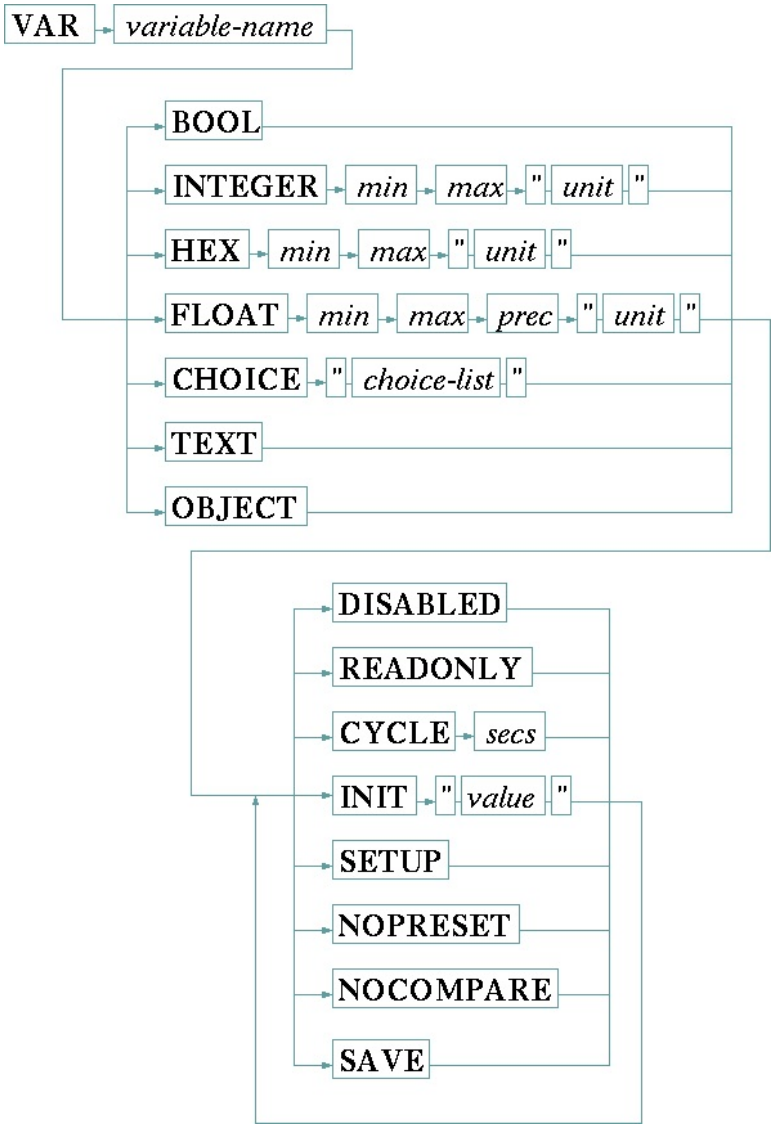
Variables are the interface between the device driver and the other components of the software, specially the user interface. Each variable acts as an end point for a parameter message. It may receive messages -- which causes the driver to set this parameter at the physical device -- but also may send it's parameter message in order to tell the user interface about the actual setting of this parameter.

Before you start writing the device driver, you should plan a list of variables which build the software interface to the device. Designing this interface should be done careful, you can save a lot of effort if you are able to re-use variable definitions from other devices. This not only saves the time to write the definitions, it also enables you to use the parameter screens available for this device in the ***sat-nms*** library.

If you intend to write are driver for a device which implements similar functions as an existing driver, it is recommended to copy the variable list from this device.

The VAR statement

Device driver variables are defined using the VAR statement. With the VAR statement you define the name, the data type, the valid range and some other properties of the variable. This is the general syntax for a VAR statement:



A variable definition consists of the VAR keyword, the variable's name, a data type / range definition and optional modifiers which control the behavior of this variable.

Data type / range definition

The ***sat-nms*** device driver knows about 7 data types. The data type of a variable is defined by one of the data type keywords BOOL, INTEGER, HEX, FLOAT, CHOICE, TEXT or OBJECT, followed by the range definition for the selected data type. Here the data types listed in tabular form:

BOOL	The BOOL data type can have the values "true" and "false". the BOOL type mainly is used for flags which shall be displayed as signal lamps at the user interface.
INTEGER	The INTEGER data type carries numeric integer values (64 bit length). When you define an INTEGER variable, you must provide the valid range (min / max) of the variable and a unit string which is shown at the user interface right of the data. If both, min and max are zero the user interface software does no range check at all. The unit string may be empty, but the double quotes are required ("").
HEX	The HEX data type also is a 64 bit integer, but formatted in hexadecimal notation.
FLOAT	The FLOAT data type carries double precision (64 bit length) floating point values. When you define a FLOAT variable, you must provide the valid range (min / max) of the variable, the number of fraction digits and a unit string which is shown at the user interface right of the data. If both, min and max are zero the user interface software does no range check at all. The unit string may be empty, but the double quotes are required ("").

	FLOAT variables are displayed with a fixed precision. Alternatively you may force a scientific notation by adding 100 to the precision value. Example: `VAR myFloat FLOAT 0 0 103 ""` defines a scientific formatted floating point variable shown with 3 digits precision (e.g. '0.123E-2')
CHOICE	The CHOICE data type defines a parameter which may contain one of a fixed set of string values. You define this set as a comma separated list, enclosed in double quotes. At the user interface such a parameter appears as a drop down box where you can select a value from this list.
TEXT	The TEXT data type carries an arbitrary character string.
OBJECT	The OBJECT data type is used with complex variables which cannot be shown by the standard user interface routines. OBJECT variables only appear together with logical devices, you never will need this data type when writing a device driver.

Modifiers

Modifiers control some properties of a variable concerning it's state, usage, initialization and polling cycle. Modifiers may before or after the type definition.

DISABLED	Variables may be 'enabled' or 'disabled'. Disabled variables appear grey at the user interface, no value is displayed and no value may be entered. The RANGESET command is used to change the enable state. By default variables start in enabled state unless they are marked as DISABLED in the VAR statement. Disabling a variable at this point may be useful if the variable stands for a parameter which is not available at all models of the device type the driver is written for. The variable can be enables by the driver when it detects that the device actually connected to the M&C/VLC supports this parameter.
READONLY	Marking a variable READONLY prohibits the operator from changing it's value. This is used for state variables like meter readings. The range information for the data type used must be provided even if the variable is marked READONLY.
CYCLE	The CYCLE modifier controls the frequency (expressed as time interval in seconds), this variable shall be polled from the device. By default, variables are read from the device with every working cycle of the driver. This is about one a second if only a few parameters are to read. With many parameters the polling rate will be lower as the response time for each interrogation extends the cycle time. Hence, most device drivers poll only a few parameters like alarm flags or some meter readings with the maximum possible rate. Other parameters, e.g. settings you do not expect to change by themselves, are polled at a much lower rate. Setting the CYCLE time to zero causes the driver to do no regular polling for this variable at all. However, after power up and after communication failures, such a variable still is read once from the device
INIT	Using the INIT modifier, a variable may be initialized to a certain value. This value remains valid until the variable gets polled the first time. The INIT option often is used with variables which are used to configure the driver and never are read from the device itself.
SETUP	The SETUP modifier marks a variable to be listed in the maintenance/setup window of the standard device screens. Chapter 'Setup variables' tells more about this special variable type.
NOPRESET	Using the NOPRESET modifier, a variable can be explicitely excluded from the set of parameters which are written to a device preset. A device preset contains all variables which define a PUT prozedure and are no SETUP parameters and don't have the NOPRESET modifier set. The 'reset' variable - if defined - is also implicitely excluded from device presets preset, for backward compatibility reasons. Please note, if you add NOPRESET to a variable in an existing device driver, this will not remove the value for this variable from existing device presets, it only will prevent the software from adding the value to new presets. You may use the preset editor to remove the unwanted value manually from existing device presets.

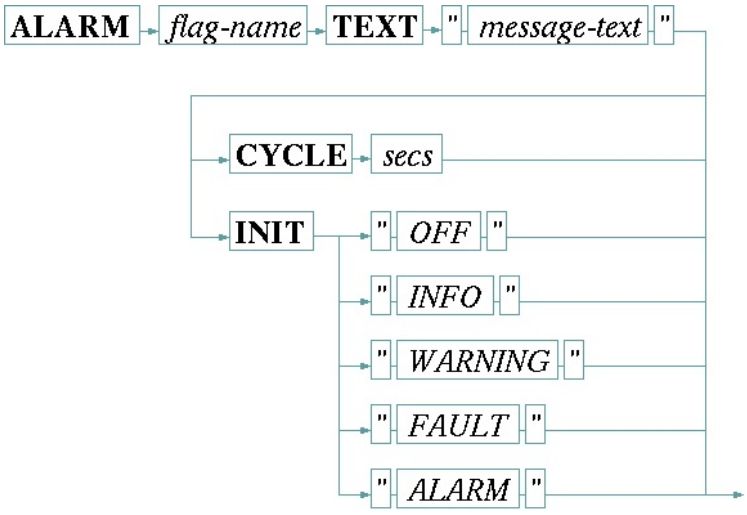
NOCOMPARE	Without the NOCOMPARE modifier the device driver will compare a value it commanded to the device against the value it read back after this. If the two values differ, an informational message showing the commanded and the read value is added to the log. NOCOMPARE suppresses this check. This is useful with parameters which are known for reading back in a wrong way, frequent messages in the log can be avoided this way.
SAVE	The SAVE modifier tells the driver to save this variable on disk and to restore it's value when the program starts. Usually all device settings are stored in the device itself, the M&C/VLC system does not change anything at a device when it starts. In some cases, e.g. with SETUP variables or if the driver implements a receive level threshold, it is useful to store variable values in the M&C system rather in the device.

Example

```
VAR audio.1.dotprogram       CYCLE 0   INTEGER 0 0 ""
VAR audio.1.dotrouting       CYCLE 0   CHOICE "NRM,MON,LFT,RGT"
VAR audio.1.dotoutput        CYCLE 0   CHOICE "ANALOG,AES/EBU,SPDIF,AC3"
VAR audio.1.dotlevel         CYCLE 0   INTEGER 6 18 "dB"
VAR audio.1.dotlanguage      CYCLE 0   TEXT
VAR audio.1.dottest          CYCLE 0   CHOICE "NRM,TEST-1,TEST-2,TEST-3,TEST-4,TEST-5"
VAR audio.1.dotinfo          CYCLE 4   TEXT READONLY
```

The ALARM statement

Alarm flags are a special variant of variables. They always are of the type BOOL and they are READONLY. For each ALARM variable you define a text message which appears in the 'Faults' page of the device's user interface screen and as a message in the event log if the value of the flag changes. The device driver summarizes all alarm flags with each cycle and generates a summary fault information for the device. Alarm flags are defined with the ALARM statement:



An alarm flag definition consists of the ALARM keyword, the flag's name and an optional CYCLE definition which work analogous to the CYCLE modifier in a VAR statement.

The name of an alarm flag must be of the form *faults.XX* where *XX* is a two digit number in the range from 01 .. 98. The *faults.99* is reserved for a communication fault.

The alarm flag definition may include an INIT clause which initializes the fault priority value of the flag. INIT must be followed by one of "OFF", "INFO", "WARNING", "FAULT" or "ALARM".

Example

```
ALARM faults.01      TEXT "Remote access" INIT "WARNING"
```

```
ALARM faults.02      TEXT "Synthesizer"
ALARM faults.03      TEXT "LO-A lock"
ALARM faults.04      TEXT "LO-B lock"
ALARM faults.05      TEXT "Power supply"
ALARM faults.06      TEXT "IF-LO level"
ALARM faults.07      TEXT "RF-LO level"
```

Info variables

Each device driver defines a number of so called info variables which tell the operator, but also the client software about the device driver. All info variables

- are named starting with `info.`
- are defined READONLY

The user interface contains a special screen which display the contents of all info variables the driver defines.

Info variables are used to display information like device types, serial numbers etc. Beside this, there are three info variables each device driver **must** define in any case. They are:

info.type	This variable tells the user interface name of the device driver. It is used to select the subdirectory for device presets and to find the help screen for this device driver. **info.type** must be initialized to the name of the device driver which in fact is the file name with the trailing '.device' cut off.
info **ort**	This variable is set by the device driver to the name of the serial port which is used to access the device. This is for convenience, offering the operator this information without opening the device setup.
info.frame	The standard user interface uses the value assigned to this variable to select the 'device oriented' screen set for this device. **info.frame** must be initialized to name of the device frame definition file to be used with this device.

Example

```
VAR info.type             CYCLE 0 TEXT READONLY INIT "Tandberg-Alteia"
VAR info.port             CYCLE 0 TEXT READONLY
VAR info.frame            CYCLE 0 TEXT READONLY INIT "IRD-Alteia"
VAR info.model            CYCLE 0 TEXT READONLY
VAR info.serial           CYCLE 0 TEXT READONLY
```

The example above - taken from the Tandberg-Alteia device driver - identifies the driver as 'Tandberg-Alteia' and tells the user interface to use the device oriented frame set called 'IRD-Alteia' for this device. The info variables info.model and info.serial are set by the driver later, when it read the model description and serial number from the device.

Setup variables

Another group of variables which are treated specially by the driver are setup variables. They are used to configure the device driver or to set parameters which shall not appear at the standard user interface.

Setup parameters are shown in an own screen which is accessible only to operators of a privilege level of 150 and above. Setup variables must be marked with the SETUP modifier, the name of setup variables must start with '.config'.

Example

```
VAR config.lbandInputs    CYCLE 0 CHOICE "4,2" SETUP SAVE
VAR config.lnbPower       CYCLE 0 CHOICE "OFF,ON.,BST" SETUP
VAR config.loFreq         CYCLE 0 FLOAT 0 0 1 "MHz" SETUP
VAR config.berThreshold   CYCLE 0 TEXT SETUP
VAR config.sigThreshold   CYCLE 0 INTEGER 0 255 ""  SETUP
VAR config.errFrame       CYCLE 0 CHOICE "FREEZE,BLACK" SETUP
```

The example above - taken from the Tandberg-Alteia device driver - defines a setup variable 'config.lbandInputs' which configures the driver for 2- or 4-input models of the IRD. This variable also is marked with the SAVE modifier to make the setting permanent. The following variables in the example are configuration settings which are placed in the setup area to keep them out from the common user interface.

Variables for internal use

Variables may be used to store intermediate values in the driver. For instance, a bit field status value may be read into a variable and then interpreted using the BITSET command.

Variables for internal use must be declared READONLY to work properly. Even though not required, it is recommended to give these variables a descriptive name which tells about the internal usage of this variable. The following example is taken from the SSE KStar device driver:

```
VAR internal.state HEX 0 0 " " READONLY   CYCLE 2

...

PROC GET WATCH internal.state
    PRINT "AL"
    INPUT "=" internal.state
    BITSET faults.01 = internal.state 9
    BITSET faults.02 = internal.state 15
    BITSET faults.03 = internal.state 11

...
```

Using conversion tables

CHOICE parameter often are implemented by the device's remote control protocol as numeric constants (0 for BPSK, 1 for QPSK) or they are abbreviated in a way which is hard to remember. The user interface of the software shall in contrast display self-explaining names for such settings.

The driver language lets you define translation tables which do such conversions while the driver performs a PRINT, INPUT, READ or WRITE statement. As the driver knows, in which direction a table translation must be done, you can use the same table to translate values when they are written to and when they are read from the device.

The TABLE statement described in following chapter is used to define translation tables.

The TABLE statement

The driver language lets you define translation tables which do such conversions while the driver performs a PRINT, INPUT, READ or WRITE statement. Tables are defined with the TABLE statement:

The TABLE keyword is followed by a name for this table and the table definition in double quotes. The table definition contains assignments 'A=B', separated by commas. Strings containing commas or equal characters cannot be translated through a table.

```
TABLE tModulation    "BPSK=BPS,QPSK=QPS,8PSK=8PS"
```

In the table definition, the 'A' value is the string visible at the user interface of the software, the 'B' value is used when communication with the device. The driver translates in a PRINT or WRITE statement BPSK -> BPS, QPSK -> QPS or 8PSK -> 8PS if the table tModulation shown in the example above is referenced. With an INPUT or READ statement, the table automatically translates the values the other way round.

For some applications a table definition may become quite large. The driver syntax permits to split up the table definition in multiple string/lines. Each string/line must be enclosed in double quotes and must contain at least one translation pair. Commas at the end of a line are omitted. Below an example for such a multi line table definition is shown.

```
TABLE tVideoTest     "NRM=00,625.1=01,625.2=02,625.3=03,625.4=04,625.5=05"
                     "625.6=06,625.7=07,625.8=08,625.9=09,625.10=10,625.11=11"
```

```
"625.12=12,625.13=13,625.14=14,625.15=15,625.16=16"
"525.1=17,525.2=18,525.3=19,525.4=20,525.5=21,525.6=22"
"525.7=23,525.8=24,525.9=25,525.10=26,525.11=27,525.12=28"
"525.13=29,525.14=30,525.15=31,525.16=32"
```

Remarks

- If a table translation is invoked with a value which is not contained in the table, the translation returns the first value in the table.
- To define a table it may be useful to copy the definition of the CHOICE variable which shall be translated at the place of the table statement. this copy then can be extended to the table definition.
- Don't add whitespace characters in the table definition to make this better readable. The driver would treat these characters as part of the strings to translate!

Adding data exchange procedures

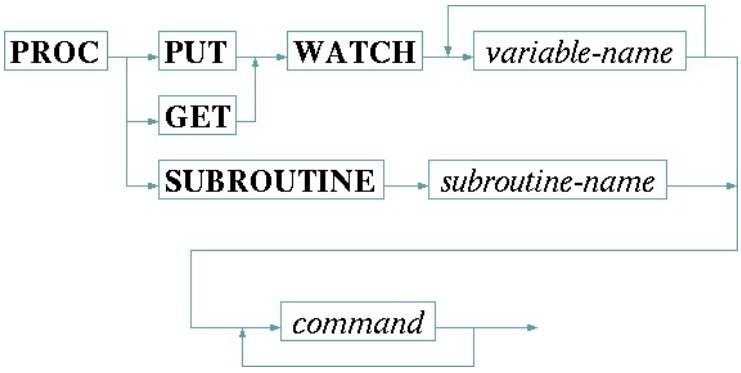
While the device driver variables discussed in the chapters above specify the driver's interface to the other parts of the software, does the device driver procedure implement the interface to the device itself. Based on the communication protocol selected in the equipment setup (the protocol handles the low level coding of the data exchanged with the device), procedures handle the chats done between the M&C and the device to perform parameter settings or to gain some information from the device.

The description of the PROC statement in the following chapter together with the examples supplied with this manual explain the usage of procedures. Generally the following rules apply to device driver procedures:

- Procedures are executed by the driver in the same order as they are defined in the driver specification.
- The driver knows GET-type procedures which read some information from the device into one or more variables and PUT-type procedures which send settings to the device.
- A procedure may handle one or more parameters.
- The driver skips any procedures where actually nothing is to do. For example a PUT-type procedure is skipped unless at least one of the values handled by it has been changed by the operator.
- A variable which has it's data source in the device must be handled at exactly one GET-type procedure.
- A variable being a device setting must be handled at exactly one PUT-type procedure.

The PROC statement

Driver procedures are defined with the PROC statement. The PROC keyword is followed by one of PUT, GET or SUBROUTINE. Chapter 'Using subroutines' tells more about the latter type of procedures. Procedures do not have an explicit 'end' keyword, a procedure automatically ends where another definition (procedure, variable or table) starts.



PUT and GET type procedures must have a WATCH keyword followed by one or more names of variables this procedure shall be bound to.

Generally, any variable which is referenced in a procedure must be defined before using the VAR statement. Although the driver language allows to define variables between procedures (a VAR statement closes an open procedure definition), the drivers supplied by SatService GmbH first define all variables and then all procedures for this reason.

Examples

There are two complete device drivers listed at the end of this section, showing several flavors of procedure definitions:

- NDSatCom-KuBand-Upconverter device driver
- Tandberg-Alteia device driver

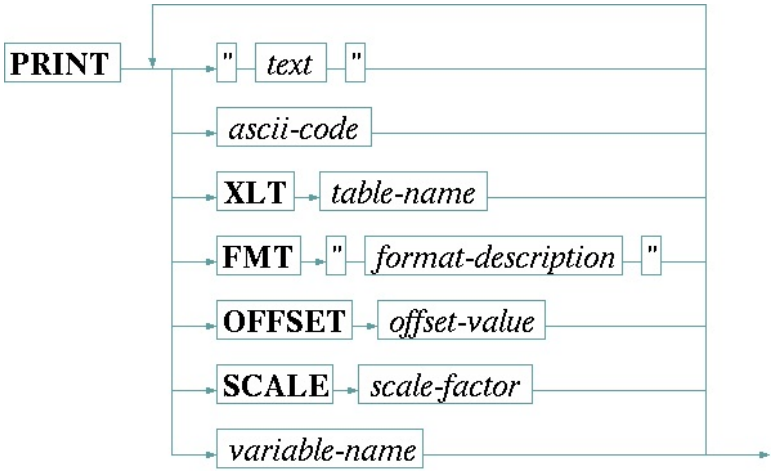
Basic I/O functions

The primary function of a driver procedure is to acquire some information from the device ('GET' procedure) or to set one or more parameters from the data commanded somewhere else in the software ('PUT' procedure). The ***sat-nms*** device driver definition language provides four highly flexible statements for this purpose. They are:

PRINT	Composes/formats s (readable) string from multiple elements which may be text fragments, numbers (formatted in various ways), tokens from a CHOICE variable and more. The composed string is packed in a protocol frame and sent to the device. PRINT is used with devices which implement a text based protocol.
INPUT	The INPUT statement complements the PRINT statement. It reads a message from the device, strips off the protocol frame parses the received data according to the rules specified with the INPUT statement.
WRITE	The WRITE statement is the equivalent to PRINT for devices providing a binary communication protocol. WRITE sets up a binary data structure from constant and variable values, packs this structure in a protocol frame and sends it to the device.
READ	Reading data from a device providing a binary communication protocol is done with the READ statement. As the counterpart of the WRITE statement it reads a message from the device, strips off the protocol frame and provides means to interpret the received data as a binary structure variables.

The PRINT statement

The PRINT statement is used to send commands to a device which uses a text based protocol. It composes a command string from the elements following the the PRINT keyword, packs this string in the protocol frame defined by the communication protocol and sends this message to the device. The syntax of the PRINT statement is:



The table below describes the elements which may follow the PRINT keyword.

" text "	Plain text, enclosed in double quotes, is added to the output buffer as it is.
ascii-code	A decimal number is interpreted as the ASCII code of a single character to output. You may use this to send special characters like carriage-return or line-feed to the device.
XLT table	The XLT keyword, followed by the name of an already defined table, tells the driver to translate the next variable value which shall be printed through this translation table. Chapter 'Using conversion tables' gives more information about tables in general.
FMT "..."	The FMT keyword, followed by a format description in double quotes, tells the device driver to format the next variable following the format description given. FMT is used to format numeric variables into the representation the device expects in it's remote control command. A format description consists of the following elements:

	d b x X f	The first letter of the format description defines the general number representation: **d** (decimal), **b** (binary), **x** (hex, lower case), **X** (hex, upper case) or **f** (floating point)
	+	If the **+** option is given, the number is preceded by a +/- character even if it is positive. Together with the '0' option below, the sign appears as an additional character at the first column, hence the field width is increased by one on this case.
	0	If the '0' option is given, the field is padded up with zeroes instead of spaces.
	1 .. 99	Here follows a one or two digit field width. The field width is the total number of characters the formatted number occupies including the padding characters. If there are more digits needed to show a number correctly, the field with is enlarged automatically. Specifying a field width '1' disables the right orientation in a fixed width completely. This specially is useful for floating point numbers where only the number of fraction digits shall be fixed, not the complete field width.
	.	For floating point formats the dot separates the precision from the field width.
	0 .. 9	The dot is followed by a one digit specification of the number of fraction digits which shall be printed. The dot and fraction digits specification is valid only with the floating point format.
	INTEGER variables may be printed using a floating point format, and FLOAT variables may be printed with a 'd' or 'x' format likewise. With FLOAT variables you should format in any case as internal precision/rounding problems may cause unpredictable results when floating point values are printed unformatted.	
OFFSET o	The OFFSET keyword, followed by the (floating point) offset value, tells the driver to add the offset value to the next variable before it is printed.	
SCALE s	The SCALE keyword, followed by the (floating point) scale factor, tells the driver to multiply the next variable with the scale factor before it is printed	
variable-name	A variable name tells the driver to print the value stored in this variable. Usually the *commanded* value is used rather than the value which has been read back from the device. If, however, there has been never a value commanded, or if this variable is a read only variable, the value recently read from the device is used. Before the variable is printed to the output buffer, any XLT, FMT, OFFSET or SCALE operations which have been specified are applied. This happens in a fixed order: 1. If a SCALE operation has been specified, this is done first. 2. The SCALE operation is followed by an OFFSET addition. 3. The so scaled value is formatted according to a FMT specification if one is given. 4. Finally, the value gets translated through a translation table, if an XLT operation has been specified. This scheme applies to numeric (INTEGER, HEX, FLOAT) and to text type variables as well. As soon as a SCALE, OFFSET or FMT keyword is present in front of a variable, this gets converted to a floating point number. Strings which cannot be converted give a zero value.	

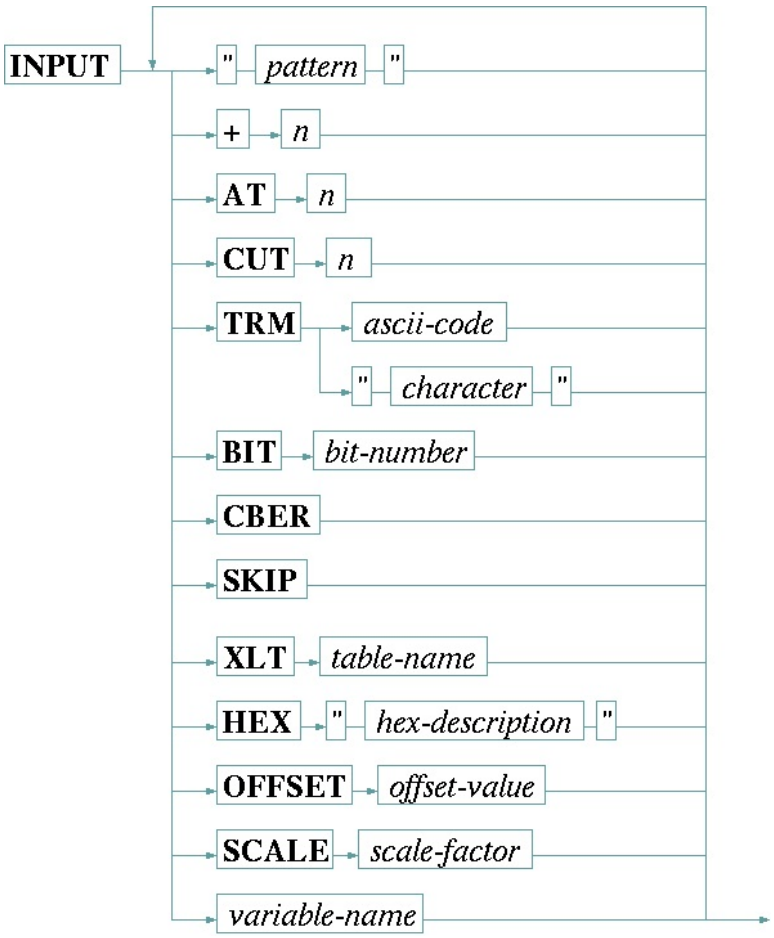
Example

```
PRINT "TUN;FRQ=" SCALE 8.0 FMT "d06" frequency
```

The example above sends a command of the format 'TUN;FRQ=######' to the device. The FLOAT variable 'frequency' is multiplied by 8.0 and the output as an integer number, 6 digits wide with leading zeroes.

The INPUT statement

The INPUT statement is used to read and interpret the reply of a device which uses a text based communication protocol. It reads a protocol frame from the device and parses the received message according to the rules defined by the description following the INPUT keyword. The syntax of the INPUT statement is:



While parsing the device's reply, the driver deals with three information buffers. To understand the way how the parsing operations work which may follow the INPUT keyword, it is necessary to learn how the driver uses these buffers.

The first buffer contains the original reply string as it is received from the device (with the protocol frame stripped off). The driver initially copies this string into a second buffer called *pad*. Search operations (text in double quotes) and the "+" operation modify the *pad*. The AT operation is the only way to restore the *pad* from the original data.

Every time, the *pad* is modified, the driver copies it's contents into the third buffer called *value*. *Value* is the string which will be assigned to a variable if it appears in the list of arguments to the INPUT statement. Operations in the INPUT statement like CUT, TRM, or XLT work on the *value* buffer but leave the *pad* unchanged. This is important to understand if you have to parse the value of more than one variable in a single INPUT statement.

" pattern "	Searches the text/pattern in the current *pad* buffer. If the pattern is found, all text including the first occurrence of the pattern is removed from the beginning of the *pad* buffer.
+ n	Removed *n* character from the beginning of the *pad* buffer.
AT n	Restores the *pad* buffer with a substring of the original data, starting at column *n*.
CUT n	Cuts the *value* buffer to a length of *n* characters.
TRM "c"	Removes the first occurrence of the termination character and all following text from the *value* buffer. The termination character may be specified as a decimal number (e.g. 10 is the ASCII code for line feed) or as a single character enclosed in double quotes.
BIT n	Interprets the *value* buffer as a decimal number and isolates the bit number *n* (*n = 0* means the least significant bit). The value buffer is replaced by '0' or '1' depending on the bit value.
CBER	Interprets the *value* buffer as a bit error rate value as it is returned by Comstream modems. A string '*mn*' is converted into the more common notation '*mE-n*'.

SKIP	Removes any whitespace (space characters, line feeds, carriage returns or tabs) from the beginning of the *value* buffer.
HEX ".."	Interprets the contents of the *value* buffer as a hex number and replaces it by it's decimal equivalent. The format definition string which must follow the HEX keyword may contain the following characters: **L** — The hex number is in 'little endian' notation. This means the least significant byte is written at first. If no 'L' character is in the format string, 'big endian' notation is assumed. **S** — The hex number is signed. The number of digits is used to calculate the sign extension: '80' for example is calculated as '-1' as the two digit number is assumed to be a byte value. '0080' in contrast is computed to '128' as a 16 bit number of this value is positive.
XLT table	The XLT keyword, followed by the name of an already defined table, tells the driver to translate the *value* buffer through this translation table from right to left. Chapter 'Using conversion tables' gives more information about tables in general.
OFFSET o	The OFFSET keyword, followed by the (floating point) offset value, interprets the *value* buffer as a floating point number and replaces the buffer with the sum of the value and the offset.
SCALE s	The SCALE keyword, followed by the (floating point) scale factor, interprets the *value* buffer as a floating point number and replaces the buffer with the product of the value and the scale factor.
variable-name	A variable name tells the driver to assign the contents of the *value* buffer to this variable. The driver performs format conversions and range checks according to the type and limit specifications made in the VAR definition of this variable.

Remarks

If a value is not assigned to a variable as you expect, you should check the following issues:

- Numeric values are converted from string to numeric representation in a very lenient way. For instance, any leading non-numeric characters are ignored. If a numeric variable is not assigned as expected, in most cases there is a range violation. The driver does not accept values outside the range defined for this variable.
- CHOICE variables and tables (referenced with the XLT operation) expect an input value which *exactly* matches one of the valid choices. See chapter 'Using conversion tables' to read how you can make tables somewhat fault tolerant.

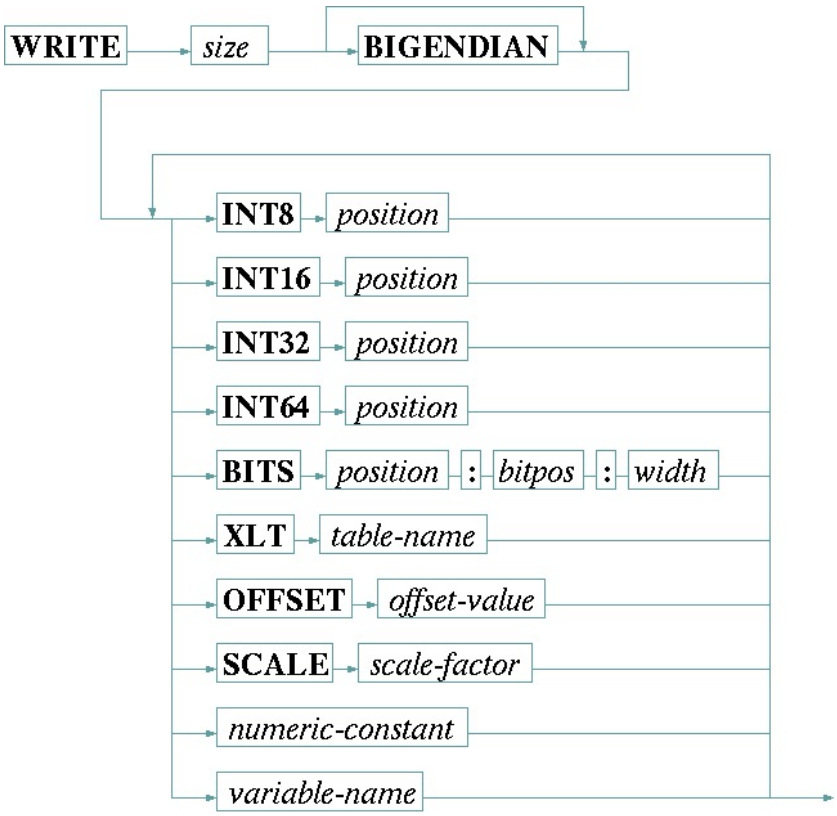
Example

```
INPUT AT 2  SCALE 0.001            tx.frequency
      AT 11 SCALE -0.1 OFFSET 30.0 tx.gain
      AT 15 CUT 1 XLT T03          faults.01
      AT 17 CUT 1 XLT T02          info.if
      AT 19 CUT 1 XLT T01          tx.on
      AT 21 CUT 1                  faults.02
      AT 22 CUT 1                  faults.03
      AT 23 CUT 1                  faults.04
      AT 24 CUT 1                  faults.05
      AT 25 CUT 1                  faults.06
      AT 26 CUT 1                  faults.07
```

The example above -- taken from the NDSatCom-KuBand-Upconverter device driver -- parses all settings an faults flags from a single status string the upconverter returns. Note that the numeric variables 'tx.frequency' and 'tx.gain' are isolated from the string without specifying a length or a termination character. The number recognition routine automatically stops where it finds a non-numeric character after the number to read. The other values however all are cut to one character length before they are interpreted.

The WRITE statement

The WRITE statement is used to send data to the device which uses a binary communication protocol. Such a device expects a command as a binary data structure rather than as a readable text. The syntax of the WRITE command is:



The WRITE statement creates a buffer of the specified number of bytes which initially is filled with zeroes. Variables or constant values are copied into this buffer according to the size and position specifications given.

The WRITE statement by default works in 'little endian' mode. 16, 32 or 64 bit values are copied into the buffer with the least significant byte first. Specifying BIGENDIAN mode reverses this byte order.

size	The size (number of bytes) of the message buffer to create must be specified as the first argument following the WRITE keyword. The size value is expected as a decimal number.
BIGENDIAN	The BIGENDIAN keyword turns the byte order from 'little endian' (LSB first) which is the default to 'big endian' (MSB first).
INT8 p	The INT8 keyword, followed by a decimal position value, tells the driver that the next constant or variable shall be copied to the buffer as a single byte value at the given position (position zero denotes the first byte in the buffer).
INT16 p	The INT16 keyword, followed by a decimal position value, tells the driver that the next constant or variable shall be copied to the buffer as a two-byte value starting at the given position (position zero denotes the first byte in the buffer). The least significant byte of the number is placed first unless BIGENDIAN was specified.
INT32 p	The INT32 keyword, followed by a decimal position value, tells the driver that the next constant or variable shall be copied to the buffer as a four-byte value starting at the given position (position zero denotes the first byte in the buffer). The least significant byte of the number is placed first unless BIGENDIAN was specified.
INT64 p	The INT32 keyword, followed by a decimal position value, tells the driver that the next constant or variable shall be copied to the buffer as a eight-byte value starting at the given position (position zero denotes the first byte in the buffer). The least significant byte of the number is placed first unless BIGENDIAN was specified.
BITS p:b:w	The BITS keyword tells the driver to place the next value as a 1 to 7 bit wide bit field within a certain byte. In this case the position parameter consists of three values, separated by colons:

position	addresses the byte within the buffer. te
bitpos	defines a number of bit positions the value shall be shifted left before it is pasted into the byte.

	width the number of bits (starting with the least significant one) which shall be copied from the next constant or variable into the destination byte.
XLT table	The XLT keyword, followed by the name of an already defined table, tells the driver to translate the next variable value which shall be printed through this translation table. When output by a WRITE statement, any non-numeric variable must be translated through a table into a numeric value. Chapter 'Using conversion tables' gives more information about tables in general.
OFFSET o	The OFFSET keyword, followed by the (floating point) offset value, tells the driver to add the offset value to the next variable before it is pasted into the buffer.
SCALE s	The SCALE keyword, followed by the (floating point) scale factor, tells the driver to multiply the next variable with the scale factor before it is pasted into the buffer
variable-name	A variable name tells the driver to paste the value stored in this variable into the output buffer according to the size and position specification given before. Usually the *commanded* value is used rather than the value which has been read back from the device. If, however, there has been never a value commanded, or if this variable is a read only variable, the value recently read from the device is used. Before the variable is printed to the output buffer, any XLT, OFFSET or SCALE operations which have been specified are applied. This happens in a fixed order: 1. If a SCALE operation has been specified, this is done first. 2. The SCALE operation is followed by an OFFSET addition. 3. Finally, the value gets translated through a translation table, if an XLT operation has been specified.
numeric-constant	Numeric (decimal) constants can be used like variable names. The constant value is pasted into the output buffer in this case. If a quoted string is given, this is treated as a hexadecimal constant and translated into a numeric value.

Remarks

- Each variable name or constant must be preceded by an INT8, INT16, INT32, INT64 or BITS specification to be pasted properly into the output buffer.
- Only INTEGER, HEX or FLOAT type variables can be used directly with the WRITE statement. For other variable types an XLT table translation must be used to turn the variable into a numeric value.
- FLOAT variables are converted to 64-bit integer values before they are used. OFFSET or SCALE operations are done before this conversion.

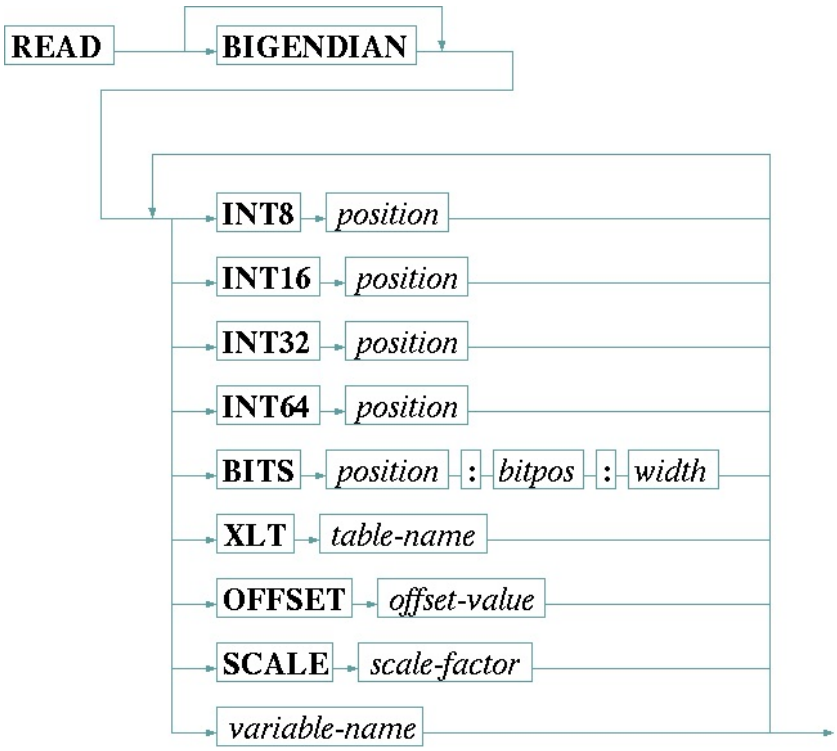
Example

```
TABLE T02 "QPSK=0,BPSK=1"

...

WRITE 3 BIGENDIAN
    INT16 0  9734
    INT8  2  XLT T02          tx.mod.type
```

The example above -- taken from the Radyne DVB3030 modulator driver -- explains how to write a CHOICE parameter to a device. Table T02 is used to convert the QPSK/BPSK selection into the numeric values 0/1. The WRITE statement sends a message (three bytes long plus protocol frame overhead) in 'big endian' byte order. The first two bytes are filled with the decimal constant 9734 (a command code). The third byte is set to 0 or 1 according to the contents of 'tx.mod.type'.

The READ statement

Receiving and interpreting of data returned from devices which use a binary communication protocol is done with the READ statement. The READ statement gets a message from the device, strips off the protocol frame and places the result in an internal buffer. Subcommands/operations following the READ keyword are used to copy values from the buffer into one or more variables of the device driver.



The READ statement by default works in 'little endian' mode. 16, 32 or 64 bit values are read from the buffer with the least significant byte first. Specifying BIGENDIAN mode reverses this byte order.

BIGENDIAN	The BIGENDIAN keyword turns the byte order from 'little endian' (LSB first) which is the default to 'big endian' (MSB first).
INT8 p	The INT8 keyword, followed by a decimal position value, tells the driver that the next variable appearing in the argument list shall be filled from a single byte value at the given position (position zero denotes the first byte in the buffer).
INT16 p	The INT16 keyword, followed by a decimal position value, tells the driver that the next variable appearing in the argument list shall be filled from a two-byte value starting at the given position (position zero denotes the first byte in the buffer). The least significant byte of the number is read first unless BIGENDIAN was specified.
INT32 p	The INT32 keyword, followed by a decimal position value, tells the driver that the next variable appearing in the argument list shall be filled from a four-byte value starting at the given position (position zero denotes the first byte in the buffer). The least significant byte of the number is read first unless BIGENDIAN was specified.
INT64 p	The INT64 keyword, followed by a decimal position value, tells the driver that the next variable appearing in the argument list shall be filled from a eight-byte value starting at the given position (position zero denotes the first byte in the buffer). The least significant byte of the number is read first unless BIGENDIAN was specified.
BITS p:b:w	The BITS keyword tells the driver to read a 1 to 7 bit wide bit field from a certain byte in the buffer. In this case the position parameter consists of three values, separated by colons: **position** — addresses the byte within the buffer. te **bitpos** — defines the bit-number (0 to 7) of the least significant bit to read. **width** — the number of bits which shall be copied from the buffer into the destination variable.
XLT table	The XLT keyword, followed by the name of an already defined table, tells the driver to translate the value read through this translation table from right to left. Chapter 'Using conversion tables' gives more information about tables in general.
OFFSET o	The OFFSET keyword, followed by the (floating point) offset value, tells the driver to add the given offset to the value read.
SCALE s	The SCALE keyword, followed by the (floating point) scale factor, tells the driver to

	multiply value read with the given factor.
variable-name	A variable name tells the driver to store the value read into the variable.

Example

```
READ BIGENDIAN
    INT32 1  SCALE 0.000001   tx.frequency
    INT32 7                   tx.mod.dataRate
    INT32 11 SCALE 0.000001   refClkFreq
    INT8  15 XLT T01          refClkSrc
    INT8  16 XLT T02          tx.mod.type
    INT8  17 XLT T03          tx.mod.fec
    INT16 22 SCALE 0.1        tx.power
    INT8  24 XLT T04          tx.on
    INT8  24 XLT T04          internal.tx.on
    INT8  25 XLT T05          tx.mod.cwMode
    INT8  26 XLT T06          tx.mod.spectrumInvert
    INT8  28 XLT T14          tx.ifc.hardware
    INT8  29 XLT T06          tx.ifc.clockPhase
    INT8  30 XLT T06          tx.ifc.dataPhase
    INT8  31 XLT T07          tx.mod.clockSource
    INT8  44 XLT T08          info.maskEnable
    INT32 45                  info.alarmMask
    INT32 49                  tx.mod.symbolRate
    INT8  53 XLT T09          tx.ifc.framingMode
    INT8  54 XLT T10          tx.mod.rollOff
    INT8  55 XLT T11          config.control
    INT8  57 XLT T12          modemType
```

The example above -- taken from the Radyne DVB3030 modulator driver -- shows the main settings READ statement of this driver. In one step almost all parameter settings are read.

Using subroutines

Procedures may be defined to act as subroutines (see chapter 'The PROC statement' for the syntax description). They are not bound to variables in this case. The CALL statement is used to invoke a subroutine from another procedure.

Subroutines are suitable to code operations which have to be done in the same way in several procedures. A common application for this is the check of the device's reply to a command. A subroutine can read the device's reply, check if it is OK and raise a fault flag if not. After a procedure sends a command to the device, it calls the subroutine which does the check.

When using subroutines, you should notice the following:

- Subroutines may be nested, this means a subroutine may contain a CALL statement to another subroutine.
- Subroutines must be defined before they can be referenced in another procedure.
- The device driver language allows to define recursive subroutines (subroutines which call themselves). You are strongly discouraged to program recursive subroutines as a program bug in your device driver may cause infinite recursion which definitely will crash the whole M&C application!

The CALL statement

The CALL statement is used to invoke a subroutine from another procedure. The called routine must be defined before it can be called.

The driver executes all statements of the called procedure and then resumes

Examples

The example below, taken from the Tandberg-Alteia device driver, shows a common application of a

subroutine. The subroutine `getAck` is called every time the driver sent a command to the IRD to check if the unit accepted the command.

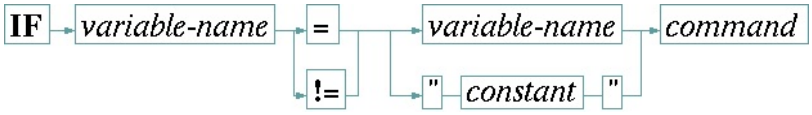
```
// called after sending a command to the IRD. checks the ACK response which is
// expected.
//
PROC SUBROUTINE getAck
    INPUT "=" TRM "_" internal.ack
    IF internal.ack = "ACK" GOTO endif
        SET faults.commstat = "ACK expected"
        SET faults.99 = "true"
    :endif
```

Conditional execution

The device driver language defines a couple of statements to control the flow of execution within a procedure. There is an IF statement as well as a GOTO which refers to a label placed elsewhere in the procedure.

The IF statement

The IF statement conditionally executes a single statement if the comparison following the IF keyword is true.



The keyword IF is followed by a comparison of a variable to another variable or constant. With the '=' operator the command is executed if the compared values match, with '!=' if they don't match respectively. Please note, that a constant value must be enclosed in double quotes, even if it is a numeric value. IF compares the string representation of the variables after formatting them as defined in the VAR statement. Hence, floating point variables always are compared after being rounded to the number of digits defined for the user interface display.

Example

```
IF info.version = "2.0" PRINT "TFR " FMT "f1.3" tx.frequency
IF info.version != "2.0" PRINT "TFR " FMT "d08" SCALE 1000.0 tx.frequency
```

Depending on the value of the *info.version* variable, the example above uses different commands to set the *tx.frequency* at the device. PRINT is considered as a single command, with all it's parameters in this case. If more than one command in sequence shall be executed conditionally, a GOTO statement must be used to jump over the this command sequence.

The GOTO statement

The GOTO statement branches to another location in the same procedure. The destination where to branch to is referenced by a label. The GOTO statement lets the execution of the procedure continue at the statement following the label.

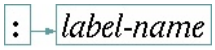
The label, the GOTO statement refers to may be defined above or below the location of the GOTO statement. However, the label must be defined in the same procedure. The device driver interpreter does not support branches across procedure boundaries.

Some words about loops

Principally GOTO statements may be used to create loops within a procedure. You are strongly discouraged from doing so. This is because all procedures for a device (more exactly spoken the procedures of all devices operated at the same physical interface) are executed sequentially. If now one procedure is caught in a loop for some time or perhaps forever, no other procedures will run. The device driver will appear to be 'frozen'.

Label definition

Labels are defined as destination locations for the GOTO statement. The colon, followed by a label name defines a label:



Labels only are visible within the procedure where they are defined. As a consequence, you may define labels with the same name in different procedures. Within one procedure however, a label name may be used only once. Between the colon and the label name no whitespace is required.

Example

```
IF info.version = "2.0" GOTO v2stuff
    PRINT "TFR " FMT "d08" SCALE 1000.0 tx.frequency
    GOTO finished
:v2stuff
    PRINT "TFR " FMT "f1.3" tx.frequency
:finished
```

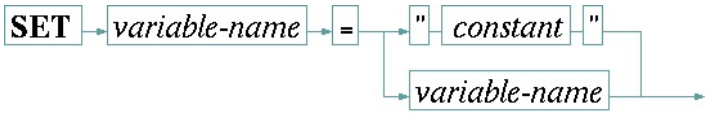
Manipulating variables

The ***sat-nms*** device driver definition language provides a number statements to manipulate driver variables within procedures. These are:

SET	Assigns a value to a variable.
BITSET	Extracts a single bit from a variable and assigns it to another.
RANGESET	Changes the range definition of a variable.
BITSPLIT	Splits up a variable in single bits. Should no longer be used.
BITMERGE	Merges several variables each containing one bit to another variable. Should no longer be used.

The SET statement

The SET statement lets you assign a value to a variable. The value may be a constant in double quotes (even numeric values must be quoted) or the contents of another variable.



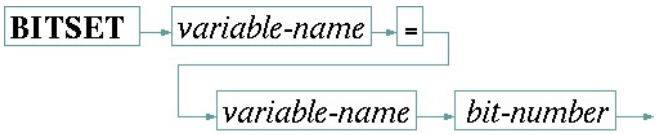
SET assigns the value to the internal memory in the variable which remembers the value read from the device. Assigning a value with set hence has the same effect as assigning it within a INPUT or READ statement. SET does not change the commanded value a variable receives from the user interface.

Example

```
SET tx.power = "33.2"
```

The BITSET statement

Some devices report their fault state as a number in which each bit represents one fault flag. The BITSET statement is used to decode flags from such a status value. Usually the fault status is read into an internal variable if the driver. Then the fault bits are decoded from this internal variable using the BITSET statement.



The bit position zero addresses the least significant bit in the source variable. The destination variable gets

set to '1' or 'true' if the addressed bit is set, to '0' or 'false' if not.

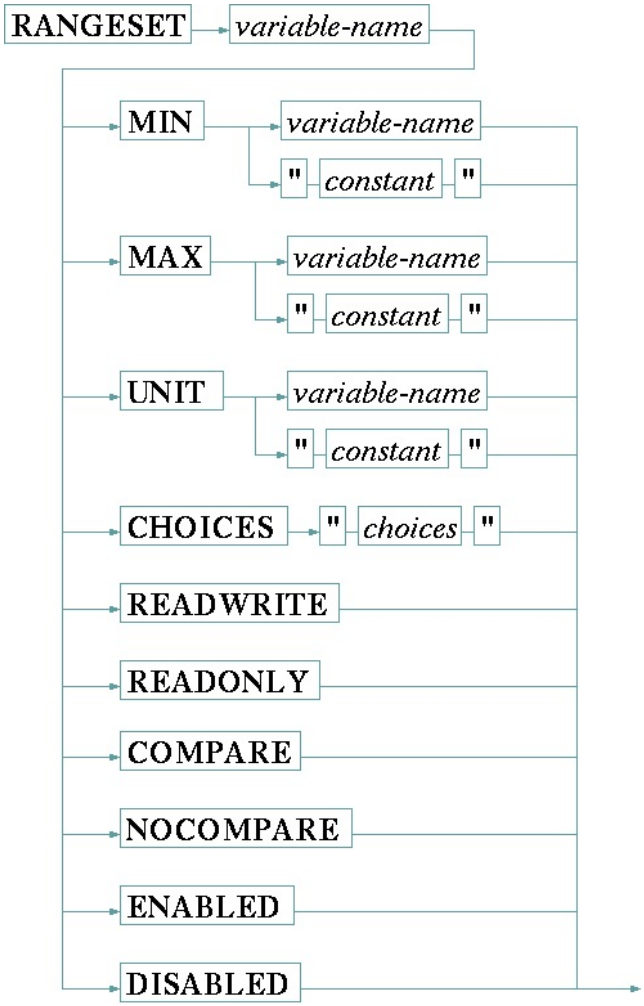
Example

```
INPUT internal.flags
BITSET faults.01 = internal.flags  4  // Temperature
BITSET faults.02 = internal.flags  5  // Signal level
BITSET faults.03 = internal.flags  11 // Video lock
BITSET faults.04 = internal.flags  9  // Audio lock
BITSET faults.05 = internal.flags  13 // High BER
BITSET faults.06 = internal.flags  15 // Demod lock
BITSET faults.07 = internal.flags  14 // Cond. Access
```

The example above reads a value into the variable 'internal.flags'. BITSET statements are used to extract seven faults flags from this variable. 'internal.flags' must be declared READONLY to make this example work.

The RANGESET statement

The RANGESET statement changes several aspects of the range definition of a variable. It is intended to be used in drivers which read some capabilities (e.g. a frequency range) from the device itself.



The options which may follow the RANGESET statement are described in the table below:

MIN	Changes the minimum value for a numeric (INTEGER, HEX, FLOAT) variable. The new minimum value may e a constant value enclosed in double quotes or the contents of another variable. MIN applies to numeric variables only.

MAX	Changes the maximum value for a numeric (INTEGER, HEX, FLOAT) variable. The new maximum value may e a constant value enclosed in double quotes or the contents of another variable. MAX applies to numeric variables only.
UNIT	Changes the maximum value for a numeric (INTEGER, HEX, FLOAT) or a ALARM flag variable. The new unit string may e a constant value enclosed in double quotes or the contents of another variable. RANGESET / UNIT applied to ALARM flags changes the alarm description text. To make the unit string for a numeric variable look like the unit specified in the VAR statement, start the string with a space character (e.g. " dBm"). The VAR statement implicitely prepend this space character.
CHOICES	Changes the set of choices for a CHOICE variable. Like with the VAR statement, the list of choices is a comma separated list of strings, enclosed in double quotes. CHOICES applies to CHOICE variables only.
READWRITE	Makes the parameter writable from the user interface, overrides a former READONLY definition. READWRITE applies to all types of variables.
READONLY	Makes the parameter read only. READONLY applies to all types of variables.
COMPARE	Enables the read after write comparison check for this variable. This check generates a log message, if the value of the variable read back from the device differs from the commanded value. By default the read after write comparison check is enabled for all variables unless they are defined with the NOCOMPARE option in the VAR statement.
NOCOMPARE	Disables the read after write comparison check for this variable.
ENABLED	Enables a formerly disabled variable. ENABLED applies to all types of variables.
DISABLED	Disables a variable. Disabled variables show no value at the user interface, any user input is blocked. Disabled variables never cause a procedure which watches this variable to run. DISABLED applies to all types of variables.

The ***sat-nms*** user interface recognizes range definitions every time a window is opened. An already opened window does not change the range definitions of it's input elements. A driver should change variable ranges only due to information which is read once on power up or after a device has been switched on.

Example

```
PRINT "RMAF" INPUT "=" internal.rx.fmax
PRINT "RMF"  INPUT "=" internal.rx.fmin

RANGESET rx.frequency MAX internal.rx.fmax
RANGESET rx.frequency MIN internal.rx.fmin
```

The example above -- taken from the SSE K-Star device driver -- reads the valid frequency range for the device into the internal driver variables 'internal.rx.fmax' and 'internal.rx.fmin'. RANGESET statements then update the range definition for the 'rx.frequency'. This is done in a procedure which is called once after the driver gains communication to the device.

The BITSPLIT statement

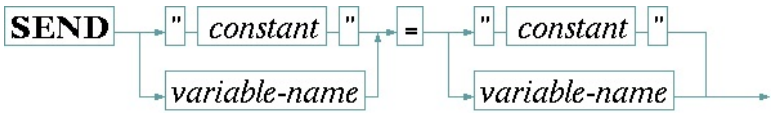
The BITSPLIT statement splits up a numeric variable in single bits. BITSPLIT will no longer be supported by future versions of the software and therefore should not be used in new device drivers.

The BITMERGE statement

The BITMERGE statement sets a numeric variable from a set of other variables each controlling one bit in the destination variable. BITMERGE will no longer be supported by future versions of the software and therefore should not be used in new device drivers.

The SEND statement

The SEND statement builds a parameter message from an address and value part and sends this to another device for execution, just like if the parameter had been issued by an operator of the software. The main purpose of this statement is to build logical devices interacting between other device by means of the universal driver language.



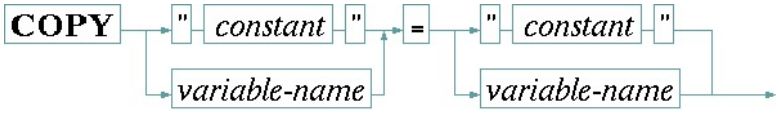
The syntax of the SEND statement looks much like the SET statement: Following the SEND keyword, you specify the destination and the value to be set, separated by '=' character. Both, the destination definition and the value to be sent, may either be quoted string or local variables of this driver:

	Quoted String	*Variable*
Destination	The message destination is literally specified like "DEVICE1.parameterName".	The contents of the variable (e.g. config.destinationId) is used as the destination ID for the parameter message. The variable must contain a string value representing a valid message ID
Value	The value to be set at the destination parameter is literally specified. Please note, that also numeric values must be enclosed in quotes here to be recognized al a literal constant.	The contents of the variable is send as the value of the parameter message.

At execution time, the SEND statement checks if the destination parameter exists and converts the type of the value to be set as required. If this fails, you will find a "SEND to "xxxx" failed." informational message in the event log in this case.

The COPY statement

The COPY statement copies either a single parameter or the complete setting from one device to another



The syntax of the COPY statement looks much like the SET statement: Following the COPY keyword, you specify the destination and the source to be copied, separated by '=' character. Both, the destination definition and the value to be sent, may either be quoted string or local variables of this driver.

Quotes strings specify the device names or parameter IDs literally, when specifying variable names, the contents of the variable at execution time is used. Please note that it not possible to copy a complete device setup to a singel variable and vice versa. If the source is specified as a plain device name, the destination must be plain device name as well.

When copying single parameters, a new message is sent to the destination ID with the actual value of the source parameter. No type checking or conversion is done, the value is copied as it is.

When copying a complete device setup, all settings of the source device are collected to an unnamed / temporary device preset. This preset is applied to the destination device. Hence, all parameters the source device stores in presets are copied to the destination.

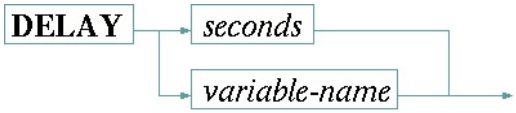
More statements

The ***sat-nms*** device driver definition language contains some more statements which have not yet been described in this document. They are:

DELAY	Pauses the device driver execution for some time.
LOG	Adds a message to the event log
DRATE	Computes an interface data rate from a symbol rate.
SRATE	Computes a symbol rate from a interface data rate.
WRITEHEX	Outputs a variable containing a hex dump string as binary data.
READHEX	Reads binary data from the device and formats this as a hex dump string into a variable.
INVALIDATE	Invalidates a variable, marks it to be read back as soon as possible.

The DELAY statement

The DELAY statement pauses the driver execution for a given number of seconds. The delay may be specified as a (floating point) constant or a variable may be referenced which contains the time to delay.



You should use DELAY statements with care. Delaying the driver execution not only slows down the execution of the current procedure, it delays the polling cycle of all devices operated at this serial interface. With longer delay times, the M&C system may no longer be able to recognize device faults within a reasonable time.

The LOG statement

The LOG statement lets you add an arbitrary message to the M&C system's event log. This may be used to signal events which shall not be treated as a fault, but are to be recorded anyhow.

Messages generated by the LOG statement by default are of the priority 'INFO'. If the first character of the message to send is '2' or '3', the first character is removed from the message and the priority id increased to 'FAULT' (2), 'ALARM' (3) or 'WARNING' (4) respectively.

Example

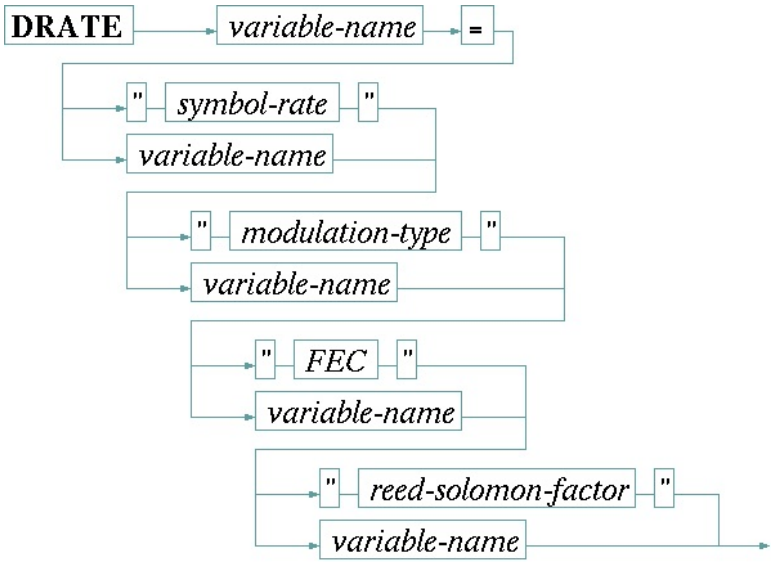
```
LOG "This is an informational message"
LOG "3This is an ALARM message !"
```

The example above adds two messages to the log. The message 'This is an informational message' is added with priority INFO, the message 'This is an ALARM message!' is added with ALARM priority.

Please note: although the priority 'WARNING' is represented by the number 4, it's logical priority is between INFORMATIONAL and FAULT. This is because warnings have been added to the software lately and there had do be defined an unused number for the new priority.

The DRATE statement

The DRATE statement implements a data rate calculator which lets you convert a symbol rate to a interface data rate. This may be useful if a device driver shall supply both values, but the device itself only supports one of these settings.



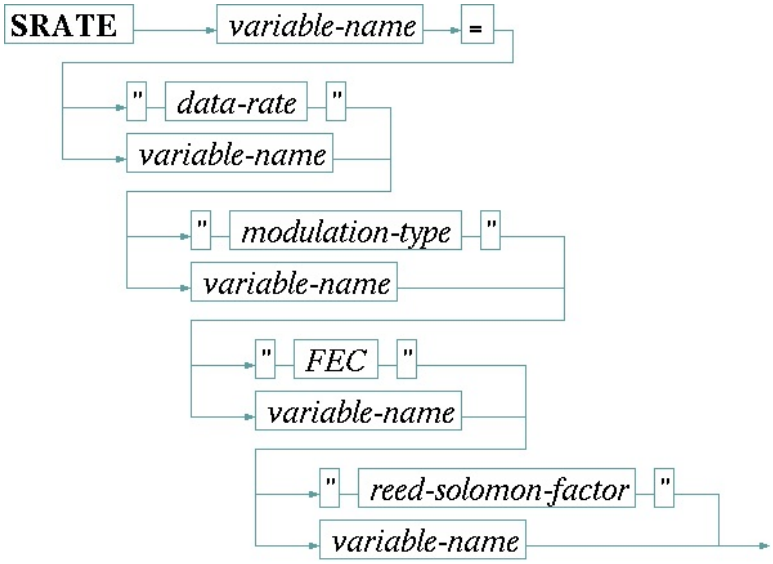
The DRATE statement collects a symbol rate value, a modulation type, a FEC value and a Reed-Solomon factor, computes an interface data rate from this and stores the result into the destination variable. The input data for the DRATE statement may be from constants given in double quotes or from the contents of driver variables.

The DRATE statement tries to guess the conversion factors from the input data following the rules described below:

modulation type	Tries to guess the modulation type from the characters the token starts with. This catches all common names for modulation types. 16* -> factor 4 8* -> factor 3 Q* -> factor 2 Everything else -> factor 1
FEC	May be one of '1/2', '2/3', '3/4', '4/5', '5/6', '6/7', '7/8' or '8/9'. Everything else is treated as '1/1' (no FEC).
Reed-Solomon factor	Accepts any factor written as 'nnn/mmm', e.g. '188/204'. If a single number is given, a denominator is assumed to be 204. Everything else is treated as '1/1' (no Reed-Solomon)

The SRATE statement

The SRATE statement implements a data rate calculator which lets you convert a interface data rate into a symbol rate. This may be useful if a device driver shall supply both values, but the device itself only supports one of these settings.



The SRATE statement collects a data rate value, a modulation type, a FEC value and a Reed-Solomon factor, computes the symbol rate from this and stores the result into the destination variable. The input data for the SRATE statement may be from constants given in double quotes or from the contents of driver variables.

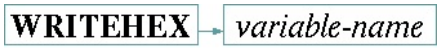
The SRATE statement tries to guess the conversion factors from the input data following the rules described below:

modulation type	Tries to guess the modulation type from the characters the token starts with. This catches all common names for modulation types. 16* -> factor 4 8* -> factor 3 Q* -> factor 2 Everything else -> factor 1
FEC	May be one of '1/2', '2/3', '3/4', '4/5', '5/6', '6/7', '7/8' or '8/9'. Everything else is treated as '1/1' (no FEC).

Reed-Solomon factor	Accepts any factor written as 'nnn/mmm', e.g. '188/204'. If a single number is given, a denominator is assumed to be 204. Everything else is treated as '1/1' (no Reed-Solomon)

The WRITEHEX statement

The WRITEHEX statement interprets the contents of a variable as a hex dump of a binary byte array and sends this binary data to the device after packing it into a protocol frame.



The WRITEHEX statement is used in the 'StandardBin.nc' include file to define a convenient method of sending a command through the 'lowLevel' driver variable for binary communication protocols. There is probably no other use for the WRITEHEX statement.

The READHEX statement

The READHEX statement reads a message from the device, strips off the protocol frame and formats the received binary data as a hex dump. This is assigned to a driver variable.

The READHEX statement is used in the 'StandardBin.nc' include file to define a convenient method of reading back the device's reply through the 'lowLevel' driver variable for binary communication protocols. There is probably no other use for the READHEX statement.

The INVALIDATE statement

The INVALIDATE statement marks a variable to be read from the device as soon as possible. It can be used if for instance a general mode setting has been changed at the device - requiring all parameter depending on this mode to be updated. INVALIDATE bypasses the "delayed read back" mechanism controlled by the conig.readBackDelay setting, forces the read back in the same cycle if the GET procedure for the variable is located after the INVALIDATE statement within the driver.

For the INVALIDATE statement, use the keyword INVALIDATE followed by the name of the variable to be invalidated.

The RPN language extension

The ***sat-nms*** device driver definition language has been designed to be easy to understand and to provide a set of commands which is optimized to program device drivers. It enables people with some technical understanding but without any programming experience to add new device drivers to the ***sat-nms*** system.

Some complex devices require the device driver to behave more intelligent than the device driver definition language can do. For such cases the RPN language extension has been added to the device driver language.

The RPN language extension adds some functionality of an RPN (RPN = Reverse Polish Notation) programmable pocket calculator to the device driver. With RPN commands a device driver procedure can do:

- Arithmetic operations.
- String manipulation operations.
- Text based I/O to the device.
- Loops, conditional branches.

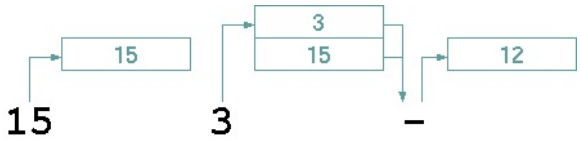
Device drivers using RPN commands are not as easy to understand as standard device drivers are. Only experienced programmers should use these commands as bad designed RPN command sequences may compromise the stability of the whole M&C system.

The RPN stack

RPN (Reverse Polish Notation) is a way to define arithmetic operations which very efficiently can be used

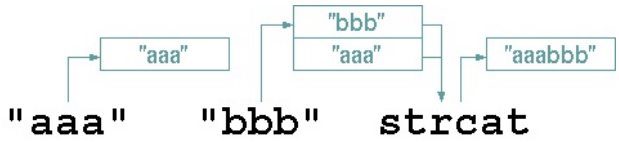
for computer programs. A number of pocket calculators use this method as well as programming languages like FORTH.

The example below illustrates how RPN works. Subtracting 3 from 15 you will be used to write as "**15 - 3**". This is known as 'infix' notation, the operator ('-') is written in between the arguments it works on. With RPN (aka. 'postfix' notation) the operator appears behind it's arguments:



Writing '15' pushes this number on the stack. Now '3' pushes the second argument on the stack, the number '3' now appears on top of the '15'. Finally the '-' operator removes both numbers from the stack and replaces them by the result of the operation.

With the ***sat-nms*** device driver language, RPN operations are not limited to plain arithmetic. The example below illustrates a string concatenation:



The stack is able to store objects of different data types. Numbers, boolean values and character strings may be used. RPN functions automatically convert the type of their input data as required. The stack generally is not limited in size (the computer's memory size however limits the stack).

RPN operations may take an arbitrary number of parameters from the stack and they may leave an arbitrary number of results there. This makes functions possible which are much more complex than a simple '+' or '-'. Furthermore, the stack may be used as a storage for intermediate results. This together allows to perform quite complex operations very efficiently.

There is one stack for each device which keeps it's contents between driver procedures and cycles. While this feature enables you to do very sophisticated things with the stack, you should be careful not to leave accidentally something on the stack at the end of an operation. The stack may grow with each cycle of the device driver, eating up slowly the whole available memory. Then, after hours, the M&C application aborts due to a lack of memory. There is a '**clr**' RPN command which clears the stack, you should call it at the end of an RPN sequence.

The { ... } statement

A sequence of words enclosed in curly braces is recognized by the device driver as an RPN command sequence. Within the RPN sequence commands must be separated by whitespace. Each word is interpreted as one of the following:

Variable names	cause the interpreter to push the variable's contents onto the stack.
Numeric (decimal) constants	are pushed onto the stack as double precision floating point values.
Character strings (in double quotes)	are pushed as they are.
Commands / keywords	are executed as the RPN command reference in the following chapter describes.

Example

```
{
    "ENQ;AUN" prt                          // request the number of
    inp "=" find                           // audio streams, get the reply
    !internal.numAudio                     // and store it

    internal.numAudio if
      ""                                   // audio stream list
      0                                    // loop counter
      do
```

```
        "ENQ;AUX=" over "d04" fmt strcat prt  // request one entry
        swap                                  // get the list on top
        inp "=" find                          // the complete entry
        dup "," trm 2 substr                  // entry number 2 digits
        " " strcat                            // delimiter
        swap "," find "," find                // language description
        strcat strcat "\n" strcat             // append the reply
        swap                                  // loop counter on top
        1 +                                   // increment it
        internal.numAudio 1 -                 // decrement numAudio,
        !internal.numAudio                    // loop until there are more
      internal.numAudio while                 // audio streams
      drop                                    // the loop counter
    else
      "NONE\n"
    endif
    !audioList
    clr                                       // due to paranoia ;-)
}
```

The example above -- taken from the Tandberg-Alteia device driver -- fills the variable 'audioList' with a newline separated list of available audio streams as reported by the IRD. The RPN sequence first gets the number of available streams from the IRD and stores this into 'internal.numAudio', Then, unless internal.numAudio is zero, the program builds the list from the information returned by the IRD for each stream.

RPN command reference

The table below summarizes all commands and operations which are accepted by the device driver in RPN mode. The second column of the table describes how a command changes the stack. Left of the '--' the objects the operation takes from the stack are listed. The TOS (top of stack) is the rightmost value. Right of the '--' the results the operation leaves on the stack are shown.

command	stack usage	description
variable-name	`-- v`	Pushes the contents of the variable onto the stack. The type of the variable is retained (CHOICE parameters are represented by string values).
numeric-constant	`-- v`	A numeric value (only decimal notation is allowed) is pushed as a floating point number onto the stack.
"text"	`-- v`	A text in double quotes is pushed onto the stack as a string constant.
! *variable-name*	`v --`	The exclamation mark, followed by a variable name, tells the driver to take one value from the stack an store it into the variable. Type conversion and range check is done as defined at the VAR statement which created the variable.
^ *variable-name*	`v --`	The caret, followed by a variable name works much like store operator described above. However, while the store (!) operator refers to the value the device driver read from the device, the caret operator loops the value to the driver as if an operator had commanded it.
<	`x y -- b`	Compares *x* and *y* numerically. The result is true if *x* < *y*.
=	`x y -- b`	Compares the string representation of *x* and *y*. The result is true if *x* = *y*. Be careful when comparing floating point values.
>	`x y -- b`	Compares *x* and *y* numerically. The result is true if *x* > *y*.
-	`x y -- z`	Subtracts two values. The result is *x* - *y*.
/	`x y -- z`	Divides two values. The result is *x* / *y*. With *y = 0* the result always is zero (although this is mathematically not correct).
*	`x y -- z`	Multiplies two values.
+	`x y -- z`	Adds two values.
@	`'s' -- z`	Replaces the name of a parameter by it's value. The parameter name must be a complete parameter ID, the value is that one displayed at the GUI, not the recently commanded one. If @ fails, the string "0" ist left

		on the stack.
binand	`x y -- z`	Performs a bitwise AND of two numeric operands.
binneg	`x -- z`	Binary negates the value on the stack.
binor	`x y -- z`	Performs a bitwise OR of two numeric operands.
binxor	`x y -- z`	Performs a bitwise XOR of two numeric operands.
bit	`n p -- b`	Isolates a bit value from a numeric value. Leaves a boolean flag on the stack which is true if the bit number *p* of the value *n* was set. Bit number 0 denotes the least significant bit in *n*.
clr	`... v --`	Clears the stack.
copy	`'s' 'd' --`	Copies a single parameter or a complete device setup from one device to another. 's', 'd' are interpreted as source and destination of the operation, must both be either plain device names or fully qualified parameter IDs ('MYDEVICE.grp.parName' e.g.). When copying complete device setups, this is done via the device preset facility: a temporary / unnamed device preset is taken from the source device an applied to the destination device.
cut	`'s' n -- 's'`	Cuts the string '*s*' to the length of *n* characters. If *n* is greater than the length of the string to cut, the latter is leaved unchanged.
debug	`x --`	Takes a numeric value from the stack. Turns on debugging output if non-zero. The debugging output can be watched on the debug console window of the M&C software.
do	`--`	Starts a **do ... while** or a **do ... until** loop.
drop	`v --`	Removes one value from the stack.
dup	`v -- v v`	Duplicates the value on top of the stack.
else	`--`	Part of the **if ... else ... endif** construct.
endif	`--`	Closes an **if ... endif** or an **if ... else ... endif** construct.
find	`'s' 'p' -- 's'`	Finds the pattern '*p*' in the string '*s*'. Removes the beginning if '*s*' including the first occurrence of the pattern '*p*'. The result starts with the character following the first occurrence of '*p*' in '*s*'. If '*p*' is not found in '*s*', find leaves an empty string on the stack.
fmt	`n 'fmt' -- 's'`	Formats a numeric value according to format specification given in '*fmt*'. Leaves the formatted number as a string on the stack. The format specification follows the same rules the FMT option of the PRINT statement does.
hex	`'x' -- n`	Interprets the top of the stack as the string representation of a hexadecimal number. Leaves the numeric value on the stack.
if	`n --`	Start a **if ... endif** or a **if ... else ... endif** clause. Takes one value from the stack. If this value is non-zero, the commands between **if** and **else** are executed.
inp	`-- 's'`	Reads one message from the device and places the data as a string on the stack. The protocol frame is removed.
log10	`x -- z`	This is the inverse function to '*pow10*'. It takes the common logarithm of the value on the TOS. To use this function to convert a 'mW' expressed power to 'dBm' follow this example: '*mwval log10 10 **' converts the contents of '*mwval*' from 'mW' to 'dBm'.
not	`v -- v`	Negates the top of stack. Works with boolean values, numeric values (non-zero is turned into 0, 0 is turned into 1), and common string codings of boolean states.
over	`a b -- a b a`	Copies the value located one below the TOS on top of the stack.
pow	`x y -- z`	Raises 'x' to the power of 'y'. May be used to compute the square of a number ('*3 2 pow*' leaves '*9*' on the stack). Floating point numbers are allowed for both operands, hence you may compute a square root like this: '*myvar 0.5 pow*' leaves the square root of the contents of myvar on the stack.
pow10	`x -- z`	Raises 10 to the power of 'x'. This mainly is intended to convert RF power values expressed in 'dBm' to 'mW'. Example: '*dbmval 10 / pow10*'

		converts the contents of '*dbmval*' from 'dBm' to 'mW', leaves the latter value on the stack.
prt	`'s' --`	Takes a value from the stack and sends it#s string representation to the device after adding the protocol frame.
rot	`a b c -- b a c`	Rotates three values on top of the stack.
rxlt *table*	`'s' -- 's'`	Translates a string value through the given translation table. Translates from right to left.
send	`'v' 'd' --`	Sends a message to another device, setting a parameter at this device. 'd' is interpreted as the full parameter ID of the message destination ('MYDEVICE.grp.parName' e.g.), 'v' is the value to be set there.
strcat	`'s' 's' -- 's'`	Concats two string values.
substr	`'s' n -- 's'`	Removes *n* character from the beginning of a string value.
swap	`a b -- b a`	Swaps two values on top of the stack.
trm	`'s' 'p' -- 's'`	Cuts the string '*s*' at that point where the pattern '*p*' is found in the string. Leaves the string 's' unchanged if '*p*' does not exist in '*s*'
until	`n --`	Closes a **do ... until** loop. Takes one value from the stack, loops again if this is zero.
while	`--`	Closes a **do ... while** loop. Takes one value from the stack, loops again if this is non-zero.
xlt *table*	`'s' -- 's'`	Translates a string value through the given translation table. Translates from left to right.

Device driver examples

The following pages contain two examples for a device driver, taken from the ***sat-nms*** device driver library. While the first driver is a quite simple implementation, the second driver makes use of the RPN language extension and other features.

- NDSatCom-KuBand-Upconverter
- Tandberg-Alteia

NDSatCom-KuBand-Upconverter

```
//
//  Device driver for the ND SatCom Ku-band upconverter.
//
//
//  CHANGE RECORD:
//
//  2001-05-05   1.00  initial version.
//  2001-06-23   1.01  the get procedure also depends on the tx.gain and
//                     the tx.frequency parameter.
//  2001-06-27   1.02  info.type set to NDSatCom-Upconverter
//  2001-08-09   1.03  changed info.type to match the file name.
//
COMMENT   "NDSatCom-KuBand-Upconverter 1.03 010809"
PROTOCOL  Miteq-MOD95
INCLUDE   "drivers/Standard.inc"

/** identification variables ***********************************************/

VAR info.type        CYCLE 0   TEXT READONLY INIT "NDSatCom-KuBand-Upconverter"
VAR info.port        CYCLE 0   TEXT READONLY
VAR info.frame       CYCLE 0   TEXT READONLY INIT "Upconverter"
VAR info.if          CYCLE 0   TEXT READONLY

/** configuration variables ************************************************/

/** M&C variables **********************************************************/
```

```
VAR tx.on            CHOICE "OFF|ON|"                        CYCLE 2
VAR tx.gain          FLOAT 0 30.0 1 "dB"                     CYCLE 0
VAR tx.frequency     FLOAT 12750.0 14500.0 3 "MHz"           CYCLE 0

/** internal variables ***************************************************/

/** alarm flags **********************************************************/

ALARM faults.01      TEXT "Remote access"
ALARM faults.02      TEXT "Synthesizer"
ALARM faults.03      TEXT "LO-A lock"
ALARM faults.04      TEXT "LO-B lock"
ALARM faults.05      TEXT "Power supply"
ALARM faults.06      TEXT "IF-LO level"
ALARM faults.07      TEXT "RF-LO level"

/** overall status / parameter fetch routine *****************************/

TABLE T01 "OFF=1,ON=0"
TABLE T02 "70 MHz=0,140MHz=1"
TABLE T03 "0=1,1=0"
PROC GET WATCH tx.on tx.gain tx.frequency
    PRINT "A"
    INPUT AT 2  SCALE 0.001            tx.frequency
          AT 11 SCALE -0.1 OFFSET 30.0 tx.gain
          AT 15 CUT 1 XLT T03          faults.01
          AT 17 CUT 1 XLT T02          info.if
          AT 19 CUT 1 XLT T01          tx.on
          AT 21 CUT 1                  faults.02
          AT 22 CUT 1                  faults.03
          AT 23 CUT 1                  faults.04
          AT 24 CUT 1                  faults.05
          AT 25 CUT 1                  faults.06
          AT 26 CUT 1                  faults.07

/** set the tx.gain ******************************************************/

PROC PUT WATCH tx.gain
    PRINT "T" SCALE -10.0 OFFSET 300.0 FMT "d03" tx.gain
    INPUT
    DELAY 1.0

/** set the rf-on state **************************************************/

TABLE T04 "OFF=M,ON=U"
PROC PUT WATCH tx.on
    PRINT XLT T04 tx.on
    INPUT

/** read / set the frequency *********************************************/

PROC PUT WATCH tx.frequency
    PRINT "F" SCALE 1000.0 FMT "d8" tx.frequency
    INPUT
    DELAY 1.0
```

Tandberg-Alteia

```
//
// Device driver for the Tandberg Alteia and Alteia Plus DVB receivers.
//
// CHANGE HISTORY:
//
// 1.00 020505 created.
//
```

```
COMMENT   "Tandberg-Alteia 1.00 020505"
PROTOCOL  Tandberg-Alteia
INCLUDE   "drivers/Standard.inc"

/** identification variables ***********************************************/

VAR info.type             CYCLE 0 TEXT READONLY INIT "Tandberg-Alteia"
VAR info.port             CYCLE 0 TEXT READONLY
VAR info.frame            CYCLE 0 TEXT READONLY INIT "IRD-Alteia"
VAR info.model            CYCLE 0 TEXT READONLY
VAR info.serial           CYCLE 0 TEXT READONLY
VAR info.ca.casid         CYCLE 0 TEXT READONLY
VAR info.ca.codeversion   CYCLE 0 TEXT READONLY
VAR info.ca.bootversion   CYCLE 0 TEXT READONLY
VAR info.ca.modelno       CYCLE 0 TEXT READONLY
VAR info.ca.hardware      CYCLE 0 TEXT READONLY
VAR info.ca.manufacturer  CYCLE 0 TEXT READONLY
VAR info.ca.download      CYCLE 0 TEXT READONLY

/** configuration variables ************************************************/

VAR config.lbandInputs    CYCLE 0 CHOICE "4,2" SETUP SAVE
VAR config.lnbPower       CYCLE 0 CHOICE "OFF,ON.,BST" SETUP
VAR config.loFreq         CYCLE 0 FLOAT 0 0 1 "MHz" SETUP
VAR config.berThreshold   CYCLE 0 TEXT SETUP
VAR config.sigThreshold   CYCLE 0 INTEGER 0 255 ""  SETUP
VAR config.errFrame       CYCLE 0 CHOICE "FREEZE,BLACK" SETUP

/** internal variables *****************************************************/

VAR internal.numServices  CYCLE 0 INTEGER 0 0 ""  READONLY
VAR internal.numAudio     CYCLE 0 INTEGER 0 0 ""  READONLY
VAR internal.ack          CYCLE 0 TEXT            READONLY
VAR internal.flags        CYCLE 0 HEX     0 0 ""  READONLY
VAR internal.scnt         CYCLE 0 INTEGER 0 0 ""  READONLY INIT "0"


/** M&C variables **********************************************************/


VAR input                 CYCLE 300 CHOICE "1,2,3,4"
VAR polarization          CYCLE 0   CHOICE "HOR,VER"
VAR frequency             CYCLE 0   FLOAT 0 0 1 "MHz"
VAR dataRate              CYCLE 0   FLOAT 0 0 3 "Mbps" READONLY
VAR symbolRate            CYCLE 300 FLOAT 0 0 3 "Msps"
VAR modulation            CYCLE 0   CHOICE "BPSK,QPSK,8PSK"
VAR fec                   CYCLE 0   CHOICE "1/2,2/3,3/4,4/5,5/6,6/7,7/8,8/9"
VAR programNo             CYCLE 0   INTEGER 0 99 ""

VAR programList           CYCLE 2   TEXT READONLY
VAR audioList             CYCLE 3   TEXT READONLY
VAR actualProgram         CYCLE 2   TEXT READONLY

VAR video.fmt625          CYCLE 300 CHOICE "PALI,PALB,PALN"
VAR video.fmt525          CYCLE 0   CHOICE "NTSC,NTSN,PALM"
VAR video.level           CYCLE 0   INTEGER -30 30 "%"
VAR video.test            CYCLE 0   CHOICE "NRM,625.1,625.2,625.3,625.4"
                                           "625.5,625.6,625.7,625.8,625.9"
                                           "625.10,625.11,625.12,625.13"
                                           "625.14,625.15,625.16,525.1"
                                           "525.2,525.3,525.4,525.5,525.6"
                                           "525.7,525.8,525.9,525.10,525.11"
                                           "525.12,525.13,525.14,525.15,525.16"

VAR audio.1.program       CYCLE 0   INTEGER 0 0 ""
VAR audio.1.routing       CYCLE 0   CHOICE "NRM,MON,LFT,RGT"
VAR audio.1.output        CYCLE 0   CHOICE "ANALOG,AES/EBU,SPDIF,AC3"
VAR audio.1.level         CYCLE 0   INTEGER 6 18 "dB"
VAR audio.1.language      CYCLE 0   TEXT
```

```
VAR audio.1.test          CYCLE 0   CHOICE "NRM,TEST-1,TEST-2,TEST-3,TEST-4,TEST-5"
VAR audio.1.info          CYCLE 4   TEXT READONLY

VAR audio.2.program       CYCLE 0   INTEGER 0 0 ""
VAR audio.2.routing       CYCLE 0   CHOICE "NRM,MON,LFT,RGT"
VAR audio.2.output        CYCLE 0   CHOICE "ANALOG,AES/EBU,SPDIF,AC3"
VAR audio.2.level         CYCLE 0   INTEGER 6 18 "dB"
VAR audio.2.language      CYCLE 0   TEXT
VAR audio.2.test          CYCLE 0   CHOICE "NRM,TEST-1,TEST-2,TEST-3,TEST-4,TEST-5"
VAR audio.2.info          CYCLE 4   TEXT READONLY

VAR tsout.routing         CYCLE 300 CHOICE "PRE-CA,POST-CA"
VAR tsout.fibre           CYCLE 0   CHOICE "ON,OFF"

VAR flags.lock            CYCLE 1   BOOL READONLY
VAR flags.ca              CYCLE 0   BOOL READONLY
VAR flags.video           CYCLE 0   BOOL READONLY
VAR flags.audio           CYCLE 0   BOOL READONLY
VAR flags.ber             CYCLE 0   BOOL READONLY

VAR state.ber             CYCLE 0   TEXT             READONLY
VAR state.signal          CYCLE 0   INTEGER 0 255 "" READONLY
VAR state.aspect          CYCLE 3   TEXT             READONLY
VAR state.lines           CYCLE 3   TEXT             READONLY
VAR state.state           CYCLE 2   TEXT             READONLY

VAR ca.status             CYCLE 4   TEXT READONLY
VAR ca.service            CYCLE 0   TEXT READONLY
VAR ca.rasmode            CYCLE 0   CHOICE "DISABLED,FIXED,DSNG,SEC-CA"
VAR ca.bissmode           CYCLE 0   CHOICE "DISABLED,MODE 1,MODE E"
VAR ca.bisskey1           CYCLE 0   TEXT
VAR ca.bisskey2           CYCLE 0   TEXT
VAR ca.bissbits           CYCLE 0   TEXT
VAR ca.dsngkey            CYCLE 0   TEXT

VAR reset                 CYCLE 0   TEXT

/** alarm flags ************************************************************/

ALARM faults.01 TEXT "Temperature"
ALARM faults.02 TEXT "Signal level"
ALARM faults.03 TEXT "Video lock"
ALARM faults.04 TEXT "Audio lock"
ALARM faults.05 TEXT "High BER"
ALARM faults.06 TEXT "Demod Lock"
ALARM faults.07 TEXT "Conditional Access"


/** translation tables *****************************************************/

TABLE tModulation   "BPSK=BPS,QPSK=QPS,8PSK=8PS"
TABLE tErrFrame     "FREEZE=FRZ,BLACK=BLK"
TABLE tVideoLevel   "-30=NEG30,-29=NEG29,-28=NEG28,-27=NEG27,-26=NEG26"
                    "-25=NEG25,-24=NEG24,-23=NEG23,-22=NEG22,-21=NEG21"
                    "-20=NEG20,-19=NEG19,-18=NEG18,-17=NEG17,-16=NEG16"
                    "-15=NEG15,-14=NEG14,-13=NEG13,-12=NEG12,-11=NEG11"
                    "-10=NEG10,-9=NEG09,-8=NEG08,-7=NEG07,-6=NEG06"
                    "-5=NEG05,-4=NEG04,-3=NEG03,-2=NEG02,-1=NEG01"
                    "0=POS00,1=POS01,2=POS02,3=POS03,4=POS04"
                    "5=POS05,6=POS06,7=POS07,8=POS08,9=POS09"
                    "10=POS10,11=POS11,12=POS12,13=POS13,14=POS14"
                    "15=POS15,16=POS16,17=POS17,18=POS18,19=POS19"
                    "20=POS20,21=POS21,22=POS22,23=POS23,24=POS24"
                    "25=POS25,26=POS26,27=POS27,28=POS28,29=POS29,30=POS30"
TABLE tVideoTest    "NRM=00,625.1=01,625.2=02,625.3=03,625.4=04,625.5=05"
                    "625.6=06,625.7=07,625.8=08,625.9=09,625.10=10,625.11=11"
                    "625.12=12,625.13=13,625.14=14,625.15=15,625.16=16"
                    "525.1=17,525.2=18,525.3=19,525.4=20,525.5=21,525.6=22"
                    "525.7=23,525.8=24,525.9=25,525.10=26,525.11=27,525.12=28"
```

```
                    "525.13=29,525.14=30,525.15=31,525.16=32"
TABLE tTsRouting    "PRE-CA=PRE,POST-CA=PST"
TABLE tTsFibre      "ON=ENA,OFF=DIS"
TABLE tAudioRouting "NRM=ST,MON=M1,LFT=M2,RGT=M3"
TABLE tAudioOutput  "ANALOG=ANA,AES/EBU=PRO,SPDIF=SPD,AC3=AC3"
TABLE tAudioTest    "NRM=0,TEST-1=1,TEST-2=2,TEST-3=3,TEST-4=4,TEST-5=5"
TABLE tRasMode      "DISABLED=DIS,FIXED=FIX,DSNG=DSN,SEC-CA=SCA"
TABLE tBissMode     "DISABLED=DIS,MODE 1=MO1,MODE E=MOE"
TABLE tCaStatus     "UNKNOWN CODE=FF"
                    "CARD INSERTED=00"
                    "CARD REMOVED=01"
                    "CARD INVALID=04"
                    "SERVICE BLOCKED=05"
                    "INVALID PACKET=06"
                    "CARD UNAUTHORIZED=07"
                    "HARDWARE FAILURE=08"
                    "CLEAR BUT RESTRICTED=09"
                    "SERVICE BLACKED OUT=10"
                    "SERVICE EXPIRED=11"
                    "CA WARNING=12"
                    "CA WARNING=13"
                    "PAIRING ERROR=14"
                    "CA WARNING=15"
                    "CA WARNING=16"
                    "CA WARNING=17"
                    "CA WARNING=21"
                    "CA WARNING=22"
TABLE tCaService    "UNKNOWN CODE=XXX"
                    "NO SERVICE SELECTED=NSS"
                    "CLEAR=CLR"
                    "RAS AUTHORIZED=RAS"
                    "RAS UNAUTHORIZED=RAU"
                    "BISS AUTHORIZED=BIA"
                    "BISS UNAUTHORIZED=BIU"
                    "VGUARD AUTHORIZED=GVA"
                    "VGUARD UNAUTHORIZED=VGU"
                    "NO CA INSTALLED=NCA"

/** procedures  ************************************************************/


// called after sending a command to the IRD. checks the ACK response which is
// expected.
//
PROC SUBROUTINE getAck
    INPUT "=" TRM "_" internal.ack
    IF internal.ack = "ACK" GOTO endif
        SET faults.commstat = "ACK expected"
        SET faults.99 = "true"
    :endif


// called if the number of l-band inputs gets changed. sets the range for the
// "input" parameter
//
PROC PUT WATCH config.lbandInputs
    IF config.lbandInputs = "2" GOTO else
        RANGESET input CHOICES "1,2,3,4"
        GOTO endif
    :else
        RANGESET input CHOICES "1,2"
    :endif

// this procedure is excuted once after the communication to the receiver ahs
// been established. it get the device identification parameters and sets the
// LNB frequency according to the position of the input switch.
//
PROC GET WATCH info.serial info.model
    PRINT "REM;MOD"
```

```
    INPUT "MOD=" TRM "_" info.model
    PRINT "REM;SNM"
    INPUT "SNM=" TRM "_" info.serial

// reads the fault flags and derived the "LED flags" from these values
//
//
PROC GET WATCH flags.lock
    PRINT "OPR;SRQ"
    INPUT
       "SIG="           state.signal
       "ALR=" TRM "_"   internal.flags
       "BER=" TRM "_"   state.ber
    BITSET faults.01 = internal.flags  4  // Temperature
    BITSET faults.02 = internal.flags  5  // Signal level
    BITSET faults.03 = internal.flags  11 // Video lock
    BITSET faults.04 = internal.flags  9  // Audio lock
    BITSET faults.05 = internal.flags  13 // High BER
    BITSET faults.06 = internal.flags  15 // Demod lock
    BITSET faults.07 = internal.flags  14 // Cond. Access
    IF faults.06 = "true" SET flags.lock = "false"
    IF faults.07 = "true" SET flags.ca = "false"
    IF faults.03 = "true" SET flags.video = "false"
    IF faults.04 = "true" SET flags.audio = "false"
    IF faults.05 = "true" SET flags.ber = "false"
    IF faults.06 = "false" SET flags.lock = "true"
    IF faults.07 = "false" SET flags.ca = "true"
    IF faults.03 = "false" SET flags.video = "true"
    IF faults.04 = "false" SET flags.audio = "true"
    IF faults.05 = "false" SET flags.ber = "true"


// reads the service status message. this also is used to select a service
// after the IRD has decoded the signal
//
PROC GET WATCH state.state
{
    "SER;SRQ" prt inp
    "SRQ=" find ! state.state

    state.state "WAIT.PMT" = if
      internal.scnt 1 + !internal.scnt
      internal.scnt 6 > if
        "SER;SEL=00" prt inp
      else
        internal.scnt 3 > if
          "SER;SEL=" programNo "d02" fmt strcat prt inp
        endif
      endif
    else
      0 !internal.scnt
    endif
}

// reads the information from the TUN:SRQ request.
//
PROC GET WATCH
    input frequency modulation polarization
    config.lnbPower config.loFreq
    PRINT "TUN;SRQ"
    INPUT
        "FRQ=" SCALE 0.125           frequency
        "LNB=" SCALE 0.125           config.loFreq
        "PWR=" CUT 3                 config.lnbPower
        "POL=" CUT 3                 polarization
        "RFI=" CUT 1                 input
        "MOD=" CUT 3 XLT tModulation  modulation
    DRATE dataRate = symbolRate modulation fec "188"
```

```
// sets the RF input and the frequency. we switch both together to ensure that
// the input is set before the frequency is tuned.
//
PROC PUT WATCH input frequency
    PRINT "TUN;RFI=NO " input
    CALL getAck
    DELAY 3.0
    PRINT "TUN;FRQ=" SCALE 8.0 FMT "d06" frequency
    CALL getAck

// sets LO frequency (of the inout actually set
//
PROC PUT WATCH config.loFreq
    PRINT "TUN;LNB=" SCALE 8.0 FMT "d06" config.loFreq
    CALL getAck

// sets the modulation type
//
PROC PUT WATCH modulation
    PRINT "TUN;MOD=" XLT tModulation modulation
    CALL getAck

// sets the polarization by a 22kHz pulse
//
PROC PUT WATCH polarization
    PRINT "TUN;POL=" polarization
    CALL getAck

// reads the information from the DEM;SRQ request.
//
PROC GET WATCH fec symbolRate config.berThreshold config.sigThreshold
    PRINT "DEM;SRQ"
    INPUT
        "FEC=" CUT 3                fec
        "SYM=" TRM "_" SCALE 0.0001  symbolRate
        "BER=" TRM "_"               config.berThreshold
        "SIG=" CUT 3                 config.sigThreshold
    DRATE dataRate = symbolRate modulation fec "188"

// sets the symbol rate
//
PROC PUT WATCH symbolRate
    PRINT "DEM;SYM=" SCALE 10000.0 FMT "d06" symbolRate
    CALL getAck

// sets the FEC
//
PROC PUT WATCH fec
    PRINT "DEM;FEC=" fec
    CALL getAck

// sets the BER threshold configuration parameter
//
PROC PUT WATCH config.berThreshold
    PRINT "DEM;BER=" config.berThreshold
    CALL getAck

// sets the signal level configuration parameter
//
PROC PUT WATCH config.sigThreshold
    PRINT "DEM;SIG=" FMT "d03" config.sigThreshold
    CALL getAck

// sets the LNB power configuration parameter
//
PROC PUT WATCH config.lnbPower
    PRINT "TUN;PWR=" config.lnbPower
    CALL getAck
```

```
////////////////////// VIDEO PARAMETERS ////////////////////////

// gets the video state (and the video settings)
//
PROC GET WATCH video.fmt625 video.fmt525 video.level video.test
               state.aspect state.lines config.errFrame
    PRINT "VID;SRQ"
    INPUT
        "625=" TRM "_" video.fmt625
        "525=" TRM "_" video.fmt525
        "ERR=" TRM "_" XLT tErrFrame config.errFrame
        "LVL=" TRM "_" XLT tVideoLevel video.level
        "OPS=" TRM "_" XLT tVideoTest video.test
        "VLS=" TRM "_" state.lines
        "SAR=" TRM "_" state.aspect

// sets the 625 lines default video mode
//
PROC PUT WATCH video.fmt625
    PRINT "VID;625=" video.fmt625
    CALL getAck

// sets the 525 lines default video mode
//
PROC PUT WATCH video.fmt525
    PRINT "VID;525=" video.fmt525
    CALL getAck

// sets what to show is video is missing
//
PROC PUT WATCH config.errFrame
    PRINT "VID;ERR=" XLT tErrFrame config.errFrame
    CALL getAck

// sets the video level
//
PROC PUT WATCH video.level
    PRINT "VID;LVL=" XLT tVideoLevel video.level
    CALL getAck

// sets the video test mode
//
PROC PUT WATCH video.test
    PRINT "VID;OPS=" XLT tVideoTest video.test
    CALL getAck

////////////////////// AUDIO CHANNEL 1 ////////////////////////////

// gets the audio channel 1 parameters
//
PROC GET WATCH audio.1.routing audio.1.output audio.1.level audio.1.language
    audio.1.test audio.1.info
    PRINT "AUD;SRQ"
    INPUT
        "ROU="  CUT 2 XLT tAudioRouting audio.1.routing
        "LEV=M" CUT 2 audio.1.level
        "OUT="  CUT 3 XLT tAudioOutput audio.1.output
        "DFL="  CUT 3 audio.1.language
        "OPS="  CUT 1 XLT tAudioTest audio.1.test
        "CLN="  audio.1.info

// set the audio channel 1 output routing
//
PROC PUT WATCH audio.1.routing
    PRINT "AUD;ROU=" XLT tAudioRouting audio.1.routing
    CALL getAck

// set the audio channel 1 level
//
```

```
PROC PUT WATCH audio.1.level
    PRINT "AUD;LEV=M" FMT "d02" audio.1.level
    CALL getAck

// set the audio channel 1 output (hardware)
//
PROC PUT WATCH audio.1.output
    PRINT "AUD;OUT=" XLT tAudioOutput audio.1.output
    CALL getAck

// set the audio channel 1 default language
//
PROC PUT WATCH audio.1.language
    PRINT "AUD;DFL=" audio.1.language
    CALL getAck

// set the audio channel 1 test mode
//
PROC PUT WATCH audio.1.test
    PRINT "AUD;OPS=" XLT tAudioTest audio.1.test
    CALL getAck


//////////////////// AUDIO CHANNEL 2 ////////////////////////////

// gets the audio channel 2 parameters
//
PROC GET WATCH audio.2.routing audio.2.output audio.2.level audio.2.language
    audio.2.test audio.2.info
    PRINT "AU2;SRQ"
    INPUT
        "ROU="  CUT 2 XLT tAudioRouting audio.2.routing
        "LEV=M" CUT 2 audio.2.level
        "OUT="  CUT 3 XLT tAudioOutput audio.2.output
        "DFL="  CUT 3 audio.2.language
        "OPS="  CUT 1 XLT tAudioTest audio.2.test
        "CLN="  audio.2.info

// set the audio channel 2 output routing
//
PROC PUT WATCH audio.2.routing
    PRINT "AU2;ROU=" XLT tAudioRouting audio.2.routing
    CALL getAck

// set the audio channel 2 level
//
PROC PUT WATCH audio.2.level
    PRINT "AU2;LEV=M" FMT "d02" audio.2.level
    CALL getAck

// set the audio channel 2 output (hardware)
//
PROC PUT WATCH audio.2.output
    PRINT "AU2;OUT=" XLT tAudioOutput audio.2.output
    CALL getAck

// set the audio channel 2 default language
//
PROC PUT WATCH audio.2.language
    PRINT "AU2;DFL=" audio.2.language
    CALL getAck

// set the audio channel 2 test mode
//
PROC PUT WATCH audio.2.test
    PRINT "AU2;OPS=" XLT tAudioTest audio.2.test
    CALL getAck
```

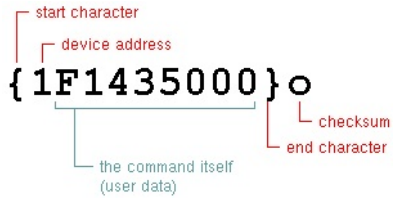
```
////////////////////// TRANSPORT STREAM OUTPUT ////////////////////////

// reads the transport stream parameters
//
PROC GET WATCH tsout.routing tsout.fibre
    PRINT "TSO;SRQ"
    INPUT
        "CAM=" CUT 3 XLT tTsRouting tsout.routing
        "ENA=" CUT 3 XLT tTsFibre   tsout.fibre

// sets the transport stream pre/post CA routing
//
PROC PUT WATCH tsout.routing
    PRINT "TSO;CAM=" XLT tTsRouting tsout.routing
    CALL getAck

// enables / disable the ASI fibre output
//
PROC PUT WATCH tsout.fibre
    PRINT "TSO;ENA=" XLT tTsFibre tsout.fibre
    CALL getAck

////////////////////// CONDITIONAL ACCESS ////////////////////////////


// reads the conditional access parameters. uses an RPN command sequence for
// this as - depending on the purchased configuration - the Alteia does not
// report all of these parameters all the time. RPN assigns empty strings to
// parameters which do not exist in the reply.
//
PROC GET WATCH ca.status ca.rasmode ca.bissmode
    ca.dsngkey ca.bisskey1 ca.bisskey2 ca.bissbits
{
    "CAS;SRQ" prt inp
    dup "CSS=" find "_" trm tCaService rxlt ! ca.service
    dup "CST=" find "_" trm tCaStatus rxlt ! ca.status
    dup "CID=" find "_" trm ! info.ca.casid
    dup "CAC=" find "_" trm ! info.ca.codeversion
    dup "BCV=" find "_" trm ! info.ca.bootversion
    dup "CMN=" find "_" trm ! info.ca.modelno
    dup "CHT=" find "_" trm ! info.ca.hardware
    dup "CMA=" find "_" trm ! info.ca.manufacturer
    dup "CDS=" find "_" trm ! info.ca.download
    dup "RAM=" find "_" trm ! tRasMode rxlt ca.rasmode
    dup "BIS=" find "_" trm ! tBissMode rxlt ca.bissmode
    dup "BM1=" find "_" trm ! ca.bisskey1
    dup "BM2=" find "_" trm ! ca.bisskey2
    dup "BKE=" find "_" trm ! ca.bissbits
    dup "DSK=" find "_" trm ! ca.dsngkey
    clr
}

// sets the RAS mode parameter
//
PROC PUT WATCH  ca.rasmode
    PRINT "CAS;RAM=" XLT tRasMode ca.rasmode
    CALL getAck

// sets the DSNG key used with one of the RAS modes
//
PROC PUT WATCH  ca.dsngkey
    PRINT "CAS;DSK=" ca.dsngkey
    CALL getAck

// sets the BISS mode parameter
//
PROC PUT WATCH  ca.bissmode
    PRINT "CAS;BIS=" XLT tBissMode ca.bissmode
    CALL getAck
```

```
// sets the BISS mode 1 key
//
PROC PUT WATCH  ca.bisskey1
    PRINT "CAS;BM1=" ca.bisskey1
    CALL getAck

// sets the BISS mode 2 key
//
PROC PUT WATCH  ca.bisskey2
    PRINT "CAS;BM2=" ca.bisskey2
    CALL getAck

// sets the BISS key length for modes 2/3
//
PROC PUT WATCH  ca.bissbits
    PRINT "CAS;BKE=" ca.bissbits
    CALL getAck

////////////////// SERVICE SELECTION ////////////////////////////////


// reads the name of the actually selected service
//
PROC GET WATCH actualProgram
    PRINT "ENQ;NAM"
    INPUT "NAM=" actualProgram


// reads the service list (the bouquet) from the IRD and distributes the list
// as the variable programList. this proc is completly written in RPN language
// as this supports more flexible building the list from the particular
// entries.
//
PROC GET WATCH programList
{

    state.state "WAIT.DEM" = if              // in WAIT.DEM state,
      0 !internal.numServices                // no services are available
    else
      "ENQ;NUM" prt                          // request the number of
      inp "=" find                           // services, get the reply
      !internal.numServices                  // and store it
    endif

    internal.numServices if
      "ENQ;NET" prt inp "NET=" find          // network name
      "\n" strcat                            // as the first line of the list
      0                                      // loop counter
      do
        "ENQ;SER=" over "d02" fmt strcat prt // request one entry
        swap                                 // get the list on top
        inp "=" find dup                     // get the reply (2x)
        "," trm                              // the service index
        " " strcat                           // append " " to it
        swap "," find strcat                 // append the service name
        strcat                               // append list entry
        "\n" strcat                          // trailing NL
        swap                                 // loop counter on top
        1 +                                  // increment it
        internal.numServices 1 -             // decrement numServices,
        !internal.numServices                // loop until there are more
      internal.numServices while             // services
      drop                                   // the loop counter
    else
      "NO PROGRAMS AVAILABLE\n"
    endif
    !programList
    clr                                      // due to paranoia ;-)
```

```
}


// selects a service.
//
PROC PUT WATCH programNo
    PRINT "SER;SEL=" FMT "d02" programNo
    CALL getAck


// reads the audio list of the actually selected service from the IRD and
// distributes the list as the variable audioList. this proc is completly
// written in RPN language as this supports more flexible building the list
// from the particular entries.
//
PROC GET WATCH audioList
{
    "ENQ;AUN" prt                              // request the number of
    inp "=" find                               // audio streams, get the reply
    !internal.numAudio                         // and store it

    internal.numAudio if
      ""                                       // audio stream list
      0                                        // loop counter
      do
        "ENQ;AUX=" over "d04" fmt strcat prt   // request one entry
        swap                                   // get the list on top
        inp "=" find                           // the complete entry
        dup "," trm 2 substr                   // entry number 2 digits
        " " strcat                             // delimiter
        swap "," find "," find                 // language description
        strcat strcat "\n" strcat              // append the reply
        swap                                   // loop counter on top
        1 +                                    // increment it
        internal.numAudio 1 -                  // decrement numAudio,
        !internal.numAudio                     // loop until there are more
      internal.numAudio while                  // audio streams
      drop                                     // the loop counter
    else
      "NONE\n"
    endif
    !audioList
    clr                                        // due to paranoia ;-)
}

// selects the audio 1 stream
//
PROC PUT WATCH audio.1.program
    PRINT "SER;A1L=" FMT "d05" audio.1.program
    CALL getAck

// selects the audio 2 stream
//
PROC PUT WATCH audio.2.program
    PRINT "SER;A2L=" FMT "d05" audio.2.program
    CALL getAck
```

Device communication protocols

A device communication protocol encapsulates the recurrent operations to handle thisngs like start and stop characters or checksums with each message to be sent or received. The example below shows the complete message a ND-SatCom upconverter receives to tune its frequency. The pure command is `F1435000` (sets the frequency to 14,350.00 MHz). The protocol frame starts with a '{' followed by the device address. The command is terminated by '}' and finally a checksum character is sent.



A device communication protocol in the ***sat-nms*** software adds the protocol frame data (here marked red) to each message sent by a device driver with a PRONT or WRITE statement. The PRINT or WRITE statement creates the user data, the pure command. The protocol handler looks up the device address in the setup settings for the device, adds the start and stop characters and calculates the checksum over the message. The other way round, for each message received, the protocol handler strips off the protocol frame data and verifies the address and checksum fields. An INPUT or READ statement then receives the pure command data.

With the ***sat-nms*** software, new protocol definitions may be added to the software, simply by editing a text file for the new type of protocol frame which is needed.

Writing a communication protocol definition

As mentioned above, protocol definitions are coded as simple text files. When the M&C program starts, it 'compiles' the protocols needed for it's equipment setup to memory. Writing a protocol definition means editing such a text file and storing it at a place in the M&C/VLC computer where the M&C program searches for these files.

In a communication protocol definition file, you compose the protocol frame around a command from elements like characters, checksums or strings using a couple of keywords. The protocol definition language is quite simple, but powerful enough to specify almost all communication protocols used by satcom equipment.

A M&C or VLC system keeps all protocol definitions in a subdirectory called `protocols`. On a M&C system this is the directory `/home/mnc/protocols`, on a VLC the directory is called `/home/vlc/protocols`. The names of the protocol files consist of the protocol name followed by the extension `.proto`.

If you are writing the protocol definition on a Linux based M&C or NMS computer, you may want to use the vi or gvim text editor for this. vi has been configured to colorize protocol definition files on these machines. Beside this, vi is a very powerful editor for programming tasks.

You also may copy protocol definition files to a MS-Windows based computer to edit them there. If you do this, you should consider the following:

- Protocol files are Unix based text files. Lines are terminated with a line-feed character only. Your favourite MS-Windows text editor may have problems to show these files.
- Unix / Linux is case sensitive with file names. Be sure that you don't mess up the case of characters in file name when you copy files between Unix and MS-Windows.

General file format

The protocol definition language uses a file format which is very similar to that one used with ***sat-nms*** device drivers. Like with device drivers the following applies:

- Whitespace (space characters, tabs, line breaks) separates words.
- Line breaks have no special termination function.
- All keywords are in upper case letters.

- Comments in C/C++ style are recognized (both, '**/* ... ***/' and '**// ...** ' comments).

Beside this, each protocol definition file has the same simple structure:

- The file starts with an (optional) comment block and some common definitions.
- Then, following the TRANSMIT keyword, the specification how a message shall be composed durong transmit is given.
- Then the RECEIVE keyword starts the specification how to parse incoming data.

Below, an example for a protocol definition file is shown.

```
//
//  The communication protocol used with SSE devices in NPI mode.
//

COMMENT  "SSE-NPI 1.00 020108"
CLASS    TTYProtocol


/** packet send procedure ***********************************************/

TRANSMIT

   CHAR        2               // start byte, STX
   CHAR        "F"             // source (master) LU
   CHAR        "F"
   ADDRESS     TEXT            // destination (slave) LU, 2 characters
   HEXLENGTH   0               // 2 characters hex coded data length
   USERDATA                    // the command string
   CHECKSUM    SUM8H 1 -1      // checksum 2 characters
   CHAR        3               // end byte, ETX

/** packet receive procedure ********************************************/

RECEIVE

   START       2               // start byte, STX
   ADDRESS     TEXT            // source (slave) LU
   CHAR        "F"             // destination (master) LU
   CHAR        "F"
   HEXLENGTH   0               // 2 characters hex coded data length
   USERDATA                    // the response string
   CHECKSUM    SUM8H 1 -1 2    // checksum 2 characters
   CHAR        3               // end byte, ETX
```

Global definitions

The first section of the protocol definition file defines the protocol identification string and the Java class which is reposonsible to perform the I/O operations at runtime.

The COMMENT statement defines an identification string which is passed to the user interface. An operator can identify the type and version of a communication protocol used with a certain device.

The text following the COMMENT keyword is free field and principally may contain any information. The device protocols coming with the ***sat-nms*** software all follow a convention which defines the comment string as

```
"protocol-name X.YY YYMMDD"
```

where X is the major version number of the protocol, YY the minor version number and YYMMDD the release date of this protocol version. It is recommended that customer defined device protocols follow this scheme, too.

The CLASS statement defines the Java class used perform the protocol I/O steps during runtime of the M&C software. Actually `TTYProtocol` is the only protocol class which is applicable for customer defined protocol definitions.

TX message elements

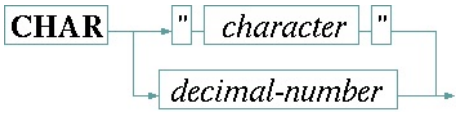
Starting with the **TRANSMIT** keyword, the second section of the protocol definition specifies the steps required to compose a valid protocol frame which is sent to the device.

The protocol frame definition consists of a sequence step specifiers, represented by a keyword followed by a defined number of parameters each. The step specifiers recognized in the the TRANSMIT section are:

CHAR	Outputs a single character.
ADDRESS	Outputs the device address.
USERDATA	Outputs the user data.
CHECKSUM	Outputs a message checksum.
DATALENGTH	Outputs a data length field (binary).
HEXLENGTH	Outputs a data length field (hex).
SEQUENCE	Outputs a binary message sequence number.

CHAR

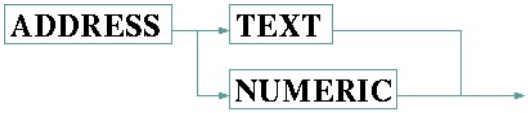
The CHAR step outputs a single character (byte).



The value may be specified as a single character in double quotes or as a decimal number in the range 0 ... 255.

ADDRESS

The ADDRESS step outputs the device address.



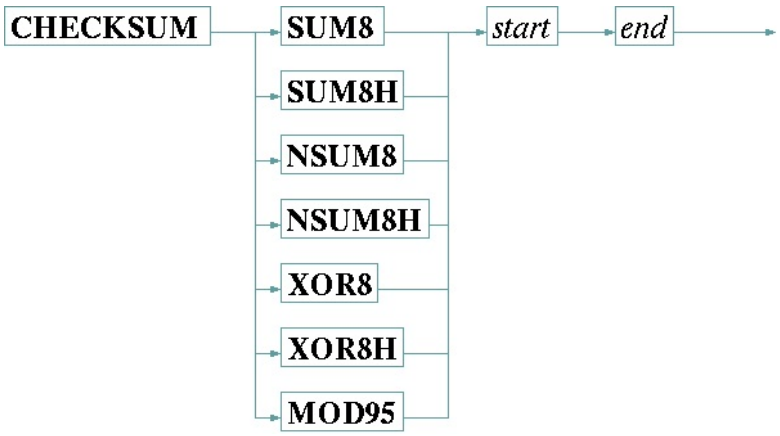
The ADDRESS keyword must be followed by one of TEXT or NUMERIC. If TEXT is specified, the address is output as a character string as it is entered at the user interface to the 'address' configuration variable. If NUMERIC is specified, the address string is converted to a integer number and output as a single byte of this value.

USERDATA

The USERDATA step copies the user data as it was generated from the PRINT or WRITE statement in the device driver to the output.

CHECKSUM

The CHECKSUM step outputs a checksum calculated from the message contents.



The parameters of this step specifier are:

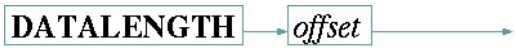
SUM8	Creates a one byte checksum by adding all bytes and truncating the sum to the lowest 8 bits.
SUM8H	Like SUM8, but the checksum is coded as a 2 digit hex number.
NSUM8	Creates a one byte checksum by adding all bytes, taking the negative value of the sum and then truncating the sum to the lowest 8 bits.
NSUM8H	Like NSUM8, but the checksum is coded as a 2 digit hex number.
XOR8	Creates a one byte checksum by XOR-ing all specified bytes.
XOR8H	Like XOR8, but the checksum is coded as a 2 digit hex number.
MOD95	Creates the one character 'modulo 95' checksum, known from the protocol used by Miteq devices (see below).
start	The buffer position of the first character to be included in the checksum computation (0 means the first character).
end	The buffer position of the last character to be included in the checksum computation, relative to the actual position (-1 means the character left of the first checksum character).

The MOD95 type checksum is computed following the formula:

$$Checksum = 32 + MOD_{95}\left[\left(\sum_{i=1}^{N} message\ byte_i\right) - (32 * N)\right]$$

DATALENGTH

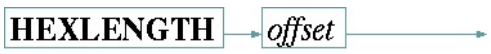
The DATALENGTH protocol step outputs a packet length field.



The packet length is computed as the length of the user data string created by the PRINT or WRITE statement in the device driver plus the offset defined as a decimal number. It is coded as a one byte binary.

HEXLENGTH

The LENGTH protocol step outputs a packet length field.



The length is computed as the length of the user data string created by the PRINT or WRITE statement in the device driver plus the offset defined as a decimal number. It is coded as a two character hex string.

SEQUENCE

The SEQUENCE step outputs a one byte binary sequence number.

The sequence number gets incremented with each message that has been sent.

RX message elements

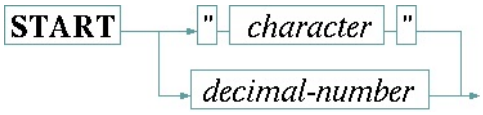
Starting with the **RECEIVE** keyword, the third section of the protocol definition specifies the steps required to parse a protocol frame which is received from the device.

The protocol frame definition consists of a sequence step specifiers, represented by a keyword followed by a defined number of parameters each. The step specifiers recognized in the the RECEIVE section are:

START	Reads a message start character.
CHAR	Reads a single character.
ADDRESS	Reads the device address.
USERDATA	Reads the user data.
STRING	Reads a terminated string as the user data
CHECKSUM	Reads a message checksum.
DATALENGTH	Reads a data length field (binary).
HEXLENGTH	Reads a data length field (hex).

START

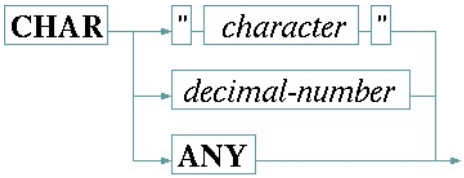
The START protocol step reads (and discards) all incoming data until the specified start character is received. The start character is not assumed to be part of the user data.



The character value may be specified as a single character in double quotes or as a decimal number in the range 0 ... 255.

CHAR

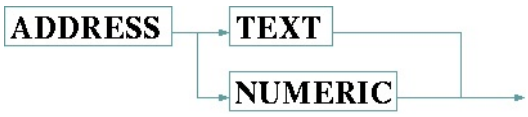
The CHAR step reads a single character and compares this to the expected value. If another character than expected has been received, the reception of this message is aborted and a communication fault is reported. The character received is not treated as part of the user data.



The value may be specified as a single character in double quotes or as a decimal number in the range 0 ... 255. The special value ANY may be specified to make the CHAR step accept any character.

ADDRESS

The ADDRESS step reads the device address and compares it to the address value set in the device's setup menu. If the ADDRESS step received other data than expected, the reception of this message is aborted and a communication fault is reported.



The ADDRESS keyword must be followed by one of TEXT or NUMERIC:

If TEXT is specified, the step reads as many characters as the address string configured for this device is

long. The address is compared character by character to the received data.

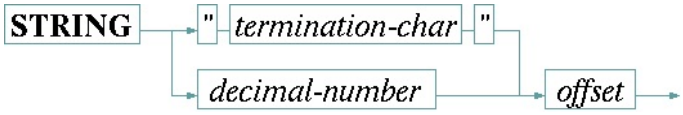
If NUMERIC is specified, one character (byte) is read. The address string is converted to a integer number and compared to the received byte.

USERDATA

The USERDATA step reads a known number of bytes and returns these as the user data of the message. USERDATA requires that the length of the message already has been read with either the DATALENGTH or the HEXLENGTH step.

STRING

The STRING step reads a character string of variable length which is terminated by a known character. The received data may be truncated by a certain number of character before it is returned as the user data part of the message.



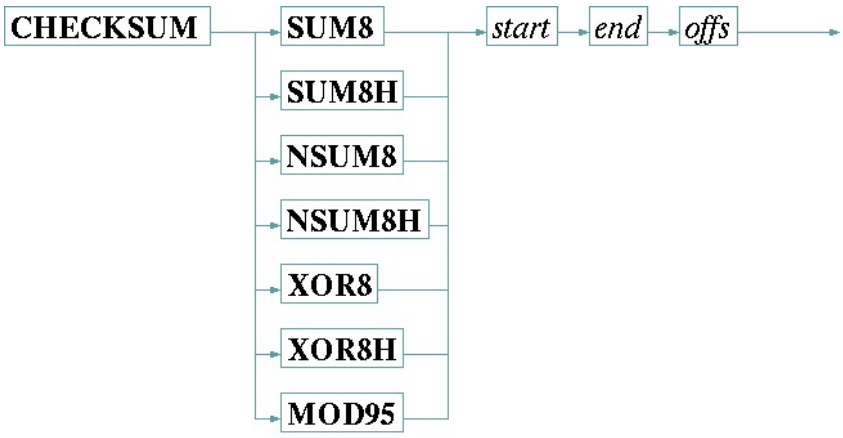
The terminating character may be specified either as a single character enclosed in double quoted or as a decimal number.

The *offset* parameter defines how many characters still have to be read or how many characters have to be cut at the end of the data to isolate the user data part of the message:

- If *offset = 0* the data read, including the termination character, is returned as the user data of the message.
- If *offset < 0* the given number of characters are cut off at the end of the data. E.g. *offset = -1* removes the termination character from the data.
- If *offset > 0* the given number of characters additionally is read and appended to the user data.

CHECKSUM

The CHECKSUM step reads a checksum and compares it to the checksum calculated from the message contents. If the values differ, the reception of this message is aborted and a communication fault is reported.



The parameters of this step specifier are:

SUM8	Expects a one byte checksum done by adding all bytes and truncating the sum to the lowest 8 bits.
SUM8H	Like SUM8, but expects the checksum coded as a 2 digit hex number.
NSUM8	Expects a one byte checksum done by adding all bytes, taking the negative value of the sum and then truncating the sum to the lowest 8 bits.

NSUM8H	Like NSUM8, but expects the checksum coded as a 2 digit hex number.
XOR8	Expects a one byte checksum, done by XOR-ing all specified bytes.
XOR8H	Like XOR8, but expects the checksum coded as a 2 digit hex number.
MOD95	Expects the one character 'modulo 95' checksum, known from the protocol used by Miteq devices (see below).
start	The buffer position of the first character to be included in the checksum computation (0 means the first character).
end	The buffer position of the last character to be included in the checksum computation, relative to the actual position (-1 means the last character read).
offs	The buffer position where the checksum starts, relative to the actual position (-1 means the last character read).

The MOD95 type checksum is computed following the formula:

$$Checksum = 32 + MOD_{95}\left[\left(\sum_{i=1}^{N} message\ byte_i\right) - (32 * N)\right]$$

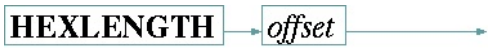
DATALENGTH

The DATALENGTH protocol step reads a one byte binary packet length field.

The received data length is remembered by the protocol until a USERDATA step is encountered. The USERDATA step will read this number of bytes *minus* the offset stated with the DATALENGTH step.

HEXLENGTH

The DATALENGTH protocol step reads packet length field coded as a two byte hexadecimal number.



The received data length is remembered by the protocol until a USERDATA step is encountered. The USERDATA step will read this number of bytes *minus* the offset stated with the HEXLENGTH step.

Device oriented user interface

The ***sat-nms*** software provides a so called 'device oriented' user interface for each type of equipment it supports. If you double click to a device icon at the M&C or VLC user interface you automatically get a device window for this device. The software selects the right type of device window for the device driver which is configured for this device.

To use a device oriented user interface for the device drivers you added to the software by yourself, it is necessary to extend the framework which implements the device oriented user interface. The device oriented user interface for a particular device consists of one or more parameter screens which are made specially for this device type and a number of 'universal' screens which appear with almost any device. So, there are principally two steps to do:

- Define the required parameter screens for the new device type
- Define the set of screens which shall be selectable in the device window.

How the software finds the screens for a device

To extend the device oriented user interface, it is important to understand how device drivers and the predefined user interface windows are linked together in the ***sat-nms*** software. Principally there are three steps from the device driver to the user interface:

1. Each device driver defines a variable called `info.frame`. The device driver sets this value to the name of the frame definition it expects.
2. The user interface software -- when the operator clicks to a device icon -- reads the frame definition file of this name in the `~/dframes` subdirectory.
3. The frame definition file contains the list of screens (the names of the files defining the screen layouts). The user interface software builds a card folder like window from this information.

Creating new screens

The software keeps the files containing the screen layouts for the device oriented user interface in a directory called `~/dscreens`. There is one file for each parameter screen. The screens are created with the same tool used to design customer supplied screens for the task oriented user interface.

To protect the predefined screens from being accidentally modified, the layout editing tool normally has no access to these screens. To edit a screen for the device oriented user interface, open an XTerm window at the M&C/NMS computer and type

```
jre -cp satnms.jar satnms.guiconf.Configurator localhost /dscreens/...
```

where `...` is the name of the screen to edit. This opens the layout editing tool with the given file name. Please note, that the NMS or M&C server must be running at this time. The layout editing tool reads the file via the data base capabilities of the server rather than accessing the disk file directly.

You also may start the layout editing tool on a MS Windows based client computer over the LAN. At this place open a MS-DOS window and enter:

```
java -cp satnms.jar satnms.guiconf.Configurator aaa.bbb.ccc.ddd
/dscreens/...
```

Like above, `...` has to be replaced by the name of the screen to edit. `aaa.bbb.ccc.ddd` stands for the IP address of the M&C or NMS server computer. If your computer does not recognize the `java` command, try `jre` instead.

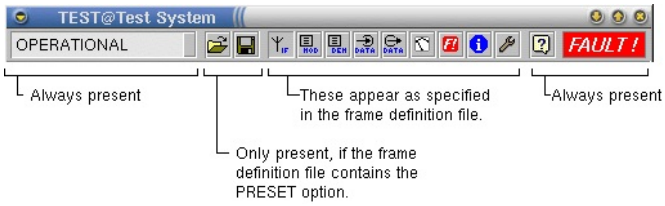
Editing the screen layout for the parameter screens is straight forward. It is recommended to use a layout similar to the existing screens. The software's user manual describes the usage of the layout editing program and introduces the types of display elements a screen may consist of.

Creating a 'frame' definition

The set of screens making up the window for a particular device type is called a frame. Frames are defined by text files located in the `~/dframes` directory of the software installation. To add a new frame type to the software, you have to edit such a file.

```
# /dframes/SCPC-Modem
#
                PRESETS
#
tb-if.gif;       /dscreens/Modem-General;          General / IF parameters
tb-mod.gif;      /dscreens/Modem-TX;               Modulator parameters
tb-dem.gif;      /dscreens/Modem-RX;               Demodulator parameters
tb-dinput.gif;   /dscreens/Modem-TX-IFC;           TX interface parameters
tb-doutput.gif;  /dscreens/Modem-RX-IFC;           RX interface parameters
tb-meter.gif;    /dscreens/Modem-Measure;          Meter Readings
tb-fault.gif;    @FAULTS;                          Faults and fault mask
tb-info.gif;     @INFO;                            Device Info
tb-tool.gif;     @CONFIG;                          Maintenance
```

The example above shows a frame definition file for a SCPC satellite modem. Lines starting with a '#' are comments, they are ignored when the file is read. Below the button bar of the device window resulting from this frame definition is shown:



The operation mode selector on the left and the help button and fault mark at the right are contained in all device screens, they need not to be specified in the frame definition file.

The **PRESET** keyword in the third line of the frame definition file tells the software to display the buttons for parameter preset storage and retrieval in the button bar of the device window.

The table starting at line five of the file specifies the other buttons in the tool bar and the screens bound to them. The buttons appear in the same order as the lines of the table. Each table row consists of three fields, separated by semicolon characters:

1. The first entry selects the icon to be displayed. The following chapter shows the icons available with their file names.
2. The second entry specifies the screen that shall be shown on a click to this button. This either is the name of a screen file (usually from the `~/dscreens` directory) or one of these keywords selecting a special screen:

@FAULTS	Shows the common screen listing the faults of this device.
@INFO	Shows the common screen listing the info variables for this device.
@CONFIG	Shows the common maintenance and configuration screen for this device.
@SATLIST	Shows a screen interfacing to an antenna pointing database (used by the AntennaPointing logical device)

3. The third field defines the the help text for this button which is shown above the mouse cursor if this id hold above the button.

All device frames provided by SatService contain the @FAULTS, @INFO and @CONFIG screens in the way shown in the example.

Icon reference

tb-123.gif	tb-1.gif	tb-2.gif	tb-3.gif
tb-a1.gif	tb-abc.gif	tb-accept.gif	tb-ackmail.gif
tb-ainput.gif	tb-aoutput.gif	tb-avoutput.gif	tb-back.gif
tb-backup.gif	tb-cam.gif	tb-cgroup.gif	tb-chain.gif
tb-chanlist.gif	tb-chdir.gif	tb-checkmark.gif	tb-clock.gif
tb-condacc.gif	tb-connect.gif	tb-copy.gif	tb-cross.gif

tb-cut.gif	tb-data.gif	tb-decode.gif	tb-delete.gif
tb-dem.gif	tb-device.gif	tb-devices.gif	tb-devicex.gif
tb-dial.gif	tb-dialing.gif	tb-diallist.gif	tb-dinput.gif
tb-dirup.gif	tb-disconnect.gif	tb-doutput.gif	tb-draw.gif
tb-dst.gif	tb-encode.gif	tb-erasor.gif	tb-exclam.gif
tb-exec.gif	tb-eye.gif	tb-farray1.gif	tb-farray2.gif
tb-farray3.gif	tb-farray4.gif	tb-farray5.gif	tb-farray6.gif
tb-farray7.gif	tb-farray8.gif	tb-fault.gif	tb-faultlog.gif
tb-filexfer.gif	tb-frame.gif	tb-frm.gif	tb-gflash.gif
tb-go.gif	tb-grid.gif	tb-groups.gif	tb-hangup.gif
tb-help.gif	tb-if.gif	tb-image.gif	tb-info.gif
tb-leftarrow.gif	tb-line.gif	tb-link.gif	tb-linklist.gif
tb-list.gif	tb-livebelt.gif	tb-livelog.gif	tb-lock.gif
tb-login.gif	tb-magnify.gif	tb-mail.gif	tb-meter.gif
tb-modems.gif	tb-mod.gif	tb-move.gif	tb-mpegout.gif
tb-newdev.gif	tb-newdevs.gif	tb-new.gif	tb-newifc.gif
tb-newitem.gif	tb-nosound.gif	tb-now.gif	tb-onestep.gif
tb-open.gif	tb-paste.gif	tb-pause.gif	tb-play.gif
tb-plug.gif	tb-preset.gif	tb-print.gif	tb-properties.gif
tb-queue.gif	tb-record.gif	tb-rectangle.gif	tb-redial.gif
tb-redstop.gif	tb-relay.gif	tb-reload.gif	tb-restore.gif
tb-rf.gif	tb-rflash.gif	tb-rightarrow.gif	tb-rmail.gif
tb-rs.gif	tb-rx.gif	tb-satellite.gif	tb-saveas.gif
tb-save.gif	tb-schedule.gif	tb-search.gif	tb-send.gif
tb-setdev.gif	tb-slavelink.gif	tb-sound.gif	tb-spider.gif
tb-srcdst.gif	tb-src.gif	tb-stop.gif	tb-switch.gif
tb-swoff.gif	tb-swon.gif	tb-textend.gif	tb-text.gif
tb-tmove.gif	tb-tool.gif	tb-tools.gif	tb-transmitting.gif
tb-trash.gif	tb-tx.gif	tb-undo.gif	tb-vgroup.gif
tb-vinput.gif	tb-vlc.gif	tb-vlclist.gif	tb-vlcmap.gif
tb-voutput.gif	tb-vupdate.gif	tb-wizard.gif	tb-yflash.gif
tb-zoomin.gif	tb-zoomout.gif		

Online Help

The ***sat-nms*** software provides a context sensitive online help based on HTML files. To make this help system easy to maintain, a simple type setting language has been defined for it. The source of the help system is contained in a couple of files containing plain text and some formatting commands. A help compiler creates all the HTML files for the online help from the sources.

With the ***sat-nms*** software there come beside a ready compiled online help also the help compiler and all sources of the help system. This enables you to extend the online help system for your needs.

You however should be aware, that the original help files (sources) are restored with each software update you install at the system. To avoid conflicts with the documentation supplied by SatService, you should modify or extend the online help only in the following situations.

1. You have written your own device driver, and you want to supply a help page for this type of equipment.
2. You want to give some additional information for the operation about the local M&C or NMS system. You may add a file 'local.hlp' to the help directory, containing your own extensions to the manual.

During a software update, the 'local.hlp' file will not be overwritten. Also the help files for your own device drivers will be retained.

Help file format

This chapter describes the format of the source files the online manual of the software is built from.

Topic Definitions

The online manual divides the complete text into topics, where each topic is compiles to one web page. A topic is identified by it's unique four digit topic number. This number is used to build the file name of the web page and also to reference the page in hyper links.

In the source text a topic starts with a topic definition line and ends where the next topic starts. The topic definition looks like this:

```
.topic TTTT L The title of this topic
```

The keyword '.topic' must start at the very first column of the line. Further on, TTTT is the for topic number of the topic to define. L is a number in the range 1..4 defining the level of this heading in the table of contents. The remaining part of the line defines the title of the topic.

Paragraphs

The HTML text is shown by the browser as left justified text, made up to the width of the browser window. Line breaks and paragraphs do **not** appear where you type them in the source code, you have explicitly to insert line break or paragraph break commands into the source text to get these breaks in the output.

`.p`	Closes a paragraph. Most browsers show this as a line break followed by a half height blank line.
`.br`	Inserts a line break.

Both commands may appear anywhere in the line, however, usually they are placed either at the line end or in the own line.

Formatted Lists

You may typeset ordered (numbered) lists and unordered (bullet) lists in the text. Browsers usually display each list item as a paragraph, preceded by either the paragraph number or a list item symbol. You may nest lists of both types to any depth. The help compiler simply translates the list formatting commands to HTML, it does not check if each list is properly terminated. If you produce invalid HTML code because of missing list end marks, some browsers will give strange results.

`.ul`	Starts a bullet list.
`.ol`	Starts an ordered (numbered) list
`.li`	Starts a list item.

`.br`	Inserts a line break.
`.eul`	Closes a bullet list.
`.eol`	Closes an ordered (numbered) list

Although these commands are recognized everywhere in the line, formatting lists as shown in the example below makes the source well readable.

```
.ol
  .li This is the first list item
  .li This is the second one, it contains a lot of text which does
      not fit in one line.
  .li The third item is a short one again.
.eol
```

Tables

Help pages may contain tables consisting of an almost arbitrary number of columns. Tables appear with a pale blue background. You have no control over the precise layout of the table, it is shown as the browser likes to display plain HTML tables with a cell background set. Because no geometry must be specified, it is very simple to define the table in the source text:

`.tl`	Starts a table definition
`.ts`	Starts the first cell of a table row
`.tc`	Separates a table cell from the next one in the same row
`.te`	Marks the end of the last table cell in a row.
`.etl`	Closes the table definition.

With the commands shown above, the table gets defined cell by cell, row by row. Table definitions are translated by the help compiler one by one to HTML tags. When defining a table, be careful to define the same number of cells in each row and to terminate each row properly by a `.te` command. The example below shows in which way a simple table definition should be formatted in the source:

```
.tl
.ts cell 1/1   .tc cell 1/2   .tc cell 1/3   .te
.ts cell 2/1   .tc cell 2/2   .tc cell 2/3   .te
.ts cell 3/1   .tc cell 3/2   .tc cell 3/3   .te
.etl
```

Images / Pictures

The user manual also contains images and diagrams. Files in GIF or JPG format may be included. The image files must be located in the same directory as the other files of the online help. You find already a bunch of image files there, most of them are copies of the tool bar icons used by the software.

`.i file-name`	Includes an image.

If this is the only command in the line, be sure to add a single space character after the file name. This is due to a flaw of the help compiler which does not recognize the file name properly if it ends at the line end.

Pre-formatted Text

The text may include segments of 'pre-formatted' text, which the browser displays using a mono-spaced font with line breaks at the same positions as in the source. Pre-formatted text is used to include for example excerpts of configuration files.

`.pre`	Starts pre-formatted text
`.epre`	Ends pre-formatted text

The `.pre` and `.epre` commands must appear as single commands in a line, starting at the first column.

Emphasing Text

Portions of text may be *emphased*, **bold printed** or set in a `typewriter font`. To do this, enclose the text to hi-light in curly braces and insert a letter 'e' for emphased, 'b' for bold or 't' for typewrite directly

after the opening brace. There must no be a space character between the opening brace and the code character. The opening and closing braces must be in the same line, nesting different hi-lighting styles is not allowed.

Cross-references / Hyper-links

You may include HTML hyper-links into the text to permit the reader to jump directly from one topic to another by a single mouse click. To insert a hyper-link, To do this, enclose the text to hi-light in braces and insert the sequence 'h####' directly after the opening brace. '####' is to be replaced by the topic number to link to. Like with the character formatting codes above, there must no be a space character between the opening brace and the 'h'. The opening and closing braces must be in the same line, no nesting of braces is allowed.

Paragraph Headings

There is no special command to insert paragraph headings. The topic title is the only heading for a help page. Only this will appear in the table of contents in the printed version.

To introduce headings on a paragraph level, use a bold printed, one line paragraph instead.

Escaping Dot Commands

Words in the help text containing dots (e.g. file names) may be confused with a dot command sequence by the help compiler. Example: "`MyDevice.proto`" in the source file will be printed as "`MyDevice`" at the end of one paragraph and "`roto`" at the beginning of the next one. This is because the "`.p`" sequence in the file name is translated to a paragraph break.

The "`.dot`" sequence is used to escape the dot command in such a situation. Spelling the file name "`MyDevice.dotproto`" in the source produces the desired output.

Comments

You may add comments or annotations to the source text of the document which later are not shown in the manual. Lines which start with a double percent character ('%%') at the first column are skipped when the file is processed by the help compiler.

Conditional Compilation

The help compiler implements a mechanism to include or skip parts of the source text depending on a couple of environment informations here called 'features'. The conditional compilation mechanism closely follows that one used with common programming language compilers:

`%if feature`	Marks the start of the documents part which only shall be included if 'feature' is present with this software installation
`%else`	Marks the end of `%if` branch, starts another one with the negated condition. The `%else` statement is optional
`%endif`	Marks the end of this `%if` or `%if`/`%else` clause.

The `%if`, `%else` and `%endif` statements must appear singly in a line and must start at the first column in the line.

The following 'features' may be tested in an `%if` clause (testing other features, always results in 'not present'):

`MNC`	This is a M&C installation
`NMS`	This is a NMS installation
`videonet`	This software installation has a 'videonet' type link management enabled.

Rebuilding the online help

The `~/help` directory of the ***sat-nms*** software installation contains a shell script called makehelp. If you change to the `~/help` directory and call this script there, the complete online help system gets rebuilt. You should do this in one of the following cases:

- You have added a device driver to the software.

- You have edited the help file for a new device driver.
- You have edited the 'local.hlp' file.
- You installed a software update.

Adding help files for new devices.

To display a context sensitive help for each device driver, the help system uses a separate file for each each device type, containing some information how to use and to configure the driver/device. This help topic is called if you click to the help button in a device's window.

Device driver help files use a slightly different format than the main help file does. The difference is, the a device driver help file must not contain topic definitions. One topic definition for each file is generated automatically when the help system is built.

Device driver help files are located in the `~/help` directory of the ***sat-nms*** software installation. The files are named like the drivers itself, but with the extension `.hlp`. The help compiler creates dummy files for missing device driver files.

The help files for the device drivers supplied by SatService all follow a common format. They first explain for which type of equipment this driver was designed for. The the button bar of the device window is described in a table. Below this the configuration/setup parameters for this device driver are explained, some device specific remarks may follow. You are encouraged to use this scheme for your customer supplied device drivers. too.

Appendix

This chapter provides a number of tables with reference information which may be useful as a quick lookup for questions regarding the extension of the ***sat-nms*** software. In particular, the supplied tables are:

- Device driver keyword reference
- Protocol definition keyword reference
- Help file keyword reference

Device driver keyword reference

The following table lists the keywords recognized in a device driver specification file in alphabetical order. When viewing this table online you may use the hyper-links in the description column to jump to the place where this keyword is explained in the manual.

=	Part of the syntax of a SET or BITSET statement.
ALARM	The ALARM statement defines a faults flag.
AT	Within an INPUT statement, the AT clause moves the read cursor to a certain position in the received data.
BIGENDIAN	Specifies that a WRITE or READ statement shall treat multibyte integer numbers in big endian (MSB first) byte order.
BIT	Reads a single bit from an integer number within an INPUT statement.
BITMERGE	Should no longer be used.
BITS	Specifies to write or read a number of bits with in a certain byte in a WRITE or a READ statement.
BITSET	The BITSET statement isolates a single bit from a numeric variable and assigns it to another one.
BITSPLIT	Should no longer be used.
BOOL	Defines a variable to be a boolean flag in a VAR statement.
CALL	The CALL statement calls a procedure as a subroutine.
CBER	Interprets a two character string as a bit error rate within an INPUT statement.
CHOICE	Defines a variable to be a choice list in a VAR statement.
CHOICES	Modifies a choice list variable with the RANGESET statement.
CLASS	The CLASS statement defines the Java class which does the real work. Customer supplied device drivers do not require this statement.
COMMENT	The COMMENT statement defines an identification for the driver which is reported to the user interface.
COPY	The COPY statement copies a single parameter or a complete device setup from one device to another.
CUT	Cuts a number of characters in the INPUT statement.
CYCLE	Defines the refresh cycle for a variable in the VAR statement.
DELAY	The DELAY statement pauses the driver execution for a certain time.
DISABLED	Marks a variable to be initially disabled in a VAR statement or disables a variable with the RANGESET statement.
DRATE	The DRATE statement computes an interface data rate from a symbol rate and modulation/encoding parameters.
ENABLED	Enables a variable with the RANGESET statement.
FLOAT	Defines a variable to be a floating point number in a VAR statement.
FMT	Formats a number to a string in the PRINT statement.
GET	Marks a procedure to be a GET-type one in the PROC statement.
GOTO	The GOTO statement jumps to a label in a procedure.
HEX	Interprets a string as a hexadecimal number in an INPUT statement or defines a variable to be a hexadecimal number in a VAR statement.

IF	The IF statement conditionally executes the following statement.
INCLUDE	The INCLUDE statement reads another source file.
INIT	Tells the driver to initialize a variable at power up with a certain value in the VAR statement.
INPUT	The INPUT statement reads a message from the device and parses the reply as text.
INT16	Writes or reads a 16 bit integer number with a a WRITE or READ statement.
INT32	Writes or reads a 32 bit integer number with a a WRITE or READ statement.
INT64	Writes or reads a 64 bit integer number with a a WRITE or READ statement.
INT8	Writes or reads an 8 bit integer number with a a WRITE or READ statement.
INTEGER	Defines a variable to be an integer number in a VAR statement.
INVALIDATE	The INVALIDATE statement marks a variable to be re-read in this or the next driver cycle.
LOG	The LOG statement writes a message into the event log.
MAX	Modifies the upper range limit of a numeric variable with the RANGESET statement.
MIN	Modifies the lower range limit of a numeric variable with the RANGESET statement.
OBJECT	Defines a variable to be a 'object' in a VAR statement.
OFFSET	Adds an offset to as value in a PRINT or an INPUT statement.
PRINT	The PRINT statement composes a text message/command and sends this to the device.
PROC	The PROC keyword starts a procedure definition.
PROTOCOL	The PROTOCOL statement defines the (preferred) communication protocol a driver is designed to use.
PUT	Marks a procedure to be a PUT-type one in the PROC statement.
RANGESET	The RANGESET statement modifies range properties of a variable during runtime.
READ	The READ statement gets a message from the device and parses the data as a binary data structure.
READHEX	The READHEX reads a message from the device and formats the data as a hex dump string.
READONLY	Marks a variable to be read only in a VAR statement or makes the variable read only with the RANGESET statement.
READWRITE	Makes a variable writable with the RANGESET statement.
SAVE	Tells the driver do save a variable's value on disk in the VAR statement.
SCALE	Multiplies a value with a scale factor in a PRINT or an INPUT statement.
SEND	The SEND statement sends a parameter message to another device.
SET	The SET statement assigns a value to a variable.
SETUP	Makes a variable appear in the setup menu for the device VAR statement.
SKIP	Skips whitespace characters in the INPUT statement.
SRATE	T h e SRATE statement computes a symbol rate from a data rate and modulation/encoding parameters.
SUBROUTINE	Marks a procedure to be a subroutine when following the PROC keyword.
TABLE	The TABLE statement defines a translation table.
TEXT	Defines a variable to be plain text in a VAR statement.
TRM	Cuts a string up to a given termination character in the INPUT statement.
VAR	The VAR statement defines a driver variable.
WATCH	Binds a procedure to one or more variables with the PROC statement.
WRITE	The WRITE statement composes a binary message/command and sends this to the device.
WRITEHEX	The WRITEHEX statement converts a hex dump string to a binary message, sends this to the device.
XLT	Translates a character string through a table in a PRINT or an INPUT statement.

Protocol definition keyword reference

The following table lists the keywords recognized in protocol definition files in alphabetic order.

ADDRESS	Outputs the device address.
ADDRESS	Reads the device address.
CHAR	Outputs a single character.
CHAR	Reads a single character.
CHECKSUM	Outputs a message checksum.
CHECKSUM	Reads a message checksum.
CLASS	Specifies the underlying protocol class.
COMMENT	Defines the protocol identification string.
DATALENGTH	Outputs a data length field (binary).
DATALENGTH	Reads a data length field (binary).
HEXLENGTH	Outputs a data length field (hex).
HEXLENGTH	Reads a data length field (hex).
RECEIVE	Starts the receive protocol step specification.
SEQUENCE	Outputs a binary message sequence number.
START	Reads a message start character.
STRING	Reads a terminated string as the user data
TRANSMIT	Starts the transmit protocol step specification.
USERDATA	Outputs the user data.
USERDATA	Reads the user data.

Help file keyword reference

The following table lists the 'dot commands' recognized by the help compiler in alphabetic order. They all are explained in the chapter 'Help file format'.

`.ul`	Starts a bullet list.
`.ol`	Starts an ordered (numbered) list
`.li`	Starts a list item.
`.br`	Inserts a line break.
`.eul`	Closes a bullet list.
`.eol`	Closes an ordered (numbered) list
`.topic`	Defines a topic header.
`.p`	Inserts a paragraph break.
`.br`	Inserts a line break.
`.dot`	Inserts a '.' (dot) character.
`.tl`	Starts a table definition
`.ts`	Starts the first cell of a table row
`.tc`	Separates a table cell from the next one in the same row
`.te`	Marks the end of the last table cell in a row.
`.etl`	Closes the table definition.
`.i`	Includes an image.
`.pre`	Starts pre-formatted text
`.epre`	Ends pre-formatted text