TU

RANGE

EUROTHERM AUTOMATION

# Digital communications for TU range thyristor units

Communications manual

# Digital communications for TU range thyristor units

## Communications Manual



Printed in France 11/94

HA 173 688 Issue 2

**Should you require any further information, please contact your EUROTHERM branch where technicans are at your disposal to advise and assist you with the commissioning of your installation.**

# Contents

Chapter 5 **TU UNIT OPERATION WITH DIGITAL COMMUNICATIONS**



Chapter 6 **ALARMS**



**Appendices**

Appendix A **ASCII CHARACTERS**



Appendix B **GLOSSARY**



Appendix C **INDEX**

## Chapter 1

# GENERAL INTRODUCTION

Contents page

# Chapter 1 GENERAL INTRODUCTION

## DIGITAL COMMUNICATION FUNCTIONS

The digital communications TU range power units are equipped with a **microprocessor board.**
The microprocessor board, or the digital Control and Communication board (CCC board) is used to communicate via a digital link with a Supervisor or a Controller.

The CCC board controls the local power feedback of the unit and sends the commands to the thyristor firing circuits.

Digital communications perform 3 main functions for the **TU** range thyristor units:

- communication with a monitoring system, with a controller or an industrial programmable logic controller
- checking, changing and monitoring of operating and adjustment parameters
- management of alarms which can be transmitted via the communication bus.

Using digital communications, the following are possible:

- modifying the monitored process feedback parameter,
- the monitoring and feedback of the associated thyristor control boards,
- modifying the setpoint limit and the current limit,
- changing configuration and checking the unit's configuration,
- remote monitoring of the load, mains voltage and currents,
- functional monitoring of the unit, during checks with a digital or analogue signal
- the energy balance per measurement.

In EUROTHERM's TU range of thyristor units, there are two microprocessor references, depending on the communication protocol used.

## COMMUNICATION PROTOCOLS

A **TU** range thyristor unit, equipped with digital communications can communicate with a monitor or controller using three standard industrial protocols:

- **EUROTHERM**
- **MODBUS® RTU**
- **JBUS® RTU**

One of these three protocols is selected by **changing** the microprocessor (**EUROTHERM** protocol or **MODBUS ®/ JBUS®** protocol ) and with a **jumper** on the CCC board (between **MODBUS ®** and **JBUS®**).

The **EUROTHERM** protocol according to **ANSI X3.28** works in a string of **ASCII** characters.

The **MODBUS®** and **JBUS®** protocols use a string of **binary** characters as a coding mode.

## COMMUNICATION SPECIFICATIONS

The transmission between a supervisor or a controller and a unit is made via a digital link.

The physical medium of the protocols is a "**full duplex circuit**" but for digital communications of **TU** range units, only the **alternate** transmission mode is used.

The absence of simultaneous "**to**" and "**fro**" exchanges makes it possible to use the communication bus with **4 wires** and **2 wires**.

The physical medium of digital communications is provided on an **RS485** (or **RS422**) standard bus with **2 differential pairs**, one for transmission and the other for the reception of the information (**4 wire** bus).

However, it is possible to use the same pair for transmission and reception (**2 wire** bus).

This type of transmission is **less sensitive** to interference, since data transmission via a differential pair is used.

The maximum number of CCC boards on an output of a Communication coupler is:

- in **RS422**: **16** CCC boards, or
  - **64** channels for **TU** range units which each have **four** independent channels,
  - **32** independent three-phase systems for **TU** range units which monitor **two** phases of **two** three-phase systems,
  - **32** channels for **TU** range units which each monitor **two** independent channels
  - **16** independent channels or systems for **single channel** units or monitoring **two** phases of **one** three-phase system;
- in **RS485** the number of CCC boards, monitoring channels or three-phase systems are **multiplied by 2.**

Maximum transmission line length: **1.2 km.**

It is possible to **increase** the length of the transmission line between the CCC boards and a Supervisor or a Communication coupler using the link via a repeater - **EUROTHERM** unit, **type 261.**

On the reception line, the adaptation impedance has been arbitrarily set to **4.7 kΩ.**
The user may reduce it if necessary.

The CCC board terminal strips for connecting the transmission bus are given in the paragraph "Communication bus connection" (see page 5-9).

## TRANSMISSION ORGANISATION

Transmission is **asynchronous**: character by character.

Two baud rates are available: **9600** and **19200 baud.**

For units monitoring two phases of three-phase systems (TU2000 range), only **one rate** at 9600 baud is used.

The communication addresses include **252** addresses (4 power channel units) to **255** addresses (single channel units) of addressable **physical units** and **one broadcast** address.

The exchanges are "**Master / Slave**" type (one Master per communication network).

During the exchange of messages between a **Supervisor**, a communication **Coupler** or a **Programmable logic controller** and a **TU unit**, the latter works as a "**Slave**", with the monitoring system or the computer as the "**Master**".

In the following chapters, the TU units, the independent power channels and the CCC boards are considered as "**Slaves**".

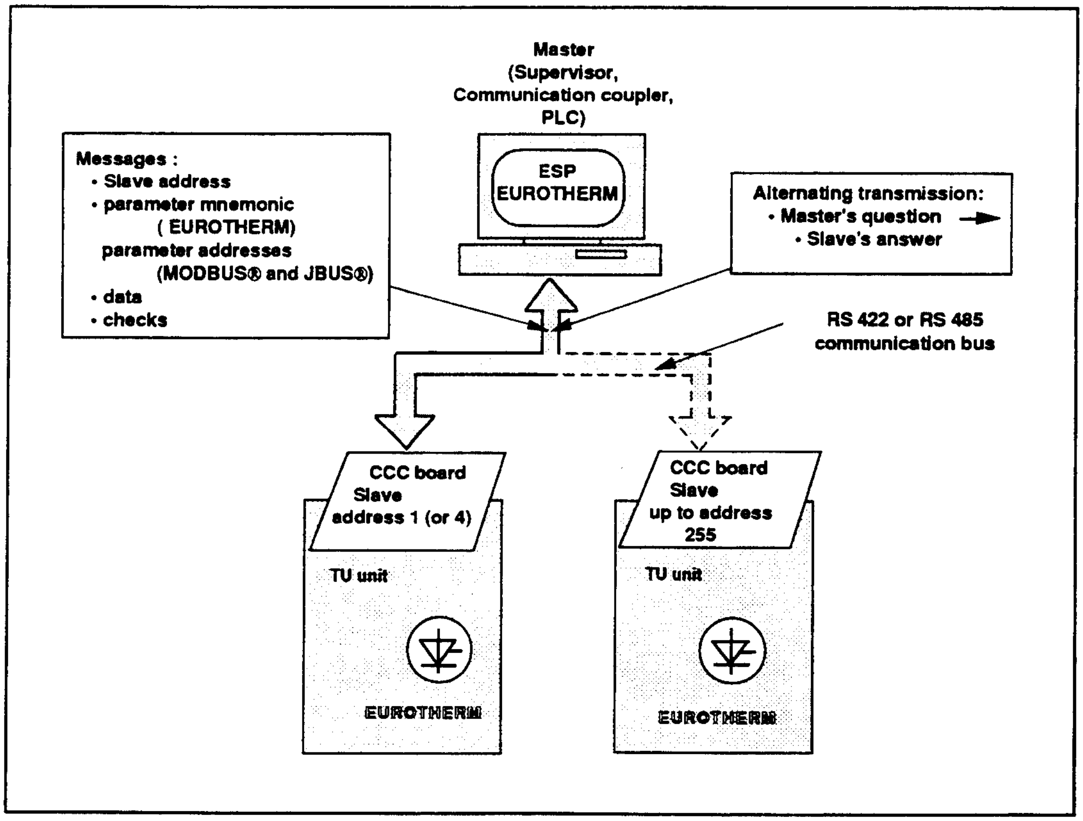



Figure 1-1 Transmission exchange organisation

# Chapter 2

# EUROTHERM COMMUNICATION PROTOCOL

Contents page

# CHAPTER 2 EUROTHERM COMMUNICATION PROTOCOL

## GENERAL DESCRIPTION

The **EUROTHERM** communication protocol corresponds to the **ANSI X3. 28** standards (release 1979 sub-category **2.5 A4**).

| | |
|---|---|
| • Transmission standard | **RS485** or **RS422** - two-way |
| • Transmission mode | **ASCII** character strings |
| • Character format | **1** start bit - **7** data bits - **1** parity bit - **1** stop bit |
| • Parity | **Even** |
| • Baud rate used for the TU range | **9600** and **19200** baud (TU2000 range: 9600 baud) |

The communication parameters can be selected using digital communications and using the correct **jumpers** on the CCC board (page 5-5).

Data exchange according to the **EUROTHERM** protocol is performed using the parameter **mnemonics**.

## TERMINOLOGY

**Address** — Two hexadecimal digit numbers indicating the Slave:
the unit, the single phase independent channel or the three-phase system of the unit.
The first digit designates the address group number and the second the unit number.

**Mnemonics** — ASCII code name which indicates the parameter (variable) the value of which is to be read or modified. The mnemonics give the meaning of all the messages during data exchange with the Slave.

**Check characters** — ASCII numbers used to check different transmission phases. The check characters perform the start and end of text, transmission and acknowledgement procedures.

**Status word** — Two byte parameter, the bits of which indicate the unit status and the alarm status.

## DATA FORMAT

Each mnemonic has an associated value which is written according to a format defined for the data item.
The data byte, the last bit of which indicates the parity, is preceded by a "start" bit and followed by a "stop" bit.

**Negative numbers are not accepted** in the **format** of data and addresses.
The "+" sign is accepted before positive numbers.

**For the TU range only** the decimal point "." is accepted but is **not** used.
For example, the number **50** could be sent in any of the following formats: **+50**; **5.0**; **050**; **50**

---

**Important**

To avoid any data errors (especially when writing the setpoint), it is recommended **not to use a decimal point**.

---

**EUROTHERM** protocol data are presented in the format **0 -100%** within **1%**.

Data from **Status words** are sent in **two hexadecimal bytes** in **ASCII** code preceded by the sign: "greater than": ">".

## READ/WRITE PRINCIPLES

The **EUROTHERM** protocol defines a standard data transmission procedure which can be divided into three phases:

- establishment of transmission
- message transfer procedure
- end of transmission.

The start of transmission deletes the previous message (end of transmission), the Slave address, and, if a data item is requested, the mnemonic.

The message transfer procedure consists of the reading of the data sent by the Unit or the writing of the data sent to the Unit. The end of sequence consists of erasing the transmission line.

Two types of transmission are associated with the **EUROTHERM** protocol :

- reading when the Supervisor (Master) requests a data item from the Unit (Slave)
- writing when the Supervisor sends a new data item to the Unit.

Table 2-1 gives all the message characters used in the read/write sequences.

| Destination | Symbol | Codes | | | Name | Description |
|---|---|---|---|---|---|---|
| | | Deci-mal | HEX | Binary | | |
| Message characters | STX | 2 | 02 | 000 0010 | Start of TeXt | Start of message text |
| | ETX | 3 | 03 | 000 0011 | End of TeXt | End of message text |
| | EOT | 4 | 04 | 0000100 | End Of Transmission | End of transmission and reset of the communication |
| | ENQ | 5 | 05 | 000 0101 | ENQuiry | End of communication establishment and response request |
| | ACK | 6 | 06 | 000 0110 | ACKnowledgement | Good reception |
| | NAK | 21 | 15 | 001 0101 | Non AcKnowledgement | Bad reception |
| Message transmission | GID | - | | | Group address IDentifier | Slave address (divided into groups and units) |
| | UID | - | | | Unit address IDentifier | |
| | D | - | | | Data | Parameter value |
| | C | (See table 4-2; page 4-6) | | | Character specifying the mnemonic | Mnemonic name |
| Message checking | BCC | - | | | Block Check Character | Number calculated as a function of the address, parameters and characters |
| Status word | > | 62 | 3E | 011 1110 | "Greater than" sign | Status word data indication |

Table 2-1 EUROTHERM protocol message characters

## PARAMETER READING

The reading sequence of a data item (parameter) consists of three phases:

- transmision establishment,
- message transfer,
- end of sequence.

The data item reading procedure is shown in figure 2-1.

### Transmission establishment

First, the Supervisor is in the transmitting position (see figure 2-1) and sends an 8-character message which identifies:

- the Unit address (which corresponds to the address of the first channel of the unit) or that of the Independent channel,
- the data item,
- the end of the message.

The transmission establishment message format is the following:

(EOT) (GID) (GID) (UID) (UID) (C1) (C2) (ENQ)

Message character definition:

EOT - **check** character which **resets** the reception interface of each Slave.

The next four characters designate the address.
Each Unit then examines the 4 characters to see if they correspond to its address.
The two digit Slave address is composed of the **group** and **unit** numbers.

GID - **group** number of the address (including 16 units) repeated **twice** for safety reasons.

UID - **unit** number of the address (number of the unit within the group) repeated **twice** for safety reasons.

The address unit and group numbers are transmitted in Hexadecimal **ASCII** code and vary from **0** to **$0F_{HEX}$**. There are therefore **16** group numbers and **16** unit numbers, giving **256** possible addresses.

C1 C2 - two characters corresponding to the mnemonics; they specify the **parameter** of the Unit that the Supervisor wishes to read.

ENQ - transmission establishment **end** character.

### Message transfer

After the Supervisor has sent the ENQ character, the protocol describes the message transfer procedure which can be divided into three phases (see figure 2-1) :

- the Unit is the **transmitter** and the Supervisor is the Receiver
- the Supervisor is the **Transmitter** and the Unit is the Receiver
- the Unit **transmits** the parameters to be read (if the answer is valid).

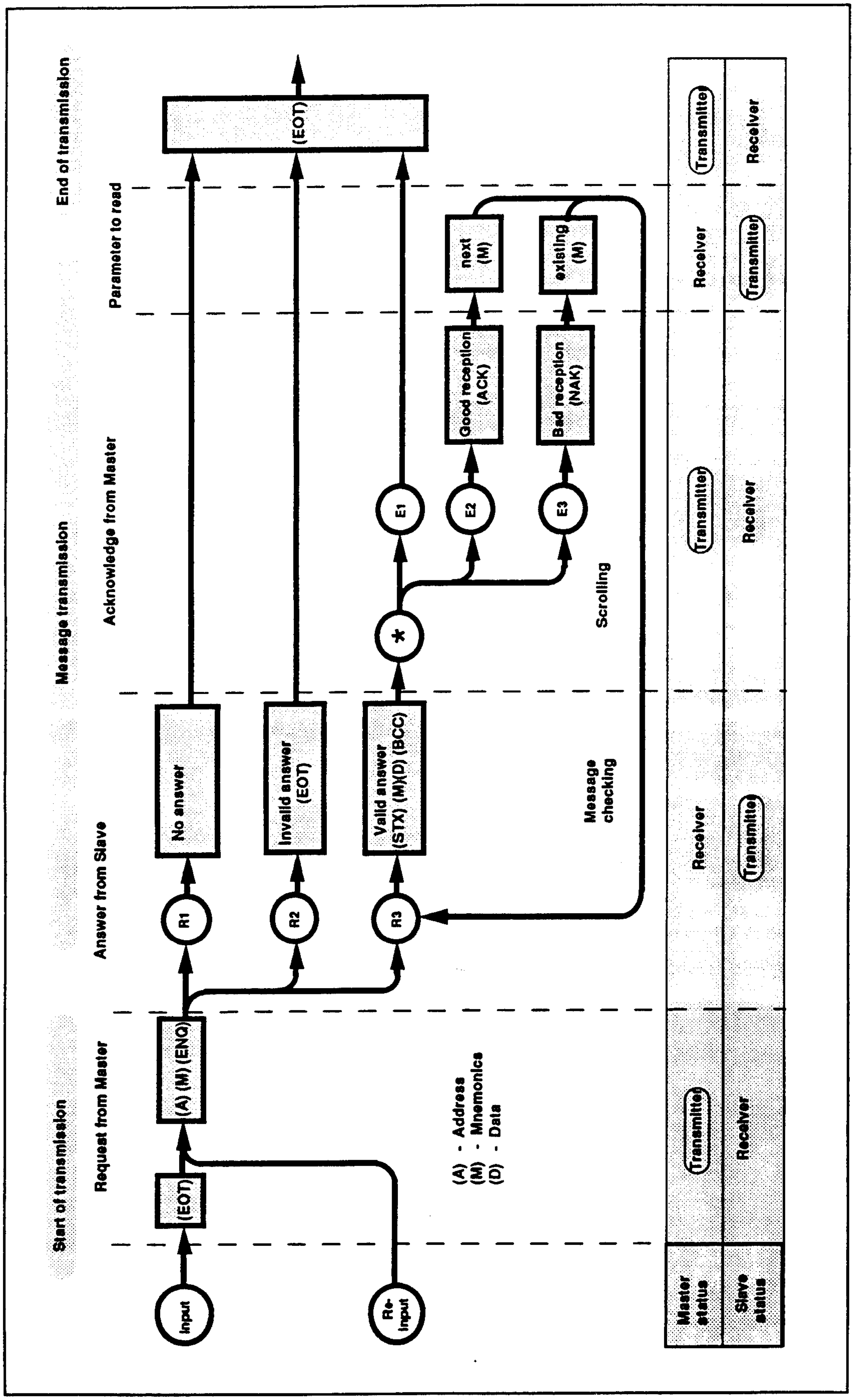



Figure 2-1 Data read procedure

## Unit transmission

After the communication establishment procedure, the Unit can answer in three possible ways (marked **R1** to **R3** on figure 2-1) :

- no answer (reply R1),
- invalid answer (reply R2),
- valid answer (reply R3).

### R1 - No answer

In certain cases, the Supervisor may receive no message after the reading sequence.
This may be due to one of the following reasons:

- the address of the group and (or) the unit has not been recognised;
- an error has been introduced into the communication establishment string of characters up to ENQ (inclusive);
- the selected unit CCC board is not configured with the correct baud rate;
- Hardware error on the addressed CCC board.

The Supervisor then becomes the transmitter and begins the end of transmission procedure.

### R2 - Invalid answer

The selected Unit can recognise the address sent by the Supervisor, but the two parameter characters (C1 and C2) sent do not correspond to the enabled mnemonics.

In this case, the Unit sends the **EOT** character to end the communication (see figure 2-1).
The Supervisor becomes the transmitter again and can start another reading sequence or select another Unit.

### R3 - Valid answer

When the message is accepted, i.e. the group and unit addresses and mnemonics are **recognised**, the interface of the Unit concerned becomes the transmitter and initialises the message transfer procedure.

The Supervisor is in receiving mode during this procedure.

The Unit's reply is composed of the following characters:

(STX) (C1) (C2) (D1) (D2) (D3) (D4) (D5) (D6) (ETX) (BCC)

These characters have the following functions (see table 2-1) :

**STX** - start of answer, the Unit is the transmitter and ready to send the data.

**C1 C2** - mnemonic name of a parameter, specified during the transmission establishment phase.

**D1** to **D6** - value of the parameter sent in physical units and without sign (data format see page 2-13).

**EXT** - check character ending the transmission of the answer.

**BCC** - two byte check word. It is sent by the Unit at the end of the message to allow the Supervisor to check that the data has been correctly received (see paragraph "Message Checking", page 2-16).

## Supervisor transmission

After the Supervisor has received the message correctly during the transfer procedure, it becomes the transmitter.

At the point marked by an **asterisk** ( * ) in figure 2-1, the Supervisor ignores all the characters sent on the bus. The Unit stays in this state as long as the Supervisor has not sent one of the three following sequences (marked **E1** to **E3** in figure 2-1):

- end of transmission (sequence E1),
- scrolling (sequence E2),
- parameter repeat (sequence E3).

### E1 - End of transmission (EOT sequence)

After the message transfer procedure, the Unit interface can end the sequence directly and stop the digital communications (see figure 2-1).

### E2 - Good reception - Scrolling (ACK sequence)

After checking the message and considering it to comply with the checking criteria, the **Master** (Supervisor) accepts the message and sends the character **ACK.**

The Unit stays in the message transfer procedure, becomes the transmitter and sends the value of the **next** mnemonic, i.e. the next parameter in the **predefined** order of the parameter list (see table 4-2).

If the Supervisor has to scan **several parameters** on the **same** Unit, it is not necessary to establish the communication procedure again, thanks to the **ACK** sequence.

### E3 - Bad reception - Parameter repeat (NAK sequence)

If the Master (Supervisor) does not acknowledge the message, i.e.:

- it does not recognize the characters or data sent, or
- the data is outside the tolerance range, or
- the BCC character does not match the data, -

it sends the **NAK** character.

The Unit stays in the message transfer procedure, becomes the transmitter and retransmits the value of the **last** mnemonic to be received and acknowledged.

Given the Unit's reaction to the negative acknowledgement, it is not necessary to perform the transmission establishment procedure to read **each** parameter.

The NAK response is sent when the Supervisor has to continuously **scan** a parameter on the **selected** Unit.

## End of sequence

The end of sequence procedure is activated each time the Master-Supervisor wants to stop the reading sequence on the Slave-Unit and establish a new link with another Unit. This may occur if:

- the Unit does not respond to the reading (**R1** in figure 2-1),
- the Unit responds with EOT (end of transmission, reply R2 in figure 2-1) during the message transfer phase.

The Supervisor becomes the transmitter and sends an end of sequence character (**EOT**) to reset the **GID-UID addresses** and reinitialize the input "buffers" (memory space reserved in each Slave).
The Supervisor is then ready to scan another Unit.

The interface can end the sequence itself with **EOT** (sequence **E1** in figure 2-1).

## Reading examples

**Example 1. Read the value of the Digital setpoint of the first channel of TU1471 unit number 4.**

- The digital setpoint is indicated by the mnemonic **SL**
- Address No. 4 is shown by **UID = 4** and **GID = 0** (since UID < 15)
- The Supervisor establishes the transmission to the address **GID=0, UID=4** and requests the value of **SL** :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **04** | **30** | **30** | **34** | **34** | **53** | **4C** | **05** |
| (**ASCII** characters) | **EOT** | **0** | **0** | **4** | **4** | **S** | **L** | **ENQ** |

- The **selected** TU1471 unit replies:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **02** | **53** | **4C** | **35** | **30** | **03** | **19** |
| (**ASCII** characters) | **STX** | **S** | **L** | **5** | **0** | **ETX** | **(BCC)** |

**Reply**: the Digital setpoint (SL) is set to **50%**.
The check character (BCC) is equal to **19** (see "Message checking", page 2- 16).

**Example 2. Read the value of the analogue signal of the 3rd channel of the TU1450 unit at address no. 4.**

- The analogue setpoint is indicated by the mnemonic **RI**
- The address of the 3rd channel which is the unit number **UID = AG + (NV-1) = 4 + (3-1) = 6**
  where : **AG** - unit address (address of first channel)
  **NV** - requested channel number (the unit TU1450 is composed of 4 channels).

  **GID = 0** (since UID = 6 < 15 )

- The Supervisor establishes the transmission to the address **GID = 0** ; **UID = 6** and requests the value of **RI**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **04** | **30** | **30** | **36** | **36** | **52** | **49** | **05** |
| (**ASCII** characters) | **EOT** | **0** | **0** | **6** | **6** | **R** | **I** | **ENQ** |

- The selected Unit replies:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **02** | **52** | **49** | **30** | **30** | **03** | **18** |
| (**ASCII** characters) | **STX** | **R** | **I** | **0** | **0** | **ETX** | **(BCC)** |

**Reply**: the analogue setpoint (**RI** ) of the requested channel is **0%.**

**Example 3 . Read the value of the Output power of the channel located at address No. 4**

- The Output power is indicated by the mnemonic **OP**.
- The Supervisor establishes the communication with address No. 4 (**UID = 4, GID = 0**) and requests the value of **OP** :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **04** | **30** | **30** | **34** | **34** | **4F** | **50** | **05** |
| (**ASCII** characters) | **EOT** | **0** | **0** | **4** | **4** | **O** | **P** | **ENQ** |

- The selected channel replies:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **02** | **4F** | **50** | **36** | **31** | **03** | **1B** |
| (**ASCII** characters) | **STX** | **O** | **P** | **6** | **1** | **ETX** | **(BCC)** |

**Reply**: the Output power is **61%**

**Example 4. Read the value of the Line voltage of the TU1470 unit, with address No. 8.**

- The Line voltage is indicated by the mnemonic **LV**.
- The Supervisor establishes the communication with the address **GID=0, UID=8** and requests the value of **LV** :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **04** | **30** | **30** | **38** | **38** | **4C** | **56** | **05** |
| (**ASCII** characters) | **EOT** | **0** | **0** | **8** | **8** | **L** | **V** | **ENQ** |

- The selected Unit replies:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **02** | **4C** | **56** | **31** | **30** | **30** | **03** | **28** |
| (**ASCII** characters) | **STX** | **L** | **V** | **1** | **0** | **0** | **ETX** | **(BCC)** |

**Reply**: the Line voltage of TU1470 unit No. 8 is equal to **100%**.

**Example 5. Read the status of channel 2 of the TU1471 unit with address No. 4**

- The address of channel 2 is equal to **UID** = 4 + (2 - 1) = 5
- The Supervisor establishes the communication and the value of the Status word (**mnemonic SW**) :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | 04 | 30 | 30 | 35 | 35 | 53 | 57 | 05 |
| (ASCII characters) | EOT | 0 | 0 | 5 | 5 | S | W | ENQ |

- The selected Channel replies:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | 02 | 53 | 57 | 3E | 43 | 30 | 34 | 32 | 03 | 3F |
| (ASCII characters) | STX | S | W | > | C | 0 | 4 | 2 | ETX | (BCC) |

The **Unit** status: thyristor firing mode, general alarms, load and setpoint types, - is indicated by the two least significant hexadecimal codes:

$34_{HEX}$ $32_{HEX}$ , or in ASCII characters : 4 2 (for Status word description see pages 4-10, 4-11).

The status of the channel with address No. 5 (channel 2 of unit No. 4): alarms specific to the channel, enable/ inhibition, - is indicated by the two most significant numbers in hexadecimal code:

$43_{HEX}$ $30_{HEX}$, or in ASCII characters : C 0.

The message can be processed after converting the SW value from hexadecimal into binary code (for structure of the SW bits see table 4-5).

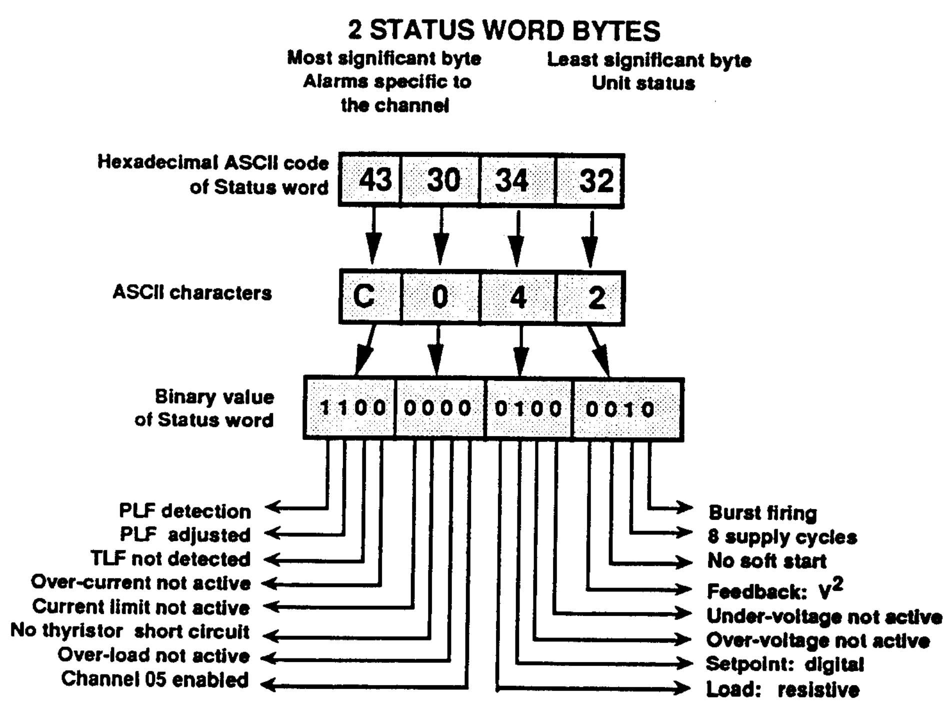



Figure 2-2 Example of Status word reading of channel 2 of the TU1471 unit

## PARAMETER WRITING

To modify certain parameters or their values, the Supervisor sends a data item (writes a parameter) to the Unit. The writing procedure is divided into the following 3 phases:

- transmission establishment
- message transfer
- end of sequence.

The writing procedure is shown in figure 2-3.

## Transmission establishment

The Supervisor is the transmitter (see figure 2-3) and sends the Unit the following five character message to initialise the sequence and indicate the address:

**(EOT) (GID (GID) (UID) (UID)**

The definition of the characters of this message is the same as the transmission establishment characters when reading a parameter (see page 2-4 and table 2-1) :

EOT - the **check** character after which each Unit examines the next characters (which represent the address).

GID - **group** number of the address repeated **twice** for safety reasons.

UID - **unit** number of the address repeated **twice** for safety reasons.

The group and unit numbers are calculated as explained on page 2-4.

The group and unit numbers of an address are sent in Hexadecimal **ASCII** code and vary from **0** to $\mathbf{0F_{HEX}}$.
As for the reading procedure, there are **16** group numbers and **16** unit numbers.

The address selection sequence starts with an **EOT** character.
They can be re-entered after the end of transmission provided that an **EOT** character is sent during the end procedure (see figure 2-3).

**Important**

When the broadcast address is used, only the unit, the first channel of which is at address N° **4** , replies.

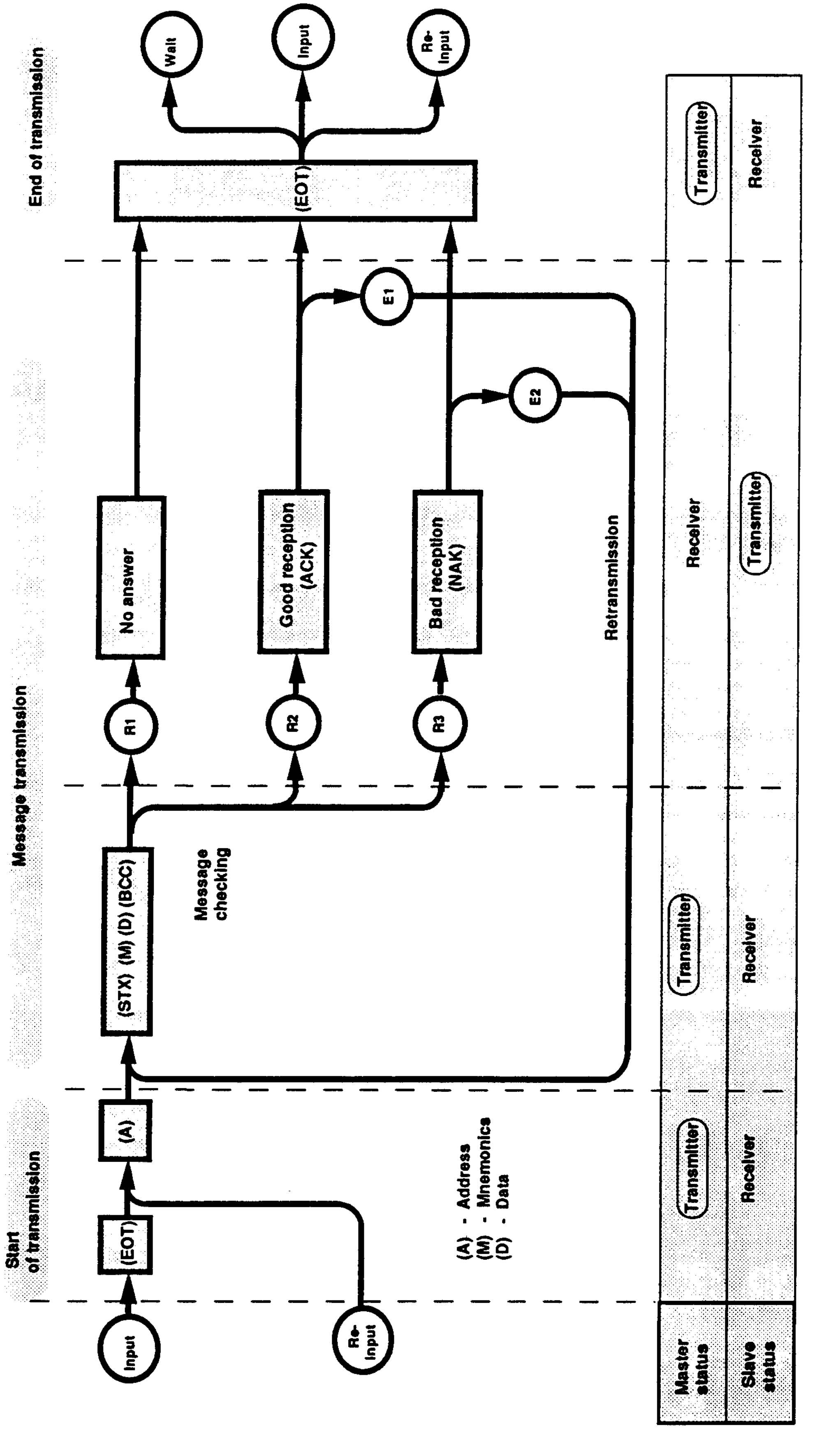



Figure 2-3 Parameter write sequence

## Message transfer

After transmission has been established, the Supervisor moves onto the message transfer phase while remaining in the transmitter position. The message transfer phase is divided into two phases according to the status (**transmitter** or **receiver**) of the Master and of the Slave (see figure 2-3).

### The Master is the transmitter

The Supervisor sends the following message:

(STX) (C1) (C2) (D1) (D2) (D3) (D4) (D5) (D6) (EXT) (BCC)

STX - Start of text to be written.
C1 C2 - Name of mnemonic to be modified.
**D1 to D6** - Value of the parameter sent, in physical units.
ETX - End of writing message text, indication that the selected Unit will change to receiving mode.

The format of the characters **D1** to **D6** which give the new value of the parameter is with 7 non-negative bits.

### The Slave is in transmitting mode

After receiving the message, the selected Unit performs the following operations:

- checks that the check character BCC corresponds to the model of the data received
- checks that the characters C1 and C2 correspond to an authorised mnemonic
- checks that the characters **D1** to **D6** contain valid data.

After the Unit has checked the message sent by the Supervisor, it changes to the transmitting position.
The Unit can answer in three possible ways marked **R1** to **R3** in figure 2-3.

### R1 - No answer

The Supervisor may receive no reply from the Unit for different reasons:

- the address unit number or that of the address group is not recognised
- an error has been found in the characters sent up to BCC inclusive
- the CCC board of the selected unit is configured at an incorrect baud rate
- a hardware fault on the selected CCC board.

In this case, the Supervisor enters the end phase (see figure 2-3).

### R2 - Good reception (ACK reply)

After checking the mnemonic, the data and the BCC character, the Unit modifies the parameter selected with the new value contained in the message.
The Unit then sends an acknowledgement character - **ACK**. After this reply has been received, the Master can enter the end phase (EOT).
Otherwise, the Master can send another message to the same Unit (sequence **E1** in figure 2-3) without having to re-establish the communication. This can be a quick way to **gain time** when updating parameters.

### R3 - Bad reception (NAK reply)

If the Slave detects an error in the message it has received, it sends the Master a negative acknowledgement (**NAK**).
After the **NAK** character has been received, the Master can start the end phase and finish the writing sequence or return to the transfer phase (sequence **E2** in figure 2-3) to retransmit the same message.

## End of sequence

This procedure is established each time the Supervisor wants to stop the write sequence on the selected Unit CCC board and establish a new transmission.

The end of the transmission is established after a failure (ACK and NAK sequences) or due to a lack of answer (see figure 2-3).

The Supervisor becomes the transmitter and sends the **EOT** character to reset all the units.

The Supervisor can then select another unit, perform another reading sequence or stay in standby.

The same message can be sent again (re-enter) without establishing the EOT procedure (with the EOT character sent at the end of the previous sequence.

Examples are given below of writing a new Digital setpoint value (mnemonic SL), a new operating mode and an incorrect request.

## Parameter writing examples

Example 1. **Write the value of 50% on the Digital setpoint of unit No. 8.**

- The Supervisor establishes the transmission and transfers the write message of the SL setpoint to **50%**:

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(Hexadecimal** ASCII code) | **04** | **30** | **30** | **38** | **38** | **02** | **53** | **4C** | **35** | **30** | **03** | **19** |
| (ASCII characters) | **EOT** | **0** | **0** | **8** | **8** | **STX** | **S** | **L** | **5** | **0** | **ETX** | **(BCC)** |

**REMINDER**
the Supervisor sends the transmission **establishment** and message **transfer** sequences **consecutively**

- The TU unit with the physical address **8** replies:

| | |
|---|---|
| **(Hexadecimal** ASCII code) | **06** |
| (ASCII characters) | **ACK** |

The selected unit acknowledges that the writing on address **8** is complete.

Example 2. **Send the Digital setpoint the value of which is broadcast 80%to all units**

- The Supervisor establishes the transmission with all the channels (address **0**) and transfers the message **SL=80%** :

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(Hexadecimal** ASCII code) | **04** | **30** | **30** | **30** | **30** | **02** | **53** | **4C** | **38** | **30** | **03** | **14** |
| (ASCII characters) | **EOT** | **0** | **0** | **0** | **0** | **STX** | **S** | **L** | **8** | **0** | **ETX** | **(BCC)** |

- **Only the Unit** with the address **4** replies that the write was executed correctly on all the units:

| | |
|---|---|
| **(Hexadecimal** ASCII code) | **06** |
| (ASCII characters) | **ACK** |

**Example 3. Send unit TU1271 No. 6 a Phase angle operation request**

The Command code for **Phase angle** mode operation is **08** (see table 4-9, page 4-13).

- The Supervisor establishes the transmission with the unit located at address **6** :

| | | | | | |
|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **04** | **30** | **30** | **36** | **36** |
| (ASCII characters) | **EOT** | **0** | **0** | **6** | **6** |

- The Supervisor transfers the write message of the command code **08** to a Status word **SW** :

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **02** | **53** | **57** | **3E** | **30** | **38** | **03** | **31** |
| (ASCII characters) | **STX** | **S** | **W** | **>** | **0** | **8** | **ETX** | **(BCC)** |

- The TU1271 Unit (with two independent channels) with the address **6** replies:

| | |
|---|---|
| (**Hexadecimal** ASCII code) | **06** |
| (ASCII characters) | **ACK** |

The thyristor firing mode modification request is complete.

**Example 4. Sending an incorrect request:**
**broadcast the Output power (mnemonic OP) at the value of 50%**

- The Supervisor establishes the transmission: at the broadcast address

| | | | | | |
|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **04** | **30** | **30** | **30** | **30** |
| (ASCII characters) | **EOT** | **0** | **0** | **0** | **0** |

and transfers the message :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | **02** | **4F** | **50** | **35** | **30** | **03** | **00** |
| (ASCII characters) | **STX** | **O** | **P** | **5** | **0** | **ETX** | **(BCC)** |

- The Unit at address **4** replies for all the others:

| | |
|---|---|
| (**Hexadecimal** ASCII code) | **15** |
| (ASCII characters) | **NAK** |

The acknowledgement is negative since the status of the Output power parameter is "Read Only" ("**RO**") and writing is impossible (table 4-2).

## MESSAGE CHECKING

The mnemonics and data sent are checked by the **BCC** character (Block Check Character).

The value of **BCC** is the result of an "**exclusive OR**" ("**XOR**") operation of all the characters sent after **STX** up to **EXT** (inclusive). The characters must be expressed in **binary code**.

| | *Mnemonic* | | *Data* | | | | | | *Check character* |
|---|---|---|---|---|---|---|---|---|---|
| (BCC)= | (C1) ⊕ | (C2) ⊕ | (D1) ⊕ | (D2) ⊕ | (D3) ⊕ | (D4) ⊕ | (D5) ⊕ | (D6) ⊕ | (ETX) |

where ⊕ - symbol of "**exclusive OR**".

The decimal, binary and hexadecimal codes of the mnemonics, characters and data are given in **Appendix A.**

After the Unit calculates the value of the BCC, the Supervisor **compares** the BCC **sent** during the message transfer and the **calculated** BCC.

**Example . Check the BCC of the answer of Example 1** (page 2-8) **of the reading of the setpoint value :**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (**Hexadecimal** ASCII code) | 02 | 53 | 4C | 35 | 30 | 03 | 19 |
| (**ASCII** characters) | STX | S | L | 5 | 0 | ETX | (BCC) |

The selected Unit calculates the result of an "**exclusive OR**" of the following STX characters:

BCC = (S) ⊕ (L) ⊕ (5) ⊕ (0) ⊕ (ETX)

In **ASCII** codes:

| | | |
|---|---|---|
| (S) | = | 1010011 ⊕ |
| (L) | = | 1001100 ⊕ |
| (5) | = | 0110101 ⊕ |
| (0) | = | 0110000 ⊕ |
| (ETX) | = | 0000011 |
| **BCC** | = | **0011001 = $19_{HEX}$** |

which corresponds to the BCC of Example 1.

## RESPONSE TO A MESSAGE ERROR

The selected Unit can detect the following errors in the message sent by the Supervisor :

- the characters **C1** and **C2** do not correspond to a combination of valid mnemonics
- the characters **C1** and **C2** describe the Supervisor parameters only
- the data defined by **D1** to **D6** is invalid or out of range
- the **BCC** character does not correspond to the data item received by the Unit
- a parity error due to interference on the line.

If one of these conditions is detected, the Unit sends the **NAK** character to signal to the Supervisor that the message received contains an error.

The response of the Master to the NAK character is described on page 2-7 (read sequence) and on page 2-13 (write sequence).

## Chapter 3

# MODBUS® AND JBUS® COMMUNICATION PROTOCOLS

Summary page

# CHAPTER 3 MODBUS® AND JBUS® PROTOCOLS

## GENERAL DESCRIPTION

The **MODBUS®** (developed by **GOULD**) and **JBUS®** (developed by **APRIL**) protocols can be used to exchange data in bits and words between a supervision system, an industrial programmable logic controller and **TU** range units.

There are two types of JBUS®/MODBUS® protocol:

- the **ASCII** protocol and
- the **binary** protocol (or **RTU**).

The **binary protocol** (**RTU**) is used by the TU range units.

The MODBUS® et JBUS® protocols have **the same data structure.**

The difference between these two protocols lies in the addresses:
the values of JBUS® addresses are **shifted** by " +1 " in relation to MODBUS® addresses.

Thus, a JBUS® network can, simply by **transcoding** addresses, comunicate with any MODBUS® compatible hardware.

| | |
|---|---|
| • Transmission standard | **RS485** or **RS422** - two-way |
| • Transmission mode | **Binary** character frame |
| • Baud rate used for the TU range | **9600** or **19200** baud (TU2000 series: 9600 baud). |

The parameters related to digital communications (physicial unit address, baud rate, protocol) must be selected by the correct jumpers on the CCC board (page 5-5).

## TERMINOLOGY

**Address**

Binary number indicating **all** data.

The **addresses** used in the MODBUS® / JBUS® protocols are
- the **physical** Slave address (unit or unit channel);
  the broadcast address for all the channels of the same communication bus
- the **parameter** address
- the address of the **bits** of the adressable byte.

**Function**

Designation:
- of the communication mode (**read** or **write**),
- of the data unit (**bit** or **word**) ,
- of the **quantity** of parameters requested: one or more.

**Check word**

Binary number used to **detect** transmission **errors.**
It is sent at the end of each message and compared to the result of a logical operation on the message parameters.

**Status word**

Two byte communication parameter, the bits of which indicate the unit status and the alarm status.

## DATA FORMAT

MODBUS® / JBUS® protocol data is expressed in binary code and given in the format **0 - 1000** (for **100%**) with an accuracy of **0.5%**. Thus, to load the input signal setpoint with the value **75.3%**, for example, **753** is sent.
However, the restored number is **755** or **75.5%**.

The format of a character is **10 bits** ; the data byte (**8 bits** of the data) is preceded by a "start" bit and followed by a "stop" bit.

In the format of data and addresses, there are no negative numbers (no significance in binary code).

## READ/WRITE PRINCIPLE

Data exchanges (**read/write**) are **ordered by the Master.**
Each exchange consists of **two** messages: a **request** from the Master and an **answer** from the Slave.

Each message (character frame) from the Supervisor or Unit contains **four** types of data :

- the Slave number - **SNU**
- the function **code** - **FNC**
- the **information** field - **IFD**
- the **check** word - **CRC.**

Request and answer messages, addressed in the first byte of the frame, have the **same format** :

| (SNU) | (FNC) | (IFD) | (CRC) |
|---|---|---|---|
| 1 byte | 1 byte | **n** bytes | 2 bytes |

The **SNU** number (address of the Unit or independent channel) is between:

**$01_{HEX}$** and **$FF_{HEX}$** (1 to 255) for single-phase or three-phase single channel (2 phase check);
**$02_{HEX}$** and **$FF_{HEX}$** (2 to 255) for unit checking 2 phases of the 2 three-phase systems;
**$04_{HEX}$** and **$FF_{HEX}$** (4 to 255) for 4-channel single-phase units.

If **SNU = 0** the Supervisor message is processed by **all** the units of the same communication bus **(broadcast).**

The function code **FNC** (table 3-1, overleaf ) is used to select a command :

- read bits, words, word groups
- write words.

The information field **IFD** of the **request** message contains function related data (communication parameter address, bit, word address, bit value, number of bits, number of words).

The information field **IFD** of the **answer** message contains the following data: value of the bits or words **read**, value of the bits or words **written**, number of words or number of bits.

**Two check bytes** are sent at the end of each communication message.
The Check word (**CRC** ) is used to detect transmission errors. When the message is received by the unit, it calculates the sequence Check word in order to validate or refuse the message (page 3-12).

## Arrangement of bits in a byte

In the address (**SNU**), function code (**FNC**) and information field (**IFC**), the **first** byte **read** is the **Most Significant** byte. The information in a byte is arranged **from right to left.**

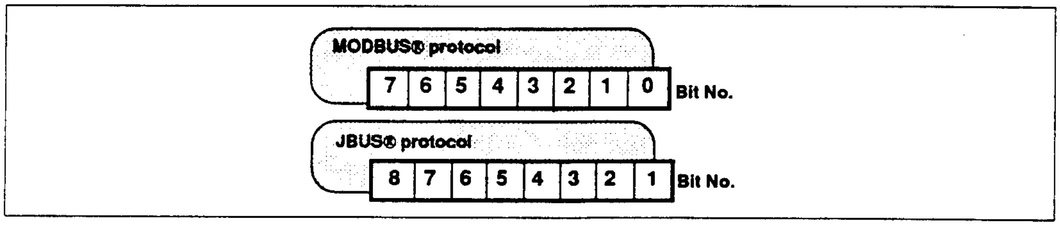



Figure 3-1 Arrangement of bits in a data byte

In the check word bytes (**CRC**) the two bytes of the information is **not** presented **in the same way** as in other parameters : they are arranged **from left to right** (see figure 3-2).

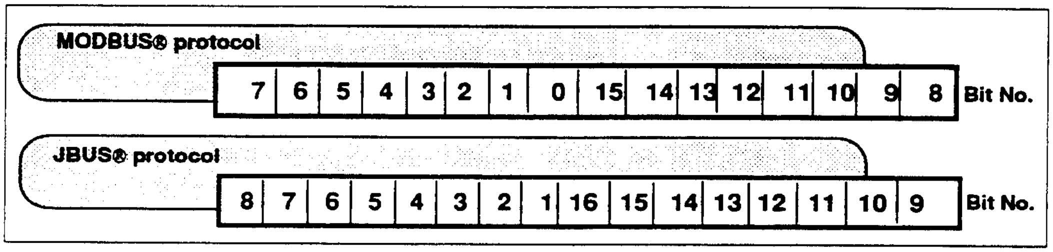



Figure 3-2 Arrangement of bits in the Check word bytes

## Read/write functions

The MODBUS® and JBUS® protocols for the TU range can be used to read information in bits or words, but can only be used to **write words.**

The TU range units have the **8** read or write functions given in table 3-1.

| Destination | Function | | Number of bits or words | Data type |
|---|---|---|---|---|
| | Number | Code (HEX) | | |
| Reading | 1<br>2 | 01<br>02 | n bits | Output or internal<br>Input (alarm or indication) |
| | 3<br>4 | 03<br>04 | n words | Output or internal<br>Input |
| | 7 | 07 | 8 bits<br>(one byte) | High speed reading of 8 preset bits (Alarms) |
| Writing | 6 | 06 | 1 word | "Write" or "Read and Write" status |
| | 16 | 10 | n words<br>Limited to **n = 1** for TU range | |
| Diagnostic | 8 | 08 | Connection to certain systems | |

Table 3-1 Read and write functions

The digital communications for the **TU** unit do not make a distinction concerning the type of bit or word.
This is why functions **1** and **2** can be used to read output or internal bits and input bits.
It is thus possible to use functions **3** and **4** to read output or internal words or input words.

The modification of the function code by a Slave indicates a transmission error.

## READ A DATA ITEM

To read a data item in bits or words, function codes **01** to **04** and **07** must be used (see table 3-1).

### Read n bits

For **TU** range units, the bits of the two Status word bytes are read.
The **addresses** of the Status word bits for the MODBUS® and JBUS® protocols are given on page **4-11**.

N data bits are read by functions **1** and **2** which are strictly **equivalent.**

The **request** frame is composed of **8 bytes** and has the following format:

| Slave number | Function code | First bit address | Number n bits to read | Check word |
|---|---|---|---|---|
| (SNU) | (01 or 02) | (IFD) | | (CRC) |
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

The number **n** of bits to be read is contained within the range **1 ≤ n ≤ 16.**

For the MODBUS® protocol, the addresses of bits to be read must be:

greater than or equal to **00** $_{\mathbf{HEX}}$ and less than or equal to **0F** $_{\mathbf{HEX}}$

For the **JBUS®** protocol, the addresses of bits to be read must be :

greater than or equal to **01** $_{\mathbf{HEX}}$ and less than or equal to **10** $_{\mathbf{HEX}}$

The arrangement of bytes in an address or in number of bits:

| Most Significant Byte (MSB) | Least Significant Byte (LSB) |
|---|---|

The Slave's **answer** is composed of **N** bytes.

N = 5 + NO

where: NO - Number of bytes read.
NO = 1 when **n ≤ 8**
NO = 2 when **n ≥ 8**

The **answer** frame format:

| Slave number | Function code | Number of bytes read | First byte read | Second byte read | Check word |
|---|---|---|---|---|---|
| (SNU) | (01 or 02) | (IFD) | | | (CRC) |
| 1 byte | 1 byte | 1 byte | 1 byte | 1 byte | 2 bytes |

The **first** bit sent is to the **right** of the byte read. The bits **not used** in the byte are set to zero.

## Fast reading of a byte

Fast reading is used to receive data on the status of the **alarms** of a channel. Fast reading is performed by **function 7** .

The addresses of the **8** bits concerned (Most Significant Byte of the Status word) accessible for fast reading with function 7 are set in the Slave coupler.

In TU range digital communications, the alarm bits of the channel concerned are between **8** and **15** (from $08_{HEX}$ to $0F_{HEX}$ for the MODBUS® protocol and from $09_{HEX}$ to $10_{HEX}$ for the JBUS® protocol) as explained in table 4-6, page 4-11.

The **request** frame is composed of 4 bytes and has the following format:

| Slave number | Function code | Check word |
|---|---|---|
| (NES) | (07) | (CRC) |
| 1 byte | 1 byte | 2 bytes |

The **answer** frame is composed of 5 bytes in the following format:

| Slave number | Function code | Most Signif. Byte of Status word | Check word |
|---|---|---|---|
| (SNU) | (07) | (IFD) | (CRC) |
| 1 byte | 1 byte | 1 byte | 2 bytes |

## Read n words

The reading of **n** words (reading in **packets** of **n** parameters) is performed by functions **3** and **4**.
In the **TU** range, functions **3** and **4** are always **equivalent**.

The number **n** of words (of operating parameters) to be read must be $1 \le n \le 12$ ($01_{HEX}$ to $0C_{HEX}$).
The addresses of the words of the TU range according to the MODBUS® /JBUS® protocols are given in table 4-3 (page 4-7).

All the data in the information fields of functions 3 or 4 are sent in **2 bytes**.
The **request** sequence format which consists of 8 bytes is shown below:

| Slave number | Function code | First word address | Number of words (n) | Check word |
|---|---|---|---|---|
| (SNU) | (03 or 04) | (IFD) | | (CRC) |
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

The **answer** frame consists of N bytes. **N = 5 + 2n**, where **n** - number of words read.

The frame format is as follows:

| Slave number | Function code | Number of bytes read (2n) | First word value | ... | Last word value | Check word |
|---|---|---|---|---|---|---|
| (SNU) | (03 or 04) | | ( IFD) | | | (CRC) |
| 1 byte | 1 byte | 1 byte | 2 bytes | ... | 2 bytes | 2 bytes |

## READ EXAMPLES

### Example 1. Read n bits

**Read the bits from $04_{HEX}$ to $0F_{HEX}$ of the Status word of a channel 2 of the TU1470 unit, where channel 1 is located at address 4; read function code 01, JBUS® protocol**

| | | |
|---|---|---|
| Physical address of an indicated channel | : | $05_{HEX}$ |
| Address (2 bytes) of the first bit to be read | : | 00 04 |
| Number of bits to be read | : | $0F_{HEX}$ - $04_{HEX}$ = $0C_{HEX}$ (or 00 0C with 2 bytes) |
| Number of bytes read | : | 02 ( since $0C_{HEX}$ > 8) |

Request frame (in Hexadecimal) : 05 01 00 04 00 0C (CRC)

Answer frame (in Hexadecimal) : 05 01 02 0 E A 9 (CRC)

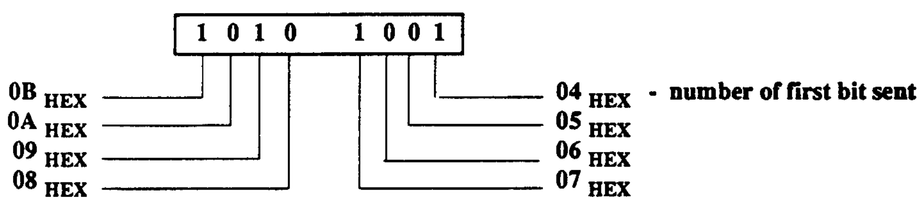
**Reminder**

The data is sent in binary code and its representation is given in Hexadecimal

Answer contained in the information field (IFD) : Status word 0 E A 9

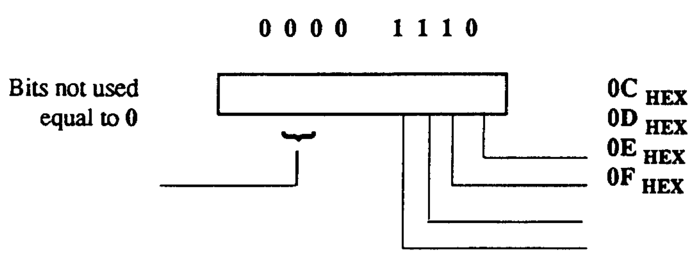
The value of the least significant byte is : $A_{HEX}$ $9_{HEX}$ or in binary code : 1010 1001

The bit numbers of the Status word are sent from the **first bit requested by the Supervisor** (or bit **No.** $04_{HEX}$).




In **IFD**, the value of the Most Significant Byte is : 0 $_{HEX}$ $E_{HEX}$ or in binary code : 0000 1110

By continuing the bit number calculation




According to table 4-5, page 4-11, which gives the designation of the Status word bits (see bit addressing according to the JBUS® protocol), the data received - bit numerals and their values - signifies:

**Least Significant Byte** : feedback in V x I; neither over-voltage nor under-voltage; digital setpoint; resistive load; channel 2 of the unit is inhibited; no over-load; thyristor short-circuit of selected channel.

**Most Significant Byte** : current limit not active; over-current alarm active; TLF detection; partial load failure detection adjusted.

## Example 2. Fast reading

**Read the status of the alarms of Slave No. 4.**

The byte concerned is the Most Significant Byte of the Status word.
The fast reading function of a byte - code 07.

Request frame (in Hexadecimal) : **04 07 42 B2**

Answer frame (in Hexadecimal) : **04 07 4 0 33 C1**

(The codes **42 B2** and **33 C1** in the request and write frames are Check words).

The information field CHI = $4_{HEX}$ $0_{HEX}$ or in binary code : **0100 0000**

Depending on the designation of the Status word bits (see table 4-5), the Most Significant Byte received signifies :

partial load failure detection adjusted; no alarm active.

## Example 3. Read n words

**Read 2 words (value of 2 parameters) : Loadvoltage and the next word.**
**Slave No. 12, read function code 03, MODBUS® protocol**

The Slave number addressed in Hexadecimal : $0C_{HEX}$

The address of the Load Voltage parameter
with the MODBUS® protocol in 2 bytes is : $0005_{HEX}$ (table 4-3, page 4-7).

The Load Current parameter is located in the following address (according to the read request) in table 4-3.

Number of words to be read: **0002** (in 2 bytes);
number of bytes read : 0002 x 2 = **0004**

The request frame (in Hexadecimal) : **0C 03 0005 0002 (CRC)**

The answer frame (in Hexadecimal) : **0C 03 0004 0 3 E 0 0 2 A C (CRC)**

The value of 1st word read : $0_{HEX}$ $3_{HEX}$ $E_{HEX}$ $0_{HEX}$
In binary code : **0000 0011 1110 0000** or in decimal - **992**

The value of 2nd word read : $0_{HEX}$ $2_{HEX}$ $A_{HEX}$ $C_{HEX}$
In binary code : **0000 0010 1010 1100** or in decimal - **684**

Then Slave No.**12** **answers** : the Load Voltage (address 05) is **99%** (within 0.5%)

the Load Current (address 06) is **68.5%** (within 0.5%).

## WRITE A DATA ITEM

Parameter values are written using functions **6** and **16.**

For TU range digital communications, function **6** and function **16** are functionally **equivalent.**

However, it is recommended to use function **6** (if enabled by the coupler), since the frame is shorter, the transaction is faster.

### Write a word

With function **6**, the writing of one of the following four parameters of the TU range units:

- the Digital setpoint
- the Fast setpoint transfer (to change the current setpoint quickly)
- the Current limit setpoint
- the Command codes.

The **request** frame to write a word is composed of **8** bytes in the following format:

| Slave number | Function code | Word address | Word value | Check word |
|---|---|---|---|---|
| (SNU) | (06) | ( IFD) | | (CRC) |
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

The arrangement of bits in a byte is shown in figures 3-1 and 3-2 (page 3-4).

The **answer** is an **echo** of the request indicating that the Unit accepts the value contained in the request and the answer frame format is the same as that of the request.

The answer is not sent if the parameters which can be broadcast (Digital setpoint and Command codes) are sent to the broadcast address.

## Write n words

Function number **16** is used to write n words.

For TU range digital communications, the interface only authorises the use of function **16** to write **one word.** This means that it is functionally **identical** with function **6**. The writing example for function **6** on page 3-9 are all valid for function **16.**

Only the frame architecture is different. The **request** frame contains **11** bytes.

| Slave number | Function code | Word address | Number of words (**n = 1**) | Number of bytes (**2**) | Word value | Check word |
|---|---|---|---|---|---|---|
| (SNU) | ($10_{HEX}$) | | | (IFD) | | (CRC) |
| 1 byte | 1 byte | 2 bytes | 2 bytes | 1 byte | 2 bytes | 2 bytes |

The **answer** is not a simple echo, and is composed of **8** bytes as follows:

| Slave number | Function code | Word address | Number of words write (**00 01**) | Check word |
|---|---|---|---|---|
| (SNU) | ($10_{HEX}$) | | ( IFD) | (CRC) |
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

As for function **6**, this answer is not sent if the Slave number is the broadcast address:
(SNU = 00).

## Data item write examples

### Example 1. Write a word (function 6)

**Set the Current limit parameter to 74% for Slave No. 5**
**Use function 6. MODBUS® protocol**

The Current limit setpoint
is at the address : **$0002_{HEX}$** (table 4-3, in 2 bytes).

The value of 74% in the format used is : **0740**
or in binary code in **2** bytes : **0000 0010 1110 0100**

This corresponds to the Hexadecimal code: **0 2 E 4**

Then, the Master requests : **05 06 0002 0 2 E 4 (CRC)**

Answer : **05 06 0002 0 2 E 4 (CRC)**

The answer-echo indicates that the transmission is **correct** and that, since the write frame was received, Slave **No. 5** has been working with the current limit threshold **sent.**

## Example 2. Write a word (function 16)

**Set the Digital setpoint of Slave No. 4 to 98%.**
**Use function 16. MODBUS® protocol**

The code of function 16 in hexadecimal is : **$10_{HEX}$**

The address of the Digital setpoint parameter in the MODBUS® protocol in 2 bytes is : **0000**

Number of words to be written (in 2 bytes) : **0001**

The value of **IFD = 98 %** in MODBUS® format is equal to : **0980**
In binary code in 2 bytes : **0000 0011 1101 0100**
This value correponds to the hexadecimal code : **0 3 D 4**

Request frame (in Hexadecimal) : **04 10 0000 0001 02 0 3 D 4 (CRC)**

Answer frame (in Hexadecimal) : **04 10 0000 0001 (CRC)**

The answer indicates that the requested value (98%) of the Digital setpoint (address **0000**) is written with function 16 (code **$10_{HEX}$** ) in Slave No. 4.

## DIAGNOSTIC FUNCTION

Function **8** (diagnostic function) is reduced to its most simple expression in TU range communications. It can only be used for **connection** to certain couplers which require this function.

The Master sends the following 8 byte frame:

| Slave number | Function code | Pre-defined word | Sub-code | Check word |
|---|---|---|---|---|
| (SNU) | (08) | (00 00) | (00 00) | (CRC) |
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

The answer is an echo of the request indicating that the Unit has taken into account the connection request sent by the Master. The sub-code is not taken into account.

The selected unit only sends the echo answer frame if the Check word is correct.

## MESSAGE CHECKING

The MODBUS® / JBUS® protocols can check the message with the Check word - "checksum" - CRC (Cyclic Redundancy Check) in the **last two bytes** of each read and write frame.
The name **CRC16** is thus used to specify the length of the Check word at **16** bits.

In the CRC, the first byte sent is the least significant byte (see figure 3-2, page 3-4).

The CRC Check word calculation is shown by the diagram in figure 3-3.

In this figure, the sign ⊕ represents the **"exclusive OR"** and the **n** - the number of data bits.

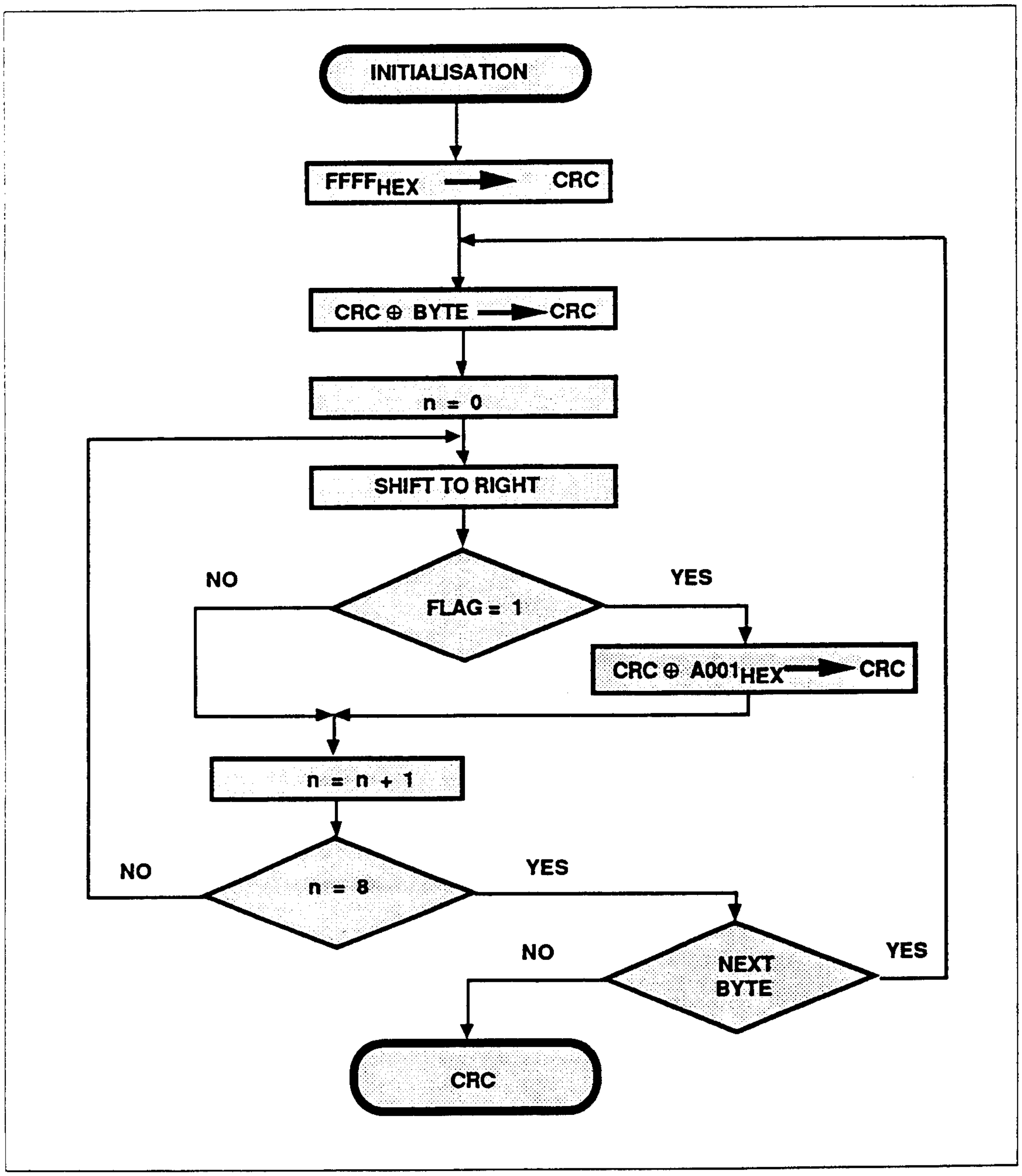



Figure 3-3 CRC Check word calculation diagram

## Example of CRC check word development

**Check the Check word for the message of the fast reading example (page 3-8)** **: 04 07 42 B2**

The message checksum is the result of the last calculation line, after the 8th shift.

| | | | | | | |
|---|---|---|---|---|---|---|
| CRC register initalisation | | 1111 | 1111 | 1111 | 1111 | FLAG |
| ⊕ of the 1st byte sent (04) | | | | | 0100 | |
| | Result | 1111 | 1111 | 1111 | 1011 | 1 |
| | Shift 1 | 0111 | 1111 | 1111 | 1101 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1101 | 1111 | 1111 | 1100 | 0 |
| | Shift 2 | 0110 | 1111 | 1111 | 1110 | 0 |
| FLAG = 0 | Shift 3 | 0011 | 0111 | 1111 | 1111 | 1 |
| FLAG = 0 | Shift 4 | 0001 | 1011 | 1111 | 1111 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1011 | 1110 | 1111 | 1110 | 0 |
| | Shift 5 | 0101 | 1101 | 1111 | 1111 | 1 |
| FLAG = 0 | Shift 6 | 0010 | 1110 | 1111 | 1111 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1000 | 1110 | 1111 | 1110 | 0 |
| | Shift 7 | 0100 | 0111 | 0111 | 1111 | 1 |
| FLAG = 0 | Shift 8 | 0010 | 0011 | 1011 | 1111 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1000 | 0011 | 1011 | 1110 | (n=8) |
| ⊕ the 2nd byte sent (07) | | | | | 0111 | |
| | | 1000 | 0011 | 1011 | 1001 | 1 |
| | Shift 1 | 0100 | 0001 | 1101 | 1100 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1110 | 0001 | 1101 | 1101 | 1 |
| | Shift 2 | 0111 | 0000 | 1110 | 1110 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1101 | 0000 | 1110 | 1111 | 1 |
| | Shift 3 | 0110 | 1000 | 0111 | 0111 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1100 | 1000 | 0111 | 0110 | 0 |
| | Shift 4 | 0110 | 0100 | 0011 | 1011 | 1 |
| FLAG = 0 | Shift 5 | 0011 | 0010 | 0001 | 1101 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| | | 1001 | 0010 | 0001 | 1100 | 0 |
| | Shift 6 | 0100 | 1001 | 0000 | 1110 | 0 |
| FLAG = 0 | Shift 7 | 0010 | 0100 | 1000 | 0111 | 1 |
| FLAG = 0 | Shift 8 | 0001 | 0010 | 0100 | 0011 | |
| FLAG = 1 | ⊕ A001 | 1010 | 0000 | 0000 | 0001 | |
| **Result** | : | 1011 | 0010 | 0100 | 0010 | (n=8) |
| in Hexadecimal | : | $B_{HEX}$ | $2_{HEX}$ | $4_{HEX}$ | $2_{HEX}$ | |

Table 3-2 Check word calculation for message **04 07**

The **least** significant byte of the CRC is displayed to the **left** of the result (it should be noted that the CRC bytes are arranged from left to right). Therefore, the checksum of message 04 07 is CRC = **4 2 B 2** which matches the example.

## ERROR CODES

Transmission errors are indicated by codes sent by the Slave during the answer message.
In this case, it **adds** the number **128** (**$80_{HEX}$** or **10000000** in binary code) to the function code.

The frame of the answer message consists of **5** bytes and has the following structure and format:

| Slave number | Function code | Error code | Check word |
|---|---|---|---|
| (SNU) | ($CF+80_{HEX}$) | (see table 3-3) | (CRC) |
| 1 byte | 1 byte | 1 byte | 2 bytes |

The error codes for TU range communications are given in table 3-3.

| Error type | Code | Description |
|---|---|---|
| Defined | 01 | Invalid function |
| | 02 | Address out of range |
| | 03 | Data not in definition |
| | 04 | Slave not ready (EEPROM is occupied) |
| | 08 | Parameter to be modified write-protected |
| Undefined | 07 | Error not defined by codes 01 to 04, and 08 |

Table 3-3 Communication error codes

Code **01** is displayed when the function code is not within the values **01** to **04, 06** to **08** and **$10_{HEX}$**.

Code **02** indicates that the addresses are not from **00** to **$0C_{HEX}$** for words or from **00** to **$0F_{HEX}$** for bits in the **Modbus®** protocol (it should be noted that, for the Jbus® protocol, addresses are **+ 1** greater than in the Modbus® protocol).

Code **03** indicates that the data does not correspond to its format, e.g. the Digital setpoint request is greater than 1000 (see table 4-3).

Code **04** indicates an attempt to write in permanent memory (EEPROM) which is already occupied or in the process of writing.

Code **07** corresponds to a **NAK** character (bad reception). It indicates incorrect requests, e.g.:

- Phase angle thyristor firing mode request for **TU1000** series units which only operate in Burst firing or Single cycle mode,

or a lack of response from certain alarms, e.g.:

- **Burst firing** request with current limit **active** while in Burst firing mode, overshooting the current threshold inhibits unit operation (see page 5-13, current limit action).

Code **08** is displayed when a write request has been sent for a variable with **RO** (read only) status.

In addition, there is a **condition** in which a transmission error can be assumed. This is the **No reply** condition, when no Slaves answer, and occurs in the following cases:

- CRC of message sent to Slave **incorrect**;
- transmission to address **00** : in this case, the lack of reply is normal;
- attempt to broadcast a parameter other than those which can be broadcast (Digital setpoint, Fast setpoint transfer, or Command codes), the command is not valid;
- the "**buffer**" is full (number of characters received by the Slave is greater than **11**), the frame is invalid.

## Chapter 4

# TU UNIT PROTOCOL APPLICATION

Contents page

# Chapter 4 TU UNIT PROTOCOL APPLICATION

## GENERAL CHARACTERISTICS OF THE TU RANGE

TU range thyristor power units are designed to monitor the power in resistive loads with high or low temperature coefficients or in short wave infrared elements.

The TU range is composed of **three** series devised for single and three-phase loads.

### Single-phase load

**TU1000 series**

The TU1000 unit series is designed for single-phase loads:

- with high resistance variations (e.g. metal alloys, iron-nickel-chromium-aluminium),
- with infrared transmitters in fields such as: agri-food, textile, glass, etc.

These applications accept feedback in sequences of **entire** thyristor firing and non-firing **periods**.

**TU1001 series**

The TU1001 unit series is devised to monitor complex single-phase loads:

- with high resistance variations (e.g. silicon carbide or graphite),
- with a high resistance to the cold (such as molybdenum disilicide, platinum, tungsten or zyrconium oxide),
- infrared transmitters for drying automobile paintwork or in the paper industry,
- primary circuits of transformers.

These applications require feedback at intervals of each supply cycle, i.e. thyristor firing **angle variation.**

The **TU1000** and **TU1001** series are composed of units with:

- a thyristor channel for a single-phase load, or
- two thyristor channels for two independent single-phase loads, or
- four thyristor channels for four independent single-phase loads.

### Three-phase load

**TU2000 series**

The **TU2000** is designed to monitor **2** phases of three-phase loads, mounted in a closed delta or in a star without a neutral. The load type is the same as for the TU1000 series.
The **TU2000** series contains the units monitoring 2 phases of **one** or **two** independent three-phase loads.

## Model names

The unit model **name** designates:

- the monitoring type (single-phase or two phase monitoring),
- the number of independent loads that can be driven per unit,
- the thyristor firing type
- the current and voltage ranges.

The name of each model is composed of **four** digits preceded by the **TU** range name.

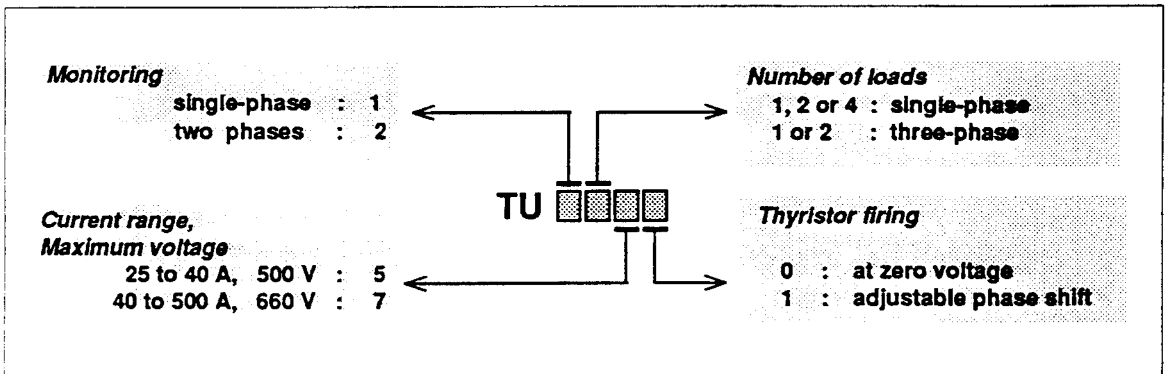



Figure 4-1 Composition of unit model name

The main characteristics of the TU range unit models are given in table 4-1, (overleaf). This table shows the TU range unit models by specifying:

- the current range,
- the maximum voltage,
- the firing type,
- the thyristor firing modes
- the existence of forced cooling (fan present).

**Depending on the series**, the TU range units have two types of thyristor firing:

- at **zero** voltage
- with adjustable firing **phase shift**

and four thyristor firing modes:

- firing angle variation - **Phase angle**
- modulation of the number of supply cycles passed or blocked on the basis of 8 supply cycles - **Burst firing**
- burst firing on the basis of a supply cycle - **Single cycle**
- burst firing with firing angle variation during the first 4 supply cycles - **Soft start.**

The thyristor firing modes are described in more detail in the chapter "TU unit operation" (pages 5-10 and 5-11).

## Models available

| Series | Thyristor firing | Number of loads | Model | Current range (A) | Max voltage (V) | Fan-cooled models (A) | Thyristor firing mode |
|---|---|---|---|---|---|---|---|
| TU1000 | At zero voltage | 1 | TU1170 | 40 to 125 | 500<br>660 | 125 | • Burst firing<br>1 supply cycle<br>(Single cycle)<br>• Burst firing<br>8 supply cycles |
| | | | | 200 and 250 | 500<br>660 | 200<br>to | |
| | | | | 315 to 500 | 660 | 500 | |
| | | 2 | TU1270 | 40 to 125 | 500<br>660 | 100 to125 | |
| | | | | 200 and 250 | 660 | 200 to 500 | |
| | | | | 315 to 500 | 660 | | |
| | | 4 | TU1450 | 25 to 40 | 500 | - | |
| | | | TU1470 | 40 to 125 | 500<br>660 | 60 to 125 | |
| TU1001 | Adjustable phase shift | 1 | TU1171 | 40 to 125 | 500<br>660 | 125 | • Phase angle<br>• Burst firing<br>1 supply cycle<br>(Single cycle)<br>• Burst firing<br>8 supply cycles<br>• Soft start<br>in Phase<br>angle |
| | | | | 200 and 250 | 500<br>660 | 200<br>to | |
| | | | | 315 to 500 | 660 | 500 | |
| | | 2 | TU1271 | 40 to 125 | 500<br>660 | 75 to 125 | |
| | | | | 200 and 250 | 660 | 200 to 500 | |
| | | | | 315 to 500 | 660 | | |
| | | 4 | TU1451 | 25 to 40 | 500 | 25 to 40 | |
| | | | TU1471 | 40 to 125 | 500<br>660 | 40 to 125 | |
| TU2000 | At zero voltage | 1 | TU2170 | 40 to 125 | 500<br>660 | 100 and 125 | • Burst firing<br>1 supply cycle<br>(Single cycle)<br>• Burst firing<br>8 supply cycles |
| | | | | 200 and 250 | 660 | 200 to 500 | |
| | | | | 315 to 500 | 660 | | |
| | | 2 | TU2250 | 25 to 40 | 500 | - | |
| | | | TU2270 | 40 to 125 | 500<br>660 | 60 to 125 | |

Table 4-1 TU unit models

Note: For the 660 V voltage, consult your Eurotherm branch.

The **TU** range units are equipped with a microprocessor board (Control and Communication Board CCC). The CCC board makes it possible to use power **feedback**, to obtain different thyristor **firing modes** and **dialogue** with a communicating control system (via a communication bus). The CCC board supervises the voltage, current and load.

Depending on the CCC board configuration, the unit can be used with **analogue signals** monitoring the thyristor channels separately, or be driven by the remote Supervisor using **digital signals** sent using the incorporated digital link. The input analogue signals have

- four voltage levels : **0 - 5 V**; **1 - 5 V**; **0 - 10 V** and **2 - 10 V**
- two current levels : **0 - 20 mA** and **4 - 20 mA.**

The CCC board provides two feedback modes with the following feedback:

- the load voltage - $V^2$ or
- the power consumption - **V x I.**

## OPERATING PARAMETERS

The unit operating **parameters** determine:
the setpoints, currents and load voltage, line voltage and calibration of each unit channel *).

In the TU range, the following setpoints are used as a standard:

- the **Digital setpoint** which describes the output power sent by the digital communications,
- the **Analogue setpoint** arriving via the analogue input of the microprocessor board,
- the **Fast setpoint transfer** which composes the output power for fast transfer (replacement) to the current digital setpoint.

To determine the unit operation, the digital communications use the rms values:

- of the current in the load (**Load current**),
- of the output terminal voltage (**Load voltage**),
- of the mains voltage used (**Line voltage**).

For feedback, the TU range uses the parameters given below:

- the **Feedback value**, which gives a feedback of V x I or $V^2$,
- the internal controller output value (**Output power**) which corresponds :
  - to the thyristor opening request in Phase angle firing mode or
  - to the cyclical ratio in Burst firing mode,
- the setting of the maximum permissible current value in the load (**Current limit**),
- the calibration current of each thyristor channel (**Current adjust**) which represents the nominal current of the load used, adjusted by the potentiometers of the unit's front fascia .

The **Status word** parameter describes the unit's operation and contains the following information on the status :

- of the alarms,
- thyristor channel enable or inhibition status,
- of the current feedback parameter,
- of the current firing mode,
- of the setpoint type used.

The firing mode, feedback, channel enable and inhibition are **modified:**

- in the Eurotherm protocol by writing in the **Status word** of the command codes
- in the Modbus® and Jbus® protocols by writing the **Command codes** parameter (see page 4-13).

In the **special version** of the communications (see page 5-17), the following are used:

- the **Setpoint limit** parameter which limits the output power with the digital or analogue setpoint
- the **Working setpoint** parameter which represents the value of the resulting setpoint after the limit.

The Digital setpoint and Fast setpoint transfer are stored in **read-write memory.**

The Current limit setpoint value (and the Setpoint limit value in the special version) is stored in **permanent memory.**

The operating parameters are indicated :

- by **mnemonics** (EUROTHERM protocol) or
- by **addresses** (MODBUS® / JBUS® protocols).

*) The word "register" is used in programmable logic controllers to designate a parameter.

## EUROTHERM protocol - parameter mnemonics

To designate operating parameters, the EUROTHERM communication protocol uses communication mnemonics. The names of the mnemonics correspond to abbreviations of their English names.

In the EUROTHERM protocol, the mnemonics are transmitted in **ASCII code**.

The mnemonics used by TU range digital communications are summarised in table 4-2 .
During scanning, the mnemonics are sent in the **pre-defined** order (from **SL** to **SW**) in which they are classified in the table below.

| No. | Parameter | Mnemonic | Status | ASCII code | Format (%) | Storage in memory |
|---|---|---|---|---|---|---|
| 1 | Digital setpoint | **SL** (Setpoint Local) | R / W<br>Read/Write | 53 4C | 0 - 100 | Read/Write |
| 2 | Fast setpoint transfer | **FS** (Fast Setpoint) | R / W<br>Read/Write | 46 53 | 0 - 100 | Read/Write |
| 3 | Current limit | **CL** (Current Limit) | R / W<br>Read/Write | 43 4C | 0 - 100 | Permanent |
| 4 | Feedback value | **PV** (Process Value) | RO - Read | 50 56 | 0 - 156 | - |
| 5 | Output power | **OP** (Output Power) | RO - Read | 4F 50 | 0 - 100 | - |
| 6 | Load voltage | **VV** (Voltage Value) | RO - Read | 56 56 | 0 - 125 | - |
| 7 | Load current | **CV** (Current Value) | RO - Read | 43 56 | 0 - 125 | - |
| 8 | Line voltage | **LV** (Line voltage Value) | RO - Read | 4C 56 | 0 - 125 | - |
| 9 | Current adjust | **CA** (Current Adjust) | RO - Read | 43 41 | 0 - 100 | - |
| 10 | Analogue setpoint | **RI** (Remote Input) | RO - Read | 52 49 | 0 - 100 | - |
| 11 | Status word | **SW** (Status Word) | RO - Read | 53 57 | Binary | - |
| | | | WO - WRITE | Command codes | Hexa-decimal | |

Table 4-2 Mnemonics of parameters used by the EUROTHERM protocol

The SL, FS and SW mnemonics can be broadcast, i.e. sent simultaneously to all the units connected to the same communication bus.

## MODBUS® and JBUS® protocols - parameter addresses

Acording to the MODBUS® and JBUS® protocols, operating parameters are determined by their **address.** The parameter addresses, sent in **binary code**, are **different** for these two protocols:

- with the **JBUS®** protocol, addresses are **greater than** those of the **MODBUS®** protocol **by 1.**

Table 4-3 gives the **parameter addresses** (according to the two protocols) used as a standard, their status and format and the suitable Read/Write functions and the storage in memory.

| No. | Parameter | Hexadecimal address | | Format | Status | Read/ Write functions | Storage in memory |
|---|---|---|---|---|---|---|---|
| | | Modbus | Jbus | | | | |
| 1 | Digital setpoint | 00 | 01 | 0 - 1000 | R / W Read/Write | 3, 4, 6, 16 | Read/Write |
| 2 | Fast setpoint transfer | 01 | 02 | 0 - 1000 | R / W Read/Write | 3, 4, 6, 16 | Read/Write |
| 3 | Current limit | 02 | 03 | 0 - 1000 | R / W Read/Write | 3, 4, 6, 16 | Permanent |
| 4 | Feedback value | 03 | 04 | 0 - 1560 | RO - Read | 3, 4 | - |
| 5 | Output power | 04 | 05 | 0 - 1000 | RO - Read | 3, 4 | - |
| 6 | Load voltage | 05 | 06 | 0 - 1250 | RO - Read | 3, 4 | - |
| 7 | Load current | 06 | 07 | 0 - 1250 | RO - Read | 3, 4 | - |
| 8 | Line voltage | 07 | 08 | 0 - 1250 | RO - Read | 3, 4 | - |
| 9 | Current adjust | 08 | 09 | 0 - 1000 | RO - Read | 3, 4 | - |
| 10 | Analogue setpoint (external) | 09 | 0A | 0 - 1000 | RO - Read | 3, 4 | - |
| 11 | Status word | 0A | 0B | Binary | RO - Read | 1, 2, 3, 4, 7 | - |
| 12 | Command codes | 0B | 0C | Hexa-decimal 0 - 0C | WO - Write | 6, 16 | - |
| | | | | | RO - Read *) | 3, 4 | |

Table 4-3 Characteristics of the parameters used by the Modbus® and Jbus® protocols

*) The read value of the Command codes parameter has no significance.

The Digital setpoint, Fast setpoint transfer and Command codes parameters can be **broadcast** for **all the units** connected to the same communication bus.

## THYRISTOR CHANNEL ADDRESSING (PHYSICAL ADDRESSES)

### General

Each channel has an address, the **physical address**, which identifies the Slave in all the messages from the Master (from the Master's point of view, a channel is a Slave). A CCC board of a unit can control **one** to **four** thyristor channels.

In the Eurotherm protocol, each physical address of a unit channel is presented in the communication frames with a **group** number and a **unit** number. A group is composed of 16 unit numbers.
There are **16** group numbers; it is therefore possible to address **256** channels in total.

In the Modbus® / Jbus® protocols, **256** Slaves can also be addressed.

However, in the TU range, depending on the model, the **first** one, two or four addresses are not used for channel addressing. This means that 252 to 255 numbered addresses are available as physical addresses for unit channels.

The address 0 is used for broadcasting (see page 4-9) and cannot be used as a physical address for a channel.

| Address characteristic | Unit type | | | | |
|---|---|---|---|---|---|
| | Single-phase | | | Three-phase 2 phase monitoring | |
| | Number of channels | | | Number of three-phase systems | |
| | 1 | 2 | 4 | 1 | 2 |
| Inhibited addresses | 0 | 0 and 1 | 0 to 3 | 0 | 0 and 1 |
| Available address numbers | 1 to 255 | 2 to 255 | 4 to 255 | 1 to 255 | 2 to 255 |
| Number of units which can be selected | 255 | 127 | 63 | 255 | 127 |
| Address of channel 1 must be divisible by: | 1 | 2 | 4 | 1 | 2 |

Table 4-4 Physical address characteristics

According to the characteristics summarised in table 4-4 :

#### Single-phase unit with 1 channel (TU11**) or monitoring 2 phases of a three-phase system (TU21**)

Each unit has 1 physical address.
The unit addresses are numbered from 1 to 255.

#### Single-phase with 2 channels (TU12**) or monitoring 2 phases of two three-phase systems (TU22**)

Each unit has 2 addresses.
The addresses of a single-phase channel (or of a three-phase system) have the numbers 2 to 255.

#### Single-phase units with four thyristor units (TU14**)

Each unit has 4 addresses.
The addresses of a channel are numbered from 4 to 255.

## Address definition

For each unit, the address of the **first** channel must be configured.
This address is determined by position of the jumpers on the CCC board (see page 5-6).

The address of the first channel must be **divisible** by the number of channels of the unit (as shown in table 4-4).

**Example 1: TU1470 unit (four thyristor channels)**

The possible addresses of channel 1 : 4, 8, 12... 252.

The addresses of the channels of the **same** CCC board are **consecutive**.
For a two channel unit, the address of channel 2 is 1 greater than that of channel 1.
For a four channel unit, the address of channel 3, for example, is 2 greater than that of channel 1 and the address of channel 4 - 3 greater.

**Example 2: TU1451 unit (four thyristor units), the address of channel 1 is 92**

The address of channel 2 is **93**,
of channel 3 is **94**
of channel 4 is **95**.

## Parameter broadcast address

When the physical address **0** is used (**SNU = 0**), the message from the Supervisor is processed by **all** the units of the communication bus at the same time (**broadcast**). The broadcast is used **only to write** the new value in certain parameters.

In the Eurotherm protocol, the value of the following **3** parameters can be broadcast:

- the Digital setpoint
- Fast setpoint transfer
- the Status word

In the Modbus® and Jbus® protocols, the following parameters can be broadcast:

- the Digital setpoint
- the Fast setpoint transfer
- the Command codes.

The broadcast of the Digital setpoint takes priority over the other setpoints, but is cancelled by a new writing operation in the current setpoint.

In the **EUROTHERM** protocol, when the address **0** is used, only one unit **answers** for all the others.
This unit is located at address 4 (irrespective of the unit series).
This requires the **presence** of a unit at address **4** when the broadcast is used.

In the case of broadcasts with the **MODBUS® / JBUS®** protocols, **there is no answer.**

# STATUS WORD

## General

The Status word contains data on the operation of a unit and on the alarm status.

In the **EUROTHERM** protocol, to modify the unit operating modes, the command codes are written **in the Status** word.

In the **MODBUS® / JBUS®** protocols, the unit operating modes are changed by writing **in the Command codes parameter.**

## Status word bit characteristics and addresses

In read mode, **each bit** of the Status word corresponds to a **specific status** of the Unit (or of a channel).

In the **EUROTHERM** protocol, the Status word is determined by the mnemonic **SW.**
The Status word is formed of 2 **bytes** sent in hexadecimal, in ASCII code, preceded by the "greater than" sign - "**>**".

In the **MODBUS® / JBUS®** protocols, the Status word is determined by the address.
The Status word is formed of 2 **bytes** sent in hexadecimal.

The **first 8 bits** of the Status word are **common** to all the channels of the same unit (apart from the TU2000 series where bit number 0 indicates the status of a three-phase system). These bits are contained in the **least significant byte.** The least significant byte is designated as follows:

- for the EUROTHERM protocol - $SW_L$
- for the Modbus® protocol, the bit addresses are **00** to **07**$_{HEX}$.

The **next 8 bits** of the Status word are **specific** to each channel for single-phase units (TU1000 and TU1001 series) or to each three-phase system for three-phase units (TU2000 series).
These bits are contained in the **Most Significant** byte. The Most Significant byte is designated as follows:

- for the EUROTHERM protocol - $SW_H$
- for the Modbus® protocol - the bit addresses are **08 to 0F**$_{HEX}$..

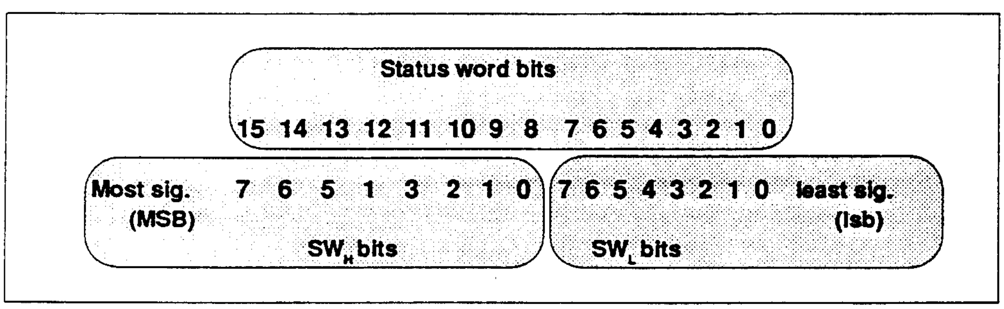



Figure 4-2 Arrangement of the Status word bits

In the MODBUS® / JBUS® protocols, the various bits of the Status word are accessible with reading functions 1 and 2. Only the bits of the Most Significant byte can be accessed with function 7 (fast reading).

The meanings of all the bits of the Status word and their addresses are summarised in table 4-5, overleaf.

| Destination | Status of alarms, thyristor channels or unit operation | | Flag (FG) Name | Stat. | Eurotherm protocol Byte and bit No. in byte | Protocol address (Hex) Modbus | Jbus |
|---|---|---|---|---|---|---|---|
| For a channel or a selected three-phase system of the same unit | Partial load failure detection | | FGPLF | 1 | $SW_H$ 7 | 0F | 10 |
| | Partial load failure detection never adjusted | | FGNPLF | 0 | $SW_H$ 6 | 0E | 0F |
| | TU1000 TU1001 | Total load failure on the selected channel | FGTLF | 1 | $SW_H$ 5 | 0D | 0E |
| | TU2000 | Total load failure on channel 2 or 4 | FGTLF2 | 1 | | | |
| | TU1000 TU1001 | Over-current on the selected channel | FGOVC | 1 | $SW_H$ 4 | 0C | 0D |
| | TU2000 | Total load failure on channel 1 or 3 | FGTLF1 | 1 | | | |
| | Current limit exceeded on a channel or a selected system | | FGLIMI | 1 | $SW_H$ 3 | 0B | 0C |
| | TU1000 TU1001 | Short circuit of thyristors of selected channel | FGSCTH | 1 | $SW_H$ 2 | 0A | 0B |
| | TU2000 | Short circuit of thyristors of channel 2 or 4 | FGSCVT2 | 1 | | | |
| | TU1000 TU1001 | Overload on selected channel | FGOVL | 1 | $SW_H$ 1 | 09 | 0A |
| | TU2000 | Short circuit of thyristors of channel 1 or 3 | FGSCVT1 | 1 | | | |
| | TU1000 TU1001 | Selected channel enabled<br>Selected channel inhibited | FGINH | 0<br>1 | $SW_H$ 0 | 08 | 09 |
| | TU2000 | Overload of three-phase system | FGOVL | 1 | | | |
| For all channels or all three-phase systems of the same unit | Resistive load<br>Short wave infrared elements | | FGIR | 0<br>1 | $SW_L$ 7 | 07 | 08 |
| | Analogue setpoint<br>Digital setpoint | | FGAN | 0<br>1 | $SW_L$ 6 | 06 | 07 |
| | Line over-voltage | | FGOVV | 1 | $SW_L$ 5 | 05 | 06 |
| | Line under-voltage | | FGUNDV | 1 | $SW_L$ 4 | 04 | 05 |
| | Feedback in $V^2$<br>Feedback in V x I | | FGREGU | 0<br>1 | $SW_L$ 3 | 03 | 04 |
| | All series | Burst firing 8 supply cycles | FGRAMP | 0 | $SW_L$ 2 | 02 | 03 |
| | TU1001 | Burst firing with soft start | FGRAMP | 1 | | | |
| | Burst firing 8 supply cycles<br>Burst firing 1 supply cycle (Single cycle) | | FGLTO | 1<br>0 | $SW_L$ 1 | 01 | 02 |
| | TU1000/1001 | Burst firing | FGAP | 0 | $SW_L$ 0 | 00 | 01 |
| | TU1001 | Phase angle | FGAP | 1 | | | |
| | TU2000 | Three-phase system enabled<br>Three-phase system inhibited | FGINH | 0<br>1 | | | |

Table 4-5 Meaning of Status word bits

## COMMAND CODES

The command codes modify certain types of unit operation.

Depending on the destination of the command codes, they are sent to a given address of a channel or a unit, or to all the unit channels communicating with the same bus (using the broadcast address - 0).
The command codes can be broadcast in **all** the protocols.

The **TU** range command codes define:

- for **all the channels** of a selected unit:

  - the thyristor firing modes
  - the feedback type
  - unit inhibition or enable
  - partial load failure detection adjustment request
  - alarm acknowledge
  - fast setpoint transfer in the current Digital setpoint;

- for **one** selected **channel**:

  - operation inhibition or enable.

Although the unit operating mode in all protocols is modified by the command code, the command code is written differently depending on the protocol.

In the **EUROTHERM** protocol, the command code is written in the Status word and then modifies the unit operation.

In the **MODBUS®** and **JBUS®** protocols, the command code is written in the Command code parameter, in the form of its address (see page4-7) and modifies the unit operation.

However, in order to ensure compatibility with other parameters, the Command code parameter in the Modbus® and Jbus ® protocols also performs **reading functions** 3 and 4. However, the value read has no significance and is always **7FFF**$_{\mathbf{HEX}}$ irrespective of the contents of the parameter.

In all the protocols (Eurotherm, Modbus® andt Jbus®), the **new configuration**, after the command code has been written, can be **re-read** in the Status word.

The command codes for **TU** range units are given in table 4-6, overleaf.
In this table, the term "channel" is used in the same way as thyristor channel (number of channels: 1, 2 or 4 - depending on the unit model). The term "system" is used to designate a three-phase system - part of the three-phase unit (TU2000 series) composed of 2 thyristor channels for monitoring 2 phases of a three-phase load.

| Destination of command codes | | Code value | | | Number of channels or systems * | Remarks |
|---|---|---|---|---|---|---|
| | | Decimal | Hexa-decimal | Binary | | |
| Inhibition | | 0 | 00 | 0000 | All unit channels / systems | For all series |
| | | 1 | 01 | 0001 | Selected channel / system | |
| Enable | | 2 | 02 | 0010 | All unit channels / systems | |
| | | 3 | 03 | 0011 | Selected channel / system | |
| Alarm acknowledge | | 4 | 04 | 0100 | All unit channels | |
| PLF adjustment request | | 5 | 05 | 0101 | | |
| Feedback | V x I | 6 | 06 | 0110 | | |
| | $V^2$ | 7 | 07 | 0111 | | |
| Firing mode | Phase angle | 8 | 08 | 1000 | | Only for TU1001 series |
| | Burst firing with Soft start | 9 | 09 | 1001 | | |
| | Burst firing 1 cycle (Single cycle) ** | 10 | 0A | 1010 | | For all series |
| | Burst firing 8 supply cycles ** | 11 | 0B | 1011 | | |
| Fast setpoint transfer to the Digital setpoint | | 12 | 0C | 1100 | | |

Table 4-6 Command code designation

*) Code sent to address **0** - broadcast for all channels of all units communicating on the same bus.
**) Accepted only if the current **does not exceed** the current limit.

## RESPONSE TIME

The response transmission time is the Master's latency time, the time taken by the Slave to perform a complete transaction, i.e. it is the time which may pass between the moment at which the Slave starts the process (end of the question from the Master) until it has completed its response.

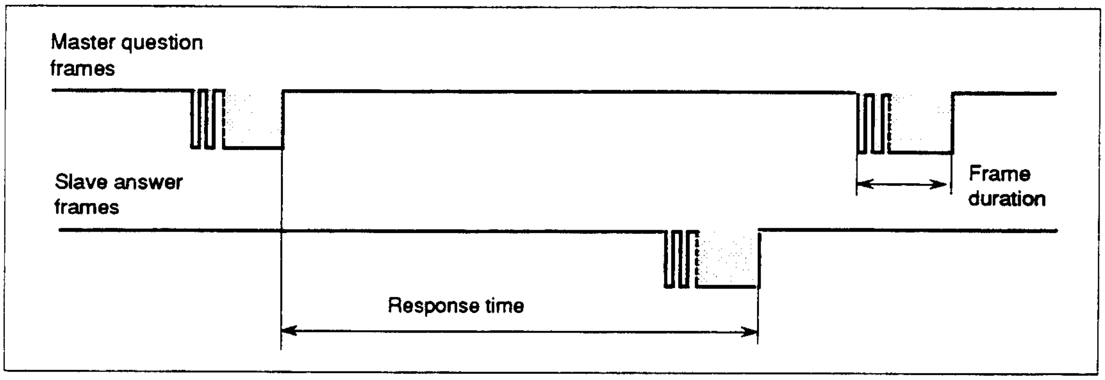



Figure 4-3 Slave response time

While the Slave recognises whether the frame sent by the Master is intended for it or not, there are two possible cases:

- the Slave recognises its address and answers;
- the Slave is not concerned; it reinitialises its communication "buffer" and disconnects from the Master, which makes it possible to connect devices with different Response times to the same communication bus..

The time taken to send the Response depends on the number of data items, the transmission format and the baud rate (see table 4-7).

| Exchange type | | EUROTHERM protocol | | Modbus® / Jbus® protocols | |
|---|---|---|---|---|---|
| | | TU1000 and TU1001 series | TU2000 series | TU1000 and TU1001 series | TU2000 series |
| Reading a parameter | 9600 bauds<br>19200 bauds | 30 to 40 ms<br>20 to 30 ms | 40 to 60 ms<br>- | 30 to 40 ms<br>20 to 30 ms | 40 to 60 ms<br>- |
| Reading n parameters | | Possibility to scan different parameters in a predefined order | | Typical time from 60 to 80 ms for 10 parameters | |
| Writing a parameter | 9600 bauds<br>19200 bauds | Typical time 10 ms | | 30 to 40 ms<br>20 to 30 ms | 40 to 60 ms<br>- |

Table 4-7 Response time according to baud rate, protocol and unit type

The Master ensures that the idle time between two consecutive characters of a frame - Time Between Characters (**TBC**) - is always less than the time for 3 characters.

The TBC is equal to **3.125 ms** max at a baud rate of 9600 baud and to **1. 56 ms** max - at 19200 baud.

The TBC presents the method used by the Slave for synchronisation. When the TBC is greater than this maximum limit, the current frame is abandoned and the next character is considered as the start of a new frame, i.e. as an address. Similarly, the Slave ensures that the TBC of the response frame never exceeds the indicated limit.

# Chapter 5

## TU UNIT OPERATION WITH DIGITAL COMMUNICATIONS

Contents page

# Chapter 5 TU UNIT OPERATION WITH DIGITAL COMMUNICATIONS

## ADDITIONAL INFORMATION ON ELECTRONIC BOARDS

Digital communications TU range power units are equipped with a **Microprocessor board.**
The Microprocessor board, or the Control and communication board (CCC board) makes it possible to communicate via a digital link with a supervisor or a controller. The CCC board is responsible for the feedback type and the firing mode selected by the jumpers or modified by the digital communications.

Each unit has a "**Power supply board**" to supply the unit electronics with signals of different levels. The alarm relay and the diagnostic connector used for connection to the EUROTHERM diagnostic unit are located on the power supply board.

TU1001 series units have a "**Power supply board**" and a "**Firing board**" for each channel.

TU1000 and TU2000 series units have a "**Basic logic firing board**" for all channels (current range 25 to 40 A, maximum voltage 500 V, such as TU1450 and TU2250) or a "**Power supply board**" (also called "Logic firing board") for each of the thyristor channels (current range 40 to 500 A, maximum voltage 660 V, such as the models TU1470 and TU2170, for example).

The figure below gives the arrangement of electronic boards for different unit models.

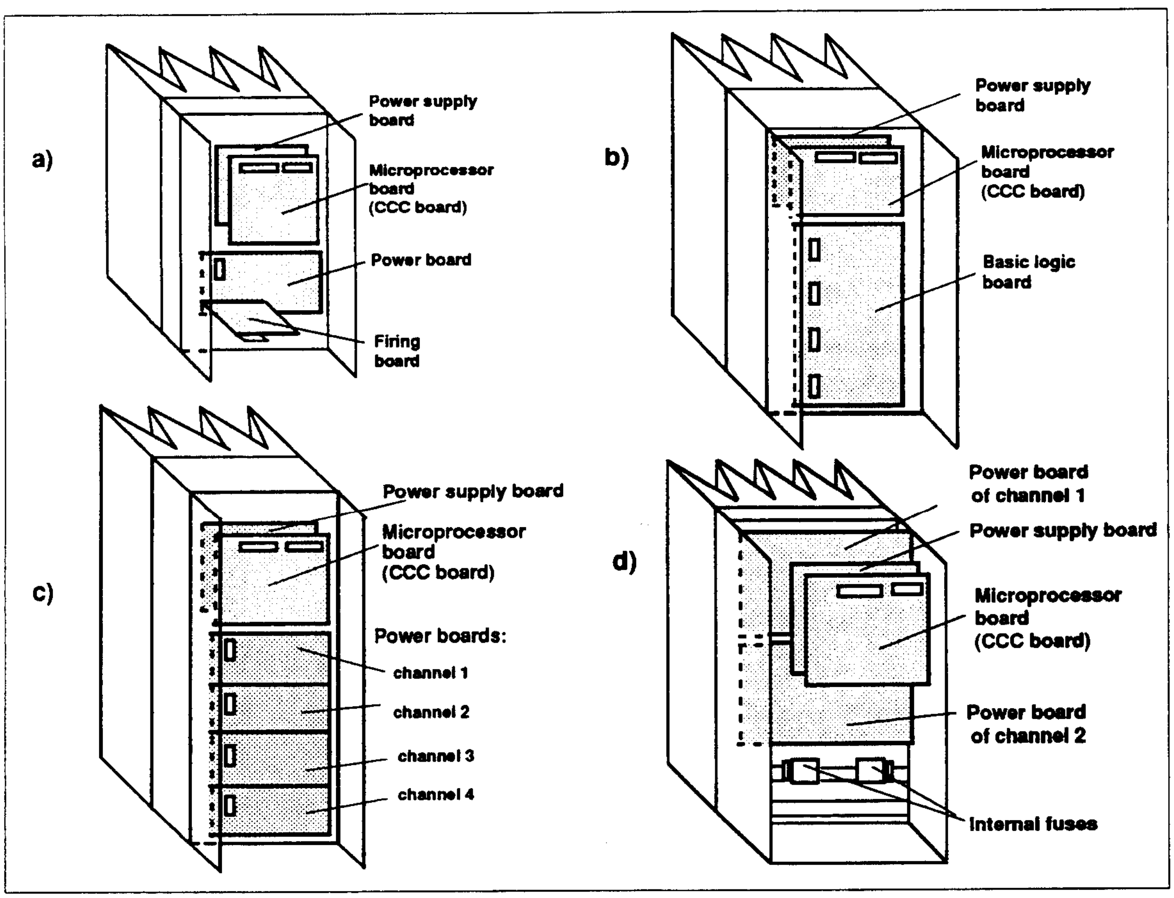



Figure 5-1 Electronic board arrangement

a. - TU1001 series, 1 channel ("Power supply board - Firing board" assembly is added according to number of channels)
b. - TU1000 and TU2000 series, 4 channels, current range 25 to 40 A
c. - TU1000 and TU2000 series, 4 channels, current range 40 to 125 A
d. - TU1000 and TU2000 series, 2 channels, current range 250 and 500 A
(For **c.** and **d.** the number of Power supply boards corresponds to the number of channels).

## ELECTRONICS VOLTAGE CONFIGURATION

The control electronics power supply voltage must correspond to the available power supply. The voltage is selected in the factory, according to the ordering code. Using a jumper on the Power supply board, it is possible to supply the electronics with **220 - 240 V** or another voltage.

The mains power supply voltage is achieved by using a transformer with two primary coils (corresponding to the unit's operating voltage).

5 types of transformer are used; their references and primary voltages are as follows:

| | |
|---|---|
| **CO 173356** | 100 and 200 V 18 V.A |
| **CO 173047** | 115 and 230 V 18 V.A |
| **CO 173394** | 230 and 400 V 18 V.A |
| **CO 173563** | 230 and 440 V 18 V.A |
| **CO 173395** | 230 and 480 V 18 V.A |

The electronics power supply voltage is selected using the **ST1** jumper on the Power supply board (figure 5-2) on the power supply primary coil.

The "**220V** " position of the **ST1** jumper (see table 5-1, overleaf) is used to supply **220-240 V** to a unit equipped with any transformer (200 V for CO 173356).

The "**OTHERS** " position of the **ST1** jumper is used to supply a unit with **100, 115, 400, 440** or **480 V** according to the transformer.

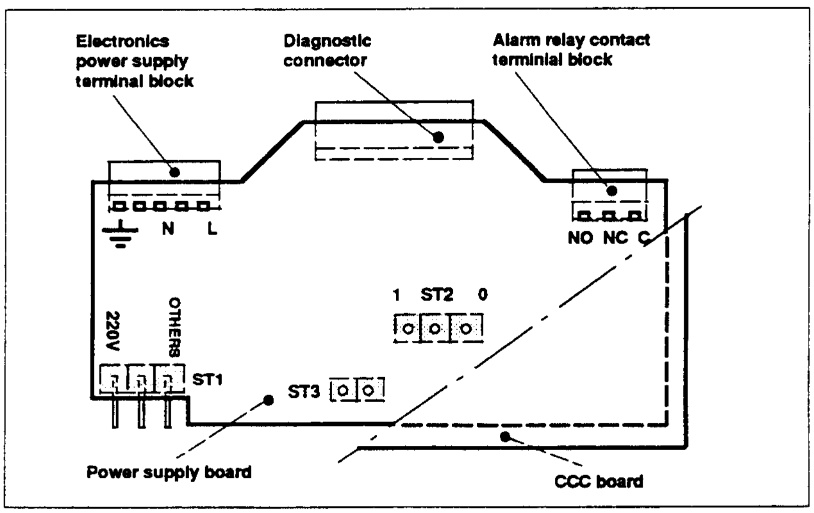



Figure 5-2 Lay-out of jumpers on the Power supply board (user's view)

The voltage selection used for the **feedback** on the CCC board (to indicate the line to line voltage to the microprocessor) is made by the **ST2** jumper on the Power supply board. This voltage may correpond to the electronics power supply voltage or to the line to line voltage.

When the voltage for the feedback is taken on the line to line voltage (TU1001 series), in order to prevent an under-voltage fault, the following must be carried out

- always connect the first channel of multichannel units;
- connect the power before or at the same time as the electronics power supply is connected.

When the voltage used for the feedback is that of the electronics power supply (TU1000 and TU2000 series), in order to obtain correct unit feedback operation, the following must be carried out:

- connect all the power channels and the electronics power supply on the same phase (or the same phases); for the TU2000 series, this is the voltage between two monitored phases.

The name and positions of the jumpers on the Power supply board are given in the following table.

| Options | | Jumper position (power supply board) | | | THSW pins (power board) |
|---|---|---|---|---|---|
| | | ST1 | ST2 | ST3 | |
| Primary power supply voltage | 220 (240) V | 220V | | | |
| | 110 (120 )V | OTHERS | | | |
| | 380 (415 )V | OTHERS | | | |
| | 480 (500) V | OTHERS | | | |
| Voltage return for feedback | TU1000 and TU2000 series | | 0 | | |
| | TU1001 series | | 1 | | |
| Temperature safety switch connection | TU1000 and TU2000 series Ventilated units | | | Jumper | W. loom |
| | TU1001 series Fan-cooled units | | | W. loom | - |
| | All non-fan-cooled units | | | Jumper | Bridge |

For ventilated units from the TU1001 series, the temperature safety switches (**"thermal switches"**) located on the thyristor heatsink, are connected by a wiring loom with the **ST3** pin on the power supply board. For TU1001 series units, the opening of the a thermal switch (in the event of abnormal overheating or a fan shutdown) or of the **ST3** jumper breaks the voltage monitoring circuit of the Firing board and produces an Under-voltage alarm with thyristor inhibition.

For ventilated units from the TU1000 and TU2000 series, the thermal switches are connected by individual **wiring looms** directly onto the **THSW** pins of the Power board of each channel. The opening of a thermal switch or of the **ST3** jumper breaks the thyristor control circuit and produces a Total load failure alarm.

For all non-fan-cooled units, the **THSW** pins of the Power board must be **short circuited** by bridges.

## CCC BOARD CONFIGURATION

The operation configuration of the digital communications and of their parameters, the remote input, the initial firing mode (after power-up), the feedback type, unit address and load type is made with the Microprocessor board jumpers. Most of these parameters can be modified with the digital communications command codes (see page 4-13).

To access the CCC board jumpers, oepn the front fascia.

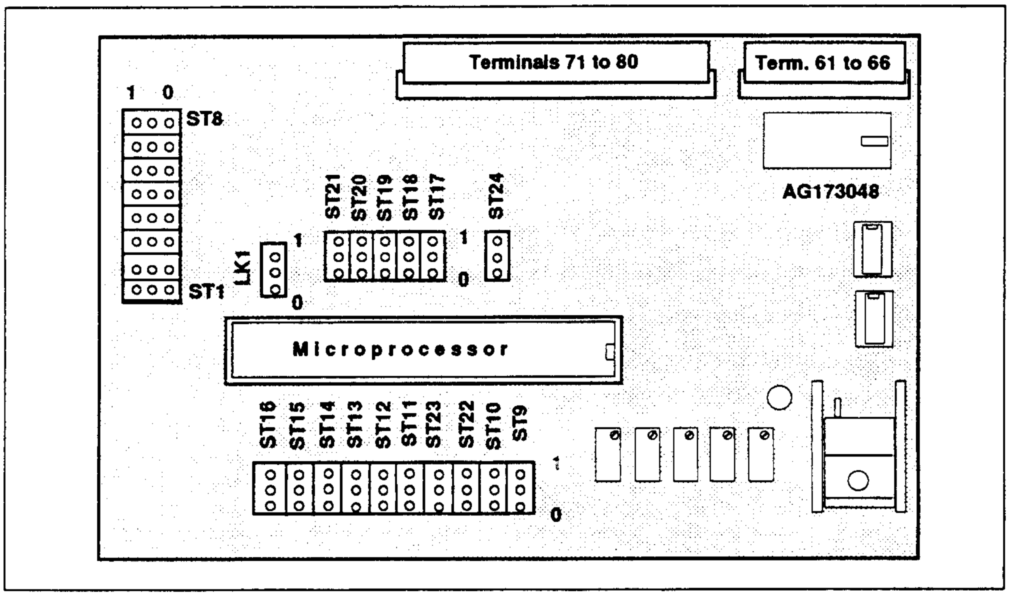



Figure 5-3 Lay-out of jumpers on the Microprocessor board

### Jumpers concerning digital communications

The "Watchdog" jumper (**LK1** in figure 5-3) must be in position **1** for correct unit operation. The position **0** is used for maintenance purposes.

The ST9 jumper determines the digital communications operation:

- for operation **with** digital communications, the **ST9** jumper must be in position **1.**
- the **ST9** jumper is in position **0** for operation **without** digital communications.

The baud rate and protocol type configuration is given in the table below.

| Communication parameter | | Reminder: digital communications valid (ST9 = 1) | |
|---|---|---|---|
| | | Jumper position | |
| | | ST10 | ST21 |
| Baud rate (Baud) | 9600 | 0 | - |
| | 19200 (except TU2000) | 1 | - |
| Protocol loaded in microprocessor | Eurotherm | - | 0 |
| | Modbus® | - | 0 |
| | Jbus® | - | 1 |

Table 5-2 Jumper configuration for digital communications

## Unit address configuration

The unit's physical address is determined by the position of the 8 jumpers **ST11** to **ST16**, **ST22** and **ST23** on the CCC board. The positions of these jumpers (**1** or **0**) are related to the address expressed in **binary code** over **8** bits.

**Example. Define the jumper position from the address for a number 92 unit.**

**The address 92** in binary over 8 bits: **0 1 0 1 1 1 0 0**

Bit N°7 — Bit N°0

This address in binary code corresponds to the following jumper configuration on the CCC board.

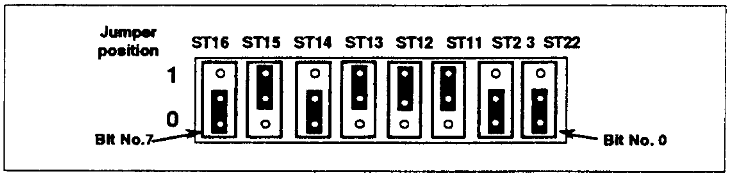



Figure 5-4 Example of jumper configuration for address 92

The address **0** (broadcast) cannot be configured by jumpers, it is sent by the communication.

## Initial thyristor firing mode selection

The ST18 jumper defines the firing mode after the power-up of the electronics power supply. This mode can be modified by digital communications command codes (see page 4-13).

| Load | Series | Initial thyristor firing mode | ST18 jumper position |
|---|---|---|---|
| Single-phase | TU1000 | Single cycle (1 supply cycle) | 0 |
| Single-phase | TU1001 | Phase angle | 1 |
| Three-phase | TU2000 | Single cycle (1 supply cycle)<br>Burst firing (8 supply cycles) | 0<br>1 |

Table 5-3 Initial thyristor firing mode configuration

## Feedback type and load type selection

The **ST17** jumper of the CCC board defines the initial feedback type (feedback selected after power-up of the electronic power supply). Two jumpers **ST20** and **ST24** define the load type.

With the "Resistive load" option (position **0** of **ST20**), the partial load failure detection uses the linear resistance curve. The "Infrared" option (position **1** of **ST20**) indicates to the microprocessor to use the typical curve of the short wave infrared elements memorised for the partial load failure detection circuit.

The ST24 jumper position depends on the single or three-phase load.

| Option | | Jumper position | | |
|---|---|---|---|---|
| | | ST17 | ST20 | ST24 |
| Feedback | V2 | 0 | - | - |
| | V x I | 1 | - | - |
| Load | Resistive | - | 0 | - |
| | Short wave infrared | - | 1 | - |
| | Single-phase (TU1000 and TU1001 series) | - | - | 0 |
| | Three-phase (TU2000 series) | - | - | 1 |

Table 5-4 Feedback type and load type configuration

It should be pointed out that the position of jumpers **ST17** and **ST20** indicated in table 5-4 defines operation **at power-up** only. The type of feedback and load (with the standard linear curve or with the typical short wave element curve) can be **modified** by Command codes sent via communications.

## Analogue input selection

TU range digital communication units can be controlled by the analogue setpoint.

The analogue setpoint is either the main setpoint sent by a controller, or the default setpoint (see page 5-16) in the event of a communication failure.

To use the analogue setpoint, carry out the following:

- select the **type** (voltage or current) and the input value using the jumpers on the CCC board for all the unit's channels
- connect the "**A/D**" input on the CCC board to "**0V**" on the same board or leave it free.

Eight jumpers (**ST1** to **ST8**) are used to select the input as voltage or as current and the **ST19** jumper indicates to the microprocessor the scale used for the analogue signal.

| **Input analogue signal** | | **Jumper position** | | |
|---|---|---|---|---|
| **Input type** | **Level** | **ST1 to ST4** | **ST5 to ST8** | **ST19** |
| Voltage (DC) | 0 - 5 V | 0 | 0 | 0 |
| | 1 - 5 V | 0 | 0 | 1 |
| | 0 - 10 V | 0 | 1 | 0 |
| | 2 - 10 V | 0 | 1 | 1 |
| Current (DC) | 0 - 20 mA | 1 | 0 | 0 |
| | 4 - 20 mA | 1 | 0 | 1 |

Table 5-5 Analogue input configuration

The analogue signals arrive on terminals **76** to **79** on the CCC board (see figure 5-6, overleaf). The use of terminals 76 to 79 depends of the number of channels or three-phase systems, as indicated in the table below.

| **Unit type** | | **Analogue input terminals used** | **Recommendation** |
|---|---|---|---|
| Single-phase | 1 channel<br>2 channels<br>4 channels | 76<br>76 and 77<br>76, 77, 78 and 79 | The analogue input terminals not used must be connected to "0V" |
| Three-phase | 1 system<br>2 systems | 76<br>76 and 77 | |

Table 5-6 Analogue setpoint signal connection on the CCC board

The analogue input **impedance** on the CCC board:

- 10 KΩ for the voltage input (10 V)
- 250 Ω for the current input.

## PROTOCOL CHECK OR MODIFICATION

There are two types of microprocessor (two references):

- that on which the EUROTHERM protocol is loaded
- that on which the MODBUS® and JBUS® protocols are loaded.

The protocol loaded in the microprocessor is defined when the order is placed.
A label attached to the microprocessor (figure 5-5) identifies the type of protocol. On this label:

- **EIP** designates the Eurotherm protocol
- **MOP / JBP** designates the Modbus® and Jbus® protocols.

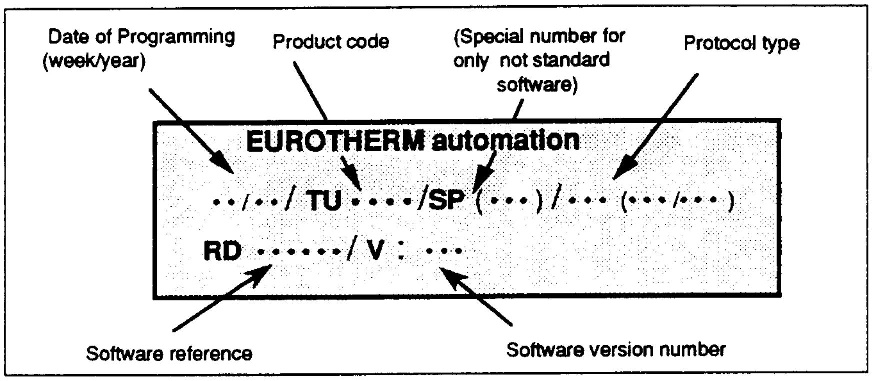



Figure 5-5 Microprocessor label

To **change** the Eurotherm protocol or the Modbus® /Jbus® protocols, the **microprocessor** must be changed.

The Modbus® and Jbus® protocols are selected with the ST21 jumper (see table 5-2, page 5-5).

## PERMANENT MEMORY CONFIGURATION

The following are stored in the Electrically-Erasable Programmable Read-Only Memory (EEPROM):

- the Partial load failure detection adjustment value **(PLF adjustment)**
- The **Current limit** setpoint value

(In the special digital communications version, the Setpoint limit parameter is stored, see p.5-17).

During the PLF adjustment phase, (see page 6-5) as soon as the microprocessor has calculated the impedance of this value, it is **memorised** in EEPROM for each channel. This enables the CCC board to find the adjustment value after each restart.

For a write entry on the Current limit setpoint (or in the Setpoint limit), the limited values for each channel are stored in EEPROM which has a capacity of **tens of thousands** of entries.
For this reason, it is **not recommended** to include these 2 parameters (Current limit and Setpoint limit) in a systematic write loop.

If the EEPROM is **not initialised**, no parameter values are stored and the Status word remains unchanged.

In the Modbus® / Jbus® protocols, the error code 04 indicates an attempt to write to EEPROM while it is already occupied (page 3-14).

In the event of an **error** or damage to the EEPROM, the microprocessor **resets** the memorised parameters to their **nominal** value.

## COMMUNICATION BUS CONNECTION

The use of the Digital Setpoint (sent via the communication bus on terminals **61** to **65** ) requires the connection of the "A/N" input on the CCC board (terminal **74**) to "**+10 V**" (terminal 73).

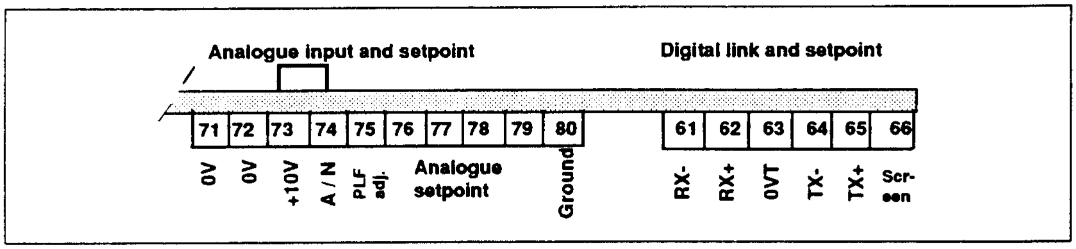



Figure 5-6 CCC board input terminal blocks

The CCC board communicates with other units via a communication bus. This link, for the TU range units, complies with two bus standards: **RS422** and **RS485.**

The maximum transmission line length is **1200 m.** On the CCC board, the thermination impedance has been set arbitrarily to **4.7 kΩ** (the user may reduce this value if required).

The **RS422** serial link is a "Full duplex" type link - exchange is possible in both directions at the same time. The **RS485** link is a "Half duplex" link - non-simultaneous link in both directions.

However, for **TU** range communications, only the **alternate** transmission mode is used, with a **non-simultaneous** link in both directions: "Question from Master - Answer from Slave".

On the RS422 and RS485 links, there are **4 active wires**: 2 Transmission wires (TX+ and TX-) and 2 Reception wires (RX+ and RX-) and a "**0V**"common reference wire for Transmission and Reception.

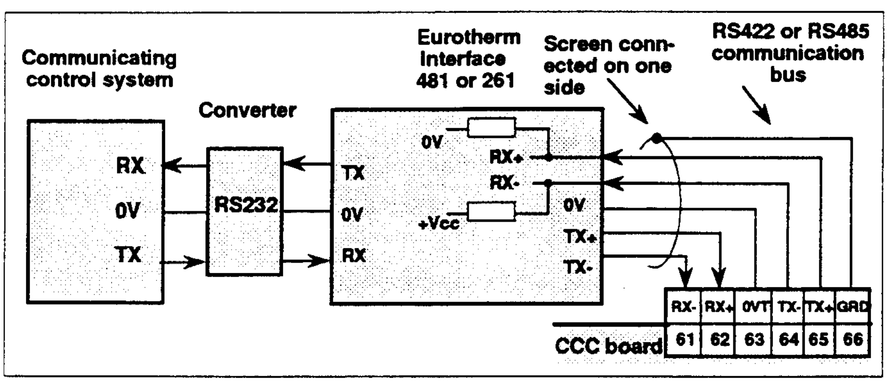



Figure 5-7 5 wire communication bus

| Desti-nation | Terminals Interface type | |
|---|---|---|
| | 481 | 261 |
| TX | 10 | 2 |
| RX | 11 | 3 |
| 0 | 8 | 7 |
| RX+ | 7 | 3 |
| RX- | 6 | 16 |
| 0V | 8 | 7 |
| TX+ | 4 | 12 |
| TX- | 5 | 13 |

Table 5-7 Interface terminal destination

Since the non-simultaneous link is used, it is possible to use the RS422 and RS485 bus with **2 active wires** (TX and RX).

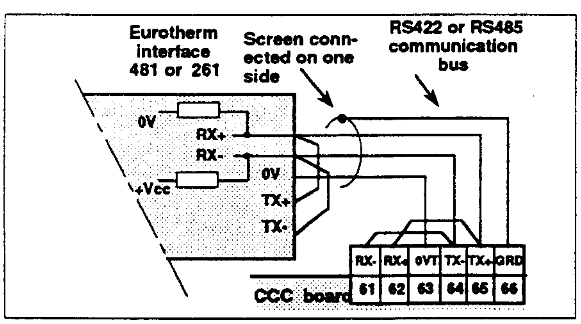



Figure 5-8 3 wire communication bus wiring diagram

**Note**

If interface 261 is used at baud rates greater than or equal to 19200 bauds, the LK4 and LK6 links must be removed inside the interface.

# OPERATION

The "Operation" paragraph contains explanations of :

- thyristor firing modes,
- the current limit,
- value measurement and retransmission for feedback,
- the special communications version and
- communication failure operation.

## Firing modes

### General

The thyristor firing modes available depend on the thyristor **firing type**:

- at **zero voltage**, the entire cycles are energised or blocked - TU1000 and TU2000 series;
- with thyristor firing **angle feedback** (form 0 to 180°) - TU1001 series.

The TU1000 and TU2000 series have 2 firing modes:

- Burst firing with 8 firing (or non-firing) supply cycles
- Burst firing with 1 firing (or non-firing) supply cycle - known as Single cycle.

The second thyristor firing type when the firing angle is 0° (at zero voltage) is the same as the first firing type. For this reason, the TU1001 series has 4 firing modes:

- Phase angle (firing angle variation within each supply cycle)
- Burst firing (1 or 8 supply cycles)
- Burst firing 8 supply cycles with 4 supply cycles of a gradual firing angle increase - known as Soft start.

The initial firing mode (after each power-up or digital communications Reset) depends on the series and the position of the ST18 jumper on the CCC board.

| Series | Initial firing | Firing mode: General | Firing mode: Type | Command code | Status word bit number 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|
| TU1000 | ST18 = 0 Single cycle | Burst firing | 1 cycle (Single cycle) | 0A | 0 | 0 | 0 |
| | | | 8 cycles | 0B | 0 | 1 | 0 |
| TU1001 | ST18 = 1 Phase angle | Phase angle | | 08 | 1 | - | - |
| | | Burst firing | 1 cycle (Single cycle) | 0A | 0 | 0 | 0 |
| | | | 8 cycles | 0B | 0 | 1 | 0 |
| | | | 8 cycles with Soft start | 09 | 0 | 1 | 1 |
| TU2000 | ST18 = 0 Single c. | Burst firing | 1 cycle (Single cycle) | 0A | - | 0 | 0 |
| | ST18 = 1 Burst firing | | 8 cycles | 0B | - | 1 | 0 |

Table 5-8 General characteristics of thyristor firing modes

## Burst firing

This firing mode is a **proportional** cycle which consists of emitting a series of the **complete** supply cycles of mains voltage on the load. To prevent significant variations in load current, the unit firing is activated and deactivated at **zero voltage.**

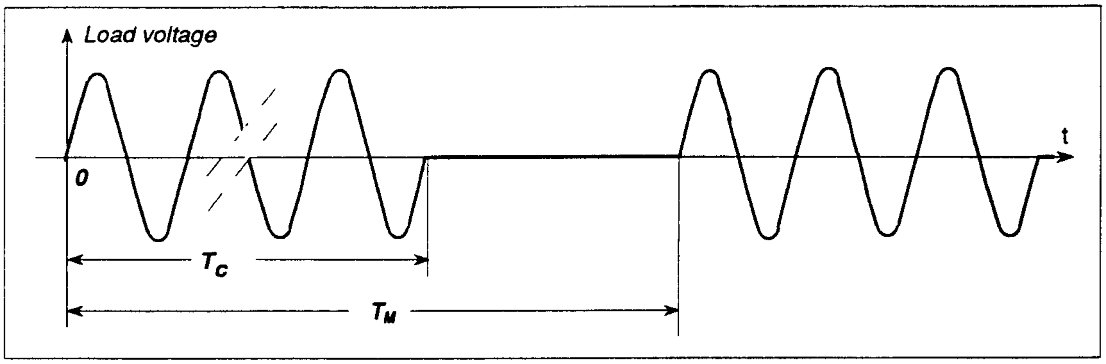



Figure 5-9 "Burst firing" mode
$T_C$ - firing time; $T_M$ - modulation period

Feedback in **Burst firing** is performed with the firing time $T_C$ (or non-firing time: $T_M$ - $T_C$) constant and equal to 8 supply periods and the variable modulation time $T_M$.

The time $T_C$ is calculated by the microprocessor as a function of the setpoint and the measurement feedback performed by the feedback system. **The cyclical ratio** of basic burst firing modulation ($T_C$ / $T_M$) is calculated by the feedback system
in order to retain the best accuracy irrespective of the output power.

**For a power less than 50%, the firing time is 8 supply cycles**
**However, for a power greater than 50%, the non-firing time is set to to 8 supply cycles.**
**For 50% of the power, the firing time (8 supply cycles) is equal to the non-firing time.**

## Single cycle

The Burst firing mode with **only one** firing (or non-firing) **cycle** is called the **Single cycle.**

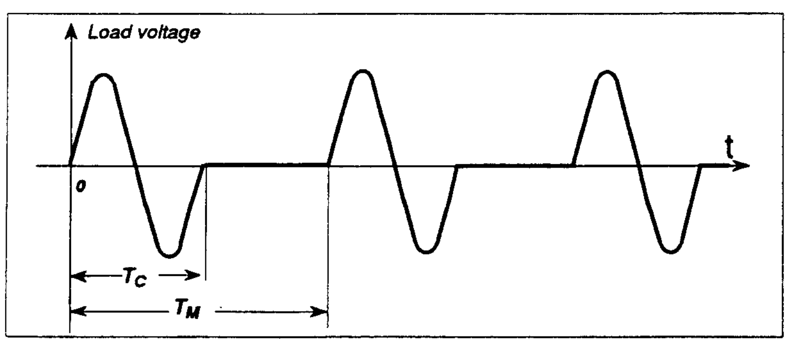



Figure 5-10 "Single cycle" firing mode (50% power)

**For a power less than 50%, one cycle is firing and a variable number of cycles is blocked.**
**For a power greater than 50%, one cycle is blocked and a variable number of cycles is firing.**
**For 50% power, one supply cycle of the main voltage is firing and one cycle is blocked.**

It should be noted that increasing the basic burst firing length (firing time - $T_C$) also induces an increase in the feedback response time. The burst firing length (1 cycle - Single cycle, or 8 cycles - Fast cycle) is selected using the command codes **0A** and **0B**, respectively.

## Phase angle (TU1001 series)

In this firing mode, the power transmitted to the load is achieved by firing the thyristors during each half cycle of the mains. The firing angle is determined by the output power demand.

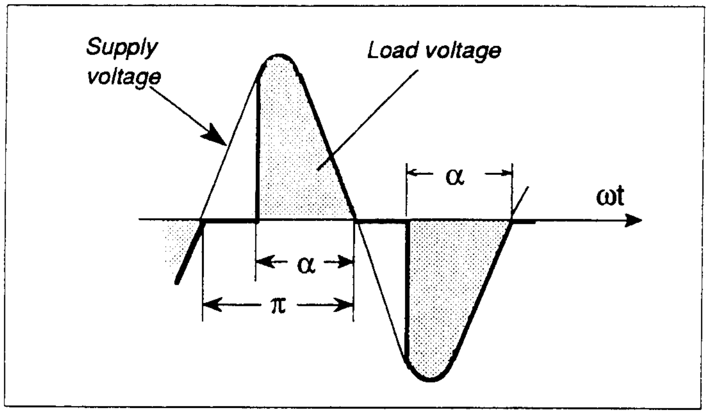



Figure 5-11 "Phase angle" thyristor firing mode

The firing angle (α) varies in the same direction as the output power, but the power emitted to the load is not a linear function of the firing angle.

The Phase angle firing mode is only available for the TU1001 series equipped with adjustable thyristor firing.

## Soft start (TU1001 series)

Units equipped with the Phase angle firing mode can be restarted at each recurring cycle in Burst firing with a low thyristor firing angle which is increased gradually. This firing mode is known as **Soft start.**

Soft start is used to prevent current peaks during the power-up of loads with a low resistance to the cold and of transformer primary coils. The firing angle is gradually increased during the first 4 supply cycles of the basic burst firing. During this start-up period, the unit output power changes from 0 to 100% by varying the thyristor firing angle from 0 (thyristors blocked) to 180° (full thyristor firing).

## Firing mode change by communication

The thyristor firing modes initially selected by jumpers on the CCC board or changed during unit operation can be modified by communication using command codes (see pages 4-12 and 4-13) on all the channels of the unit simultaneously.

Sending Command codes (Modbus® and Jbus® protocols) or writing in the Status word (Eurotherm protocol) modifies the firing mode. Between each change of mode, the feedback is reinitialised and the Output power feedback loop is reset.

The codes **8** to **11** (corresponding to the four firing modes described above) are used to change the firing mode in TU1001 series units.
If the current limit is active on one of the channels in Phase angle mode, changes to Burst firing mode are rejected since in this mode, exceeding the current limit inhibits the unit.

For the TU1000 and TU2000 series, the codes **8** and **9**, corresponding to the Phase angle and Soft start firing modes, are not available.

## Current limit

The term **Current limit** is used in two different contexts:

- as an operating **parameter**, to indicate the Current limit setpoint which contains the permissible current threshold values for each channel (see page 4-5)
- as an operating **mode** for TU1001 series units in Phase angle firing mode after the current threshold has been exceeded in one of the channels in order to **limit the rms value** of the current.

In this paragraph, the Current limit is described in the second context, as a current **reduction** (limiting) **action** of the load concerned by the thyristor **firing angle variation** in order **to maintain the rms current at the current threshold** set with the Current limit setpoint.

The "Current limiting" **action** is activated when the **rms** value of the load current (calculated by the microprocessor) exceeds the current threshold fixed by the Current limit setpoint.

The current limit status is available with bit **3** of $\mathbf{SW_H}$ (Most significant byte of Status Word). This bit is set to **1** when the "Current limit" action is active.

## Enabling and inhibition

Each thyristor unit can be enabled or inhibited, channel by channel (three-phase system by system) or all channels, using digital communications. Using the broadcast address, all the units of the same communication bus can be enabled or inhibited simultaneously.

These procedures are performed by sending Command codes (Modbus®/Jbus® protocols) or by writing command codes in the Status word (Eurotherm protocol). The relevant codes are given in table 4-6, page 4-13.

For all units (except TU2200 models), the channel status (**channel** enabled or inhibited) can be accessed with Most significant byte bit **No. 0** of the Status word (see table 4-5, page 4-11). The Inhibition flag (**FGINH**) is set to **0** when the selected channel is **enabled**, and set to 1 when the selected channel is **inhibited.** For TU2200 models, Most significant byte bit No. 0 of the Status word indicates the status of the **unit**. The unit is enabled when flag FGINH = 0.

After the interface power-up or after a reset (reinitialisation) due to the "Watchdog", the flags FGINH = 0 for all the channels. Therefore, the unit is enabled.

Channel inhibition is planned as an **action** after the current threshold has been **exceeded** by 10% for units operating in Burst firing, Single cycle or Soft start (see "Alarms" chapter).

In the event of failure of the digital communications and operation in default mode with the analogue setpoint (see page 5-16), the following must be carried out for channel **inhibition**:

- disconnect the link "+10V" (terminal 3) to "VAL" (terminal 4) on the Firing board (TU1001 series) or on the Power board (TU1000 series, except for model TU1450, and TU2000).

- open the switch in the input circuit when the signal is a voltage or short circuit the command if the inputs are a current (TU1450 model);

The channels are initially enabled by connecting the "+10V" and "VAL" terminals. Enabling by communication is performed with command codes 2 and 3 (see page 4-13).

After channel inhibition, restarting is only possible **after the alarm acknowledge** (see page 6-8).

# Feedback

## General

TU range units have two types of feedback:

- the load **voltage** - with feedback in "$V^2$" ($V_{rms}$ x $V_{rms}$) and
- the **load power** - with feedback in "**V x I**" ($V_{rms}$ x $I_{rms}$).

The choice between two types of feedback is made using the **ST17** jumper on the CCC board (see page 5-6). After each power-up or reset of the microprocessor, the feedback is in "$V^2$" if the position of the ST17 jumper = **0** and in "**V x I**" if ST17 = **1.** This choice can be modified by sending command codes.

The current feedback type can be accessed with Most significant byte Bit **No. 3** of the Status word. The **Feedback flag** FGREGU = **0** when the feedback is in "$V^2$" and FGREGU = **1** during the use of the feedback in "**V x I**".

It should be noted that the feedback type is the **same** for all unit channels.

## Value measurement and retransmission for feedback

To obtain the rms value of the load voltage ($V_{rms}$ ) in order to produce the feedback algorithm, the microprocessor measures the line voltage. This value correponds:

- either to the electronics supply voltage for the TU1000 and TU2000 series,
- or to the power supply voltage of channel 1 for the TU1001 series.

The microprocessor retransmits the voltage measured by the **Line to line voltage** (mnemonic **LV** in Eurotherm protocol or address **07** in the Modbus® protocol). From this value, the microprocessor produces $V_{rms}$ taking into account the thyristor firing angle (in Phase angle) or the cyclical ratio of the modulation (in Burst firing). The value of $V_{rms}$ is retransmitted using the **Load voltage** parameter (mnemonic **VV** in the Eurotherm protocol or address **05** in the Modbus® protocol).

Using the same principle, but taking into account the measurement of the mean current in the load (rectified double alternation, filtered), the microprocessor calculates the value of $I_{rms}$ which is retransmitted by the **Load current** parameter (mnemonic CV in the Eurotherm protocol or address **06** in the Modbus® protocol).

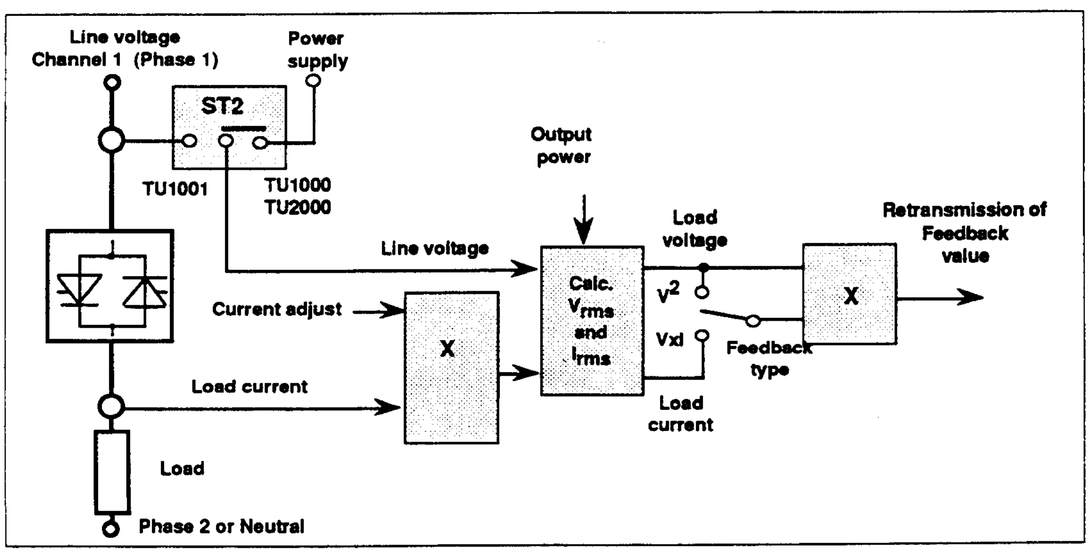



Figure 5-12 Retransmission mimic diagram

## Output power production

The feedback algorithm produces the Output power setpoint (thyristor control setpoint).
This parameter shows the value of the internal controller output, which corresponds:

- either to the thyristor firing angle setpoint (in Phase angle),
- or to the cyclical ratio of the modulation (in Burst firing, Single cycle or Soft start).

The **Output power** parameter is identified with the mnemonic **OP** (Eurotherm protocol) or the address **04** (Modbus® protocol)

In the standard version, the Output power is produced using the digital setpoint or the analogue setpoint (depending on the user's choice) and the feedback value (Feedback value). The **Feedback value** parameter is represented by the mnemonic **PV** (Eurotherm protcol) or by the address **03** (Modbus® protocol).

It should be noted that the type of setpoint used by the user determines the "A/N" input position on the CCC board. The "A/N" input (terminal 74) must be:

- connected to "10V" (Digital setpoint) or
- connected to "0V" or "free" (Analogue setpoint).

The value of the digital and analogue setpoints and of the fast setpoint transfer can be **read** irrespective of the "A/N" input position.

It is always possible to write in the Digital setpoint and Fast setpoint transfer.

These two setpoints can be **broadcast.**

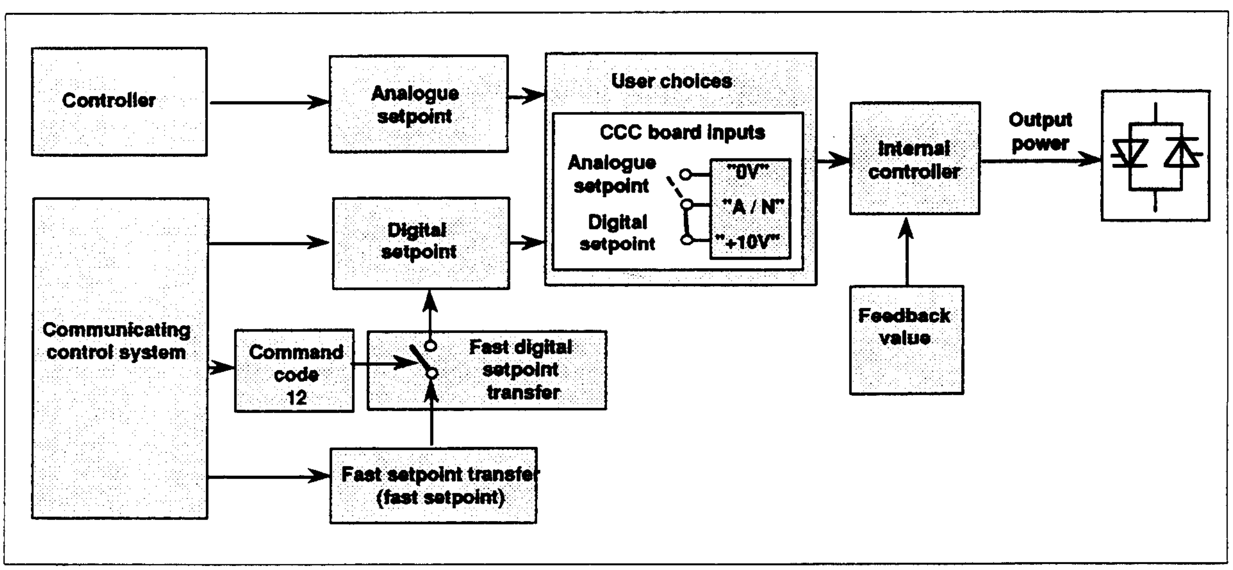



Figure 5-13 Output power setpoint production

In Phase angle firing mode (TU1001 series), for producing the Output power, the minimum of two setpoints is taken into account: Current limit and feedback.

## Operation in the event of communication failure

In the event of communication failure, the default position consists of controlling the unit in local mode, using the analogue inputs available on the CCC (microprocessor) board.

The digital communications failure can be detected by the Master's unit or by an external unit since the protocols used are totally asynchronous and do not provide for overshooting the assigned time reserved for a response.

Digital communications failure can have 2 different causes :

- faulty Master operation (detection by a different system)
- communication line failure (detection of absence of CCC board response)

If the unit operates with the Digital Setpoint at the time as the communication failure, the use of the Analogue Setpoint in local mode requires:

- the **disconnection** of the "A/N" input from "+10V" (terminals 74 and 73 on the CCC board, respectively)
- the **application** of the analogue setpoint to the remote units **or**
- **control** with the analogue signal sent by a potentiometer (local mode).

The **10 kΩ** potentiometers are provided to control each of the unit channels in local mode. The potentiometers used are connected between the **"0V"** and **"+10V"** terminals on the CCC board (or connected to another analogue signal 0 - 10 V). The potentiometer cursor is connected to the analogue input of the channel monitored on the CCC board.

The analogue inputs and the corresponding terminals used in the various unit models are described in table 5-6 (page 5-7). It is recommended that unused inputs are connected to 0V (terminal 71 or 72).

An example of the connection of 2 potentiometers for local mode control of the unit with 2 independent channels is given in the figure below.

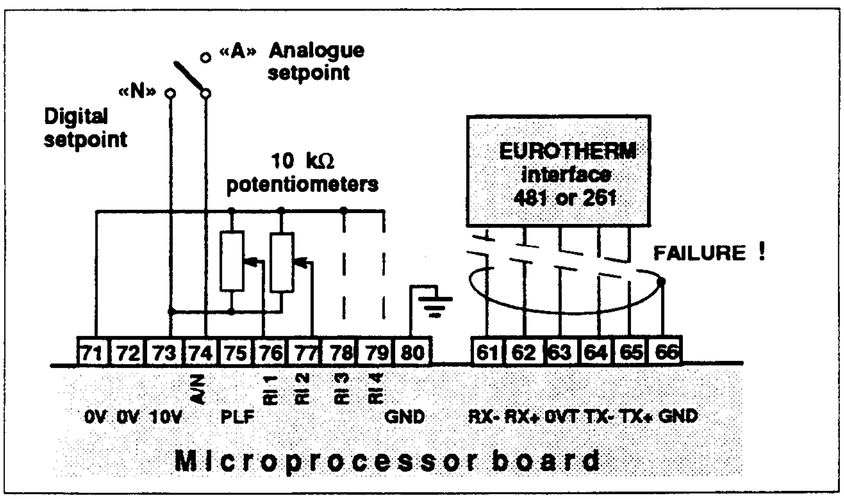



Figure 5-14 2 channel unit local mode wiring diagram in the event of communication failure

If, at the time of the communication failure, the unit operates with the Analogue Setpoint with digital checking, the unit **continues to operate** with the analogue inputs configured by the jumpers.

It is possible to inhibit the unit after a communication failure has been detected (see page 5-13).

## SPECIAL VERSION

The special digital communications version was developed to produce an output power with command setpoint limiting. The special version uses two new parameters:

- **Setpoint limit**
- **Working setpoint.**

The Setpoint limit parameter sets the maximum level of command setpoints (both digital and analogue) taken into account by the feedback, while retaining the linearity of the "Input - Output" function.

The Setpoint limit parameter **replaces** the Fast setpoint transfer of the standard version, it is identified by the same addresses in the Modbus® / Jbus® protocols as the Fast setpoint transfer and is characterised by the same format (0-1000) and status ("Read only"). In the Eurotherm protocol, the Setpoint limit is transmitted by the mnemonic **HS**.

| Parameter | | | Standard version | Special version |
|---|---|---|---|---|
| Fast setpoint transfer | Mnemonic | Eurotherm | FS | - |
| | Address | Modbus® (Jbus®) | 01 (02) | - |
| Setpoint limit | Mnemonic (code) | Eurotherm | - | HS (48 53) |
| | Address | Modbus® (Jbus®) | - | 01 (02) |
| Feedback value | Mnemonic | Eurotherm | PV | No access by communication |
| | Address | Modbus® (Jbus®) | 03 (04) | |
| Working setpoint | Mnemonic (code) | Eurotherm | - | SP (53 50) |
| | Address | Modbus® (Jbus®) | - | 03 (04) |

Table 5- 9 Characteristics of the parameters of the special communications version

The Working setpoint parameter represents a **resultant** setpoint, taking into account the current setpoint and the Setpoint limit. In the special version, the Working setpoint is the result of **multiplying** the Setpoint limit **value** by the value of a Digital setpoint or Analogue setpoint parameter.

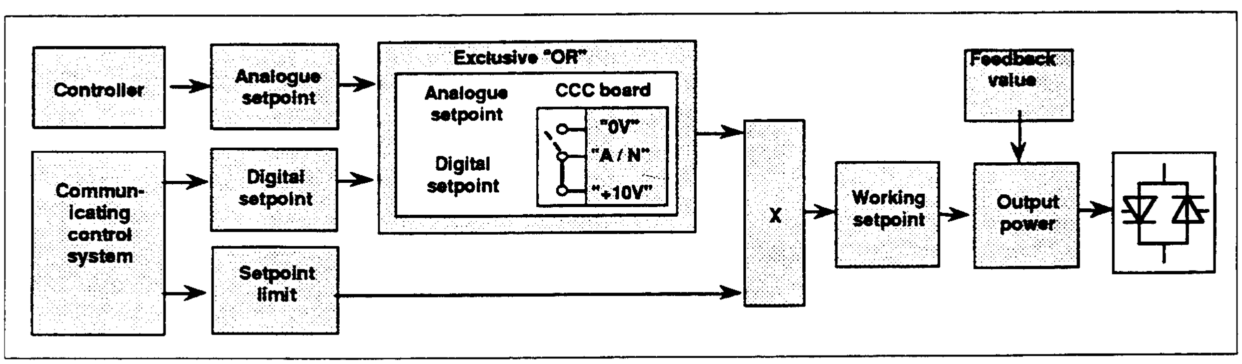



Figure 5-15 Working setpoint production in the special version

The algorithm shown in figure 5-15 is used for normal addressing. For broadcasting, Working setpoint production only uses the Limit setpoint and the Digital setpoint.

In the list of parameters, the Working setpoint occupies **the place** of the Feedback value, but **allows** it to perform its role in the feedback algorithm (the feedback value is no longer accessible by communication).

In the Eurotherm protocol, the **Working setpoint** is retransmitted by the mnemonic **SP** ("Read only" status and 0-100% format).
In the Modbus® protocol, the **Working setpoint** is located at address **03**, its status is "Read only" and its format 0-1000. It can be accessed with read functions 3 and 4 .
The use of the special version requires a **change of microprocessor**.

# UNIT CALIBRATION AND DIAGNOSIS

## General

The nominal currents of the loads may be less than or equal to the unit's nominal current. To adjust the operating parameters of the digital communications and the unit, the unit must be calibrated.

The unit's nominal voltage, the supply voltage used (**unit voltage calibration**), the currents of each load and the unit's nominal current (**channel current calibration**) can be adjusted for the TU range using:

- **digital communications**
- the **EUROTHERM diagnostic unit, type 260.**

The **P2** potentiometer of the CCC board is intended to calibrate the **voltage** of the unit.

The potentiometers **P3** to **P6** of the CCC board are used to calibrate the current of each independent **channel or each** three-phase **system**. The number of available potentiometers corresponds to the number of channels (three-phase systems) of the model used.

The calibration potentiometers can be accessed via the **front fascia** of the unit.
They are identified as follows on the front fascia:

- "**V**" - to calibrate the unit's voltage
- "**I1**" to "**I4**" (depending on the unit model) - to calibrate the current of the channels.

An example of calibration potentiometer designation for a 4 channel unit is given in the figure below.

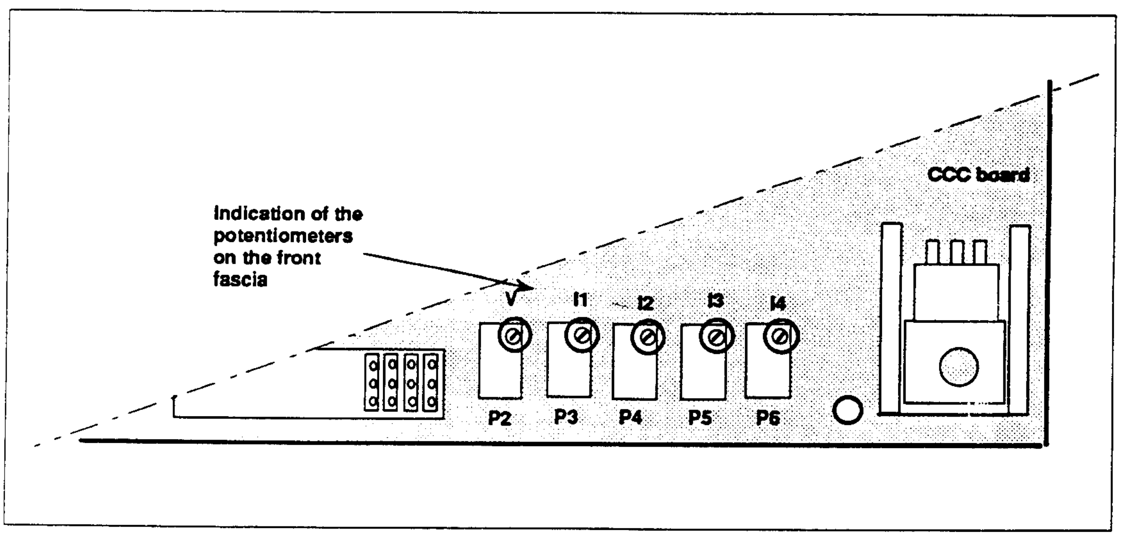



Figure 5-16 Calibration potentiometer lay-out (4 channel unit)

Calibration must **not** be performed during firing.

## Calibration with digital communications

To calibrate the unit's current and voltage with digital communications, the following information is required:

- unit's nominal current
- nominal load currents
- line to line voltage.

### Channel current calibration

- For each channel (or for each three-phase system), calculate the **Current adjust** parameter

$$\text{Current } \textbf{adjust} \quad (\%) = \frac{\text{Nominal } \textbf{load} \text{ current}}{\text{Nominal } \textbf{unit} \text{ current}} \times 100\ \%.$$

- Switch on the unit and connect the power supply
- Read the Current adjust information on each unit channel.
- With the relevant potentiometers (marked on the front fascia from "I1" to "I4" depending on the unit model) adjust to obtain the Current adjust parameter at the value calculated for each channel (or each three-phase system for TU2000 series units).

After the calibration, the **Load current** parameter read by digital communications expresses the rms value of the channel current in % of the **nominal** load current. The value of the Current adjust parameter becomes the nominal value for all current threshold current calculations, V x I feedback and for retransmission.

It should be noted that the Current adjust and Load current are identified

- by the mnemonics **CA** and **CV**, respectively, in the Eurotherm protocol
- by the addresses $\mathbf{08_{HEX}}$ and $\mathbf{06_{HEX}}$ in the Modbus® protocol.

### Unit voltage calibration

- Read the value of the **Line to line voltage** by digital communications (mnemonic **LV** in the Eurotherm protocol or address $\mathbf{07_{HEX}}$ in the Modbus® protocol).
- Adjust the **P2** potentiometer (marked "V" on the front fascia) so that the Line to line voltage parameter value is equal to **100%**.

After calibration, the value of the Line to line voltage parameter becomes nominal for feedback and for the alarms.

## Diagnostic unit operation

For easier commissioning and maintenance adjustments and to diagnose the unit status, it is recommended to use the **EUROTHERM diagnostic unit, type 260,** which can be connected to the Power supply board.

The 20 way switch of the EUROTHERM unit, type 260, is used to display the unit operating parameter values. The EUROTHERM diagnostic unit, type 260, only measures **DC** values. AC signals are retransmitted by the two terminals marked "**Scope**" (to observe with the oscilloscope, for example).

The names of each position of the diagnostic unit and the typical values of the measured signals (read by the diagnostic unit) are given in table 5-10 (overleaf).

Unused positions:

- one channel units : 2, 3, 4, 6, 7, 8, 17, 19 and 20
- two channel units : 3, 4, 7, 8, 19 and 20.

| Position | Name | Ch. | Typical values read by the diagnostic unit | Comments |
|---|---|---|---|---|
| 1<br>2<br>3<br>4 | Current measurement | 1<br>2<br>3<br>4 | For nominal current<br>Mean : 3.6 V<br>rms : 4 V<br>Peak : 5.65 V | Double alternation rectified signal |
| 5<br>6<br>7<br>8 | Command signal to analogue input on the CCC board | 1<br>2<br>3<br>4 | For the input signal<br>0-100 % : 0 - 5 V | Factory adjusted (P1 potentiometer on the CCC board) |
| 9 | Power supply | | -15.5 V (-15.45 to -15.55) | Factory adjusted (P1 potentiometer on the Power supply board) |
| 10 | | | +15 V (14.5 to 15.5) | |
| 11 | | | +21 V (21 to 26 V) | Rectified, filtered |
| 12 | El. supply voltage | | - | AC ("Scope" terminals) |
| 13 | Power supply | | +5 V | Controlled |
| 14 | Alarm relay status | | 0 V : alarm<br>3.5 to 5 V : no alarm | Alarm relay de-energised |
| 15 | Line voltage image (after calibration) | | For nominal supply voltage : 4 V | Adjustment by P2 potentiometer ("V") |
| 16<br>17<br>18<br>20 | Current calibration | 1<br>2<br>3<br>4 | For load nominal current equal to the unit nominal current :<br>5 V | Adjusted by potentiometers :<br>P3 («I1»)<br>P4 («I2»)<br>P5 («I3»)<br>P6 («I4») |
| 18 | Power supply | | 0 V | Electronics power supply |

Table 5-10 Characteristics of the EUROTHERM diagnostic unit, type 260

## Channel current calibration

- For each channel or for each three-phase system, calculate the calibration voltage $V_{CA}$

$$V_{CA}(V) = 5\ V \times \frac{\text{Nominal load current}}{\text{Nominal unit current}}$$

- By turning the **P3** potentiometer (identified by "**I1**" for the first channel) display the value $V_{CA}$ on the Diagnostic unit display in position **16.**

The value $V_{CA}$ corresponds to the nominal current for all the calculations of the channel current, feedback V x I, the current threshold and for the retransmission for digital communications. Calibrate the following channels in the same way using the relevant potentiometers.

**Example.** Calculate the calibration voltage for a channel of a unit of **40 A** nominal, load used **30 A.**

$$V_{CA}(V) = 5\ V \times \frac{30\ A}{40\ A} = 3.75\ V$$

## Unit voltage calibration

- Turn the **P2** potentiometer (identified by "V" on the front fascia) until the display of the diagnostic unit display gives **4 V** in position **15.** The calibration is then nominal.

## CHECKS IN THE EVENT OF ABNORMAL OPERATION

| Symptom | Action |
|---|---|
| 1. The unit does not communicate | 1.1. Check that the electronics power supply is present (green LED)<br>1.2. Check the position of the ST9 = 1 (CCC board)<br>1.3. Check the addressing of the unit (ST11 to ST16, ST22 and ST23) and that no other unit of the same bus is located at the same address<br>1.4. Check the baud rate (position of ST10)<br>1.5. Check the selected protocol (ST21) and that indicated on the label of the microprocessor used<br>1.6. Check the wiring of the digital link and that the RX and TX and "+" and "-" terminals are not inverted (terminal block 60 on the CCC board)<br>1.7. Check that the unit has been "reset" (electronics power off and on) after a modification to the configuration |
| 2. The unit does not fire after a firing request by the digital signal (digital communications operate correctly) | 2.1.Check the supply phase wiring and that the voltage is present<br>2.2.Check the load connection<br>2.3. For the TU1000 and TU2000 series, check that the electronics power supply is in phase with the line to line voltage (terminal 5 on the Power supply board is connected to the Phase)<br>For the TU1001 series, check the presence of the power supply and that the Neutral (or second phase) is correctly connected to the N terminal blocks of the Power boards<br>2.4.Check the setpoint type selection wiring; the "A/D" input (terminal 74 on the CCC board) must be connected to "+10 V" (terminal 73)<br>2.5. Check that the enable terminals on the Power boards are connected<br>2.6.Check that the digital setpoint has been received<br>2.7.Check that the unit channel(s) are not in alarm status: indication by relay or by communication (Status word).<br>2.8. Using the diagnostic unit, check the current calibration<br>2.9. Using digital communications, read the current limit level<br>2.10.Check the connection of the thermal switches (fan-cooled units) |
| 3. The unit configured with digital communications does not fire after a firing request by the analogue setpoint | 3.1.Check that the ST9 jumper on the CCC board is set to 1<br>3.2.Check setpoint type wiring; the "A/D" input (terminal 74 on the CCC board) must not be connected to "+10 V" (terminal 73)<br>3.3.Check the analogue signal wiring on the CCC board between "0V" (terminals 71 or 72) and the inputs used (terminals 76 to 79)<br>3.4.Check that the input signal configuration corresponds to the signals used (jumpers ST1 to ST8 and ST19 on the CCC board)<br><br>The following actions correspond to actions 2.1 to 2.3 and 2.5 to 2.11 |
| 4. The unit is at full power, but the digital and analogue setpoints are zero | 4.1. The thyristors are short circuited<br>4.2. The thyristor firing circuit is faulty if the red LEDs are not lit<br>4.3. The control electronics are faulty or the microprocessor is out of operation if the red LEDs are lit |

| Symptom | Action |
|---|---|
| 5. The output power is very different to the Output power setpoint | 5.1.Check the unit's nominal current on the serial number label<br>5.2.Check the current calibration<br>5.3.Check the Current limit parameter value<br>5.4. Check the Current limit exceeded alarm status<br>5.5. Check the firing mode and the feedback type<br>5.6. Check that the current transformers are correctly connected |
| 6. Command reading is random | 6.1. Check the communication protocol configuration (ST21)<br>6.2. Check that the microprocessor label corresponds to the protocol specified during the order<br>6.3. Check the position of the ST24 jumper on the CCC board |
| 7. The green electronics supply voltage LED (indicated on the front fascia: $V_{DC}$) does not light up during power-up | 7.1.Check the connection of the electronics power supply and the presence of its voltage (terminals 3 and 5 on the Power supply board)<br>7.2.Check that the supply voltage corresponds to the voltage indicated on the unit's identification label<br>7.3.Check the ST1 jumper configuration on the Power supply board<br>7.4.Check the voltages: -15.5 V ; +15 V and +5 V with the diagnostic unit (positions 9, 10 and 13) |
| 8. The unit voltage is calibrated, but for the nominal voltage, the Line to line voltage parameter is not equal to 100% and the diagnostic unit in position 15 does not give 4 V | 8.1.Check on the unit's identification label that the unit's nominal voltage complies with the voltage applied<br>8.2.Check the presence and value of the electronics supply voltage<br>8.3.Check the position of the ST1 jumper on the Power supply board<br>8.4.Check the position of the ST18 jumper on the CCC board |

# Chapter 6

# ALARMS

Contents page

# Chapter 6 ALARMS

## GENERAL

The TU range alarms are entirely **managed by the microprocessor** which retransmits its data (alarms **active or** inactive) via digital communications (see Status word) and via an Alarm relay. The active status of certain alarms is retransmitted by red light emitting diodes (**LEDs**) on the front fascia of the unit.

The alarms detect the following faults:

- Over- and under-voltage
- Abnormal heatsink overheating
- Over-load
- Thyristor short circuit
- Current limit exceeded
- Total or partial load failure.

There are two types of alarm:

- **general** - common to all channels (or all three-phase systems) of the unit - (line to line voltage sensor)
- **local** - specific to each channel (or three-phase system) of the unit - (load and load current sensors).

The overtemperature sensor of the heatsink is **general** for TU1001 series 4 channel units and **local for all other units.**

The alarms are **hierarchised**, i.e. the active status of certain alarms inhibits the processing of lower level alarms. **Higher** level alarms are alarms which **inhibit** the unit. The under-voltage, current limit exceeded, total load failure and thyristor short circuit alarms cause the channel (of the three-phase system) or unit to **stop immediately.**

All the alarms, except the over-load detection, change the status of the N/O and N/C break-make contact **Alarm relay** with a common terminal (C). Total or partial load **failure** is displayed on the front fascia with a red light emitting diode (**LED**) on the relevant channel (TU1000 and TU1001 series). For the TU2000 series, the total and partial load failure alarms are displayed with different red **LEDs.**

## GENERAL ALARMS

General alarms detect significant variations in the line to line voltage which is permanently monitored (for TU1451/71 units, also abnomal heatsink overheating, see page 6-3).

The data on general alarm status is available via digital communications in the least significant byte of the Status word - the byte $\mathbf{SW_L}$, index **L** - Low (see page 4-10).

### Voltage drop

If the line to line voltage drops by over **20%** in relation to the nominal value, the unit enters alarm status and:

- inhibits all the channels
- activates the alarm relay
- sets bit **4** of the $\mathbf{SW_L}$ to **1.**

When the nominal voltage returns to above **85%**, the unit is automatically restarted (re-enable and positioning of bit **4** of $\mathbf{SW_L}$ to **0.**

### Over-voltage

If the line to line voltage is more than **10%** greater than the nominal voltage, the alarm relay **is activated and bit 5** of $\mathbf{SW_L}$ is set to **1.** In the event of over-voltage, unit operation **is not inhibited**, the feedback maintains the value of **V x I** or $V^2$ constant for the given operating point.

When the voltage returns to less than 105% of the unit's nominal voltage, the alarm relay returns to a non-alarm status and sets bit 5 of $\mathbf{SW_L}$ to **0.**

## LOCAL ALARMS

On each of the channels, the local alarm system detects the following faults:

- Thyristor short circuit
- Overtemperature sensor (general alarm for TU1451/71 units)
- Total load failure (**TLF**) and partial load failure (**PLF**)
- Over-load, Over-current (TU1000 and TU1001 series) and Current limit exceeded.

The alarm data specific to each channel or to each three-phase system is available via digital communications in the most significant byte of the Status word - the byte designated $SW_H$ (index **H** - High).
The bit numbers of $SW_H$ are **8** less than those of SW.

### Thyristor short circuit

The thyristor short circuit detection is active if the **measured** current is greater than **70%** of the load nominal current (current adjust), when the thyristor firing time demand is zero. Detection is not performed if the current calibration is less than **10%** of the unit's nominal current.

In the event of a thyristor short circuit being detected in one of 4 channels, the channel concerned is inhibited and the alarm relay is activated. Depending on the unit series and the short circuited thyristor channel, bit **1** or **2** of $SW_H$ (see table 4-5, page 4-11) is set to **1**.

An alarm acknowledge or switching the power off deactivates this alarm and restarts the unit.

### Overtemperature sensor

The temperature of **fan-cooled TU** units is monitored by **thermal switches**. In the event of abnormal heatsink overheating, the thermal switch opens to break the thyristor control circuit (TU1000 and TU2000 series) or the Firing board voltage monitoring circuit (TU1001 series). The microprocessor then detects a Total load failure fault which causes:

- the unit operation to stop for TU1451/71 units
- the inhibition of the channel containing thyristors with overheated junctions for the other models of the TU1001 series and for the TU1000 and TU2000 series
- the activation of the Alarm relay
- the setting of bits **4** and **5** of $SW_H$ to **1** (see page 4-11)
- the **LEDs** corresponding to the channels concerned to be lit up.

In order to restart the inhibited unit, an alarm acknowledge is required (see page 6-8).

### Over-load

The Over-load alarm indicates that the resistance of one of the channels at the time of the PLF adjustment is less than the nominal load resistance.

Detection of the Over-load on each of the channels is performed by comparing the nominal load resistance ($R_{LN}$) and current load resistance ($R_L$). These resistances are calculated with the ratio of the calibrated voltage and current ($R_{LN}$) and with the ratio of the measured voltage and current ($R_C$). The comparison is made after each partial load failure detection adjustment request.

The Over-load alarm is active if $R_L < R_{LN}$.

The Over-load detection takes into account the load type (linear or short-wave infrared elements).
In the event of over-load detection, bit **0** of $SW_H$ of the relevant three-phase system is set to **1** ( TU2000 series); for other units, bit **1** of $SW_H$ transmits the Over-load alarm status. The alarm relay does not change status.

The acknowledge is made after a new PLF adjustment request if the error has disappeared, or by sending command code **04** to the address of the relevant channel. If the alarm has disappeared, the corresponding bits of $SW_H$ are set to **0**.

The Over-load alarm is due to either a low resistance load or an incorrect calibration.

## Over-current

If the rms current exceeds the nominal load current, an Over-current error is detected.

Over-current detection is active on **TU1000** and **TU1001** series units.

In the event of over-current, the unit continues to operate, the data is available with the status of bit **4 of the most** significant byte of the Status word. After the Over-current detection, bit **4** of $SW_H$ is set to 1 (except **TU2000 series**).

With the Over-current alarm, the partial load failure detection adjustment is no longer enabled.

The alarm disappears when the current returns to less than the nominal load current value (the Load current value is less than the Current adjust parameter) or with an alarm acknowledge.

## Total load failure (TLF)

Unit operation with the current less than **1.5%** of the nominal load current, when the load voltage is **greater than 30%** of the calibrated voltage, is considered as a total load failure.

The **TLF** detection is performed on each channel. The cause of the **TLF** alarm is one of the following cases :

- total load failure
- abnormal heatsink overheating (thermal switch protection, see previous page)
- fuse failure (thyristor or power supply protection)
- connection fault
- thyristors in open circuit
- thyristor firing system faulty
- disconnection of "**VAL**" terminal from "**+10V**" (TU1001 series, Firing boards) or the "**VAL**" terminals (TU1000 and TU2000 series, Power boards)

For TU2000 series units monitoring two phases of three-phase loads, the absence of supply voltage **for one of the monitored** phases produces a **TLF** alarm. The absence of a **direct** phase produces the **PLF** alarm.

The TLF detection is only active for a channel calibration **greater than 10% of the nominal unit current. If total load** failure is detected on one of the channels, after an integration time of **5** s, the channel is **inhibited and the alarm relay is activated.**

The red LED, corresponding to the relevant channel, is lit at the front fascia of the unit.

The total load failure detection sets the following bits to **1:**

- bit **5** or bit **4** of $SW_H$ depending on the channel of the three-phase system at fault (**TU2000 series**)
- bit **5** of $SW_H$ for the selected channel (TU1000 and TU1001 channel, see page 4-11).

The channel or the inhibited system restarts after the alarm acknowledge (see page 6-8).

## Partial load failure (PLF)

The considerable increase in load impedance due to damage to load elements or connections, or the failure of some of the elements connected in parallel is called Partial load failure (PLF).

The use of the PLF function includes two separate phases:

- an adjustment phase
- a monitoring phase (detection).

### Partial load failure detection adjustment

The partial load failure **(PLF)** detection threshold is adjusted automatically.
**All the channels** of the same unit can be adjusted at the same time irrespective of the adjustment type.

This adjustment can be requested using the front fascia push button, the remote input or communications.

To adjust a PLF detection threshold, the unit's current and voltage must be calibrated: adjust the nominal operating values in order to obtain the best sensistivity for the PLF detection and then select an adjustment type from the following 3 possibilities:

- Press the **"PLF"** push button on the front panel
- Apply the signal **0 V** on the connector's **"PLF adjustment"** analogue input on the CCC board (terminal **75**)
- Send the command code **05** via the digital link to the address of the relevant channel or to the broadcast address (all the units on the same communication bus are adjusted).

---

**Important**

The PLF can only be adjusted if the following conditions are fulfilled:

- Current calibration greater than 25% of the unit's nominal current
  **(Current adjust parameter > 25%)**
- RMS load current greater than 30% of the current adjust
  **(Load current parameter > 30%)**
- RMS load voltage greater than 30% of the current adjust
  **(Load voltage parameter > 30%).**

---

In these conditions, the microprocessor makes the adjustment and calculates the impedance. The adjustment value is stored in EEPROM which enables the CCC board to find its adjustment after each start-up. For the TU2000 series, the adjustment is made using values which are the **means** of **three rms** currents and of **three rms** voltages.

It is recommended to request a new PLF adjustment after changing the thyristor firing mode.

### Adjustment check by digital communications

If the display of bit **14** of the Status word is **1**, the adjustment sequence has been executed correctly.

Otherwise, the value of bit **14** of the Status word is equal to **0.**

The adjustment (impedance calculated by microprocessor) is stored in the permanent memory (EEPROM). If the EEPROM is not initialised, none of the parameter values are stored.

In the event of non-initialisation or damage to the EEPROM irrespective of the source, the partial load failure detection is not adjusted and the relevant Status word remains unchanged.

## PLF detection

During the monitoring phase, the microprocessor regularly calculates the impedance of each channel by scanning and compares it to the impedance value stored in memory during the detection threshold adjustment sequence.

PLF detection cannot take place if the adjustment has not been made or if it has failed.
In this case, bit **6** of **$SW_H$** is equal to **0**.

The measured values of the rms supply voltage (between the monitored phases for the TU2000 series) and the rms line currents and the data concerning the thyristor firing angle of the cyclical ratio enabling the microprocessor to calculate the impedances of each load. As for the adjustment phase, this calculation is made using the values of the **Load current** parameter (value of current as percentage of current adjust) and of the **Load voltage** parameter (value of voltage as percentage of voltage adjust). For the TU2000 series, these load parameters are the **means** of the three rms values of the currents and voltages, respectively.

The comparison of the impedance values calculated using the measurements and stored in memory during the PLF adjustment is used to detect partial failure or an increase in load resistance on one of the channels.

The PLF detection is adapted to the load type (fixed resistive or short wave infrared elements).

For partial load failure detection:

- bit **7** of **$SW_H$** for the relevant channel is set to **1**
- the relevant **LED** (or LEDs for the TU2000 series) is lit on the front fascia
- the Alarm relay is **deactivated**.

Given that the PLF detection is performed using the measurements of the thyristor currents and of the load voltage, the PLF detection level is **different** according to whether the load is single-phase or three-phase, coupled in a **star** or a **delta** and whether the load failure takes place in a **monitored** phase or not.

The PLF sensitivity can be described by the number N of elements mounted in parallel, the failure of one of which is detected by the PLF circuit. The table below gives the information used to define the PLF sensitivity for different TU range series, when the monitored load is composed of N identical elements mounted in parallel, irrespective of the element type (resistive or short wave infrared).

| **Series** | **Load** | **Mounting** | **Number N of elements in parallel** |
|---|---|---|---|
| TU1000<br>TU1001 | Single-phase | - | 6 |
| TU2000 | Three-phase | Star without neutral<br>Monitored phase | 4 |
| | | Star without neutral<br>Direct phase | 2 |
| | | Delta<br>(irrespective of branch of delta concerned) | 3 |

Table 6-1 Sensitivity of partial load failure detection

The PLF alarm is acknowledged in the following cases if:

- the fault **disappears**
- an alarm **acknowledge** is transmitted
- a new PLF **adjustment** is requested.

## Current limit exceeded

The current limit exceeded setpoint (Current Limit parameter) sets the maximum level of rms current permissible in each load.

The nominal load current value ($I_{LN}$) after the current calibration procedure for each channel is equivalent to **100%** of the Current limit value:

$$I_{LN}(A) = \frac{\textbf{Nominal unit current}\ (A)\ \times\ \textbf{Current adjust}\ (\%)}{\textbf{100}}$$

The **current threshold** (or Limited current - $I_{LIM}$), taking into account the Current limit parameter, is set at:

$$I_{LIM}(A) = \frac{\textbf{Nominal load current}\ (A)\ \times\ \textbf{Current limit}\ (\%)}{\textbf{100}}$$

**Example. Determine the Limited Current (current threshold) for the unit with a nominal current of 75 A, a calibration of 80% and a Current limit setpoint of 50%.**

Nominal load current:

$$I_{LN} = \frac{\textbf{75 A x 80\%}}{\textbf{100\%}} = \textbf{60 A}$$

The limited current:

$$I_{LIM} = \frac{\textbf{60 A x 50\%}}{\textbf{100\%}} = \textbf{30 A}$$

The rms value of the load current (calculated by microprocessor on the repeated cycle in Burst firing mode or at each supply cycle in Phase angle mode) is compared to the Current limit threshold at each calculation cycle.

**Two modes of action** are provided for when the current limit is exceeded according to the thyristor **firing mode.**

**Phase Angle firing mode** (TU1001 series only):

The appearance of a current greater than the Limited current causes a modification of the Output power, giving priority to feedback, to **reduce the thyristor firing angle** in order to maintain the rms load current less than the current threshold (**"Current limit" action**).

The relevant channel **remains** active. The Output power setpoint is **the lowest** of:
- the Current limit setpoint and
- the Feedback setpoint.

**Burst firing, Single cycle and Soft start firing modes** (all series):

When the load current exceeds the current threshold by 10%, the relevant channel (or the three-phase system) is **inhibited.** Restarting is only possible after an alarm acknowledge (see overleaf).

The Current limit exceeded alarm status irrespective of the mode of action (Current limit or Inhibition) is available with bit 3 of $SW_H$ (see table 4-5, page 4-11). Bit 3 is equal to 1 when the load current in the selected channel has exceeded the current threshold (100% of the Limited Current in Phase Angle or 110% of the Limited Current in other firing modes).

In the event of non-initialisation or damage to the EPROM, the microprocessor initialises the current limit exceeded parameter 100%.

## ALARM RELAY

The alarm relay changes its status when one of the alarms (except Over-load and Over-current) is active.

Its break-make contacts (normally open: N/O, normally closed: N/C and common: C) can be used to indicate certain load and supply alarms. The alarm relay is de energised in alarm status.

The alarm relay is located on the Power supply board.

The contact's breaking capacity is **0.25 Aac** (**220 Vac** or **30 Vdc**).

## ALARM ACKNOWLEDGE

To acknowledge alarms (except under- and over-voltage alarms), it is possible to:

- switch **off** the electronics power supply (on the **CCC** board)
- use the command code.

Sending the command code **04** acknowledges the following faults:

- Total load failure
- Partial load failure
- Thyristor short circuit
- Over-current
- Over-load
- Current limit exceeded (in Burst firing mode).

When digital communications are not used (**ST9 = 0**), applying a **positive signal** between the "**RX-**" and "**RX+**" implies an alarm acknowledge.

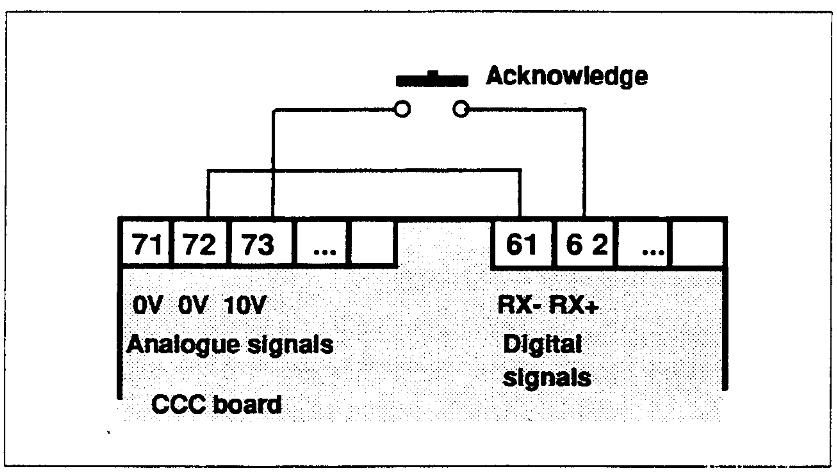



Figure 6-1 Alarm acknowledge when communications are not used

## ALARM MANAGEMENT

For a more comprehensive idea of TU range unit alarm operation, the main characteristics of all the alarm types are given in tables 6-2 and 6-3.

In these tables:

- $V_{LINE}$ - line to line voltage
- $V_N$ - nominal line voltage
- $V_L$ - load voltage
- $V_{LN}$ - nominal load voltage (calibration current)

- $I_L$ - load current
- $I_{LN}$ - nominal load current (calibration current)
- $I_{UN}$ - rating
- $I_{LIM}$ - limited current

- $R_{LN}$ - nominal load resistance
- $R_L$ - load resistance
- $R_S$ - resistance $R_{LN}$ stored in memory at the time of PLF adjustment.

| Alarm | | | Alarm |
|---|---|---|---|
| **Type** | **Monitored value** | **Anomaly** | **activation conditions** |
| General | Voltage | Over-voltage | $V_{LINE} > 110\% V_N$ |
| | | Under-voltage | $V_{LINE} < 80\% V_N$ |
| Local | Load | Over-load | $R_L < (R_{LN} = R_S)$ and PLF adjustment request |
| | | Partial load failure (PLF) | Failure of one element out of 6 (TU1000/1001 series)<br>Failure of one element out of 2 to 4 (TU2000 series)<br>with the following conditions:<br>• Current adjust > 25% $I_{UN}$<br>• Load current > 30% $I_{LN}$<br>• Load voltage > 30% $V_{LN}$ |
| | | Total load failure (TLF) | $I_L < 1.5\% I_{LN}$ with the following conditions:<br>• Current adjust > 10% $I_{UN}$<br>• Load voltage > 30% $V_{LN}$<br>• Output power ≠0 |
| | Current | Over-current | $I_L > I_{LN}$ (TU1000/1001 series) |
| | | Thyristor short circuit | $I_L > 70\% I_{LN}$ with the following conditions:<br>• Current adjust > 10% $I_{UN}$<br>• Output power = 0 |
| | | Current limit exceeded | $I_L > 110\% I_{LIM}$ in Burst firing<br>$I_L > 100\% I_{LIM}$ in Phase angle |
| | Temperature | Abnormal overheating | Thyristor heatsink temperature greater than permissible value |

Table 6-2 General alarm characteristics

The table below gives the alarm status of the alarm relay, the thyristors and the light emitting diodes (LEDs) and observations.

| Anomaly | | Statuses: Alarm relay | Statuses: Thyristor inhibition | Statuses: Lighting of LEDs | Statuses: Status word bit number | Observation: Acknowledge | Observation: No alarm | Observation: PLF function |
|---|---|---|---|---|---|---|---|---|
| Over-voltage | | + | - | - | 5 | - | 105% $V_N$ | Active |
| Under-voltage | | + | + | - | 4 | - | 85% $V_N$ | Inactive after inhibition |
| Over-load (during PLF adjustment) | TU1000<br>TU1001 | - | - | - | 9 | + | - | Active after adjustment |
| | TU2000 | | | | 8 | | | |
| PLF | TU1000<br>TU1001 | + | - | LED 1 to 4<br>Dep. on ch. concerned | 15 | + | $R_L=R_S$ | Active |
| | TU2000 | | | LED1<br>System 1 | | | | |
| | | | | LED3<br>System 2 | | | | |
| TLF | TU1000<br>TU1001 | + | + | LED 1 to 4<br>Dep. on ch. concerned | 13 | + | After acknowledge | Inactive |
| | TU2000 | | | LED1 or 2<br>Ch. 1 or 2 | 12 | | | |
| | | | | LED 3 or 4<br>Ch. 3 or 4 | 13 | | | |
| Over-current | TU1000<br>TU1001 | - | - | - | 12 | + | $I_L < I_{LN}$ | Active (adjustment inactive) |
| Thyristor short circuit | TU1000<br>TU1001 | + | + | - | 10<br>Selected ch. | + | After acknowledge | Inactive |
| | TU2000 | | | | 9<br>Ch. 1 or 3 | | | |
| | | | | | 10<br>Ch. 2 or 4 | | | |
| Current limit exceeded | Burst firing | + | + | - | 11 | + | After acknowledge | Inactive after inhibition |
| | Phase angle | - | - | - | 11 | - | - | Active |

Table 6-3 Alarm information and observations

# APPENDICES

Contents | page

# Appendix A

## ASCII CHARACTERS

| Character | Explanation | ASCII code | | |
|---|---|---|---|---|
| | | Decimal | Hexadecimal | Binary (7 bits) |
| STX | Start of text | 2 | 02 | 000 0010 |
| ETX | End of text | 3 | 03 | 000 0011 |
| EOT | End of transmission | 4 | 04 | 000 0100 |
| ENQ | Response request | 5 | 05 | 000 0101 |
| ACK | Good reception | 6 | 06 | 000 0110 |
| NAK | Bad reception | 21 | 15 | 000 0111 |
| Espace | | 32 | 20 | 010 0000 |
| + | "Plus" sign | 43 | 2B | 010 1011 |
| - | "Minus" sign | 44 | 2C | 010 1100 |
| . | Decimal point | 46 | 2E | 010 1110 |
| 0 | Digits | 48 | 30 | 011 0000 |
| 1 | | 49 | 31 | 011 0001 |
| 2 | | 50 | 32 | 011 0010 |
| 3 | | 51 | 33 | 011 0011 |
| 4 | | 52 | 34 | 011 0100 |
| 5 | | 53 | 35 | 011 0101 |
| 6 | | 54 | 36 | 011 0110 |
| 7 | | 55 | 37 | 011 0111 |
| 8 | | 56 | 38 | 011 1000 |
| 9 | | 57 | 39 | 011 1001 |
| > | "Greater than" sign | 62 | 3E | 011 1110 |
| A | Upper case letters | 65 | 41 | 100 0001 |
| B | | 66 | 42 | 100 0010 |
| C | | 67 | 43 | 100 0011 |
| D | | 68 | 44 | 100 0100 |
| E | | 69 | 45 | 100 0101 |
| F | | 70 | 46 | 100 0110 |
| G | | 71 | 47 | 100 0111 |
| H | | 72 | 48 | 100 1000 |
| I | | 73 | 49 | 100 1001 |
| J | | 74 | 4A | 100 1010 |
| K | | 75 | 4B | 100 1011 |
| L | | 76 | 4C | 100 1100 |
| M | | 77 | 4D | 100 1101 |
| N | | 78 | 4E | 100 1110 |
| O | | 79 | 4F | 100 1111 |
| P | | 80 | 50 | 101 0000 |
| Q | | 81 | 51 | 101 0001 |
| R | | 82 | 52 | 101 0010 |
| S | | 83 | 53 | 101 0011 |
| T | | 84 | 54 | 101 0100 |
| U | | 85 | 55 | 101 0101 |
| V | | 86 | 56 | 101 0110 |
| W | | 87 | 57 | 101 0111 |
| X | | 88 | 58 | 101 1000 |
| Y | | 89 | 59 | 101 1001 |
| Z | | 90 | 5A | 101 1010 |

Table App-1 ASCII characters used in TU range digital communications

# Appendix B

## GLOSSARY

**Acknowledge**
Unit operation unlocking procedure and/or reset of the alarm indication to normal status (provided that the fault(s) have disappeared)

**Address**
Hexadecimal number indicating the position of the parameter or code in the memory

**ASCII**
Code instituted by American National Standards Institute and represented by letters, digits and punctuation marks.

**Baud**
Data transmission rate unit for a serial link which represents the number of bits transmitted in one second.

**Buffer (Input)**
Memory space reserved for each Slave.

**Burst firing**
Thyristor firing mode introducing a proportional cycle which consists of sending a series of complete supply voltage cycles to the monitored load. The unit firing is activated and deactivated at zero voltage. The feedback of the power sent to the load is performed with the firing (or non-firing) time constant (for the TU range, this time is fixed at 8 supply cycles) and the modulation time variable.

**Bus (Communication bus, Serial bus)**
General term describing the hardware support (wiring loom, flex, etc.) used to link units (CPU and various peripherals) which must dialogue together.

**Calibration**
Physical installation value standardisation procedure (nominal load current and nominal voltage of supply used) in relation to the unit's current and voltage, making it possible to adjust the images of the physical values in the microprocessor to 100%.

**CCC board**
Electronic control and digital communication board, equipped with a micro-processor, which controls local unit feedback, alarm management, sends control orders to the thyristor firing systems and which communicates with a supervision system (or with a controller) via a digital bus.

**Check word**
1. In the EUROTHERM protocol: BCC (Block Check Character - Check Characters) Numbers in ASCII used to check various transmission phases (start and end of text, data transmission, acknowledgement).
2. In the MODBUS®/JBUS® protocols: CRC (Cyclic Redundancy Check) Binary checksum offering the highest probability of transmission error detection; sent at the end of each message and compared to the result of a logic operation on the message characters.

**Communication protocol**
Set of rules determining the organisation and all data exchange elements between data transmitter and receiver.

**Configuration**
1. Installation procedure for the operating mode, the level of input signals, digital communication parameters, etc., using jumpers or command codes.
2. Unit operating mode, installed according to the user's order or according to modifications during the commissioning procedure.

**Configuration jumper**
Short circuiting plug of a pair of pins on the electronic boards, used to produce the desired configuration.

| | |
|---|---|
| **Current adjust** | Operating parameter indicating the current calibration value (equal to the nominal current of the load used). |
| **Current limit** | 1. Setpoint, containing the permissible current threshold values for each channel (user setpoint)<br>2. Action of decreasing the load current by thyristor firing angle variation in order to maintain the rms current below the current threshold fixed by the Current Limit setpoint. |
| **Diagnostic unit** | Type 260 EUROTHERM unit used to measure and display the monitoring signals, the electronics and Alarm relay supply voltage in digital figures during procedures such as calibration, start-up, maintenance, unit operation diagnostic procedures, etc. |
| **Digital communications** | Data exchange system transmitting in character strings, composed of a series of bits emitted one after the other on a standardised link. |
| **EEPROM** | Electrically-Erasable Programmable Read-Only Memory used for data storage. |
| **Enable** | Operation authorisation process for the unit or one of the three-phase systems performed by sending a command code or by connecting two terminals on the power board. |
| **EUROTHERM protocol** | Communication protocol in compliance with standards ANSI x3.28 which uses the ASCII character string in 10 bit format as a transmission mode. |
| **Fast setpoint transfer** | Output power for fast transfer of the current digital setpoint (replacement of the current digital setpoint). |
| **Firing angle** | 1. Duration of firing status of a thyristor (during alternation of a positive supply voltage) expressed in electrical degrees or radians<br>2. Phase shift (expressed in electrical degrees or radians) between the positivevoltage alternation zero and thyristor firing. |
| **Inhibition** | Stop of operation of the unit (or part of the unit) and operation lock-out until a new authorisation (by a logic or digital signal or by a planned connection). |
| **Interface** | Circuit which generates or receives digital or analogue signals from a process. |
| **Master** | Digital system which monitors and controls units (slaves) by sending orders to change parameter values or to transmit the information required via the communication bus. |
| **Mnemonic** | Description of one of the operating parameters in the EUROTHERM protocol representing the abbreviation of the names of the parameters in English. |
| **Status word** | Operating parameter of the unit and alarms containing data on the status of the unit and alarms. Status word composed of two bytes, the status (0 or 1) of each bit indicates the predefined data item. |
| **MODBUS® / JBUS® / protocols** | For the TU range: binary communication protocols complying with RTU (Remote Terminal Unit) standards which uses the binary character string in 10 bit format as a transmission mode. |
| **Output power** | The internal controller output value which corresponds:<br>- to the cyclical ratio in Burst firing mode.<br>- to the thyristor firing time demand in Phase angle firing mode |

| | |
|---|---|
| **Over-current** | Alarm signalling that the rms load current has exceeded the current adjust value (nominal load current) |
| **Over-load** | Alarm signalling that the load resistance of one of the channels at the time of the PLF adjustment is less than the nominal load resistance. |
| **Parameter** | One of the variables (digital or analogue) of unit operation (voltage, current, output power, input signal setpoints used, limited current or setpoint thresholds) or data on the status of the unit and alarms. |
| **Parity bit** | Configurable bit of a communication character frame which is used to check the characters transmitted; configuration: even, odd parity and no parity |
| **Partial load failure detection** | Data via digital communications, via red LEDs on the front fascia and via the Alarm relay break-make contacts on an abnormal increase in load impedance (e.g. of the failure of one or more heating elements connected in parallel). |
| **Phase angle** | Thyristor firing mode with firing angle variation |
| **Physical address** | Decimal number indicating the independent power channel or a three-phase system of the unit.<br>In the Eurotherm protocol, the physical address formed of two hexadecimal haracters indicating the group number (per 16 units) and the unit number within the group.<br>In the Modbus®/Jbus® protocols, the physical address is the Slave number (SNU) in binary code (1 byte). |
| **Read** | Process used to request information on the value of one or more parameters. |
| **RS232 and RS422** | Name given to two communication standards, used to carry data on a communication bus; these standards define the number of wires, the maximum length of the link and the voltage levels. |
| **Setpoint** | Signal which represents the specified value for the feedback value. |
| **Single cycle** | Thyristor firing mode introducing a proportional cycle with a single complete firing (or non-firing) supply cycle and which consists of sending a series of supply voltage cycles to the load. The thyristor channel firing is activated and deactivated at zero thyristor voltage. |
| **Slave** | Unit (for the TU range - an independent power channel or a three-phase system of a unit) which does not control the communication bus and which, consequently, operates under the control of the Master (it can answer the Master's request or change its operation). |
| **Soft start** | Gradual establishment of the load current with thyristor firing angle variation during the first four of the eight supply cycles of operation in Burst firing. |
| **Start bit** | Bit of a communication character frame which signals the start of transmission to the receiver |
| **Stop bit** | Bit of a communication character frame which signals the end of transmission to the receiver |
| **Supervision system** | Supervision and communicating control station which gives quick and hierarchised access to the operational data display in real time. |

**Supervisor**
Peripheral elements used to manage all the units in real time.

**Three-phase system**
Part of the TU2000 series unit composed of two thyristor channels. With a direct phase, this part of the unit monitors a three-phase load in a star mounting without neutral or in a closed delta.

**Thyristor channel (Power channel)**
Independent part of the unit which is composed of two thyristors connected head to spade with a firing system, a current measurement transformer and a protection circuit.

**Total load failure detection**
Process to determine and signal an abnormal decrease in the load current (less than 1.5% of the nominal current) when the load voltage is over 30% of the calibrated voltage. The TLF data is transmitted via digital communications, red LEDs on the front fascia and via the Alarm relay break-make contacts.

**Unit**
Thyristor unit, connected between the supply and the load, intended to monitor the power dissipated in an electrical load by monitoring the thyristor firing status. The unit is monitored by an analogue or digital command signal and contains an internal feedback loop.

**Write**
Process used to modify the value of one or more parameters.

# Appendix C

## INDEX

EUROTHERM

# EUROTHERM COMPANIES

**Australia**
**Eurotherm Pty Ltd**
Unit 3
16-18 Bridge Road
Hornsby New South Wales 2077
Telephone: (61) 2 477 7022
Fax:(61) 2 477 7756

**Austria**
**Eurotherm GmbH**
Geiereckstrasse 18/1
A 1110 Wienna
Telephone: (43) 1 787 601
Telex:1132000 EI AUT A
Fax: (43) 1 787605

**Belgium**
**Eurotherm BV**
Herentalsebaan 71-75
B-2100 Deurne Antwerpen
Telephone: (32) 3 322 3870
Fax: 33317 EIBNL B
Telex: (32) 3 321 7363

**Denmark**
**Eurotherm Danmark A/S**
Finsensvej 86
DK-2000 Frederiksberg
Copebhagen
Telephone: (45) 31 871622
Fax: (45) 31 872 124

**France**
**Eurotherm Automation SA**
Parc d'Affaires de Dardilly
6, Chemin des Joncs, BP 55
69572 Dardilly Cedex
Telephone: (33) 78 66 45 00
Telex: 380038 F
Fax: (33) 78 35 24 90

**Germany**
**Eurotherm Regler GmbH**
Ottostrasse 1
D-65549 Limburg a.d. Lahn 1
Telephone: (49) 6431 2980
Telex: 484791 EUROT D
Fax: (49) 6431 298119

**Hong Kong**
**Eurotherm Ltd**
Unit D
18/F Gee Chang Hong Centre
65 Wong Chuk Hang Road
Aberdeen
Telephone: (852) 873 3826
Telex: 69257 EIFEL HX
Fax: (852) 870 0148

**Ireland**
**Eurotherm Ireland Ltd**
I.D.A. Industrial Estate
Monread Road
Naas Co Kildare
Telephone: (353) 45 79937
Telex: 60745 ETMA EI
Fax: (353) 45 75123

**Italy**
**Eurotherm S.p.A.**
Via XXIV Maggio
22070 Guanzate (CO)
Telephone: (39) 31 975111
Fax: (39) 31 977512
Telex: 380 893

**Japan**
**Eurotherm (Japan) Ltd**
Marushima Building
28-2 Chuo 1, Chome
Nakano-ku Tokyo 164
Telephone: (81) 33 363 8324
Fax: (81) 33 363 832 0

**Korea**
**Eurotherm Korea Ltd**
Suite #903, DaejooBuilding
132-19 Chungdam-Dong,
Kangnam-Ku
Seoul 135-100
*Telephone:* (82) 2 543 8507
Fax: (82) 2 545 9758

**Netherlands**
**Eurotherm B.V.**
Johan Frisostraat 1
2382 HJ Zoeterwoude
Telephone : (31) 71 411 841
Telex: 39073 EIBNL NL
Fax: (31) 71 414 526

**Norway**
**Eurotherm A/S**
Post Boks 199
N-1412 Oslo
Telephone: (47) 66 80 33 30
Fax: (47) 66 80 33 31

**Spain**
**Eurotherm Espana SA**
Calle La Granja 74
Pol. Ind. Alcobendas
Madrid
Telephone: (34) 1 661 6001
Fax: (34) 1 6619093

**Sweden**
**Eurotherm AB**
PO Box 24
S-23221 Arlov
Telephone: (46) 404 35460
Fax: (46) 404 35520

**Switzerland**
**Eurotherm Produkte (Schweiz) AG**
Kanalstasse 17
CH-8152 Glattbrugg
Telephone: *(41) 1 810 3646*
Fax: (41) 1 810 8920

**United Kingdom**
**Eurotherm Controls Ltd**
Faraday Close, Durrington
Worthing
West Sussex, BN13 3PL
Telephone: (44) 903 268500
Telex: 87114 EUROWG G
Fax: (44) 903 265982

**U.S.A.**
**Eurotherm Controls Inc**
11485 Sunset Hills Road
Reston Virginia 22090-5286
Telephone: (1) 703 471 4870
Fax: (1) 703 787 3436

***Sales and Support in over 30 countries*** worldwide

For countries not listed above all enquiries / orders to : EUROTHERM CONTROLS Ltd, Faraday Close, Durrington Worthing West Sussex, BN13 3PL ENGLAND / Telephone : (44) 903 268500 Fax : (44) 903 265982



Made in France