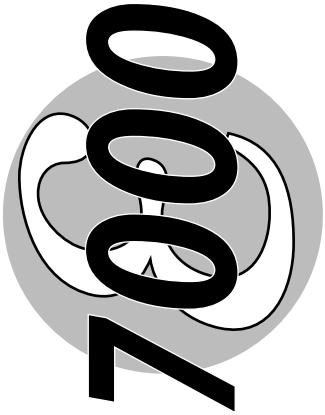

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EUROTHERM

Digital Communication Manual

MODBUS®

ENG

CE

User Manual

DIGITAL COMMUNICATION
SOLID STATE CONTACTORS
FOR 7000 SERIES

User Manual

CONTENTS

PURPOSE OF MANUAL

This manual describes the operations of the digital communication option used to control 7000 series somid state relays ant power thyristor units.

The user needs an understanding of :

• the operation of 7000S solid state contactors from Eurotherm's 7000 series (a detailed description of each unit is given in the corresponding user manual)

• the definitions of the MODBUS® digital communication protocol.

ADDITIONAL INFORMATION

For all further information and questions please contact your Eurotherm branch. Our technicians will be pleased to advise you and can also help during commissioning of your facility.

EUROPEAN DIRECTIVES AND APPLICABLE STANDARDS

COMPLIANCE WITH PRODUCT STANDARD

7000S series products comply with the terms of product standard EN 60947-4-3 'Contactors and motor-starters - AC semiconductor controllers and contactors for non-motor loads'. The number of this standard is indicated on the front panel label.

CE LABELLING

7000S series products, installed and used in accordance with their user manual, bear CE labelling to indocate compliance with the essential requirements of :

- The European Low Voltage Directive 73/23 EEC dated 19 February 1973, amended by 93/68 EEC dated 22 July 1993.
- The Electromagnetic Compatibility Directive 89/336 RRC dated 3 March 1969 amande by 92/31 EEC dated 28 April 1992 and 93/68 EEC dated 22 July 1993.

SAFETY

The units have IP20 protection rating as defined by standard IEC 60529.
External wiring must comply with standards IEC 60364-4-43 and IEC 60943.
Copper cables and conductors rated to a temperature of 75°C (167°F) must be used.

ELECTROMAGNETIC COMPATIBILITY (EMC) TEST STANDARDS

7000 products installed and used in accordance with the user manual, are designed for an industrial environment and must not be used in the home.

IMMUNITY The EMC immunity test standards required by product standard EN 60947-4-3.

Test type	Minimum levels	EMC test standard
Electrostatic discharge	4 kV on contact; 8 kV in air	EN 61000-4-2
Radiated, radio frequency electromagnetic field	10 V/m 80 MHz ≤ f ≤ 1 GHz; 80% modulation 1 kHz sinusoidal	EN 61000-4-3
Electrical fast transient / burst	2 kV / 5 kHz	EN 61000-4-4
Electrical surge	4 kV line to earth ; 2 kV line to line	EN 61000-4-5
Conducted disturbances	140 dBµV; 150 kHz ≤ f ≤ 80 MHz	EN 61000-4-6
Voltage dips, short interruptions and voltage variation	5 s interruptions	EN 61000-4-11

Table 1 EMC immunity standards compliance

EMISSIONS The EMC emissions test standards required by product standard EN 60947-4-3

Emission type	Firing mode	EMC test standard
Radiated, radio frequency	All firing modes	CISPR 11 Class A
Conducted, radio frequency	All firing modes	CISPR 11 Class A Group 2

Table 2 EMC emissions standards compliance

EMC GUIDE

To help you deal with installation-dependent electromagnetic interference effects, Eurotherm provides an 'Electromagnetic compatibility' installation guide (ref. HA025464) which sets out best current practice regarding EMC.

DECLARATION OF CONFORMITY

A CE declaration of conformity is available on request.

1. Chapter 1

IDENTIFICATION

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1. Chapter 1 IDENTIFICATION

1.1. GENERAL PRESENTAION

The digital communication option is used for digital control of 7000 series solid state contactors and power thyristor units.
The digital communication option is an electronic card integrated into the ***7000 series*** with power supply and communication terminals.

Three LEDs on th front pannel indicates :
- the interface's power supply condition
- the status of exchange on the communication bus
- initialisation phase progress (green LED)
- communication bus status (two orange LEDs)

The interface receives digital instructions from the Master (Supervisor) via a communication bus, ans sends out modulated logic signals to the power unit which it controls..
The interface also provides supply voltage compensation if this function is activated by the communication
This information is transmitted to the supervisor via the communication bus.

Firing modes supported :
- 'Burst mode' (modulation period configurable by communication)
- 'Singl-cycle' and 'Intelligent half-cycle'
  (with restrictions related to the interface power supply and, in some cases, restrictions related to the three-phase load configuration).

7000S series solid state contactors, can be operated by the digital communication interface in 'Burst mode' firing (base time T_b = 8 cycles or more) with all auxiliary supply.

The solid state contactors can be operated in 'Burst mode' (base time T_b = 2 cycles or more), 'Single cycle' (T_b = 1 cycle) or 'Intelligent single-cycle' (see 'Operation' section) with an AC auxiliary supply (for single-phase loads or three-phase loads in 4 or 6 wire configuration).

1.2. TECHNICAL SPECIFICATIONS

1.2.1. USE

The digital communication interface is designed to control and monitor 7000 series solid state contactors and power thyristor units

1.2.2. POWER SUPPLY

Source	24 Vac (±20%), 47 à 63 Hz or 24 Vdc (±20%) non-polarised (filtered)
Typical consumption	1,5 VA

1.2.3. COMMUNICATION

Protocol	Modbus® RTU
Compliance	Communication complies with the specifications given in 'GOULD MODICON Protocol Reference Guide PI-MBUS-300 rev J'

Transmission

Standard	RS485 2 wires
Speed	9600 ou 19200 baud (selection by switch SW8 only)
Diagnostics	• Green LED an front panel indicates that power is applied and the unit is awaiting communications. • Two orange LEDs indicate the communication satus.
Terminaison	The communication bus must have termination resistors fitted at each end: •One line impedance matching resistor. • two RS485 bus polarisation resistors.

1.2.4. CONFIGURATION

Address	Selection by switches on front panel only. Physical adress 32 is configured by default.
Speed	Selection by switch SW8 only.
Reconfiguration	The transmission speed and physical address of the unit can be **configured on site**.
Other parameters	Read and Write by digital communication. (see chapter 3. Digital communication)

1.2.5. PROTECTION

Power supply	External 2 A fuse
External wiring	in accordance with IEC 60364 standard

1.2.6. ENVIRONNEMENT

Temperature of use	0°C to 45°C at a maximum altitude of 1000 m
Storage temperature	-10°C to +70°C
Atmosphere for use	Non-explosive, non-corrosive and non-conducting
Humidity	RH 5% to 95%, no condensing, no steaming.
Pollution	Degree 2 admissible (as defined by IEC 60664 standard)

1.3. OPERATION

Thyristor firing

Switching	Zero crossing
Firing modes	With DC auxiliary supply : • 'Burst mode' (base time T_b 8 to 255 cycles). With AC auxiliary supply : • 'Burst mode' (base time 2 to 255 cycles) • 'Singl-cycle' (base time T_b = 1 cycles) or • 'Intelligent half-cycle' (base time T_b = 0.5 cycles)
Selection mode	The firing mode can be configured over the communication link
Load voltage stabilisation	Compensation of supply voltage variations ±20% V^2 control.Compensation can be enabled or disabled over the communication link. Linearite and stability better than ±2% of full scale.
Response time	Without compensation : 20 ms typical With compensation : 400 ms typical

2. Chapter 2

INSTALLATION

Contents Page

2. Chapter 2 INSTALLATION

2.1. SAFETY DURING INSTALLATION

Danger!

The interface and the power units controlled must be installed and wired by qualified personnel, authorised to work in an industrial low voltage environment.

Units must be installed in a metal fan-cooled cabinet, to ensure that condensation and pollution are excluded, with a class of at least 2 according to IEC 364.

The cabinet must be closed and connected to the protective earth according to IEC 60364 or applicable national standards.
We recommend fitting fan-cooled cabinets with a fan failure detection device or a thermal safety cut-out.

Danger!

It is the user's responsibility to wire and protect the facility according to best practice and applicable standards.

Before connecting or disconnecting the unit check that power and control cables and leads are isolated from voltage sources.

Important!

To ensure that the communication lead shield is correctly earthed, ensure that the different reference ground planes (DIN rails, cabinet panels and bases) are connected together.

2.2. CONNECTION

2.2.1. DESCRIPTION OF TERMINALS

	Description	Terminal name	Terminal number	Terminal capcity mm²	Terminal capcity AWG	Stripping mm
AUX2	24 V auxiliary power supply 3 point connector	24V 0VS GND	19 20 29	2.5	16	6 to 7
COM	Digital communication 2 point connector	A B	92 91	1.5	16	6 to 7

Table 2.1. Terminal description

2.2.2. POWER SUPPLY CONNECTION 'AUX2'

The digital communication option auxiliary power supply is **24 Vac** or **24 Vdc** (the voltage type affects the thyristor firing mode). The typical power consumption is **1.5 VA** A 2 Amps slow blow fuse is required to protect the connection leads.

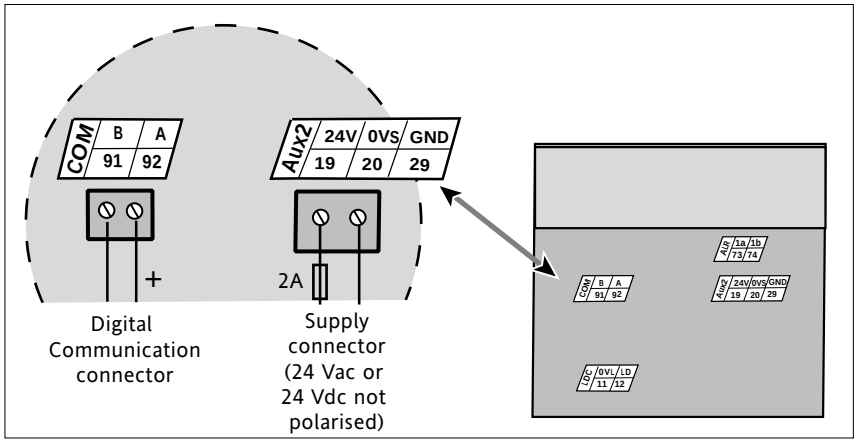

Figure 2.1. Power supply connection diagram

2.2.3. COMMUNICATION BUS CONNECTION («COM»)

2.2.3.1. Polarity

By convention, the voltage on **line 'A'** of the bus, is **higher** than the voltage on **line 'B'** of the bus, when the RS485 line is active.

2.2.3.2. Wires screening

To guarantee reliable operation of the digital communication link, the bus must be connected using shielded **twisted pairs**.

Important !

- The shield of the communication cable must be connected to ground using the shortest possible connection at both ends.
- We recommend connecting the shieleding to the DIN mounting rails as near as possible to the interface.

2.2.3.3. Termination resistors

The communication bus must have termination resistors fitted at each end :

- One line impedance matching resistor
- Two RS485 bus polarisation resistors

The intertface as standard with the following internal resistors :

- **100 kΩ** polarisation resistors,
- a **100 kΩ** resistor betweeen the 'A' and 'B' terminals

Important !

- To ensure correct operation, we recommend installing a matchig resistor typical value 220 Ω, on the last unit on the communication bus

- If the last unit on the bus is one of the 7000S series with digital communication, this resistor must be connected between terminals 'A' and 'B'

2.2.2.4. CONNECTION EXAMPLE FOR A 7100S POWER UNIT

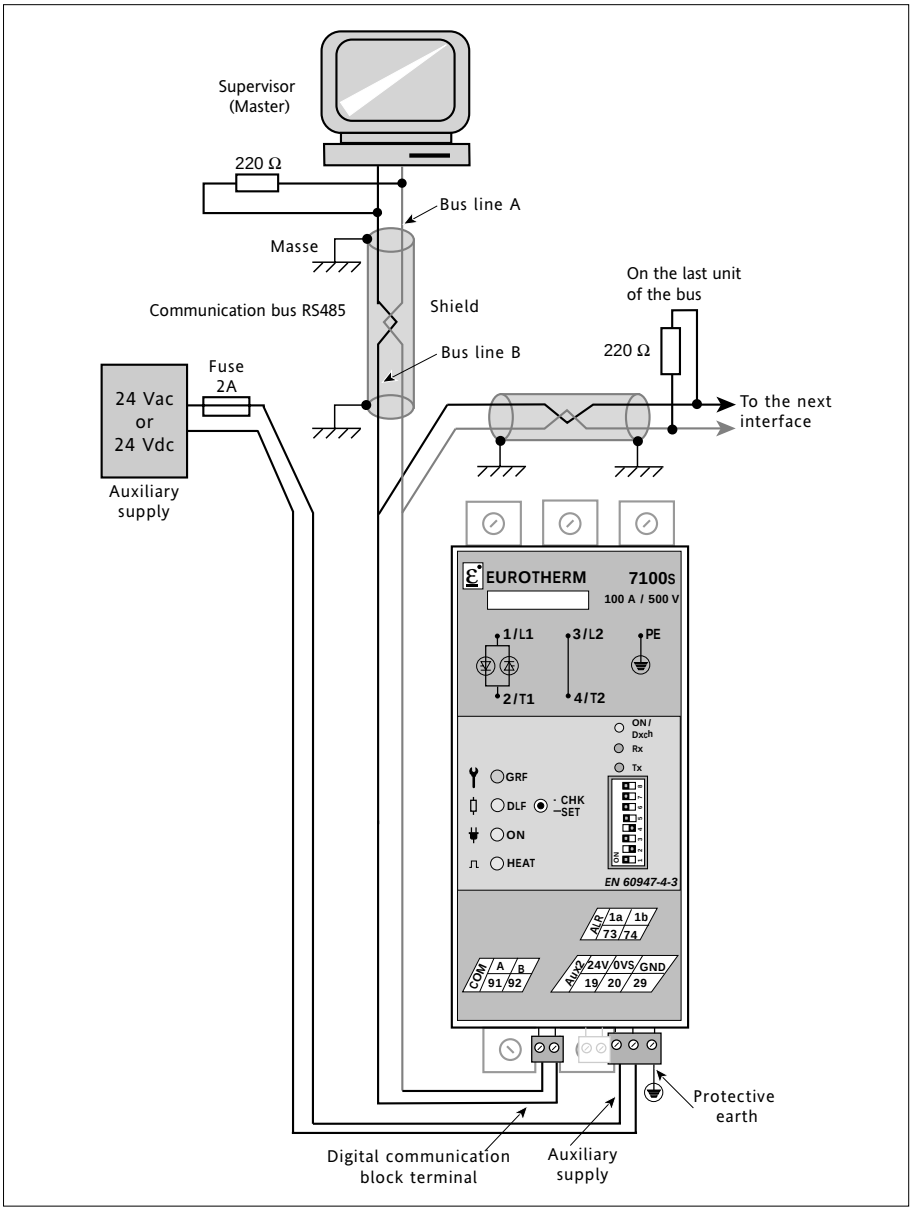

Figure 2.2. 7100S unit connection diagram

2.3. CONFIGURING THE PHYSICAL ADDRESS AND SPEED

In order to desingn the power unit and the differnet parameters, the Modbus protocoluses :
- The 7000 series unit **Physical** address on the communication bus.
- The **parameter** addresses which determine the parameter required.

Important : The physical address is configured by microswitches on the front panel of the unit, and cannot be chosen or changed using digital communication.

Configuring the digital communication involves selecting :
- the **physical Interface address** communication the communication bus
- The transmission **speed**.

2.3.1. PHYSICAL INTERFACE ADDRESS

The interface address on the communication bus is set by switches **SW1** (LSB bit 0) to **SW7** (MSB bit 6). The address may be set between 1 to 127.

Example : Switch positions to set the unit's address to **74**
(0101001 binary in 7 bits) which is the factory-set address.

Address 74 in binary, **7 bits**	1	0	0	1	0	1	0
Swithches position	On	Off	Off	On	Off	On	Off
Swithe number SW	7	6	5	4	3	2	1
	LSB						MSB

2.3.2. TRANSMISSION SPEED

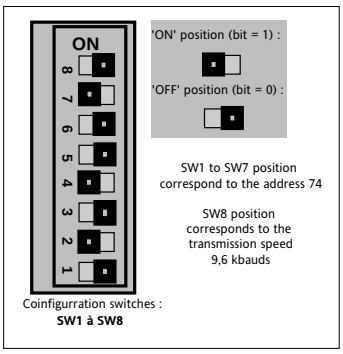

Figure 2.3. Example : Switch positions.

The transmission speed is determined by switch **SW8** :
- the ' **OFF**' position corresponds to a speed of **9,6** kbaud
- the ' **ON**' position corresponds to a speed of **19,2** kbaud

Important : The factory default settings are for an address of 32 and the transmission speed corresponding tp the product code.

2.3.3. ADRESSING BY MESSAGE BROADCASTING

00 address is reserved for the message diffusion to all the units connected to the bus.
In this case, all the Slaves carry out the order but none will answer.
Writting diffusion is available on every parameters with the 'Read and Write' status.

Improtant !

User is responsible for ensuring that a write command broadcast does not affect the operation of other units on the same communication bus.

Improtant !

In a program loop, the writting of a parameter which is saved in permanent memeory must not be included

2.4. DIAGNOSTIC LEDs

Three LEDs on the front panel show the interface status

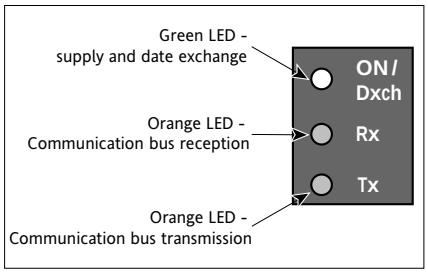

Figure 2.4. Interface status diagnostic LEDs

Green 'ON/Dxch' diagnostic LED

Initialisation phase on power up	Waiting for frame Master	Communication established
Flashes 5 times : 400 ms on - 400 ms off	Flashes at @ 0.5 Hz 1 s on / 1 s off	Lit standily

Table 2.2. operation of green 'ON/Dxch' LED

Important :
If 00 address (reserved for broadcast) is selected by mistake, the interface remains in the initialisation phase

Orange 'Rx' LED
Linked to data received, and flashes as requests are sent by the master.

Important :
If the 'Rx' LED is lit stedily, the polarity of the communication signals may be inverted

Orange 'Tx' LED
linked to data sent, and flashes as responses are sent by the Slave.

ERROR CODES

If the interface detects an error in the frame received, it returns an error code :

Error Code (decimal)	Error type
1	Prohibited function
2	Prohibited parameter address (unauthirised code sent)
3	Internal link failure (if present)
4	Prohibited data value
9	No data in request
10	Too much data in request

Table 2.3. Meaning of communication error codes

3. Chapter 3

DIGITAL COMMUNICATION

Contents Page

Chapitre 3 DIGITAL COMMUNICATION

3.1.GENERAL

Digital communication option can :
- control 7000S solid state contactors.
- monitor all operating parameters via the Supervisor.

3.1.1. Exchange type

Message are exchanged in 'Master/Slave' mode.
The digital communication option always operates as a slave, with the supervision system or PLC as Master. All exchange comprise a request from the Master and an answer from the slave (except in broadcast mode).

3.1.2. Communication protocol

The Modbus® RTU communication protocol is used.
Communication complies with the specifications given in 'GOULD MODICON Protocol Reference Guide PI-MBUS-300 rev J'.

3.1.3. Transmission

Transmission standard : **RS485,** 2 wires. The transmission frame uses binary characters.
Format of each character :
- 1 start bit
- 8 dta bits
- 1 stop bit

Transmission is asynchronous.
Two transmision speeds are availaible : **9,6** ou **19,2** kbaud.
The speed can only be selected by the microswitch SW8 on the interface.

3.1.4. Parameters status

The status of a parameter may be Read, Read and Wrtite or Memorised Read/Write :
- **Read only** parameters are labelled '**R**'
- **Read and Write** parameters are labelled '**R/W**'
- **Memorised Read and Write** parameters are labelled '**R/W/M**'

3.1.5. Power failure

If the power supply 'AUX2' fails, the interface stops communicationg and the output is set to zero.

When power is restored, the interface enters 'waiting for communication' state and the setpoint is zero.

3.2. DIGITAL COMMUNICATION PARAMETERS

3.2.1. GENERAL PARAMETERS

The following parameters are at fixed addresses allowing the Master Modbus in order to obtain data from the slave whatever power units from the 7000 range is used with the digital comminication option.

Abreviation	Parameter name	Address	Status
MI	Manufacturer Identifier	**65280**	R
CW	Command Word	**65488**	R/W
GSW	General Status Word	**65504**	R
SN	Serial Number	**65520**	R
V0	Version 0	**65522**	R
V1	Version 1	**65526**	R
DI	Device Identifier	**65528**	R
MF	Modbus Function	**65529**	R
CTO	Comm Time Out	**65531**	R/W
STO	Setpoint Time Out	**65532**	R/W

3.2.1.1. DESCRIPTION OF PARAMETERS

Manufacturer Identifier (MI) :
This parameter returns 'EUROTHERM Automation' as an ASCII character string (32 consecutive bytes read, starting at address 65280)

Command Word (CW) :
This parameter is used to modify the operation of the digital communication
Codes and associated functions are given in the following table :

Command	Function
0	Inhibit firing
1	Enable firing
2	Enable supply variation compensation
3	Disable supply variation compensation
4	Modify reference for compensation
5	Transfer waiting setpoint to active setpoint
6	Alarms discharge
7	PLF rating demand
8	PLF monitoring disabled

The operations coded 2,3,4,7 and 8 are stored in permanent memory

General Status Word (GSW) :
This parameter indicates the status of the main alarms and the status of monitoring during the time between communication frames. The byte containig 0 to 7 may be read by Modbus function 7 (Quick Read) Bit definition :

Bit number	Definition
0	State '1' : GRF alarm (TLF and THSC) active
1	State '1' : PLF and TLF fault channel 1 (7100, 7200 and 7300)
2	State '1' : PLF and TLF fault channel 2 (7200 and 7300 only)
3	State '1' : PLF and TLF fault channel 2 (7200 and 7300 only)
4	Resevred
5	State '1' : Power unit conduction stpped due to an alarm
6	State '1' : Over-temperature alarm activated (fan-cooled unit)
7	State '1' : Link failure with the communication option for S basic versions with DLF and A versions
8	State '1' : Time-out exceeded channel 1 (7103S)
9	State '1' : Time-out exceeded channel 1 (7103S)
10	State '1' : Time-out exceeded channel 1 (7103S))
11 à 15	Not used

Serial Number (SN) :
Each power units has a unique serial number at the address 65520

Communication software version number (V0)
Board version number (V1) :
This parameter is divided into bytes, BIts 8 to 15 correspond to the board version number and Bits 0 to 7 correspond to the software version number.

Device Identifier (DI) :
This parameter is a unique factory-configured code (7000S series only) which enables the option to determine the type of unit.

Product name	Read Value
7100S	102
7100S + GRF	103
7100S + DLF	104
7200S	106
7200S + GRF	107
7200S + DLF	108
7103S	121
7103S + GRF	122
7103S + DLF	123

Product name	Read Value
7300S	110
7300S + GRF	111
7300S + DLF	112
7300S	114
7300S + GRF	115
7300S + DLF	116
7300S	118
7300S + GRF	119
7300S + DLF	120

Product name	Read Value
7300A	150

Modbus functions supported (MF) :
Returns the value 186 (decimal) which means that the option supports the functions 3,7,8,16.

Communication Time-Out (CTO) :
Sets the time (in seconds) for which the interface listens between two venlidated communication frames sent to the interface. If the parameter is set to 0 monitoring is disabled.
The time-out is disabled by default (CTO = 0). The authorised values are between 1 s and 65535 s and are stored in permanent memory.

> If the time-out is exceeded, the interface behaves as follows :
> The green 'ON/Dxch' front panel LED, flashes at a freqency of 0.5 Hz, instead of being steady on. The value in the 'Setpoint after time-out' parameter is transfered to the active setpoint if its value is higher.
> Bit 8 of the General Status Word is set to 1 and will be set to 0 when next read.

Setpoint after time-out (STO) :
used to set the setpointused if the time-out is exceeded.
Authorised values are between 0 and 255, stored in permanent memeory.

3.2.2. APPLICATION PARAMETERS

Abreviation	Parameter name	Address	Status
SL	Setpoint Local	01	R/W
FS	Fast Setpoint Transfer	02	R/W
HS	High Setpoint Limit	16	R/W
OPH	Output Power High Limit	17	R/W
CT	Cycle Time	18	R
OP	Output Power	32	R
SP	Working Setpoint	33	R
ISW	Interface Status Word	34	R

3.2.2.1. DESCRIPTION OF APPLICATION PARAMETERS

Digital Setpoint (SL) :
Corresponds to the required duty ratio. Authorised value between 0 and 255.

Fast setpoint (FS) :
Used to store a setpoint prepared in advance in live memory.
Authorised value between 0 and 255.

High setpoint Limit (HS) :
Sets the maximum allowable value of the resulting digital input request.
Authorised value between 0 and 255, stored in permanent memory.

Output Power High Limit (OPH)
Sets the maximum allowable for the output power request.
Authorised value between 0 and 255, stored in permanent memory.

Base Time in 'Burst Mode'(CT)
Used to set the firing period, defined at 50% of the duty ratio.
Authorised value between 0 and 255, stored in permanent memory.
Value '0' : intelligent half-cycle firing mode.
Value '1' : Single cycle firing mode
Value 2 to 255 : base tome of 2 to 255 cycles in burst mode

Output Power Request (OP)
Corresponds to the duty ratio value sent to the 7000 series unit.
The value is identical to the setpoint if compensation is not active.
Authorised value between 0 and 255.

Working Setpoint (SP) :
is the result of the product between the setpoint local and the setpoint limit
SP = (SL * HS)/255 (Read value between 0 and 255)

Interface Status Word (ISW) :
Indicates 7000S status

Bit number	7000S
0	Interface synchronisation (Voltage 24 Vac)
1	'1' : Supply voltage compensation active
2	'1' : power outpu disabled
3 à 15	Not used

3.2.3. SPECIFIC PARAMETERS

3.2.3.1. 7100S VERSION WITH GRF OPTION

Abreviation	Parameters name	Adresse	Status
SW	Status Word	35	R

Status word (SW)
Corresponds to the GRF option status
Bit definition :

Bit number	7100S
0	'1' : GRF alarm (TCF or THcs) active
1 à 3	Reserved for 3-phased units
4 et 5	reserved
6	Over-temperatue fault (fan-cooled units)

3.2.3.2. 7100S VERSION WITH DLF OPTION

Abreviation	Parameters name	Adresse	Status
SW	Status Word	35	R
CV	Current Value	36	R
CF	Current Fast Response Time	37	R

Status word (sw) parameter for DLF option

Corresponds to the status parameters sent by the DLF option.
Bit definition :

Bit number	7100S
0	'1' : Short Wave Infrared elements '0' : low temperature coefficient load
1	DLF setting state ('1' : set)
2	'1' : Partial load failure alarm
3	'1' : Total load failure alarm
4	'1' : Over-temperature (fan-cooled units)
5	'1' : Thyristor short circuit
6 à 15	Not used

Current value during modulation period (CV)
Corresponds to the rms current value during the modulation period.
the maximum integration time is 70 s.
The values read are betwenn 0 and 255 (linear ratio).
Nominal value CV - 204

Current value during fixed period(CF)
Corresponds to the rms current value measured during a fixed 1.6 S cycle, which gives quick readings during 'On/Off' operation or with a high modulation period.
The values read are betwenn 0 and 255 (linear ratio). Nominal value CF - 204

3.2.3.3. 7200S AND 7300S VERSION WITHE GRF OPTION

Abreviation	Parameters name	Adresse	Status
SW	Status Word	35	R

STATUS WORD (SW) PARAMETER
Corresponds to the GRF option alarm status
Bit definition :

Bit number	7200S or 7300S
0	'1' : GRF Alarm (TCF or THSC) active
1	TLF fault channel 1
2	TLF fault channel 2
3	TLF fault channel 3
4 et 5	Reserved
6	over-temperature fault (fan-cooled units)

3.2.3.3. 7200S AND 7300S VERSION WITHE DLF OPTION

Abreviation	Parameters name	Adresse	Status
SW	Status Word	35	R
C1	Current Value 1	36	R
CF1	Current Fast Response Time line 1	37	R
C2	Current Value 2	38	R
CF2	Current Fast Response Time line 2	39	R
C3	Current Value 3	40	R
CF3	Current Fast Response Time line 3	41	R
CV	Current Value (avarage)	42	R
CF	Current Fast Response Time (average)	43	R

STATUS WORD (SW) PARAMETER FOR THE DLF OPTION

Corresponds to the status parameters sent by the DLF option.
Bit definition :

Numéro de bit	7200S ou 7300S
0	GRF fault (TLF or THSC)
1	PLF and TLF fault channel 1
2	PLF and TLF fault channel 1
3	PLF and TLF fault channel 1
4	PLF setting state (‘1’ : set)
5	Reserved
6	Reserved
7	‘1’ : Short Wave Infrared elements ‘0’ : low temperature coefficient load
8	Reserved
9	Reserved
10	Thermic fault
11	THSC fault
12 à 15	Reserved

Type 1 Current parameters (C1, C2, C3) :
Correspond to the rms current value, for each channel respectively during the modulation period. Maximum integratio time 70 s.Read values are between 0 and 255 (linear ratio)
Nominal value 204

Typr 2 Curren parameter (CF1, CF2, CF3) :
Ccorrespond to the current value measures during a 1.6 s cycle,
for each channels respectively.ce qui permet d’obtenir une
which gives quick readings during ‘On/Off’ operation or with a high modulation period.
The values read are betwenn 0 and 255 (linear ratio). Nominal value CF - 204
Read values are between 0 and 255 (linear ratio). Nominal value 204

Type 1 current average **(CV)**.
Read values are between 0 and 25.

Type 2 current average **(CF)**.
Read values are between 0 and 25.

Remarks:

If one parameter has no signification for the power unit used, the returned value is '1'.
(e.g : Current limitation on front panel on a basic version)

For functionning safety reason, only the folowing changes ara allowed :

- For basic units (no options apart from the digital communication) or for units with DLF and over current alarm, the digital communication option allows to change between PA, FC1, C16, C64 and ASC for the firing modes.

- For the control types, no changes permitted if the firing mode chosen is 'Burst firing', on the other hand with phase angle mode, the shift from U^2 to open loop is permitted.

- The shifts authorised using the digital communication option for the firng modes are : from FC1, C16, C16, C64 or ASC to HC16, but not tha other way round.
  The changes allowed are : from FC1, C16, C64 to SCA
  from PA or HC16
  For the control mode, if the unit is configured in PA, the following changes are allowed :

From $U^2 \leftrightarrow I^2$ to I^2 and reciprocally
From $U^2 \leftrightarrow I^2$ to $U*I \leftrightarrow I^2$ and reciprocally
(Authorised if the factory setting is $U*I \leftrightarrow I^2$)
From I^2 to $U*I \leftrightarrow I^2$ and reciprocally
(Authorised if the factory setting is est $U*I \leftrightarrow I^2$)
From Open Loop or U^2 to I^2 but not the other way round
(Reset to original settings after having switched the supply off)
From BO or U^2 to $U^2 \leftrightarrow I^2$ but not the other way round
(Reset to original settings after having switched the supply off)
From BO or U^2 to $U*I \leftrightarrow I^2$ but not the other way round
(Authorised if the factory setting is $U*I \leftrightarrow I^2$
Reset to original settings after having switched the supply off)

- Using inductive loads, FC1 or ASC are automatically shifted to C16.
  Using three-wire configuration, ASC is shifted to FC1

- For a power unit factory set ('burst-firing' mode) and after a shift to 'phase angle' mode, swithching back to 'burst firing' is only possible after having switched off the unit.

- When changing from 'burst firing' mode to 'phase angle' mode, the regulation loop is reset to zero in order to have a slope start.
  When changing from 'phase angle' to 'burst mode', a slope of angle is applied on next conduction.

With identical functions, digital communication settings are has priority on factory settings.

4. Chapter 4

OPERATION OF CONTROLLED 7000S UNITS

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4. Chapter 4 OPERATION OF CONTROLLED UNITS

4.1. THYRISTOR FIRING MODES

4.1.1. GENERAL

The i7000 communication interface can drive thyristor solid state contactors using three firing modes:

- 'Burst mode' (base time T_b = 2 to 255 cycles).
- 'Single-cycle' (base time T_b = 1 cycle)
- 'Intelligent half-cycle'
  (firing and non-firing for half-cycles possible)

All these modes are available if the product is connected to an **AC** power source, specifically a **24 Vac** (**± 20%**) auxiliary supply.

The i7000 interface may also be powered with a **24 Vdc (± 20%)** auxiliary supply.
In this case only 'Burst mode' firing with a base time T_b = 8 to 255 cycles is available

4.1.2. VOLTAGE VARIATION COMPENSATION

Voltage compensation involves maintaining the **constant power** at the **setpoint** value despite supply **variations**. (This relates to the power delivered by the solid state contactor to a low temperature coefficient load).

Important:
- The supply voltage is read via the auxiliary supply.
- Accordingly the **same supply network** should be used for the AC auxiliary supply as for the power connection to controlled devices.

If this is the case, when compensation is **active**, supply network variations are **compensated** via the AC auxiliary supply which is an **image** of the power device supply.

Supply voltage compensation operates for variations up to ± 20% of nominal voltage, using V^2 control.

The compensation status (enabled or disabled) is defined by bit **9** of the interface status word. This status can be modified with command word code **2** (enable) or code **3** (disable) the compensation.

The factory default sets the compensation for a **nominal** voltage of **24 Vac**, but with the function disabled (bit **9** of the interface status word is set to **0**).

The user may either:

- enable compensation using the factory-set nominal 24 Vac setting
  (set bit 9 of the interface status word to 1 by sending command word code 2)
- or set a voltage other than 24 Vac (using command word code 4) and then enable compensation (command word code 2)

4.1.3. FIRING MODES AVAILABLE

The firing mode of the 7000 series solid state contactor controlled by the i7000 communication interface is determined by:

- the type of auxiliary supply and the presence of the synchronisation interface
- the configuration of the i7000 interface
  (see product code for firing mode codes)
- the number of phases controlled
- the three-phase load configuration
  (for units controlling 2 or 3 phases).

The thyristor firing modes are based on modulating supply cycles: ('Burst mode' or 'Single-cycle') or half-cycles ('Intelligent half-cycle' mode).
For these modes the base time determines modulation and thyristor firing (for a definition and explanations see the 'Burst mode' section).

The base time can be configured over the digital communication link:

T_b = **0.5** to **255** cycles

within the **limits** due to the i7000 interface auxiliary **supply type** and the three-phase **load configuration** for series 7200S and 7300S units.

The following table summarises all information about firing mode availability.

7000 series unit	Three-phase load configuration	power source	'Burst mode'		'Single-cycle' T_b = 1 'Intelligent half-cycle' T_b = 0.5
			T_b = 2 to 255	T_b = 8 to 255	
7100S	Single-phase	AC	+	+	+
		DC	-	+	-
7200S	3 wires	AC	-	+	-
		DC			
7300S	3 wires	AC	-	+	-
		DC	-	+	-
	4 wires	AC	+	+	+
		DC	_	+	-
	6 wires	AC	+	+	+
		DC	-	+	-

Table 4-1 Possible firing modes depending on power supply and load types
(means that mode is available)

4.1.3.1. 'BURST MODE' FIRING

'**Burst mode**' firing is a **proportional cycle** which delivers a series of **whole** supply **cycles** to the load.
Thyristor firing and cut-off is synchronised with the supply and occurs at zero crossing.

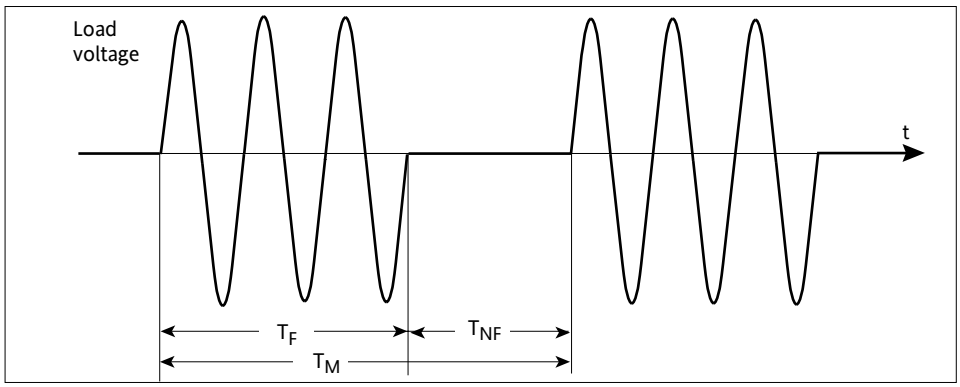

Figure 4-1 Thyristor firing in 'Burst mode' (zero crossing firing)

Thyristor firing in 'Burst mode' may be described by:

- the firing time ($\mathbf{T_F}$)
- the non-firing time ($\mathbf{T_{NF}}$)
- the modulation time ($\mathbf{T_M}$)

defined by:

$$\mathbf{T_M = T_F + T_{NF}}$$

The power delivered to the load is defined by the **duty ratio** η:

$$\eta = \mathbf{T_F / T_M}$$

Firing in 'Burst mode' is defined by the **base time** ($\mathbf{T_B}$).

Definition: The base time is equal to the **number of cycles** firing at **50%** of the duty ratio (or 50% of the power supplied to the load):
$\mathbf{T_B = T_F = T_{NF}}$.

Example: With a base time $\mathbf{T_B = 16}$ and duty ratio η **= 50%**

- the firing period $\mathbf{T_F}$ is equal to **16** supply cycles
- the modulation period $\mathbf{T_M}$ is equal to **32** supply cycles.

Important: With an **AC** power supply, changing the supply frequency (50 Hz or 60 Hz) does not change the number of base time **cycles** which can be programmed (**0.5** to **255** supply cycles).

With a **DC** power supply the **firing time** (in ms) is determined independently of the supply frequency (the base time may be between **160 ms** and **5.1 s**). The base time parameter is nonetheless always expressed as a number of cycles at 50 Hz.

4.1.3.2. 'SINGLE-CYCLE' AND 'INTELLIGENT HALF-CYCLE' FIRING MODES

' Burst mode' firing with a **single** firing or non-firing cycle (base time $\mathbf{T_B = 1}$) is known as '**Single-cycle**' (or 'Standard single-cycle').

In 'Standard single-cycle' mode thyristor firing or non-firing is **one supply cycle**.

In order to reduce power fluctuations during firing time, '**Intelligent half-cycle**' thyristor firing mode uses **half-cycles** as firing or non-firing periods.

'Intelligent half-cycle' firing mode significantly **reduces** the **modulation time** relative to whole cycle firing, resulting in less fluctuation of the controlled power.
For example, this mode **reduces flicker** on short wave infrared elements and is thus less annoying on the eyes.

Reminder: 'Standard single-cycle' and 'Intelligent half-cycle' modes are only available with an **AC** supply (as for all 'Burst mode' with T_B = 0.5 to 255).

For a duty ratio η **= 50%** the firing and non-firing time for both modes each correspond to a **single** supply cycle.
Accordingly, the controlled device operates identically in either mode (in this case only) as shown on the figure below.

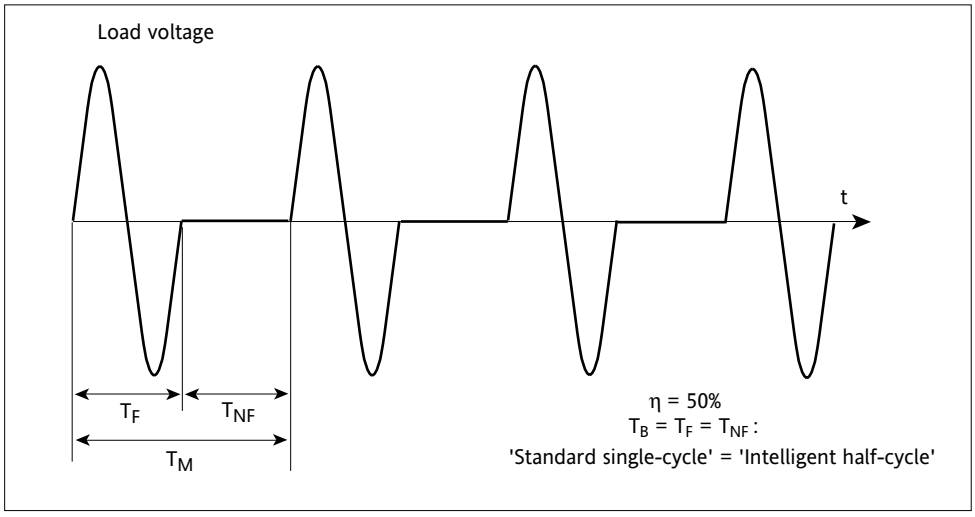

Figure 4-2 Example of firing with duty ratio η = 50% ($T_B = T_F = T_{NF}$) in 'Single-cycle' and 'Intelligent half-cycle' modes

4.1.3.2.1. Firing at less than 50% duty ratio

For all firing at **less than 50%** of the maximum setpoint (η **< 50%**) the **firing** time for 'Intelligent half-cycle' is **one** supply **half-cycle**.

The **non-firing** period, and thus the modulation period, are varied to ensure that the controlled device operates at the requested setpoint.

Figure 4-3 shows an example of firing with a duty ratio η **= 33%** in 'Standard single-cycle' and 'Intelligent half-cycle' modes.

As shown in the example, 'Intelligent half-cycle' firing significantly reduces the modulation time compared to firing for full cycles.

Important: To avoid a DC component the control system adjusts the number of positive and negative half-cycles.

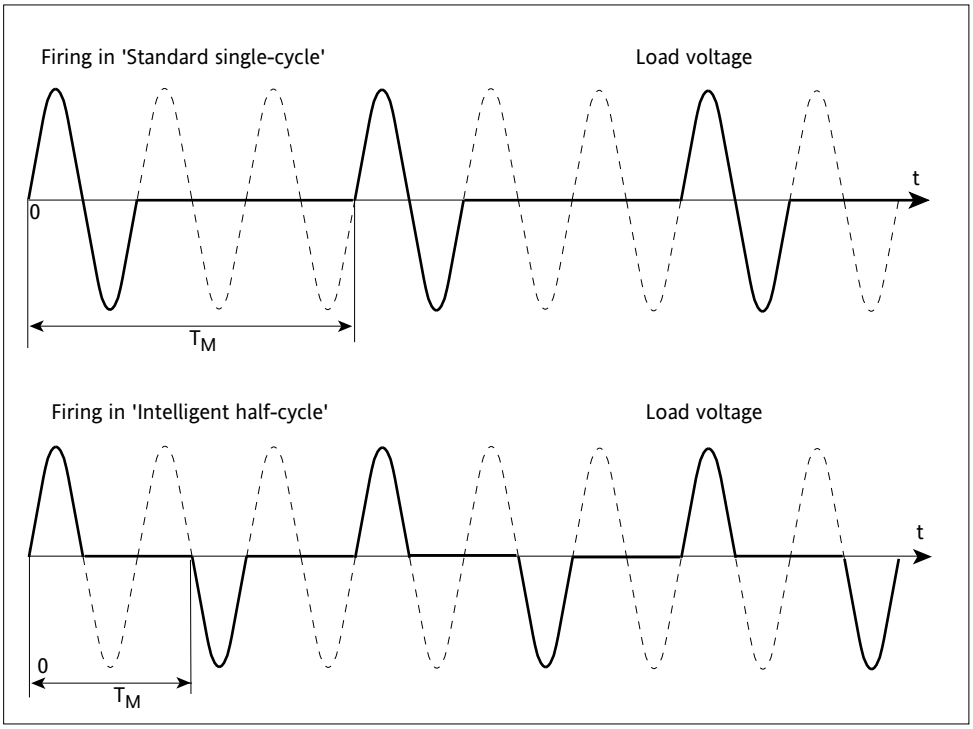

Figure 4-3 Example of firing with duty ratio h = 33% (T_{NF} = 2 T_F) in 'Single-cycle' and 'Intelligent half-cycle' modes

4.1.3.2.2. Firing at more than 50% duty ratio

For all firing at **more than 50%** of the maximum setpoint (η **> 50%**) the **non-firing** time for 'Intelligent half-cycle' is **one** supply **half-cycle**.

The **firing** period, and thus the modulation period, are varied to ensure that the controlled device operates at the requested setpoint.

Figure 4-4 shows an example of firing with a duty ratio η **= 66%** in 'Standard single-cycle' and 'Intelligent half-cycle' modes.

As shown in the example, 'Intelligent half-cycle' firing significantly reduces the modulation time compared to 'Standard single-cycle' because control is based on **faster modulation**.

Important: To avoid a DC component the control system adjusts the number of positive and negative half-cycles.

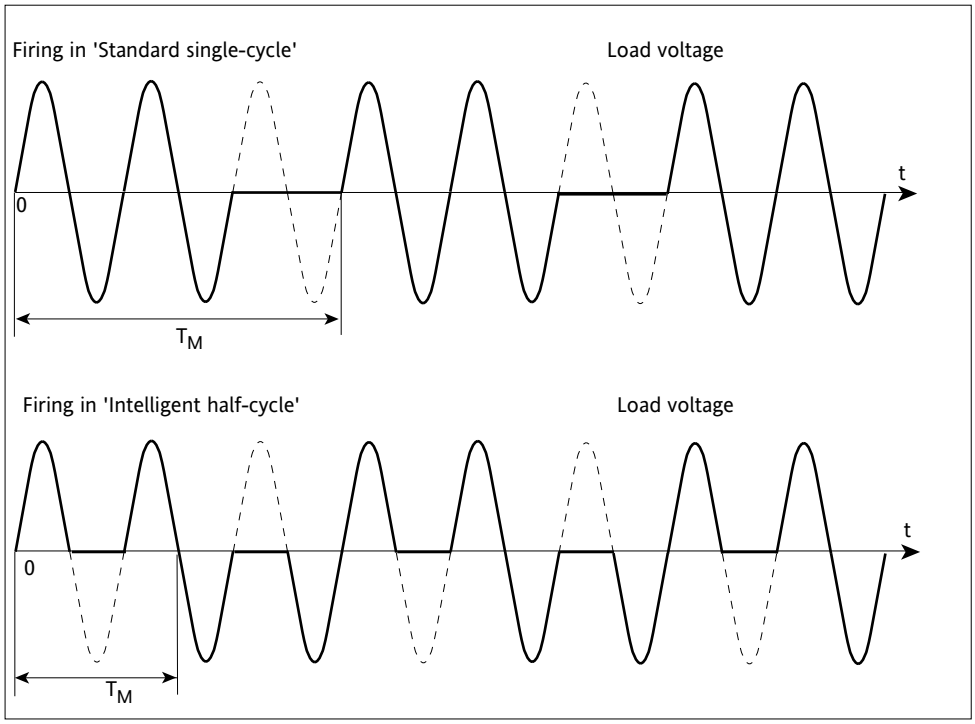

Figure 4-4 Example of firing with duty ratio η = 66% (T_F =2 T_{NF}) in 'Single-cycle' and 'Intelligent half-cycle' modes

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