MOTION CONTROL SYSTEMS

SOFTWARE INSTRUCTION MANUAL

STEPPING MOTOR DRIVES

HI-MOD ET A5F2HK

HI-MOD ET A5K2HK.L

HI-MOD ETS A4F2HK

R-MOD ET A3K2MK

Release - 02

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WARNING: It is user RESPONSIBILITY to check that this manual refers to product model and version that will be used.

1. NOTICES AND MANUAL STRUCTURE

This manual has been realized in order to give all the necessary information to program and manage HI-MOD ET, HI-MOD ETS and R-MOD ET series drives. The manual is valid for the following models:

- **HI-MOD ET A5F2HK (from FW version: PHC8LHC8)**
- **HI-MOD ET A5K2HK.L (from FW version: PHC8LHC8)**
- **HI-MOD ETS A4F2HK (from FW version: PHC9LHC9)**
- **R-MOD ET A3H2MK (from FW version: PRC7LRC7)**

It is user responsibility to check that this manual refers to product model and version that will be used. For warnings and precautions for use, refer to the hardware manual. This manual is an integral part of the hardware manual.

Note: The ESI files (file .xml) corresponding to the model listed above are available on the RTA website in section download. It is mandatory to use the particular ESI file conceived for the specific release.

2. DRIVE DESCRIPTION

The main characteristics of HI-MOD and R-MOD series drives are the following:

- EtherCAT communication protocol (CoE).
- **Full Closed Loop** mode: working in full closed loop through multi-turn absolute encoder (see object index 0x3220.2).
- **Auto Sync** mode: auto recovery the motor synchronization in case of synloss with encoder (Auto Syncronization function).
- Two coordinates mode: relative coordinates mode, absolute coordinates mode (see Chap. 2.1.1).

Full Closed Loop mode

Full Closed Loop function mode(index 0x3220.2 = 1) has the following advantages compared to traditional system:

- high operating efficiency
- less heating
- higher performance with the use possibility at the limits of the maximum torque supplied by the motor

Compared to a traditional synchronous system, the closed loop system requires the setting of some parameters able to define the best configuration between application needs and following error management.

The adjustment parameters are the following, with reference to what is explained in this manual:

- **CL_Loop parameters** (index 0x3220): closed loop adjustment parameters according to the load characteristics
- **Standstill CL_Loop parameters** (index 0x3221): setting parameters for standstill condition of the system. The default settings allow to avoid vibrations at standstill.
- **Following Error Control Parameters** (index 0x3222): setting parameters of the alarm windows that allow to check the dynamic trend of the following error, if it is necessary.
- **Position Loop** (index 0x3224): position loop gain setting parameters.
- **Velocity Loop** (index 0x3225): velocity loop gain setting parameters.
- **Current Loop** (index 0x3226): current loop gain setting parameters.
- **Current Limiting** (oggetto 0x3227): maximum value of provided current.

When tuning the system for specific applications, we suggest to:

- Verify settings of 0x3220 e 0x3226 depending on supply voltage
- Make first evaluations about dynamic performances basing on suggested settings og Table 11, depending on Jrat of the specific application, and considering the content of chapter 3.7 about the reverse energy, with particular reference to power supply features (capacity
- Modify suggested values depending on required perfomances (see dedicated chapter 3.5)

Auto Sync mode

Compared to a traditional syncronous system, the Auto Synchronization mode (object 0x3220.2 = 2) allows the drive to recover – within specific range limits – possible gaps between rotor position and drive command that can be result in a loss of syncronism.

If rotor is stopped, the range limits are equal to 1 full step (±1.8°).

If rotor is moving, the range limits corresponds to 2 full steps (3.6°).

In practice, the Auto-Sync function enable a sort of hybrid control system similar to a Closed Loop system: when the gap between rotor position and drive command is lower than 1 full step, the drive works in Open Loop mode (micro-stepping); when the gap between rotor position and drive command is greater than 1 full step, the drive works in Closed Loop mode up to the complete recovery of motor synchronism, then the drive turn to work in Open Loop mode. When operating in Closed Loop mode, the drive operates to provides the maximum torque at the motor depending on nominal current (see Current Ratio, object index 0x3201) and speed.

2.1. MODE OF OPERATION

According to object value 0x6060 (Mode of Operation) can be set 4 modes of operation:

- 1: **Profile position** mode of operation.
- 3: **Profile Velocity** mode (only in Full Closed Loop mode, obj. index 0x3220.2 = 1 and 0x3220.3 = 1)
- 6: **Homing** mode of operation
- 8: **Cyclic Sync Position (CSP)** mode of operation

2.1.1. PROFILE POSITION MODE OF OPERATION

With **Profile position** mode of operation, coordinates system (see Chap. 3.4.1) is set by bit 6 of CONTROL WORD.

- bit 6 = 0 absolute coordinates system
- bit 6 = 1 relative coordinates system

RELATIVE COORDINATES SYSTEM

Using this operation mode, the number of steps is a relative shift not dependent on the starting position of the motor. For example, executing the run corresponding to the storage shown in Table 1, motor covers 2400 steps in the positive direction; the starting position of the motor has no influence on the number of covered steps. The operation range is between [-419430400; 419430399] – 12.800 step/rev.

Index (hex)	Sub Ind.	Object type	Access type		Default value	Entry description	Set Value
607A	0	I32	RW		0	Target position	**24000**
6081	0	U32	RW		0x5DC0 (24000)	Profile Velocity	**3000 [Hz]**
6083	0	U32	RW		0x9C400 (640000)	Profile Acceleration	**80000 [Hz/sec]**

Table 1

ABSOLUTE COORDINATES SYSTEM

Using this operation mode, the number of motor steps depends on the position of the motor shaft before the movement start. Supposing to execute the same run described in the example of Table 1, the motor shift is in positive direction if the motor is in a position lower then +24000 steps, or in negative direction if the position before the start of the movement is higher than +24000. The borderline case is when the starting position is +24000, in this case then motor doesn't move.
Working with absolute coordinates operation mode requires the definition of an origin corresponding to coordinate 0. Usually coordinate 0 can be defined through the execution of HOMING procedure.
The operation range is between [-419430400; 419430399] at 12.800 step/rev, which correspond to 32767 revolutions.
The execution of an homing operation in a position different from the zero factory position (with or without any value of Home Offset) can produce a variation in the range of operation of the absolute encoder with respect to the nominal value of "Position Actual Value". In any case, the actual value of the encoder range can be read in the object index 0x607B, "Position Range Limit".
In Profile Position, Mode Of Operation can be switched from the following sub-states: Switched On, Ready to Switch ON, Switch On Disabled, Operation Enabled.

MOTION PROFILES

The "0" to "1" transition of the 4th bit of the Control Word determines the start of a movement (see Chapter 3.4.1).
The motion profile depends on the setting values of Profile Velocity (PV), Profile Acceleration (PA) and from the steps difference between start position and target position (ΔS). In relative coordinates system, this difference is equal to the absolute value of the Target Position, whereas in absolute coordinates system, this difference is equal to the absolute value of the difference from Target Position and the Actual Position of the shaft before moving starts.
Motion profiles can be of three type:

1. START-STOP, if PV is minor or equal to 16000 Hz (12800 step/rev)
2. TRAPEZOIDAL, if the relation $PV^2 < PA * \Delta S$ is valid
3. TRIANGULAR, in all the other cases

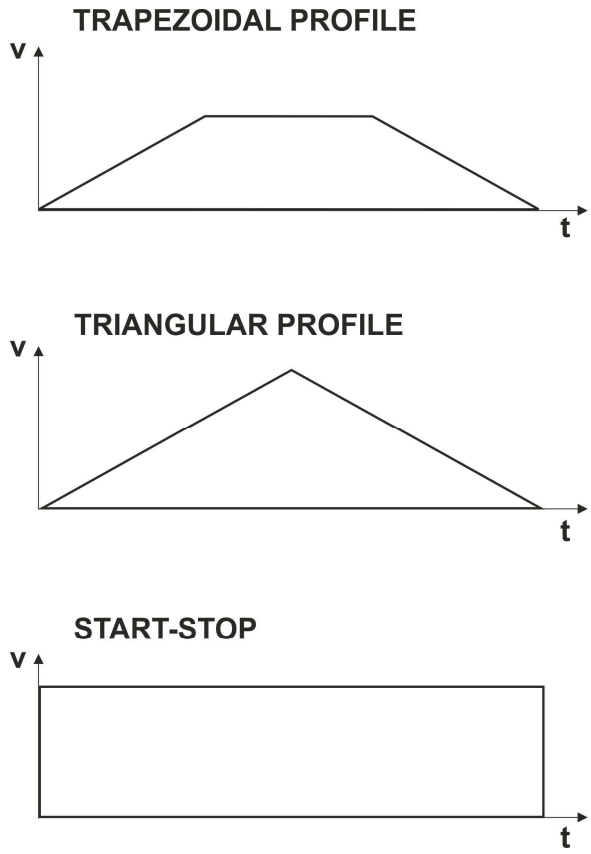

Figure 1: Motor frequency related to motor position during a generic motion execution. Acceleration profiles are only an example.

2.1.2. HOMING MODE OF OPERATION

With **Homing** mode of operation, the encoder position can be reset.
Available Homing Method: 37 (homing on current position); homing offset can be set = 0 only.
Homing operation must be set in Operation Enabled.

In Profile Homing, Mode Of Operation can be changed from the following sub-states: Switched On, Ready to Switch ON, Switch On Disabled, Operation Enabled.

2.1.3. CSP MODE OF OPERATION

In **CSP** mode of operation, Target Position is refreshed from the master every Cycle Time. In this mode of operation, the Target Position is always considered as an absolute reference.
Cycle Time allowed: 1ms, 2ms, 4ms.
In CSP, Mode Of Operation can be changed from the following sub-states: Switched On, Ready to Switch ON, Switch On Disabled, Operation Enabled.

2.1.4. PROFILE VELOCITY MODE OF OPERATION

In Profile Velocity (mode of operation available only when the drive is in Full Closed Loop mode, set by object index 0x3220.2 = 1), the drive receive from the master the requested Target Velocity (object 0x60FF) following the Master timing.
Velocity tolerance = ±0.24% ±1.5RPM.
Velocity lower than 1200 step/s cannot be set.
In this mode of operation, the drive working always in Full Closed Loop mode (the drive behavior is the same in standstill or when the object index 0x3221.1 is set to 0).
The real motor velocity depends only by the values of current and closed loop gain setting parameters.

Note: Switching between different mode of operations in Operation Enabled state must be done when the motor is standstill. Pay attention to Target Position and Target Velocity values.

2.2. DRIVE SUB-STATES

In accordance with standard CiA DSP 402, the drive can be described as a state machine.

When the drive is in Operational Mode, the behavior of the drive complies with diagram of Figure 2 in accordance with CiA DSP402 V.2.0 standard. Change of sub-states are manage through the CONTROL WORD.

NOTA: When the drive is power supplied, it automatically goes into the SWITCH ON DISABLED status.

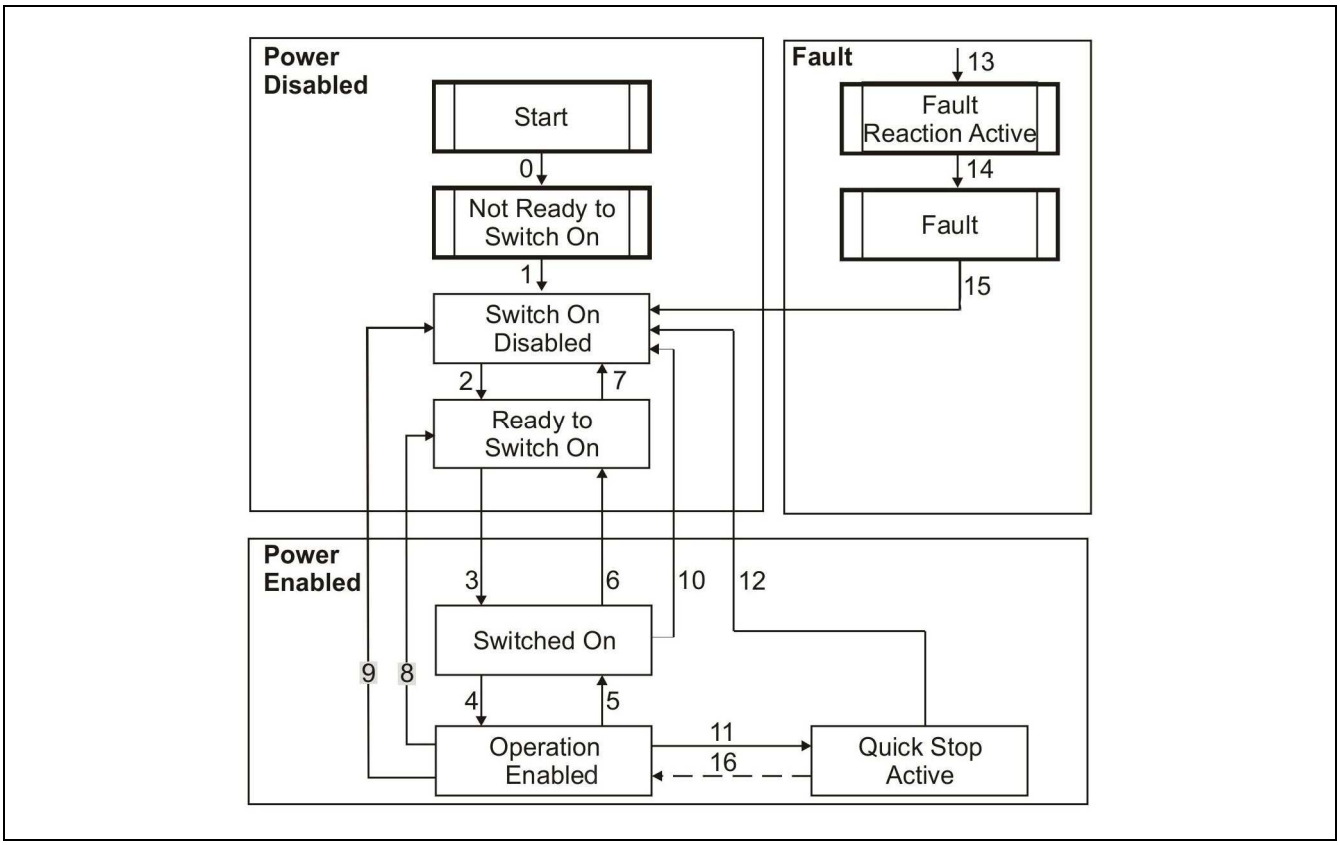

Figure 2

In detail:

Transition 3: READY TO SWITCH ON => SWITCHED ON
'Switch On' command received from master.
This transition is possible when drive power section is supplied (between HVDC+ and HVDC-) at least 500ms before the transition itself; otherwise drive remains in "READY TO SWITCH ON" state.

Transition 4: SWITCHED ON => OPERATION ENABLED
'Enable Operation' command received from master.
After this transition current in stepping motor windings is enabled.

In CSP, these cases are possible:
Master must set Target Position = encoder position before Enable Operation command.
Target Position can be changed only after 200 ms from this command in order to ensure a suitable/fitting mechanical settling time of the system.

Transition 5: OPERATION ENABLED => SWITCHED ON
'Disable Operation' command received from master.
After this transition current in stepping motor windings is disabled (CURRENT OFF).

Transition 6: SWITCHED ON => READY TO SWITCH ON
'Shutdown' command received from master.

After this transition drive power supply can be disconnected.

Transition 8: OPERATION ENABLED => READY TO SWITCH ON
'Shutdown' command received from master.
After this transition current in stepping motor windings is disabled (CURRENT OFF); after this transition drive power supply can be disconnected.

Transition 9: OPERATION ENABLED => SWITCH ON DISABLED
'Disable Voltage' command received from master.
After this transition current in stepping motor windings is disabled (CURRENT OFF); after this transition drive power supply can be disconnected.

Transition 10: SWITCHED ON => SWITCH ON DISABLED
'Disable Voltage' or 'Quick Stop' command received from master.
After this transition drive power supply can be disconnected.

Transition 11: OPERATION ENABLED => QUICK STOP ACTIVE
'Quick Stop' command received from master.

- **Profile Position and Homing Profile (Quick Stop Option Code = 5)**
  Drive automatically goes into the quick stop status and, if the motor is running, bit 10 (target reached) of SW is 0 until the motor is stopped (in this case bit 10 = high and **that means that the motor stopped, it does NOT mean that the motor reached the target position**). Current is not disabled in stepping motor windings (motor torque is maintained).
- **CSP (Quick Stop Option Code = 0)**
  Drive automatically goes into the quick stop status, current is disabled in stepping motor windings and Transition 12 is automatically executed.

Transition 12: QUICK STOP ACTIVE => SWITCH ON DISABLED

- **Profile Position and Homing Profile (Quick Stop Option Code = 5)** - *'Disable Voltage' command received from master.*
  The drive does not execute this transition automatically, this transition is possible by means of 'Disable Voltage' command only. In this case current is disabled in stepping motor windings (CURRENT OFF).
- **CSP (Quick Stop Option Code = 0)** AUTOMATIC TRANSITION AT STANDSTILL MOTOR
  In quick stop active status, if the motor is running during Quick Stop reception, bit 10 (TARGET REACHED) of SW is set to 0 until the motor is stopped. After that bit 10 is set to 1 and **that means that the motor stopped, it does NOT mean that the motor reached the target position**. The automatic transition to Switch On Disabled causes the setting of bit 10 of SW to 0.

Transition 13-14: => FAULT
This transition is caused by drive internal faults only (thermal protection, no power supply, etc.); before this transition there is an EMERGENCY message (see chap. 3.6 about error codes); at the same time current in stepping motor windings is disabled (CURRENT OFF). In Fault state drive power supply can be disconnected.

Transition 15: FAULT => SWITCH ON DISABLED
'Fault Reset' command received from master.
This transition is allowed when the fault of the drive is solved. It is shown with EMERGENCY message 0x0000.

Transition 16: QUICK STOP ACTIVE => OPERATION ENABLED
'Enable Operation' command received from master.

- **Profile Position and Homing Profile (Quick Stop Option Code = 5)**
  This transition is allowed because Quick-Stop-Option-Code = 5. Current is kept into the motor windings (motor torque is kept).
- **CSP (Quick Stop Option Code = 0)**
  This transition is not possible because Quick-Stop-Option-Code = 0.

Note: because of electro-mechanical interactions in stepping motors, when current in motor windings is enabled or disabled (for example Transition 4), it is required to wait for a settling time of the motor of ~ 50-200ms before the motor is stabilized from the mechanical point of view. Therefore, Status Word indicating the transition to Operation Enable **means only the acknowledge of the transition, it does not mean that the drive is already stabilized. Any New Set Point commands sent before the stabilization of the drive can cause a loss of synchronism of the run in execution sent into execution.**

The above-mentioned commands are achieved setting the CONTROL WORD as in Table 2, in compliance with the Table in Chapter 10.3.1 of "CiA DSP 402 V.2.0", reported as follows.

Command	Bit of the CONTROL WORD					Transitions
	Fault reset	Enable operation	Quick stop	Enable voltage	Switch on	
Shutdown	0	X	1	1	0	2,6,8
Switch on	0	X	1	1	1	3
Disable voltage	0	X	X	0	X	7,9,10,12
Quick stop	0	X	0	1	X	7,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	Trans. L/H	X	X	X	X	15

Table 2

Drive status can be read by means bit of STATUS WORD as in Table 3, in compliance with the Table 5 in Chapter 10.3.2 of "CiA DSP 402 V.2.0", reported as follows.

Status	Bit of the STATUS WORD					
	Switch On Disabled Bit 6	Quick Stop Bit 5	Fault Bit 3	Operation Enable Bit 2	Switched On Bit 1	Ready to Switch ON Bit 0
Switch on disabled	1	1	0	0	0	0
Ready to switch on	0	1	0	0	0	1
Switched on	0	1	0	0	1	1
Operation enable	0	1	0	1	1	1
Quick stop active	0	0	0	1	1	1
Fault	0	x	1	0	0	0

Table 3

Basically: from Switch On Disabled state, in order to enable motor Current-ON and then start the motion (relating to the previously set parameters), the **requested Control Word (CW) command sequence** is the following:

CW = **0x0006** -> (Drive goes in Ready to Switch-ON state, Status Word = 0x0221 or 0x1221 if High Voltage is not available, StatusWord = 0x0231 or 0x1231 if High Voltage is available)
CW = **0x0007** -> (Drive goes in Switched-ON state, Status Word = 0x0233 or 0x1233 only if High Voltage is available, in other cases, the transition cannot be completed)
CW = **0x000F** -> (Drive goes in Operation Enabled state, Status Word = 0x0637 or 0x1637 or 0x1237, regarded to the value of Mode of Operation)
CW = **0x001F** or CW = **0x005F** (Motor starts to move following absolute or relative coordinate system, respectively. Relative coordinate are available only if the set value of Mode of Operation enables them)

The direct sequence from CW = 0x0006 to CW = 0x000F can be done. Pay attention to the High Voltage restrictions

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3. OBJECT DICTIONARY

Object dictionary structure is described in the following chapter. In the appendix a summarizing table with all the object dictionary is shown.

3.1 BASIC PARAMETERS AND IDENTIFICATION (0x100-0x1018)

In accordance with standard CANopen DS301 following objects are implemented:

Index (hex)	Sub Ind.	Object type	Acces s type	Note	Default value	Entry description	Valid values
1000		U32	RO		0x0004 0192	Device type	0x0004 0192
1001		U8	RO	1	0	Error Register	0 / 1
1008			RO		--	Device name	HI-MOD ETS / R-MOD ET
1009			RO		-	Hardware version	
100A			RO			Software version	
1010		Rec				**Store parameters**	
"	0	U8	RO		1	Number of entries	
"	1	U32	RW		0x00000001 (1)	Save all parameters	0x65766173 ("save")
1011		Rec				**Restore Default Parameters**	
	0	U8	RO		1	Number of entries	
"	1	U32	RW		0x00000001 (1)	Restore all Default Parameters	0x64616F6C ("load")
1018		Rec				**Identity**	
"	0	U8	RO		4	Number of entries	
"	1	U32	RO		0x0000017F (383)	Vendor ID	0x0000 017F
"	2	U32	RO		0x00000000 (0)	Product code	0x0000 0000…0x FFFF FFFF
"	3	U32	RO		0x00000000 (0)	Revision	0x0000 0000…0x FFFF FFFF
"	4	U32	RO		0x00000000 (0)	Serial number	0x0000 0000…0x FFFF FFFF

Table 4

In accordance with Table 4:

Index 0x1001: Error register
Valid values are:

- 0: normal operating condition; no errors
- 1: there is an error; EMERGENCY telegram is sent and the error type is shown to the Index 0x603F (Error Code).

Index 0x1010: Store parameters
The object is used to save parameters.
In order to avoid storage of parameters by misstate, storage is only executed when a specific signature is written to the Sub Index 1. The signature is "save":

MSB			LSB
e	**v**	**a**	**s**
0x65	0x76	0x61	0x73

Note1: Keep the control power ON more than 5 seconds, after the "save" command.
Note2: "Confirmed message" via SDO means "Command Accepted", it does not mean "Parameter Saving Completed" for this object.

Index 0x1011: Restore Default Parameters
The object is used to restore the default parameters.
In order to avoid the restoring of default parameters by misstate, restoring is only executed when a specific signature is written to the Sub Index 1. The signature is "load":

MSB			LSB
d	**a**	**o**	**l**
0x64	0x61	0x6F	0x6C

Note1: Keep the control power ON more than 5 seconds, after the "load" command.
Note2: "Confirmed message" via SDO means "Command Accepted", it does not mean "Parameter Loading Completed" for this object.

3.2 COMMUNICATION OBJECTS (0x1600-0x1B00)

Index (hex)	Sub Ind.	Object type	Access type		Default value	Entry description	Valid values
1600		Rec				**RPDO1**	
"	0	U8	RO		1	Number of entries	
"	1	U32	RO		0x6040 0010	Control Word	0x6040 0010
1601		Rec				**RPDO2**	
"	0	U8	RO		2	Number of entries	
"	1	U32	RO		0x6040 0010	Control Word	0x6040 0010
"	2	U32	RO		0x607A 0020	Target Position	0x607A 0020
1700		Rec				**RPDO100**	
"	0	U8	RW	1	5	Number of entries	
"	1	U32	RW		0x6040 0010	1st mapping data	See the following NOTE
"	2	U32	RW		0x6060 0008	2nd mapping data	
"	3	U32	RW		0x0000 0008	3rd mapping data	
"	4	U32	RW		0x607A 0020	4th mapping data	
"	5	U32	RW		0x0000 0000	5th mapping data	
"	6	U32	RW		0x0000 0000	6th mapping data	
"	7	U32	RW		0x0000 0000	7th mapping data	
"	8	U32	RW		0x0000 0000	8th mapping data	
1A00		Rec				**TPDO1**	
"	0	U8	RO		1	Number of entries	
"	1	U32	RO		0x6041 0010	1st mapping data	0x6041 0010
1A01		Rec				**TPDO2**	
"	0	U8	RO		2	Number of entries	
"	1	U32	RO		0x6041 0010	Status Word	0x6041 0010
"	2	U32	RO		0x6064 0020	Actual Position	0x6064 0020
1B00		Rec				**TPDO100**	
"	0	U8	RW	1	7	Number of entries	See the following NOTE
"	1	U32	RW		0x6041 0010	1st mapping data	
"	2	U32	RW		0x6061 0008	2nd mapping data	
"	3	U32	RW		0x0000:0008	3rd mapping data	
"	4	U32	RW		0x6064 0020	4th mapping data	
"	5	U32	RW		0x0000 0000	5th mapping data	
"	6	U32	RW		0x0000 0000	6th mapping data	
"	7	U32	RW		0x0000 0000	7th mapping data	
"	8	U32	RW		0x0000 0000	8th mapping data	

Table 5

EMERGENCY OBJECT
The error codes mapped in the EMERGENCY message are listed in the description of 0x603F (see Chap. 3.6).

PROCESS DATA OBJECT (PDO)
Every PDO can be enabled.
The available PDO are the following (the example about TPDO100 and RPDO100 corresponds to default configuration):

RPDO 1:

Byte0	Byte1
Control Word	

RPDO 2:

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5
Control Word		Target Position			

RPDO 100:

Byte0	Byte1	Byte2	ByteEmpty	Byte4	Byte5	Byte6	Byte7
Control Word		Mode of Operation		Target Position			

TPDO 1:

Byte0	Byte1
Status Word	

TPDO 2:

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5
Status Word		Actual Position			

TPDO 100:

Byte0	Byte1	Byte2	ByteEmpty	Byte4	Byte5	Byte6	Byte7
Status Word		Mode of Op.disp		Actual Position			

Note: RPDO100 / TPDO100
It is available the mapping of the following objects:

- RPDO100:
CONTROL WORD (obj 0x6040),
MODE OF OPERATION (obj 0x6060),
TARGET POSITION (obj 0x607A),
TOUCH PROBE FUNCTION (obj 0x60B8),
PROFILE VELOCITY (obj 0x6081),
SET OUTPUT (obj 0x320A),
CL_LOOP STANDSTILL MODE (obj 0x3221.01),
TARGET VELOCITY (obj 0x60FF)

- TPDO100:
STATUS WORD (obj 0x6041),
MODE OF OPERATION DISPLAY (obj 0x6061),
ACTUAL POSITION (obj 0x6064),
FOLLOWING ERROR (obj 0x3230),
COMMANDED CURRENT (obj 0x3231),
VELOCITY ACTUAL VALUE (obj 0x606C),
TOUCH PROBE POSITION POSITIVE VALUE (obj 0x60BA),
TOUCH PROBE POSITION NEGATIVE VALUE (obj 0x60BB),
TOUCH PROBE STATUS (obj 0x60B9),
DIGITAL INPUTS (obj 0x60FD),
ERROR CODE (obj 0x603F),
LAST ERROR CODE (obj 0x303F)

Mapping an 8 bit object (for example MODE OF OPERATION) requires an empty byte, placed immediately after the same object. For more details, see the previous examples. It is forbidden mapping more than one empty byte (i.e. empty space of 16 or 32 bit).
If required, it is possible to map empty object of 16 or 32 bit dimension.

TOUCH PROBE POSITION POSITIVE VALUE and TOUCH PROBE POSITION NEGATIVE VALUE objects can be mapped at the same time, but it is not possible to use Touch Probe Function to sample at the same time the positive edge trigger position and the negative edge trigger position.

The maximum range of mapping objects in TPDO100 and RPDO100 is 16 byte (dummy objects with 1 byte included); the maximum number of mapping objects in TPDO100 and RPDO100 is 8 (dummy objects included).
In the case of use at the same time RPDO1 (or RPDO2) and RPDO100, it is strictly forbidden to map objects Control Word and Target Position also as a copy in RPDO100.

When SET OUTPUT is mapped in RPDO100:

- The minimum time between two switching requests of any output cannot be less than 10ms
- The minimum time between the switching request of any output and writing of SDO cannot be less than 5ms

If it is necessary to map SET OUTPUT object and TOUCH PROBE FUNCTION object at the same time and Mode of Operation is set to Profile Position or Homing, please contact RTA in order to evaluate the specific application limits.

3.3 COMMUNICATION TIMING (1C32-1C33)

In EtherCAT, synchronization mode is displayed in 0x1C32 and 0x1C33 Sub Index in Object Dictionary. About setting of synchronization mode, refer to Chap. 4.1.
The synchronous mode supported to RTA series drives are the following:

3.3.1 SYNCHRONOUS WITH SM2 EVENT

Since slave process is started to SM2 event cycle, always synchronizes with SM2 event.
Operated in local cycle time receiving SM2 event.

1C32		Rec		**SM output parameter**	
“	1	U16	RW	Sync mode	Synchronized with 0x01: SM2
“	2	U32	RO	Cycle time	Communication Cycle time
“	4	U16	RO	Sync modes supported	Bit1=1: Synchronization Supported
“	5	U32	RO	Minimum cycle time	
“	8	U16	RW	Get cycle time	
“	B	U32	RO	Cycle exceeded counter	
“	C	U32	RO	SM event missed counter	
“	20	U32	RO	Sync error	
1C33		Rec		**SM input parameter**	
“	1	U16	RW	Sync mode	Synchronized with 0x22: SM2
“	2	U32	RO	Cycle time	Same set to 0x1C32.2
“	4	U16	RO	Sync modes supported	Same set to 0x1C32.4
“	5	U32	RO	Minimum cycle time	Same set to 0x1C32.5
“	8	U16	RW	Get cycle time	Same set to 0x1C32.8
“	B	U32	RO	Cycle exceeded counter	Same set to 0x1C32.B
“	C	U32	RO	SM event missed counter	Same set to 0x1C32.C
“	20	U32	RO	Sync error	Same set to 0x1C32.20

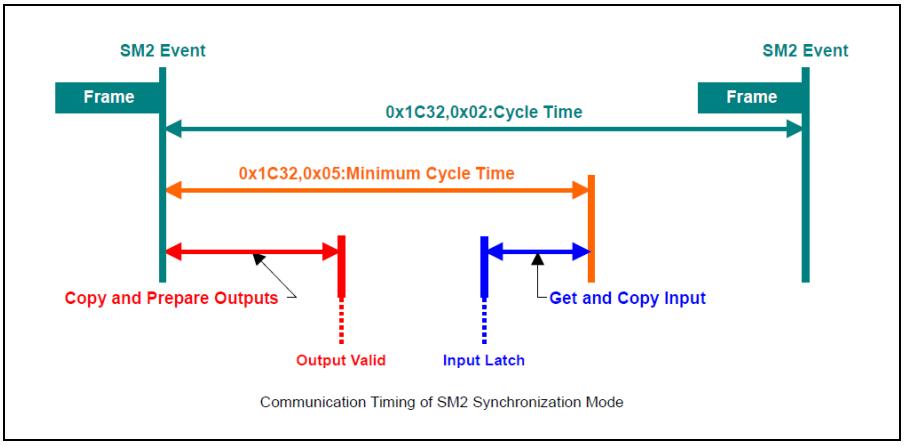

Figure 4

3.3.2 DC MODE 1 (SYNC0 Event Synchronization)

Local cycle of slave is started to SYNC0 event reception.
Process data frame (on SM2) must complete data reception within slave before the next SYNC0 interruption generating. “Get cycle time” contains the minimum time lag between frame reception and SYNC0 event.

1C32		Rec		**SM output parameter**	
“	1	U16	RW	Sync mode	Synchronized with 0x02: DC SYNC0
“	2	U32	RW	Cycle time	Cycle time SYNC0
“	4	U16	RO	Sync modes supported	Bit4:2=001: Synchronization Supported
“	5	U32	RO	Minimum cycle time	
“	8	U16	RW	Get cycle time	
“	B	U32	RO	Cycle exceeded counter	
“	C	U32	RO	SM event missed counter	
“	20	U32	RO	Sync error	
1C33		Rec		**SM input parameter**	
“	1	U16	RW	Sync mode	Synchronized with 0x02: DC SYNC0
“	2	U32	RW	Cycle time	Same set to 0x1C32.2
“	4	U16	RO	Sync modes supported	Same set to 0x1C32.4
“	5	U32	RO	Minimum cycle time	Same set to 0x1C32.5
“	8	U16	RW	Get cycle time	Same set to 0x1C32.8
“	B	U32	RO	Cycle exceeded counter	Same set to 0x1C32.B
“	C	U32	RO	SM event missed counter	Same set to 0x1C32.C
“	20	U32	RO	Sync error	Same set to 0x1C32.20

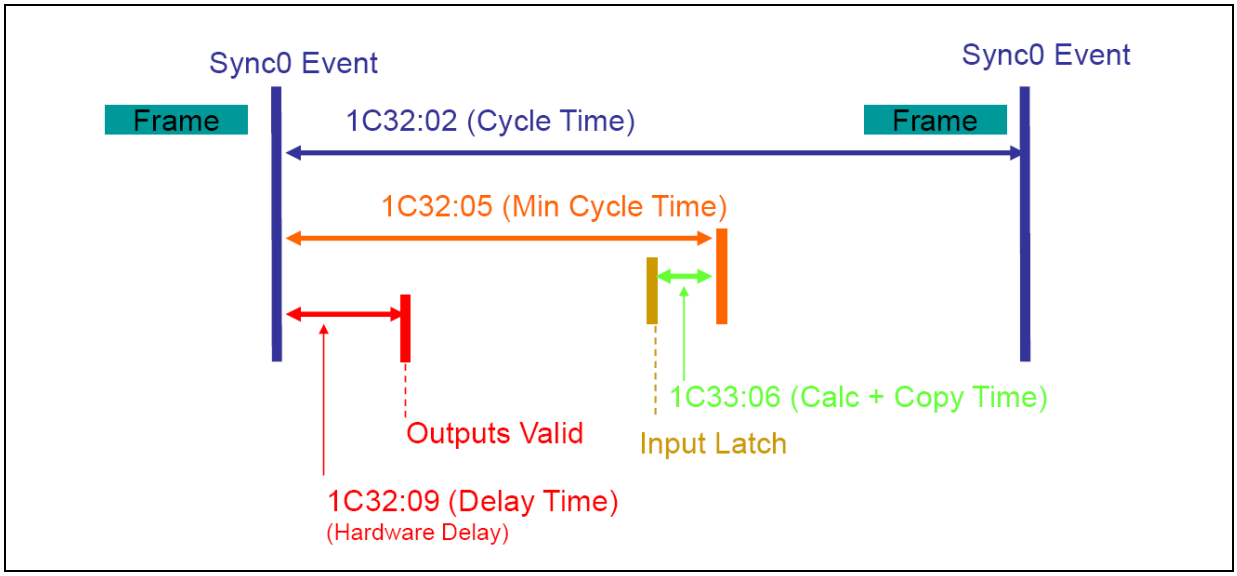

Figure 5

Note: DC MODE on ETHERCAT MASTER

With DC MODE and Mode of Operation set to CSP, some Ethercat masters may show a communication jitter so large that the frames including Target Position do not get the slave into the correct timeout limits. As a consequence, movements can be noisy. To overcome this challenge, the DC MODE master parameter named “Shift Time” must be set to a value in the range of +150 µs and +300 µs.

3.3.1 TRIO MASTER CONFIGURATION

In order to adjust the communication jitter, the DC shift time must be set to the proper value. It is thus mandatory to insert in any project the following instruction lines:

In MC_CONFIG:

```
AUTO_ETHERCAT = $21                    ' start the master up to PREOP and then wait
```

In STARTUP:

```
ETHERCAT($91, -1, 1000 * SERVO_PERIOD + 300)    ' DC shift time = + 300 µs
ETHERCAT(0,0)                                   ' start the EtherCAT net
UNIT_CLEAR                                      ' clear system errors register, once in OPERATIONAL
```

3.4 CONTROL WORD, STATUS WORD (0x6040-0x6041)

Index (hex)	Sub Ind.	Object type	Access type.		Default value	Entry description	Valid values
6040		U16	RW		--	Control Word	0x 0000…0x FFFF
6041		U16	RO		--	Status Word	0x 0000…0x FFFF

Table 6

3.4.1 CONTROL WORD STRUCTURE

In accordance with standard CAN (DSP 402 V.2.0, Chap 10.3.1) CONTROL WORD (object 6040h of Object Dictionary) corresponds to a string of 16 bit. Through the control word the user can control the condition of the device.
In the following table the meaning of control word bits is shown.

Profile Position mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
User specification					reserved		Halt	Fault reset	abs/rel	Change set immed	New set point	Enable operat	quick stop	Enable voltage	switch ON
S	**0**	**0**	**0**	**0**	**0**	**0**	**S**	**S**	**S**	**0**	**S**	**S**	**S**	**S**	**S**

Homing mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
User specification					reserved		Halt	Fault reset	reserved	reserved	New set point	Enable operat	quick stop	Enable voltage	switch ON
0	**0**	**0**	**0**	**0**	**0**	**0**	**S**	**S**	**0**	**0**	**S**	**S**	**S**	**S**	**S**

CSP mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
User specification					reserved		--	Fault reset	--	--	--	Enable Operat	Quick Stop	Enable voltage	switch ON
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**S**	**0**	**0**	**0**	**S**	**S**	**S**	**S**

Profile Velocity mode of operation															
Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
User specification					reserved		**Halt**	Fault Reset	--	--	--	Enable Operat	Quick Stop	Enable Voltage	Switch ON
0	**0**	**0**	**0**	**0**	**0**	**0**	**S**	**S**	**S**	**0**	**S**	**S**	**S**	**S**	**S**

Key:
S: managed. 0: Not managed; set always bit = 0
To have a right transition between OPERATIONAL MODE status, refer to Chap. 2.3, Table 4.

Bit 2: Quick Stop
1 = no Quick Stop execution
0 = Quick Stop execution.

Bit 3: Enable Operation
1 = normal working drive (CURRENT ON)
0 = CURRENT OFF

Bit 4: New Set Point
If it set to 1 by master it modifies bit 12 of the STATUS WORD (Set Point Acknowledge) and executes a run depending on Target Position sent to the drive.

Bit 6: Rel/Abs
0 = absolute coordinates system
1 = relative coordinates system
(See Chap. 2.1.1 and 2.2).
In CSP operation mode, bit 6 is always = 0; master can emulate a relative coordinate system, but it must always send information in absolute coordinate to the drive.

Bit 7: Fault Reset
If set to 1, Fault condition is reset, if the problem is finished (that means an EMERGENCY 0x0000 is sent, the value of the object 0x603F is 0x0000). After this bit 7 has to be set to 0.

Bit 8: Halt
0 = normal working condition

1 = Halt execution and stopped of the motor. At motor stand still, after Halt execution, Target Reached = 1 (bit 10 of STATUS WORD). If Halt is then set to 0, Target Reached is automatically set to 0 and the interrupted movement is not completed.

3.4.2 STATUS WORD STRUCTURE

In accordance with standard CAN (DSP 402 V.2.0, Chap 10.3.2) the STATUS WORD (object 0x6041 of object dictionary) corresponds to a string of 16 bit used to communicate the device condition.

Profile Position mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
User specification		Position Error	Set point acknowledge	Int. Limit active	Target Reached	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready to switch ON
0	**0**	**S**	**S**	**0**	**S**	**S**	**0**	**0**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

Homing Mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
User specification		Position Error	Homing Attained	Int. limit active	Target Reached	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready to switch ON
0	**0**	**S**	**S**	**0**	**S**	**S**	**0**	**0**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

CSP Mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
User specification		Following Error	Target Position Ignored	Int. Limit Active	Reserved	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready To Switch ON
0	**0**	**S**	**S**	**0**	**S**	**S**	**0**	**0**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

Profyle Velocity Mode of operation															
Bit **15**	Bit **14**	Bit **13**	Bit **12**	Bit **11**	Bit **10**	Bit **9**	Bit **8**	Bit **7**	Bit **6**	Bit **5**	Bit **4**	Bit **3**	Bit **2**	Bit **1**	Bit **0**
Manufac Spec	Manufac Spec	Max slippage error	**Zero speed**	Int. Limit Active	Target Reached	Remote	Manufact Spec	Warning	Switch ON Disabled	Quick Stop	Voltage Enabled	Fault	Oper. Enabled	Switched On	Ready To Switch ON
0	**S**	**S**	**S**	**0**	**S**	**S**	**0**	**0**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

Key:
S: managed. 0: always = 0. 1: always = 1.
For the right meaning of the current status in OPERATIONAL MODE, refer to Chap. 2.3 Table 5.
Managed bits of the STATUS WORD have the following meaning:

Bit 2: Operation Enable
1 = Drive is in CURRENT ON status and the current flows in each motor winding.

Bit 3: Fault
Usually is 0, when it is 1 the drive is in Fault condition.

Bit 4: Voltage Enabled
0 = The power supply is higher than maximum allowed voltage or lower than minimum allowed voltage.

Bit 5: Quick stop
Usually 1, when it is 0 drive is in QUICK STOP status.

Bit 9: Remote
Drive can receive and execute command through communication bus when it is 1. Communication through PDO is not allowed when it is 0.

Bit 10: Target reached
Usually it is 0, it is 1 when a run or an homing procedure or a quick stop or halt command is successfully executed.
In Profile Velocity Mode, bit 10 becomes equal to 1 when the motor speed is equal to Target Velocity (or 0 after an Halt command) with a tolerance range defined by the object index 0x606D and for a time interval defined in the object index 0x606E.
In CSP mode of operation, the bit 10 is a toggle and indicates Target Position drive interpolation is active following the communication period set on Master.

Bit 11: Internal limit active
It is 1 when the motor position exceeded the limit switch (if limit switch function is active).
Note: see the object 0x320C.

Bit 12: Zero speed status
In Profile Velocity mode, the bit 12 is equal to 1 when motor speed is 0 with a tolerance range defined in object index 0x606F, for a time interval defined in object 0x6070.

Bit 13: Following Error
It indicates the Position Error for motor stall, read by the drive through encoder.
0: No Position Error
1: Position Error

Note: Control Word/Status Word timing on a Master state Machine
When designing a state machine on an Ethercat Master, and starting from the Control Word sending moment, we suggest to wait at least 12ms before verify (read) the effects on the Status word. This time delay not depends on the communication Cycle tyme.

3.5 DRIVE SETTINGS (0x303F-0x3333)

Index (hex)	Sub Ind.	Object type	Acc. type	Note	Default value	Entry description	Valid values
303F	0	U16	RO	1	0x0000 (0)	Last Error Code	0x0000…0x8611
3201	0	U8	RW	1,2	0x46 (70)	Current Ratio (only autosync mode)	0…120
3202	0	U16	RO	1	12800	Step Revolution	12800
3204	0	U8	RW	1,2	0x01 (1)	Current Reduction	0/1
320A	0	U8	RW		0x00 (0)	Set Output	0…3 only for Hi-Mod
320C	0	U8	RW	1,2	0x0F (15)	Input Config	0x0D, 0x0F, 0x8D, 0x8F (for Hi-Mod ETS) 0x07, 0x0F (for Hi-Mod ET and R-Mod ET)
320D	0	U8	RW	1,2	0x01 (1) for Hi-Mod ETS	Output Config	0x01, 0x03 (for Hi-Mod ET and Hi-Mod ETS)
3210	0	U32	RO	1	0x00045E2C (286252) for Hi-Mod ET and Hi-Mod ETS 0x000ADFA9 (712617) for R-Mod ET	Motor Code	
3211	0	U32	RW	2	0x00000000 (0)	Final Velocity	
3220		Rec				**CL_Loop parameters**	
	0	U8	RO		3	Number of entries	
	1	U16	RW	1,2	0x1194 (4500) for Hi-Mod 0x0F3C (3900) for R-Mod A3H1MK 0x157C (5500) for R-Mod A3H2MK	Phase Shift	3900…8900 (cfr. Tab.11 and 12)
	2	U16	RW	1,2	1	CL Mode	1, 2
	3	U16	RO	1,2	1	CL Mode Display	1, 2
3221		Rec				**Standstill CL_Loop parameters**	
	0	U8	RO		3	Number of entries	
	1	U16	RW	1,2	2	CL_Loop Standstill Mode	0 / 2 / 3
	2	U16	RW	1,2	50	CL_Loop Standstill Current	0...120 [%]
	3	U16	RW	1,2	100	CL_Loop Standstill Time	100…. 3000 [ms]
3222		Rec				**Following Error Control Par**	
	0	U8	RO		5	Number of entries	
	1	U16	RW	1,2	0x0001	Following Error Fault Enable	0 / 1
	2	U16	RW	1,2	0x1900 (6400)	Following Error Warn Window	0...25600
	3	U16	RW	1,2	0x4B00 (19200)	Following Error Fault Window	0...25600
	4	U32	RW	1,2	320000	Following Error Speed Warning Window	0...800 000
	5	U32	RW	1,2	430000	Following Error Speed Fault Window	0...800 000
3223		Rec				**ABS Enc Parameters**	
	0	U8	RO		7	Number of entries	
	1	U16	RW	1	0x0000	NU	0
	2	U32	RW	1	0x0000 0000 (0)	Read Encoder ABS	
	3	U16	RW	1	0x0000 (0)	Request Encoder ABS	0 / 1
	4	U32	RW	1	0x0000 0000 (0)	Read Encoder Offset	0x 18FF FFFF…0x E700 0000
	5	U16	RW	1	0x0000 (0)	Request Encoder Offset	0 / 1
	6	U16	RW	1	0x0000 (0)	Reset Encoder Offset	
	7	U16	RW	1	0x0000 (0)	W-Enc	
	8	U16	RW	1	0x0000 (0)	Reset W-Enc	
3224		Rec				**Position Loop**	
	0	U8	RO		2	Number of entries	
	1	U16	RW	1,2	0x0004	Proportional Gain	1…32 (see Tab.11)
	2	U16	RO	1	0x0000 (0)	Derivative Gain	
3225		Rec				**Velocity Loop**	
	0	U8	RO		4	Number of entries	
	1	U16	RW	1,2	0x0002	Sample Time	2 / 4 / 8 [ms]
	2	U16	RW	1,2	0x0004	Proportional Gain	1…64 (see Tab.11)
	3	U16	RW	1,2	0x0000 (0)	Integral Gain	0…32 (see Tab.11)
	4	U16	RO	1	0x0000 (0)	FFD Gain	

Index (hex)	Sub Ind.	Object type	Acc. type	Note	Default value	Entry description	Valid values
3226		Rec				**Current Loop**	
	0	U8	RO		2	Number of entries	
	1	U16	RW	1,2	0x0014 (20)	Proportional Gain	See the object description
	2	U16	RO	1	0x0019 (25)	Derivative Gain	
3227		U8	RW	1,2	120	Current Limiting	10…120 [%]
3230	1	U16	RO	1	0	Following Error	-8128…+8128
3231	1	U16	RO	1	0	Commanded Current	-120…+120
3305	0	U8	RW	2	0x01 (0)	Emcy Enable	0 / 1
3306	0	U8	RW	2	0x00 (0)	Interp_Enable Bit	0 / 1
3307	0	U8	RW	2	0x00 (0)	INIT Reaction	0 / 3
330A	0	U16		1,2	0x012C (100)	Brake Delay Lock	0…1000
330B		Rec		1,2		**Brake Unlock Delay**	
	0	U8	RO		0x03 (3)	Number of entries	--
	1	U16	RW		0x0064 (100)	Brake Delay Unlock	0…1000
	2	U16	RW		0x0000 (0)	Brake Delay Current ON	0…1000
	3	U16	RW		0x012C (230)	Brake Delay Ready	0…1000
330C	1	U16	RW	1,2	0x0640 (1600)	Following Error Resolution View	200…3200
3333		Rec				**Drive Alarm Register**	
"	0	U8	RO		20	Number of entries	
"	1	I32	RO		0	1st Latest Alarm Time	
"	2	I32	RO		0	1st Latest Alarm	
"	...	I32	RO		0	nth Latest Alarm Time	
"	...	I32	RO		0	nth Latest Alarm	
"	19	I32	RO		0	10th Latest Alarm Time	
"	20	I32	RO		0	10th Latest Alarm	

Table 7

In the column "**Note**":
1: This value shows that there is a comment for this object in the preceding chapters.
2: This value shows that the data written in the object can be stored in permanent storage (see Index 0x1010).

Index 0x303F: Last Error Code
Shows the same Error Code saved in object index 0x603F and mapped in EMERGENCY message.
Last Error Code, in case of Fault Transition, does not switch automatically to 0x0000 when the alarm cause vanish.
Implemented error code:
0x8611: "Motor following error"
0x8600: "Absolute Encoder error"
0x5100: "Error power supply out of range"
0x4310: "Error drive excessive temperature"
0x2130: "Error short circuit" (or overcurrent on motor phase)
0x0000: "Emergency end"

After sending the message 0x2130, 0x4310, 0x5100, 0x8400, 0x8611, the drive state switch to Fault (and the current in motor winding become zero).

Index 0x3201: Current Ratio
Parameter is active only in Auto Sync mode (object 0x3220.2 = 2 and 0x3220.3 = 2)
Valid values are in the range **0** - **120**% and corresponds to nominal current percentage set as regards to full-scale current of the drive (6A for Hi-Mod and 4A for R-Mod).

The current can be automatically reduced in case of motor standstill (see object 0x3204).
It is suggested to avoid the continuous use of current values higher than 100% to avoid overheating of the motor and drive.

It is suggested to set a new setting only if motor is stopped.

Index 0x3202: Step/rev
Valid values are:

- 12800 = 12800 step/rev

Index 0x3204: Current Reduction
This parameter affect the value of the object index 0x3201 only in Autosync mode (object 0x3220.2 = 2 and 0x3220.3 = 2)
Valid values are:

- 0: automatic reduction excluded (this value is not available for R-MOD ET)
- 1: automatic reduction active

It is suggested to set a new setting only if motor is stopped.

If automatic reduction is active the current is reduced with respect to the nominal current set in the object 0x3201 about 80ms after the end of the run, when motor is in standstill condition with no load on the shaft.

Note: With the exception of particular applications, we recommend to maintain the automatic current reduction enabled to avoid overheating.

Index 0x320A: Set Output
Set Output object value allows to set O0 programmable output, depending on the binary code shown in the following table:

- For Hi-Mod ET / ETS:

0x320A	O0	O1
0	0	0
1	1	0
2	0	1
3	1	1

Table 8

In the tables, 0 corresponds to OFF output and 1 corresponds to ON output.
The outputs are considered ON when they are closed as regards to common of outputs (see hardware instruction manual).
Note1: In the tables, the outputs are set as “general-purpose” by means Index 0x320D (Output Config = 15).

- For R-MOD ET: no hardware outputs are available. This settings have to be considered as virtual outputs only.

Index 0x320C: Input Config
Input Config allows to set the operation mode of hardware inputs (see hardware manual) as shown in the following table:

For HI-MOD ET A:

INPUT CONFIG	OPERATION MODE	
0x0D (13)	**I0**: GENERAL-PURPOSE INPUT **I1**: TOUCH-PROBE INPUT **I2**: GENERAL-PURPOSE INPUT **I3**: GENERAL-PURPOSE INPUT	
0x0F (15)	**I0**: GENERAL-PURPOSE INPUT **I1**: GENERAL-PURPOSE INPUT **I2**: GENERAL-PURPOSE INPUT **I3**: GENERAL-PURPOSE INPUT	Default value

Table 9a

Note: The maximum value for the frequence of signal applied to I2 and I3 input cannot be over 50 Hz.

For HI-MOD ETS A:

INPUT CONFIG	OPERATION MODE	
0x0D (15)	**I0**: GENERAL-PURPOSE INPUT **I1**: TOUCH-PROBE INPUT	
0x0F (15)	**I0**: GENERAL-PURPOSE INPUT **I1**: GENERAL-PURPOSE INPUT	Default value
0x8D (141)	**I0**: GENERAL-PURPOSE INPUT **I1**: TOUCH-PROBE INPUT VIEW STO INPUTS STATUS ON B24 OF OBJ DIGITAL INPUT (0X60FD)	
0x8F (143)	**I0**: GENERAL-PURPOSE INPUT **I1**: GENERAL-PURPOSE INPUT VIEW STO INPUTS STATUS ON B24 OF OBJ DIGITAL INPUT (0X60FD)	

Table 9b

For R-MOD ET A:

INPUT CONFIG	OPERATION MODE	
0x07 (7)	**I0**: TOUCH PROBE INPUT	
0x0F (15)	**I0**: GENERAL-PURPOSE INPUT	Default value

Table 9c

Index 0x320D: Output Config
Output Config allows to set the operation mode of hardware outputs (see hardware manual) as shown in the following table:

- For HI-MOD ET A:

OUTPUT CONFIG	OPERATION MODE	
0x01	**O0**: GENERAL-PURPOSE OUTPUT **O1**: DRIVE FAULT OUTPUT	Default value
0x03	**O0**: GENERAL-PURPOSE OUTPUT **O1**: GENERAL-PURPOSE OUTPUT	
0x21	**O0**: BRAKE OUTPUT **O1**: DRIVE FAULT OUTPUT	
0x23	**O0**: BRAKE OUTPUT **O1**: GENERAL-PURPOSE OUTPUT	

Tabella 10a

- For HI-MOD ETS A:

OUTPUT CONFIG	OPERATION MODE	
0x01	**O0**: GENERAL-PURPOSE OUTPUT **O1**: DRIVE FAULT OUTPUT	
0x03	**O0**: GENERAL-PURPOSE OUTPUT **O1**: EDM OUTPUT (USCITA MONITOR).	Default value
0x07	**O0**: GENERAL-PURPOSE OUTPUT **O1**: GENERAL-PURPOSE OUTPUT	
0x21	**O0**: BRAKE OUTPUT **O1**: DRIVE FAULT OUTPUT	
0x23	**O0**: BRAKE OUTPUT **O1**: EDM OUTPUT (USCITA MONITOR).	

Tabella 10b

- For R-Mod ET A:

No outputs available. Any value in OUTPUT CONFIG object does not produce any effect.

Index 0x3210: Motor Code
Motor Code object is read only value (RO) and it is not set by user.

Index 0x3220, CL_Loop parameters
Closed-Loop Gain settings. See also Table 12.

subindex1: Phase-Shift

For HI-MOD:
Suggested values:
- 4500 for 80 V_{DC} power supply;
- 5800 for 48 V_{DC} power supply.
Default value: 4500.

For R-MOD ET A3H1MK:
Suggested values:
- 3900 for 48 V_{DC} power supply;
- 4900 for 24 V_{DC} power supply.
Default value: 4500.

For R-MOD ET A3H2MK:
Suggested values:
- 5500 for 48 V_{DC} power supply;
- 8900 for 24 V_{DC} power supply.
Default value: 4500.

Note: We advise to not change the above values. In case of needs please contact RTA.

Sub2: Closed Loop Mode
Setting of closed loop operation mode (type of closed loop):

- 1: Full Closed Loop
- 2: Auto Sync

The closed loop operation mode can be written in anytime, but the drive acquire the new value only when it is in a Current Off state (for example: Switch On Disabled or Ready to Switch On). The actual closed loop operation mode can be read in the sub index 3 (Closed Loop Mode Display).

Sub3: Closed Loop Mode Display
Allow reading the actual value of closed loop mode.

Index 0x3221, Standstill CL_Loop parameters
These parameters are available only in Full Closed Loop mode
Standstill CL_Loop parameters reduce Closed-Loop gain system and thus to reduce the standstill motor noise. These parameters are preset and they can be changed in case of not stability of the system in standstill condition only.

subindex1: CL_Loop Standstill Mode
This object allows to set the drive at standstill according to the following operation modes.
Setting values are:

- **0** no change in Closed-loop
- **2** after **CL_Loop Standstill Time,** starting from the end of a command position, the motor control loop becomes motor position closed-loop only. The drive switch automatically to a mode of operation similar to the Auto Sync mode. The motor current can be set by **CL_Loop Standstill Current** parameter**.**

- **3** immediately (not after **CL_Loop Standstill Time),** starting from the end of a command position, the motor control loop becomes motor position closed-loop only. The motor current can be set by **CL_Loop Standstill Current** parameter**.**
  Mapping this object (0x3221, sub1) in RxPDO100, the master can switch **CL_Loop Standstill Mode** 0 and 3 related to the motor move or standstill state.

subindex2: CL_Loop Standstill Current
CL_Loop Standstill Mode = 2 / 3, it corresponds to nominal current percentage set as regards to full-scale current related to motor used. It is suggested to avoid long-term use of values > 100% to avoid motor and drive overheating

subindex3: CL_Loop Standstill Time
This object is the time (in ms) after which the motor management with CL_Loop Standstill Mode (1/2) is set, starting from the end of a command position.
Note: the end of command position does not take into account the motor following delay; it is recommended to evaluate this delay and set this object with a right value.

Index 0x3222, Following Error Control parameters

subindex1: Following Error Fault Enable
Enable/Disable transition to the Fault state due to exceeded number of steps set in sub3.
Setting values are:
- **1**.

subindex2: Following Error Warn Window
Following Error Warn Window allows to set maximum phase shift (@12800 step/rev) between electric field and motor. When this value is exceeded, bit Position Error of Status Word is set = 1.

subindex3: Following Error Fault Window
Following Error Fault Window allows to set maximum phase shift (@12800 step/rev) between electric field and motor. When this value is exceeded, the drive goes in Fault state and current in the motor windings is disabled (current off).
subindex4: Following Error Speed Warn Window
Following Error Speed Warning Window allows to set the maximum error (in Hz, as a difference between the set velocity value and the actual velocity value). If the error become greater than the set value, the “Position Error” bit of the StatusWord become equal to 1.
This parameter in used only in Profile Velocity mode of operation and Full Closed Loop mode (0x3220.2 =1 and 0x3220.3 = 1).

subindex5: Following Error Speed Fault Window
Following Error Speed Fault Window allows to set the maximum error (in Hz, as a difference between the set velocity value and the actual velocity value). If the error become greater than the set value, the “Position Error” bit of the StatusWord become equal to 1.
This parameter in used only in Profile Velocity mode of operation and Full Closed Loop mode (0x3220.2 =1 and 0x3220.3 = 1).

OBJECTS for setting of Closed Loop Parameters (Full Closed Loop mode): Position loop (Index 0x3224), Velocity loop (Index 0x3225), Current loop (Index 0x3226)

By means of the parameters setting in the objects index 0x3224, 0x3225 and 0x3226 it is possible to modify the proportional factor that define the behavior of the closed loop control system (**controller PID)**, which results from the sum of 3 components: a **Proportional**, an **Integral** and a **Derivative** component.

The **proportional** factor depends on the actual value of the feedback. An high value of the proportional factor produce a large control-action even with small feedback. Low values of the proportional factor give a control-action weakly related to the actual feedback value but more related to the old values of the feedback (integral action) and to the futures changes of the feedback value (derivative action).

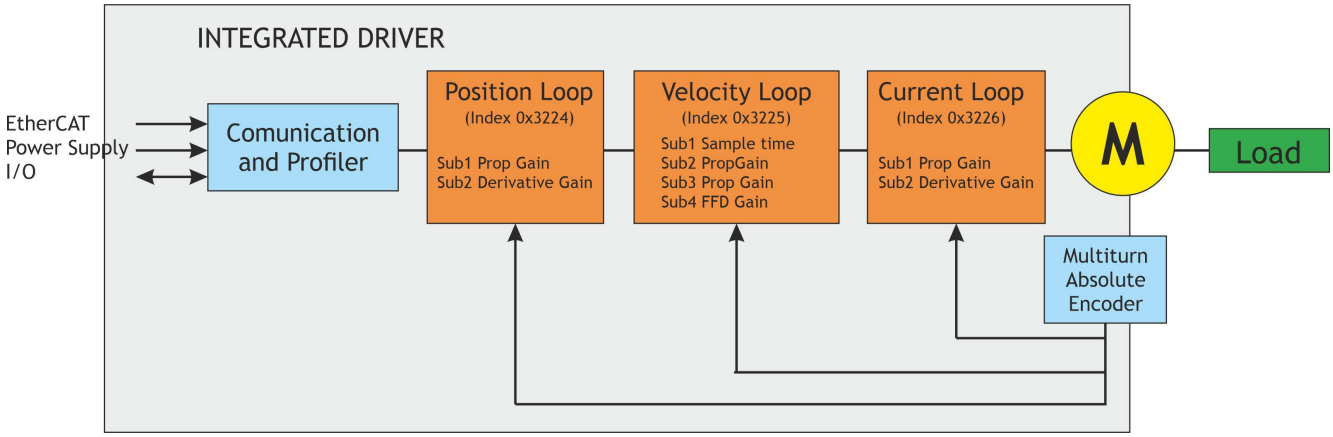

Figure 5

Loop parameters values for Hi-Mod and R-Mod					
Jrat	**Velocity Loop (index 0x3225)**			**Position Loop (index 0x3224)**	
	Proportional Gain	**Integral Gain**	**Sample Time (ms)**	**Proportional Gain (range)**	
1	**4**	**0**	**2**	**4 .. 12**	**Default setting**
2	6	0	2	4 .. 12	
5	10	0	2	4 .. 12	
10	14	0	4	4 .. 12	
20	20	0	4	4 .. 12	
30	24	0	4	4 .. 12	
50	30	0	8	2 .. 8	

Table 11

The values in Table11 are starting values and must be carefully checked on the system.
In particular, pay attention to important backlash and transmission elasticity.
Jrat is defined as the Moment of Inertia related to load motor axes and Moment of Inertia of the motor ratio:

$$J_{RAT} = (J_{LOAD} + J_{MOT}) / J_{MOT}$$

According to the values shown in Table 11:
- low values of **Position Loop Proportional Gain** produces a smoothly response of the system and a following error rising, while the highest values in the suggested range produces quickly response.
- the parameter **Velocity Loop Proportional Gain** (obj. Index 0x3525.2) should be set to values near the ones shown in table 11;
- the parameter **Velocity Loop Integral Gain** (obj. Index 0x3525.3) must be set at the first to 0. We advise to gradually increase this value only in the case of high position errors due to the particular load conditions;
- high values of **Position Loop Proportional Gain** and of **Velocity Loop Proportional Gain** can affect the stability of the control system;
- lower values of **Position Loop Proportional Gain** and of **Velocity Loop Proportional Gain** produce slow and less precise response of the control system;

Note1: better dynamic performances can be obtained if the power supply of the combo unit is about the nominal value (80 V_{DC} for Hi-Mod and 48 V_{DC} for R-Mod).
Note2: for the setting of standstill condition please see the object Standstill CL_Loop Parameters (Index 0x3221).

The values indicated in the setting table (Table 11) are valid for the maximum working speed shown in the following table:

Suggested maximum speed					
Model	**Power Supply Voltage (V)**	**Max Speed (RPM)**	**Phase shift (0x3220.1)**	**Proportional Gain Current (0x3226.1)**	
Hi-Mod ET-A5F2HK / ETS-A4F2HK	80	0 ÷ 1200	4500	20	**default**
Hi-Mod ET-A5F2HK / ETS-A4F2HK	48	0 ÷ 900	5800	20	
R-Mod ET A3H2MK	48	0 ÷ 1200	5500	20	**default**
R-Mod ET A3H2MK	24	0 ÷ 600	8900	40	
R-Mod ET A3H1MK	48	0 ÷ 1400	3900	20	**default**
R-Mod ET A3H1MK	24	0 ÷ 700	4900	30	

Table 12

Index 0x3224, Position loop
Parameters available only for Full Closed Loop operation

subindex1: Proportional Gain
Allow to set the position loop proportional gain.
The setting values range is: 1÷32.

subindex2: Derivative Gain
This is a Read Only parameter.

Index 0x3225, Velocity loop
Parameters available only for Full Closed Loop operation

subindex1: Sample Time
Allow to set the time constant used in velocity calculation. The measurement unit is milliseconds (ms).

subindex2: Proportional Gain
Allow to set the velocity loop proportional gain.
The setting values range is: 1÷64.

subindex3: Integral Gain
Allow to set the velocity loop integral gain.
The setting values range is: 1÷32.

Subindex4: FFD Gain
Allow to read the velocity loop Feed Forward value. This is a Read Only parameter.

Index 0x3226, Current loop parameters
Parameters available only for Full Closed Loop operation

Note: we advise to not change the default values of these subindexes. In case of needs please contact RTA.

subindex1: Proportional Gain
Allow to set the current loop proportional gain.

For HI-MOD:
Suggested values:
- 20 for 80 V_{DC} power supply;
- 20 for 48 V_{DC} power supply.
Default value: 20.

For R-MOD ET A3H1MK:
Suggested values:
- 20 for 48 V_{DC} power supply;
- 30 for 24 V_{DC} power supply.
Default value: 20

For R-MOD ET A3H2MK:
Suggested values:
- 20 for 48 V_{DC} power supply;
- 40 for 24 V_{DC} power supply.
Default value: 20

subindex2: Derivative Gain
This is a Read Only parameter.

Index 0x3227: Current Limiting
Parameters available only for Full Closed Loop operation (0x3220.2 = 1 and 0x3220.3 = 1).
Allow to set the value of the drive maximum current when motor is moving state and in steady state in mode 0 (0x3221.1 = 0).
Setting values are in the range: 10 ÷ 120.

Index 0x3230: Following Error
Allow to view the real time position following error.
The value can be read in step/revolution unit set by the object index 0x330C (following error resolution view).
This is a Read Only parameter.

Index 0x3231: Commanded Current
Allow to view the real time current motor current.
The range of values is: -120 ÷ +120 for:
- motor running and Full Closed Loop mode (0x3220.2 = 1 and 0x3220.3 = 1)
- motor stopped, Full Closed Loop mode and CL_Standstill Mode (0x3221.1 = 0)
The range of values is: 0 ÷ +120 for:
- Autosync mode of operation (0x3220.2 = 2 and 0x3220.3 = 2)
- motor stopped, Full Closed Loop modeof operation and CL_Loop Standstill Mode (0x3221.1 = 1)
The value 120 corresponds to the 120% of the full scale current value.
This is a Read Only parameter.

Index 0x330A: Brake Delay Lock
This object allow to set the delay time between the Current-ON -> Current-OFF command and the real going to zero of the current in motor windings during the transitions: 5,8 and 9 (see Fig. 2).
The setting value range is from 0 to 1000 ms.
The default value is: 100 ms.

Note: Current ON is equal to: Operation Enable. Current OFF is equal to: Switched ON or Ready to Switch ON.

Index 0x330B: Brake Delay Unlock
This object allow to set the following time delays, starting from a the Current-OFF -> Current-ON command:

subindex1 (**Brake UL**): NOT USED
subindex2 (**Brake CON**): delay time to Current ON transition, (motor current > 0). The default value is 0 ms;
subindex3 (**Brake RDY**): delay time to the state transition notification and e drive ready to receice motion commands (default value is 230 ms).
All the above parameters can be set from 0 to 1000 ms.

Note: Current ON is equal to: Operation Enable. Current OFF is equal to: Switched ON or Ready to Switch ON.

In Figure 5 are shown the timing diagram of signal affecting by the delay time by index 0x330A and 0x330B.
Please contact RTA before modify the default values in the index 0x330A and 0x330B.

OGGETTO 0x330C: Following Error Resolution View
This object allow to set the range of the real time following error value. Display in the object index 0x3230.
When the actual following error value is greater than the top value of the range previously set, the displayed value become equal to the top value of the range.
Setting Impostando un range più esteso, la precisione della misura dell'errore di inseguimento si riduce.
I valori impostabili sono:

- **200** corrispondente ad un range di ± 8128 passi @ 12800 p/g (circa 228° con precisione di 1,8°)
- **400** corrispondente ad un range di ± 4064 passi @ 12800 p/g (circa 114° con precisione di 0,9°)
- **800** corrispondente ad un range di ± 2032 passi @ 12800 p/g (circa 57° con precisione di 0,45°)
- **1600**corrispondente ad un range di ± 1016 passi @ 12800 p/g (circa 28° con precisione di 0,23°)
- **3200**corrispondente ad un range di ± 508 passi @ 12800 p/g (circa 14° con precisione di 0,12°)

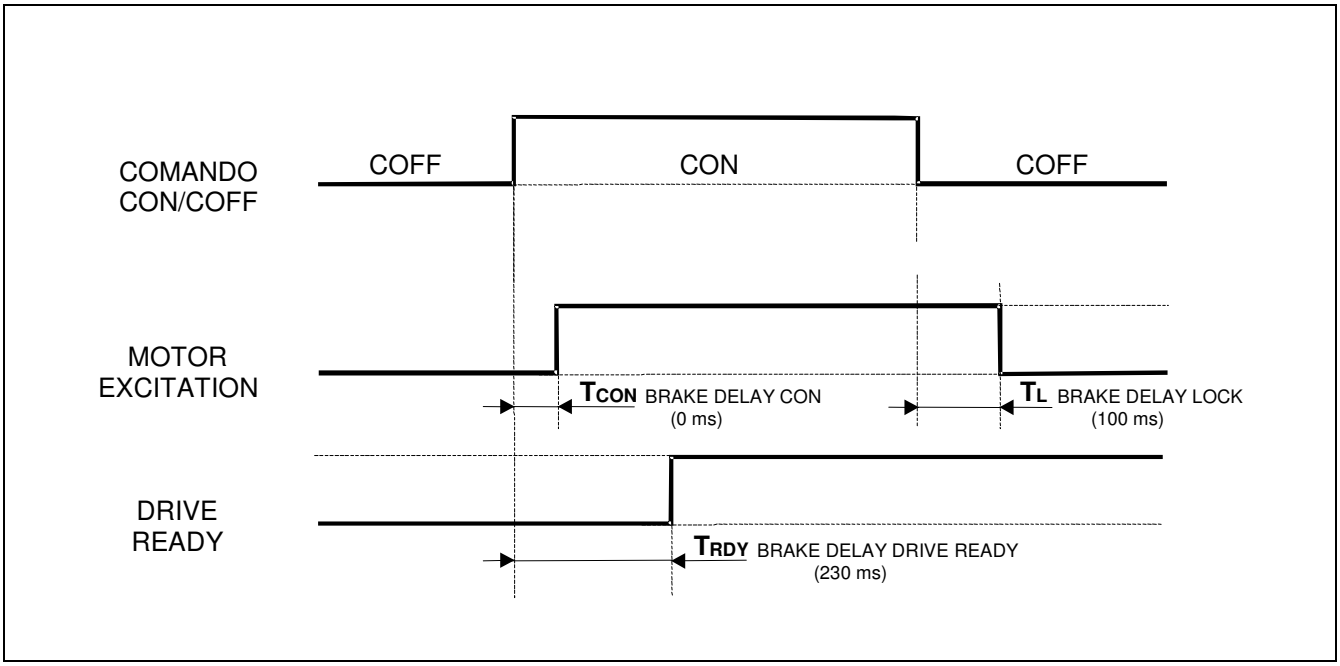

Figure 6

Index 0x3333: Drive Alarm Register
10 events Alarm Register.
For each event the following values are logged:
- Event delay since the last power on of the drive (ms)
- Alarm code as the following example:

Event Number			Drive State			Emergency Code			
0	7		1	0		5	1	0	0

The available values in “Emergency Code” are the following:

0x8611: “Motor following error”
0x8600: “Absolute Encoder error”
0x5100: “Error power supply out of range”
0x4310: “Error drive excessive temperature”
0x2130: “Error short circuit” (or overcurrent on motor phase)
0x0000: “Emergency end”

The available values in “Drive State” are the following:

0x01: Not ready to switch on
0x02: Switch on disable
0x04: Ready to switch on
0x08: Switched on
0x10: Operation Enabled

The available values in “Event Number” are 00-99.

Note: Set “1” in sub index 0 of object 0x3333 to reset Drive Alarm Register.

3.6 MOTION CONTROL PARAMETERS SETTINGS (0x603F-0x6502)

Index (hex)	Sub Ind.	Dato	Acc.		Valore di default	Funzione	Valori Ammessi
603F		U16	RO	1	0x0000 (0)	Error Code	0x0000…0x8611
6040		U16	RW		0x0000 (0)	Control Word	0x 0000…0x FFFF
6041		U16	RO		0x0000 (0)	Status Word	0x 0000…0x FFFF
605A		I16	RW		5	Quick Stop Option Code	5, 0
605B		I16	RW		0	Shutdown Option Code	0
605C		I16	RW		0	Disable Operation Option Code	0
605D		I16	RW		1	Halt Option Code	1
605E		I16	RW		0	Fault Reaction Code	0
6060		I8	RW		0	Modes of Operation	1 / 6 / 8
6061		I8	RO		0	Mode of Operation Display	1 / 6 / 8
6064		I32	RO	1	0	Position Actual Value	-419430400...419430399 *
606C		I32	RO		0	Velocity Actual Value	0…800 000
606D		U16	RW	1,2	6400 [30RPM]	Velocity Window	0…65 536
606E		U16	RW	1,2	100 [ms]	Velocity Window Time	0… 5 000
606F		U16	RW	1,2	6400 [30RPM]	Velocity Threshold	0…65 536
6070		U16	RW	1,2	100 [ms]	Velocity Threshold time	0…5 000
607A		I32	RW	1	0	Target position	0x8000 0000…0x 7FFF FFFF
607B		Rec				**Position Range Limit**	
“	0	U8	RO		2	Number of entries	
“	1	I32	RW		0	Minimum position range limit	0x E700 0000
“	2	I32	RW		0	Maximum position range limit	0x18FF FFFF
607C		I32	RW	1	0	Home Offset	-419430400...419430399 *
6080		U32	RW	1	300 000	Max Motor Speed	0…800 000
6081		U32	RW	1	0x5DC0 (24000)	Profile Velocity	0…800 000
6083		U32	RW	1 2 Hi-mod	0x9C400 (640000)	Profile Acceleration	2000…10 000 000
6098		I8	RW		37	Homing Method	37
60B8		U16	RW		0x0000 (0)	Touch Probe Function	
60B9		U16	RW		0x0000 (0)	Touch Probe Status	
60BA		I32	RO		--	Touch Probe Pos Pos Value	
60BB		I32	RO		--	Touch Probe Pos Neg Value	
60E3		Rec				**Supported Homing Methods**	
	0	U8	RO		3	Number of entries	
	1	I8	RO		0x003 (3)	1st supported homing method	35
	2	I8	RO		0x004 (4)	2nd supported homing method	37
60FD	0	U32	RO	1	0x00000000 (0)	Digital Inputs	0
60FE		Rec				**Digital Outputs**	
“	0	U8	RO		1	Number of entries	
“	1	U32	RO		0x00000000 (0)	Physical Outputs	0x0…0x01F00001
60FF		U32	RW		0x00000000 (0)	Target Velocity	0…800 000
6502		I8	RO		0x000001A1 (417)	Supported Drive Modes	0x000000A1 (161)

Table 13

*: see **Note** pg.30 (object **Home Offset**)

Index 0x603F: Error Code
Error codes mapped in the EMERGENCY message; the following are added:

0x8611: Motor following error
0x8600: Absolute Encoder error
0x5100: Error supply.
0x4310: Error excess temperature drive.
0x2130: Error short circuit.

After 0x2130, 0x4310, 0x5100, 0x8600, 0x8611 messages, the drive goes in Fault state and current in the motor windings is disabled (current off).
Note: The Error Code value switch back automatically to 0x0000 after 200 ms minimum from the emergency end. As a consequence, once detected the fault state through the bit 3 of Status Word, the master has to read the Error Code as quickly as possible. In any case, it is always possible to read the Fault event register (object 0x3333).

Index 0x6064: Position actual value
Number of steps corresponding to the position of the motor shaft read through encoder.

Index 0x606C: Velocity Actual Value
Represents the velocity value calculated by means of the sample position in object Position Actual Value (0x6064).
The unit of measure is step/s, in accordance to the resolution set in object 0x3202
The default value for the speed sample period is 100 ms; this value can be modified by the object 0x3321 subindex1.

Index 0x606D: Velocity Window (*)
Allows the setting of a threshold speed value (in step/s).
When Actual Velocity become greater than the set value, after the delay written in register "Velocity Window Time" (object 0x606E), the bit 10 of Status Word "Target Velocity Reached" switch to the value "1".

Index 0x606E: Velocity Window Time (*)
Allow to set a time threshold.
When Actual Velocity become greater than the velocity threshold set in register "Velocity Window" (0x606D), the bit 10 of Status Word "Target Velocity Reached" switch to "**1**" after a time delay equal to the value set in this register (in ms).

Index 0x606F: Velocity Threshold (*)
Allow to set a velocity threshold (in steps/s).
When Actual Velocity become lower than the velocity threshold, after a time delay equal to the value set in register "Velocity Threshold Time" (0x6070), the bit 10 of Status Word "Target Velocity Reached" switch to "**0**".

Index 0x6070: Velocity Threshold Time (*)
Allow to set a time threshold.
When Actual Velocity become lower than the velocity threshold set in register "Velocity Threshold" (0x606F), the bit 10 of Status Word "Target Velocity Reached" switch to "**0**" after a time delay equal to the value set in this register (in ms).

Note (*)*: These objects are active in "Profile Velocity" mode of Operation only.*

Index 0x607A: Target Position (number of steps)
If bit 6 of CONTROL WORD =1, Target Position corresponds to number of steps in relative coordinates to be executed after receiving a "New Set Point".
If bit 6 of CONTROL WORD =0, Target Position corresponds to the position in absolute coordinates to be reached after receiving a "New Set Point".

Index 0x607B: Position Range Limit
Number of steps corresponding to operating range. The exceeding of the limits is not allowed.

Index 0x607C: Home offset
This object represents the load value in Position Actual Value (0x6064) at the end of Homing procedure.
The setting values are in the range of -419430400 and 419430399.
The default value is 0.
Note: The execution of an homing operation in a position different from the zero factory position (with or without any value of Home Offset) can produce a variation in the range of operation of the absolute encoder with respect to the nominal value of "Position Actual Value". In any case, the actual value of the encoder range can be read in the object index 0x607B, "Position Range Limit".
In case of particular needs related to the position range, please contact RTA.

Index 0x6081: Profile Velocity
Maximum speed of the movement in Profile Position. Hz corresponds to steps/sec.

Index 0x6083: Profile Acceleration
Acceleration used to reach maximum speed of the movement in Profile Position. Hz / sec corresponds to number of steps / sec^2.

Index 0x6098: Homing Method
- 37 (0x25) homing on current position

Note: The execution of an homing operation in a position different from the zero factory position (with or without any value of Home Offset) can produce a variation in the range of operation of the absolute encoder with respect to the nominal value of "Position Actual Value". In any case, the actual value of the encoder range can be read in the object index 0x607B, "Position Range Limit".
In case of particular needs related to the position range, please contact RTA.

Index 0x60B8: Touch Probe Function
Bit 0 enables Touch Probe Function. Disable and enable Touch Probe Function to reset stored position.
Bit 4 enables position sampling on positive edge of the signal on input I1 (I0 for R-Mod).
Bit 5 enables position sampling on negative edge of the signal on input I1 (I0 for R-Mod).
The other bit must be set = 0.
Note1: The sampling of the position can be affected by a maximum delay of 300us, compared to the switching of the TOUCH PROBE INPUT. In some particular cases the delay can be greater (for example when SET OUTPUT and TOUCH PROBE FUNCTION are both PDO mapped at the same time and Mode of Operation is set to Profile Position or Homing).
Note2: The sampling of the Touch Probe Function cannot be enabled simultaneously on positive and negative edge trigger. The desired sampling edge (positive or negative) must be chosen when function is enabled.

Index 0x60B9: Touch Probe Status

Bit 0 indicates Touch Probe Function is active.
Bit 1 indicates that a position has been sampled on positive edge of sampling signal.
Bit 2 indicates that a position has been sampled on negative edge of sampling signal.
Bit 7 indicates current logic state of sampling signal.

Index 0x60FD: Digital Inputs
This object shall monitor the status of general-purpose input and the status of special function inputs as shown in the following table:

Bit 25…31	Bit 24 (*)	Bit 18…23	Bit 17	Bit 16	Bit 15…3	Bit 2	Bit 1	Bit 0
Reserved	STO	Reserved	I1	I0	Reserved	Reserved	Reserved	Reserved

Note: Available/Setting inputs are described in 0x320C Index.

(*) For HI-MOD ETS:
If bit 7 of Input Config (obj 0x320C) is set to 1, bit 24 become "1" in case of drive is in Safe Torque Off state.

When Input Config (Index 0x320C) = 0x8E / 0x8F, bit 24 (of Digital Inputs) = 1 when the drive is in Safe Torque Off status.

Index 0x60FF: Target Velocity
Allow to set the value of target velocity when the Mode of Operation is equal to Profile Velocity (only in Full Closed Loop mode by objects index 0x3220.2 = 1 and 0x3220.3 = 1). The set value corresponds to number of steps per second (Hz).
The max difference between the target velocity set and the real velocity = ±0.24% ±1.5RPM.
It is not possible to set values lower than 1200 step/s.
In the Profile Velocity mode of operation, the drive works always in Full Closed Loop mode (object index 0x3221.1 = 0).
The real motor running velocity depends on the settings values of current and closed loopp gain parameters.

3.7 REVERSE ENERGY MANAGEMENT

⚠ During deceleration of load with high inertia, some amount of energy can flow from motor to drive.

In case of excessive reverse energy, the overvoltage protection could inhibit the drive operation making impossible the application.
High value of reverse energy could cause power supply and/or drive failure.
In order to avoid failure, it is recommended to execute test on the machinery with high speed and acceleration settings not before carefully checking the power supply sizing.

The Tables 13 and 14 show, with respect to J_{RAT} inertia ratio and $V_{NOM} = 80V_{DC}$ for Hi-Mod ET and Hi-Mod ETS or $V_{NOM} = 48V_{DC}$ for R-Mod ET, the speed **theoretical values** (in RPM) that can enable the overvoltage protection. The J_{RAT} inertia ratio is defined as follows:

$$J_{RAT} = (J_{LOAD} + J_{MOT}) / J_{MOT}$$

Each column is related to different capacity value on the power input.

- For Hi-Mod ETS:

Jrat	Vmax (RPM) C = 4700uF	Vmax (RPM) C = 2200uF	Vmax (RPM) C = 1000uF	Vmax (RPM) C = 470uF
1	5686	3890	2623	1798
2	4021	2751	1855	1271
5	2543	1740	1173	804
10	1798	1230	829	569
20	1271	870	586	402
30	1038	710	479	328

Table 14

- For R-Mod ET:

J_{RAT}	Vmax (RPM) C = 4700uF	Vmax (RPM) C = 2200uF	Vmax (RPM) C = 1000uF	Vmax (RPM) C = 470uF
1	5831	3989	2690	1844
2	4123	2821	1902	1304
5	2608	1784	1203	825
10	1844	1262	851	583
20	1304	892	601	412
30	1065	728	491	337

Table 15

The power supply must be suitable to tolerate overvoltages generated by the load.
The power supply must be sized with respect to the power requested from the load in the specific application. Anyway, we advise to use power supply with power capability non lower than 480 Watt for Hi-Mod and 240 Watt for R-Mod.
In case of use switching power supply, it is important to check that the its output capacitance is not lower than the values mentioned in the above tables. If the output capacitance is lower, it is necessary to connect one or more capacitor on the power supply line to increase the total capacitance up to the correct value shown in the above tables.

4. DATA LINK LAYER (configuration registers)

ASIC address space (from 0x0000 to 0x1000) is dedicated for configuration registers common to all EtherCAT products.

	START ADDRESS	FINAL ADDRESS
ESC INFORMATION	0x0000	0x0009
STATION ADDRESS	0x0010	0x0013
WRITE PROTECTION	0x0020	0x0031
DATA LINK LAYER	0x0040	0x0111
APPLICATION LAYER	0x0120	0x0135
PDI	0x0140	0x0153
INTERRUPTS	0x0200	0x0223
ERROR COUNTERS	0x0300	0x0313
WATCHDOGS	0x0400	0x0443
ESI EEPROM Interface (ESI)	0x0500	0x050F
MII MANAGEMENT Interface (ESI)	0x0510	0x0515
FMMU (Fieldbus Memory Management Unit)	0x0600	0x06FF
SYNC MANAGER (SM)	0x0800	0x087F
DISTRIBUTED CLOCKS (DC)	0x0900	0x090F
DC-TIME LOOP CONTROL UNIT	0x0910	0x0935
DC-CYCLIC UNIT CONTROL	0x0980	0x0980
DC-SYNC OUT UNIT	0x0981	0x09A7
DC-LATCH IN UNIT	0x09A8	0x09CF
DC-SYNCMANAGER EVENT TIMES	0x09F0	0x09FF
ESC SPECIFIC	0x0E00	0x0EFF
DIGITAL INPUT/OUTPUT	0x0F00	0x0F19
USER RAM	0x0F80	0x0FFF
PROCESS DATA RAM	0x1000	0x2FFF

4.1 SYNCHRONIZATION MODE

In EtherCAT, master-slave synchronization mode can be set by writing on configuration registers 0x0981 e 0x09A0÷0x09A3

RTA synchronization mode are: SM2 Event and SYNC0 Event (DC Mode1).

The setting of desired synchronization mode needs configuration registers must be written as follows. Settings must be written before PRE-OPERATIONAL → SAFE OPERATIONAL state transition.

REGISTER ADDRESS	REGISTER NAME	DC MODE VALUE	SM2 MODE VALUE
0x0981	SYNC OUT UNIT	0x03	0x00
0x09A0÷0x09A3	SYNC0 CYCLE TIME	Tempo di ciclo (ns)	Not used

APPENDIX 1. OBJECTS DICTIONARY COMPLETE TABLE

Index (hex)	Sub Ind.	Object type	Access type	Note	Default value	Entry description	Valid values
1000		U32	RO		0x0004 0192	Device type	0x0004 0192
1001		U8	RO	1	0	Error Register	0 / 1
1008			RO		--	Device name	
1009			RO			Hardware version	
100A			RO			Software version	
1010		Rec		1		**Store parameters**	
"	0	U8	RO		1	Number of entries	
"	1	U32	RW		0x00000001 (1)	Save all parameters	0x65766173 ("save")
1011		Rec		1		**Restore Default Parameters**	
	0	U8	RO		1	Number of entries	
"	1	U32	RW		0x00000001 (1)	Restore all Default Parameters	0x64616F6C ("load")
1018		Rec				**Identity**	
"	0	U8	RO		4	Number of entries	
"	1	U32	RO		0x0000017F (383)	Vendor ID	0x0000 017F
"	2	U32	RO		0x00000000 (0)	Product code	0x0000 0000…0xFFFF FFFF
"	3	U32	RO		0x00000000 (0)	Revision	0x0000 0000…0x FFFF FFFF
"	4	U32	RO		0x00000000 (0)	Serial number	0x0000 0000…0x FFFF FFFF
1600		Rec				**RPDO1**	
"	0	U8	RO		1	Number of entries	
"	1	U32	RO		0x6040 0010	Control Word	0x6040 0010
1601		Rec				**RPDO2**	
"	0	U8	RO		2	Number of entries	
"	1	U32	RO		0x6040 0010	Control Word	0x6040 0010
"	2	U32	RO		0x607A 0020	Target Position	0x607A 0020
1700		Rec				**RPDO100**	
"	0	U8	RW	1	5	Number of entries	
"	1	U32	RW		0x6040 0010	1st mapping data	
"	2	U32	RW		0x6060 0008	2nd mapping data	
"	3	U32	RW		0x0000 0008	3rd mapping data	
"	4	U32	RW		0x607A 0020	4th mapping data	
"	5	U32	RW		0x0000 0000	5th mapping data	
"	6	U32	RW		0x0000 0000	6th mapping data	
"	7	U32	RW		0x0000 0000	7th mapping data	
"	8	U32	RW		0x0000 0000	8th mapping data	
1A00		Rec				**TPDO1**	
"	0	U8	RO		1	Number of entries	
"	1	U32	RO		0x6041 0010	1st mapping data	0x6041 0010
1A01		Rec				**TPDO2**	
"	0	U8	RO		2	Number of entries	
"	1	U32	RO		0x6041 0010	Status Word	0x6041 0010
"	2	U32	RO		0x6064 0020	Actual Position	0x6064 0020
1B00		Rec				**TPDO100**	
"	0	U8	RW	1	7	Number of entries	
"	1	U32	RW		0x6041 0010	1st mapping data	
"	2	U32	RW		0x6061 0008	2nd mapping data	
"	3	U32	RW		0x0000:0008	3rd mapping data	
"	4	U32	RW		0x6064 0020	4th mapping data	
"	5	U32	RW		0x0000 0000	5th mapping data	
"	6	U32	RW		0x0000 0000	6th mapping data	
"	7	U32	RW		0x0000 0000	7th mapping data	
"	8	U32	RW		0x0000 0000	8th mapping data	
1C00		Rec				**Sync manager type**	
"	0	U8	RO		4	Number of entries	
"	1	U32	RO		0x01 (1)	SubIndex 001	0x01 (1)
"	2	U32	RO		0x02 (2)	SubIndex 002	0x02 (2)
"	3	U32	RO		0x03 (3)	SubIndex 003	0x03 (3)
"	4	U32	RO		0x04 (4)	SubIndex 004	0x04 (4)

1C12		Rec				**RPDO assign**	
“	0	U8	RW		1	Number of entries	
“	1	U16	RW		0x1700	SubIndex 001	0x1600…0x1700
“	2	U16	RW		--	SubIndex 002	0x1600…0x1700
“	3	U16	RW		--	SubIndex 003	0x1600…0x1700
1C13		Rec				**TPDO assign**	
“	0	U8	RW		1	Number of entries	
“	1	U16	RW		0x1B00	SubIndex 001	0x1A00… 0x1B00
“	2	U16	RW		--	SubIndex 002	0x 1A00…0x1B00
“	3	U16	RW		--	SubIndex 003	0x 1A00…0x1B00
“	4	U16	RW		--	SubIndex 004	0x 1A00…0x1B00
1C13		Rec				**TPDO assign**	
1C32		Rec				**SM output parameter**	
“	0	U8	RO		32	Number of entries	
“	1	U16	RW		0x0000 (0)	Sync mode	0 (Free Run) / 1 (SM) / 2 (DC)
“	2	U32	RO		0x00000000 (0)	Cycle time	1000000 / 2000000 / 4000000
“	3	U32	RO		0x00000000 (0)	Shift time	0x00000000 (0)
“	4	U16	RO		0x0000 (0)	Sync modes supported	0x4007 (16391)
“	5	U32	RO		0x00000000 (0)	Minimum cycle time	0x0007A120 (500000)
“	6	U32	RO		0x00000000 (0)	Calc and copy time	0x00000000 (0)
“	8	U16	RW		0x0000 (0)	Get cycle time	0x0000 (0)
“	9	U32	RO		0x00000000 (0)	Delay time	0x00000000 (0)
“	A	U32	RW		0x00000000 (0)	Sync0 time	0x00000000 (0)
“	B	U32	RO		0x00000000 (0)	Cycle exceeded counter	0x00000000 (0)
“	C	U32	RO		0x00000000 (0)	SM event missed counter	0x00000000 (0)
“	D	U32	RO		0x00000000 (0)	Shift too short counter	0x00000000 (0)
“	20	U32	RO		FALSE	Sync error	FALSE
1C33		Rec				**SM input parameter**	
“	0	U8	RO		32	Number of entries	
“	1	U16	RW		0x0000 (0)	Sync mode	0x0002 (2)
“	2	U32	RO		0x00000000 (0)	Cycle time	0x003D0900 (4000000)
“	3	U32	RO		0x00000000 (0)	Shift time	0x00000000 (0)
“	4	U16	RO		0x0000 (0)	Sync modes supported	0x4006 (16390)
“	5	U32	RO		0x00000000 (0)	Minimum cycle time	0x0007A120 (500000)
“	6	U32	RO		0x00000000 (0)	Calc and copy time	0x00000000 (0)
“	8	U16	RW		0x0000 (0)	Get cycle time	0x0000 (0)
“	9	U32	RO		0x00000000 (0)	Delay time	0x00000000 (0)
“	A	U32	RW		0x00000000 (0)	Sync0 time	0…4000000
“	B	U32	RO		0x00000000 (0)	Cycle exceeded counter	0x00000000 (0)
“	C	U32	RO		0x00000000 (0)	SM event missed counter	0x00000000 (0)
“	D	U32	RO		0x00000000 (0)	Shift too short counter	0x00000000 (0)
“	20	U32	RO		FALSE	Sync error	FALSE
303F	0	U16	RO	1	0x0000 (0)	Last Error Code	0x0000…0x8611
3201	0	U8	RW	1,2	0x46 (70)	Current Ratio (only mod autosync)	0…120
3202	0	U16	RO	1	12800	Step Revolution	12800
320A	0	U8	RW		0x00 (0)	Set Output	0…1
320C	0	U8	RW	1,2	0x0F (15)	Input Config	0x0D, 0x0F, 0x8D, 0x8F (for Hi-Mod ETS) 0x07, 0x0F (for R-Mod ET)
320D	0	U8	RW	1,2	0x03 (3) for Hi-Mod	Output Config	0x01, 0x03 (for Hi-Mod ET and Hi-Mod ETS)
3210	0	U32	RO	1	0x00045E2C (286252) for Hi-Mod ETS 0x000ADFA9 (712617) for R-Mod ET	Motor Code	286252
3211	0	U32	RW	2	0x0000 0000 (0)	Final Velocity	[reserved]
3220		Rec				**CL_Loop parameters**	
	0	U8	RO		3	Number of entries	
	1	U16	RW	1,2	0x1194 (4500) for Hi-Mod 0x0F3C (3900) for R-Mod A3H1MK 0x157C (5500) for R-Mod A3H2MK	Phase Shift	3900…8900 (see Tab.11 and 12)
	2	U16	RW	1,2	1	CL Mode	0, 1, 2

	3	U16	RO	1,2	1	CL Mode Display	0, 1, 2
3221		Rec				**Standstill CL_Loop parameters**	
	0	U8	RO		5	Number of entries	
	1	U16	RW	1,2	0x0002	CL_Loop Standstill Mode	0…3
	2	U16	RW	1,2	30	CL_Loop Standstill Current	0...120 [%]
	3	U16	RW	1,2	100	CL_Loop Standstill Time	100…. 3000 [ms]
3222		Rec				**Following Error Parameters**	
	0	U8	RO		5	Number of entries	
	1	U16	RW	1,2	0x0001	Following Error Fault Enable	0 / 1
	2	U16	RW	1,2	0x1900 (6400)	Following Error Warn Window	0...25600
	3	U16	RW	1,2	0x4B00 (19200)	Following Error Fault Window	0...25600
	4	U32	RW	1,2	320000	Following Error Speed Warning Window	0...800 000
	5	U32	RW	1,2	430000	Following Error Speed Fault Window	0...800 000
3223		Rec				**ABS Enc Parameters**	
	0	U8	RO		8	Number of entries	
	1	U16	RW	1	0x0000	NU	0
	2	U32	RW	1	0x0000 0000 (0)	Read Encoder ABS	
	3	U16	RW	1	0x0000 (0)	Request Encoder ABS	0 / 1
	4	U32	RW	1	0x0000 0000 (0)	Read Encoder Offset	0x 18FF FFFF…0x E700 0000
	5	U16	RW	1	0x0000 (0)	Request Encoder Offset	0 / 1
	6	U16	RW	1	0x0000 (0)	Reset Encoder Offset	
	7	U16	RW	1	0x0000 (0)	W-Enc	
	8	U16	RW	1	0x0000 (0)	Reset W-Enc	
3224		Rec				**Position Loop**	
	0	U8	RO		2	Number of entries	
	1	U16	RW	1	0x0001	Proportional Gain	1…32
	2	U16	RO	1	0x0000 (0)	Derivative Gain	
3225		Rec				**Velocity Loop**	
	0	U8	RO		4	Number of entries	
	1	U16	RW	1	0x0002	Sample Time	2 / 4 / 8 [ms]
	2	U16	RW	1	0x0001	Proportional Gain	1…64 (see Tab.11)
	3	U16	RW	1	0x0000 (0)	Integral Gain	0…32 (see Tab.11)
	4	U16	RO	1	0x0000 (0)	FFD Gain	
3226		Rec				**Current Loop**	
	0	U8	RO		2	Number of entries	
	1	U16	RW	1	0x0014 (20)	Proportional Gain	see object description
	2	U16	RO	1	0x0019 (25)	Derivative Gain	
3227		U8	RW	1,2	120	Current Limiting	10…120 [%]
3230	1	U16	RO	1	0	Following Error	-8128…+8128
3231	1	U16	RO	1	0	Commanded Current	-120…+120
3305	0	U8	RW	2	0x01 (0)	Emcy Enable	0 / 1
3306	0	U8	RW	2	0x00 (0)	Interp_Enable Bit	0 / 1
3307	0	U8	RW	2	0x00 (0)	INIT Reaction	0 / 3
330A	0	U16		1,2	0x012C (100)	Brake Delay Lock	0…1000
330B		Rec		1,2		**Brake Unlock Delay**	
	0	U8	RO		0x03 (3)	Number of entries	–
	1	U16	RW		0x0064 (100)	Brake Delay Unlock	0…1000
	2	U16	RW		0x0000 (0)	Brake Delay Current ON	0…1000
	3	U16	RW		0x012C (230)	Brake Delay Ready	0…1000
330C	1	U16	RW		0x0640 (1600)	Following Error Resolution View	200…3200
3333		Rec				**Drive Alarm Register**	
“	0	U8	RO		20	Number of entries	
“	1	I32	RO		0	1st Latest Alarm Time	
“	2	I32	RO		0	1st Latest Alarm	
“	...	I32	RO		0	nth Latest Alarm Time	
“	...	I32	RO		0	nth Latest Alarm	
“	19	I32	RO		0	10th Latest Alarm Time	
“	20	I32	RO		0	10th Latest Alarm	
603F		U16	RO	1	0x0000 (0)	Error Code	0x0000…0x8611
6040		U16	RW		0x0000 (0)	Control Word	0x 0000…0x FFFF
6041		U16	RO		0x0000 (0)	Status Word	0x 0000…0x FFFF
605A		I16	RW		5	Quick Stop Option Code	5, 0
605B		I16	RW		0	Shutdown Option Code	0
605C		I16	RW		0	Disable Operation Option Code	0

605D		I16	RW		1	Halt Option Code	1
605E		I16	RW		0	Fault Reaction Code	0
6060		I8	RW		0	Modes of Operation	1 / 6 / 8
6061		I8	RO		0	Mode of Operation Display	1 / 6 / 8
6064		I32	RO	1	0	Position Actual Value	-419430400…419430399 *
606C		I32	RO		0	Velocity Actual Value	0…800 000
606D		U16	RW	1,2	6400 [30RPM]	Velocity Window	0…65 536
606E		U16	RW	1,2	100 [ms]	Velocity Window Time	0… 5 000
606F		U16	RW	1,2	6400 [30RPM]	Velocity Threshold	0…65 536
6070		U16	RW	1,2	100 [ms]	Velocity Threshold time	0…5 000
607A		I32	RW	1	0	Target position	0x8000 0000…0x 7FFF FFFF *
607B		Rec				**Position Range Limit**	
“	0	U8	RO		2	Number of entries	
“	1	I32	RW		0	Minimum position range limit	-419430400 *
“	2	I32	RW		0	Maximum position range limit	419430399 *
607C		I32	RW	1	0	Home Offset	-419430400…419430399 *
6080		U32	RW	1	320 000	Max Motor Speed	0…800 000
6081		U32	RW	1	0x5DC0 (24000)	Profile Velocity	0…800 000
6083		U32	RW	1	0x9C400 (640000)	Profile Acceleration	2000…10 000 000
6098		I8	RW		37	Homing Method	35 / 37
60B8		U16	RW		0x0000 (0)	Touch Probe Function	
60B9		U16	RW		0x0000 (0)	Touch Probe Status	
60BA		I32	RO		--	Touch Probe Pos Pos Value	
60BB		I32	RO		--	Touch Probe Pos Neg Value	
60E3		Rec				**Supported Homing Methods**	
	0	U8	RO		3	Number of entries	
	1	I8	RO		0x003 (3)	1st supported homing method	35
	2	I8	RO		0x004 (4)	2nd supported homing method	37
60FD	0	U32	RO	1	0x00000000 (0)	Digital Inputs	0
60FE		Rec				**Digital Outputs**	
“	0	U8	RO		1	Number of entries	
“	1	U32	RO		0x00000000 (0)	Physical Outputs	0x0…0x01F00001
60FF		U32	RW		0x00000000 (0)	Target Velocity	0…800 000
6502		I8	RO		0x000001A1 (417)	Supported Drive Modes	0x000000A1 (161)

In the column “**Note**”:
1: This value shows that there is a comment for this object in the preceding chapters.
2: This value shows that the data written in the object can be stored in non volatile memory (see Index 0x1010-0x1011).
3: This value shows that the data written in the object can be stored in non volatile memory only for Hi-Mod ET/ETS (see Index 0x1010-0x1011).

*: See **Note** pg. 30 (object **Home Offset)**.