Real time clock synchronization
REF 542plus Application notes

IRIG-B input time master

Contents

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1. Introduction

1.1. This manual

This manual provides thorough information on the protection relay REF 542plus and its applications, focusing on giving a technical description of the relay.

1.2. Use of symbols

This publication includes the following icons that point out safety-related conditions or other important information:

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader to relevant facts and conditions.

Although warning hazards are related to personal injury, it should be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.3. Intended audience

This manual is intended for operators and engineers to support normal use of as well as configuration of the product.

1.4. Product documentation

Name of the Manual	Document ID
Application Notes	1MRS755870
CAN Manual	1VTA100189-Rev 1, en
Configuration Manual	1MRS755871

Table 4.2.-1 (Continued)

Name of the Manual	Document ID
iButton Programmer User Manual	1MRS755863
Manual Part 3, Installation and Commission	1 VTA100004
Manual Part 4, Communication	1VTA100005
Motor Protection with ATEX Certification, Manual	1MRS755862
Operator's Manual	1MRS755869
Protection Manual	1MRS755860
Technical Catalogue	1MRS755859
Technical Reference Modbus RTU	1MRS755868
Web Manual, Installation	1MRS755865
Web Manual, Operation	1MRS755864

1.5. Revision history

Version	Date	History
1VTA3000114	01.11.2001	Document created
A	28.02.2006	Document updated • language • layout
B	30.09.2006	Document updated

1.6. Related software release

Mainboard	since E4D01-5
Modbus	since E1.03A
RHMI	since E4D01-2
Configuration tool	since E4D01-HSTD

2. Safety information

Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.

Non-observance can result in death, personal injury or substantial property damage.

Only a competent electrician is allowed to carry out the electrical installation.

National and local electrical safety regulations must always be followed.

The frame of the device has to be carefully earthed.

The device contains components which are sensitive to electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.

3. REFplus time handling

3.1. Time master sources

The internal real time clock (RTC) can be synchronized by different time sources. They are automatically selected according to the following fixed priority list.

1. GPS master clock

   IRIG-B master clock must be connected and active at the start up of the REF 542plus. Local Time Clock or Universal Time Clock is provided for the IRIG-B input on REF 542plus.

2. COM board

   If ready to provide the time information, the IEC and LON (ABB LAG 1.4) boards are only ready to be time mastered.

3. Internal RTC

   Either the COM boards or the GSP master clock are inactive. The internal RTC device is taken as reference for the Local Time Clock information.

At the REF 542plus power up, an automatic recognition of the time master is started to select the time reference source. Therefore, the preferred priority list in table 1 is than taken to select one of them if more the one sources are present.

In case both the systems, IRIG-B and LON [ABB LAG 1.4] or IEC 60870-5-103, are active on the REF 542plus ports, the IRIG-B is taken as time reference for the internal clock synchronization.

3.2. GPS input port

The external master clock signal has to be connected to REF 542plus via an optical fibre. The optical input features are presented in the following table.

Table 3.2.-1 Optical input features

Feature	Value
REF 542plus connector name	X74 on the cover plate
Transducer type	HFBR-0400 series
Wave length	820 nm
Maximum distance	1500 m
Connector type	ST

3.3. Signal specification

- Signal type: Digital
- Supported protocol: IRIG, time format B000, B002, B003

3.4. GPS master clock signal distribution

The master clock source must be distributed via a star coupler to the REF 542plus units in the switchboard or by an integrated master clock decoder and distributor.

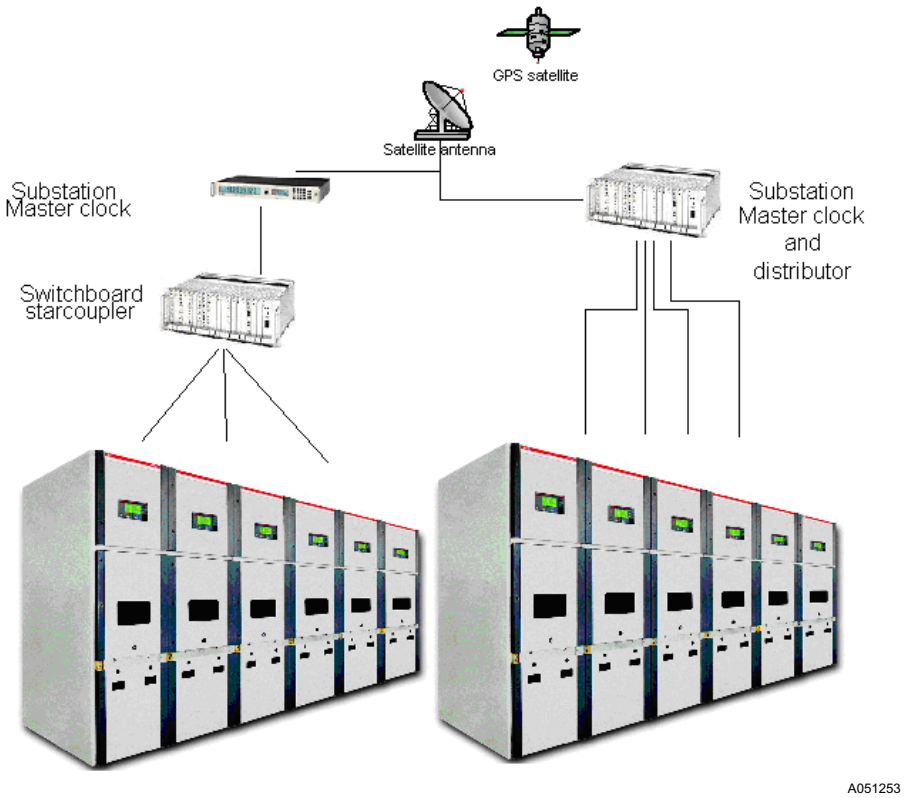

Fig. 3.4.-1 GPS master clock signal distribution

3.5. REF 542plus operations

Since the IRIG-B signal does not provide the information regarding the current year, this information must be programmed in REF 542plus manually by setting it on the remote HMI.

Once the substation master clock is connected to REF 542plus, it automatically synchronizes the internal RTC with the time received from the master clock.

The master clock provides the UTC or LTC depending on the preferred time settings on it. Refer to its user manual to see how to set it. However, the master clock IRIG-B output will be synchronized with the GPS satellite time when they are well detected by the decoder. Normally, the detection time by the master clock is around 20–30 minutes. This fact may depend on several conditions, satellite visibility, antenna position, and weather conditions. In the meanwhile, the time decoded is the one set on the master clock. Therefore, the time displayed on the unit can be the default time and not the real UTC. However, all the REF 542plus units receiving the IRIG-B signal will display the same time clock, but the events recorded during this period will be time stamped with a wrong absolute time.

The information on the time signal source can be checked in the RHMI service page, which is the MC time subpage. In this subpage, the time synchronization source is as shown if the signals are properly detected.

Text shown		Time master selected
GPS	→	GPS
Remote clock	→	COM board
Internal clock	→	Internal Real Time Clock

In case GPS is the time master, the RHMI will allow changing only the year data to complete the setting of the internal RTC.

In case the time master is the remote clock (COM boards) no changes are allowed of the internal time.

3.6. Synchronization accuracy

The embedded IRIG-B decoder allows synchronizing the REF 542plus central unit to the master clock source with an accuracy of ~100 µs. This means that two or more units in different places are synchronized with UTC with an accuracy of ~100 µs.

Therefore, the internal events will be stamped with the synchronized RTC. Depending on the event source, the accuracy of the event time stamp recorded may be different, refer to the following table.

Table 3.6.-1 Accuracy of the event time stamp

Event	Value
Internal protection event	~100 μs
Binary input variation	< 1 ms
Other event related to FUPLA logic	< 2 FUPLA cycle time

3.7. Extended time stamp format

Since the main board software release E4D01-5, the internal events are time stamped with the full time information (extended format). The time structure is based on the CP56Time2a (56 bit) IEC standard. The time data information is a bit fill structure as the following (short is 2 bytes long, long is 4 bytes long and char is 1 byte long):

Data type		bits	
unsigned char		:1;	
unsigned char	year	:7;	
unsigned char		:4;	
unsigned char	month	:4;	
unsigned char	day_of_week	:3;	// unused
unsigned char	day_of_month	:4;	
unsigned char	summer_time	:1;	// unused
unsigned char		:2;	
unsigned char	hour	:5;	
unsigned char	invalid	:1;	
unsigned char		:2;	
unsigned char	min	:6;	
unsigned char	m_sec_high	:8;	
unsigned char	m_sec_low	:8;	
unsigned char	Reserved2	:8;	// unused

The REF 542plus unit does not provide the fields Day of the week and Summer time.

4. Event reading by Modbus board

The Modbus board keeps in its permanent memory (Flash) the last 100 events generated by REF 542plus.

Both the standard and extended format are available through the Modbus card by accessing different file registers.

The Control System may read one or more REF 542plus events accessing to the File 2 registers (standard format) or to the File 5 registers (extended format) according to the rules described in the paragraph "Function 20". For more information, refer to the Modbus Technical reference manual.

4.1. Standard format file 2

Table 4.1.-1 Structure of the file 2

Register	Meaning	Direction	Values
0	Number of events stored	r	0..100
1	Overflow flag	r	0 = no overflow 1 = overflow
2	Clear RCE	w	0xFF00 = clear other = error
3	Event 1 (the oldest)	r	
.....			
9			
10	Event 2	r	
.....			
16			
...	…..	….	
696	Event 100	r	
.....			
702			
703	Unused	error	
	…..	….	
9999	Unused	error	

The structure of the single event in standard format (14 bytes long) is:

```
unsigned short ChanNum; // channel number
unsigned char Reserved;
unsigned char EventType; // event type
unsigned short EventNum; // event number (0..127)
unsigned long time; // number of milliseconds
// elapsed between the
// REF542 power-on and the
// event raising
signed long par1; // optional parameter
```

4.2. Extended format file 5

Table 4.2.-1 Structure of the file 5

Register	Meaning	Direction	Values
0	Number of events stored	R	0..100
1	Overflow flag	R	0 = no overflow 1 = overflow
2	Clear event buffer	W	0xFF00 = clear other = error
3	Event 1 (the oldest)	R	
.....			
13			
14	Event 2	R	
.....			
24			
...	.....	....	
1086	Event 100	R	
.....			
1096			
1097	Unused	error	
	.....	....	
9999	Unused	error	

The structure of the single event in an extended form (22 bytes long) is:

```
unsigned short ChanNum; // channel number
unsigned char Reserved1; // unused
unsigned char EventType; // event type
unsigned short EventNum; // event number (0..127)
unsigned long time; // number of milliseconds
// elapsed between the
// REF542 power-on and the
// event raising
```

```
signed long par1; // optional parameter


// absolute event time

unsigned char :1;
unsigned char year :7;
unsigned char :4;
unsigned char month :4;
unsigned char day_of_week :3; // unused
unsigned char day_of_month :4;
unsigned char summer_time :1; // unused
unsigned char :2;
unsigned char hour :5;
unsigned char invalid :1;
unsigned char :2;
unsigned char min :6;
unsigned char m_sec_high :8;
unsigned char m_sec_low :8;
unsigned char Reserved2 :8; // unused
```

4.3. Events reading procedure

Events may be read singly or by groups (consecutive events). After the reading, the events are still present in the board memory buffer. They are deleted only after writing 0xFF00 in the register #2 of file 2 or file 5. Note that by deleting the event memory buffer by means of file 2, also the file 5 will be deleted as well and vice versa. The delete command has no effects on the other channel for the board event memory buffer.

If the event memory buffer is full and new events are generated by the REF 542plus system, the oldest events will be overwritten and the overflow flag is set to 1. Only clearing the entire event memory buffer (writing 0xFF00 in the register 2 of file 2 or file 5) clears the overflow flag.

4.4. Event memory buffer operations

The following functions allow operating on the internal buffer event.

4.4.1. Requiring the number of available events (reading register 0)

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count
Dimension	1	1	1	1	2	2	2
Value	xx	20	7	6	2 or 5	0	1

If 2 events are stored, the Modbus board answers with:

Field	Address	Function	Byte Count	Sub resp Byte Count	Ref Type	Data
Dimension	1	1	1	1	1	2
Value	xx	20	4	3	6	2

4.4.2. Reading the overflow flag (reading register 1)

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count
Dimension	1	1	1	1	2	2	2
Value	Xx	20	7	6	2 or 5	1	1

In case of event memory buffer overflow, the Modbus board answers with:

Field	Address	Function	Byte Count	Sub resp Byte Count	Ref Type	Data
Dimension	1	1	1	1	1	2
Value	Xx	20	4	3	6	1

4.4.3. Delete event memory buffer (writing 0xFF00 on register 2)

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count	Data
Dimension	1	1	1	1	2	2	2	2
Value	xx	21	9	6	2 or 5	2	1	0xFF00

The Modbus board answers with the echo message:

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count	Data
Dimension	1	1	1	1	2	2	2	2
Value	xx	21	9	6	2	2	1	0xFF00

4.4.4. Reading a single event (reading the relating registers)

The request is valid if, and only if, the addressed event is available and the register range equals the dimension of the event structure[1)].

For example, if 2 events are stored, the following request (read the last event in standard form) is valid:

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count
Dimension	1	1	1	1	2	2	2
Value	Xx	20	7	6	2	10	7

The Modbus board answers with a message like the following:

Field	Address	Function	Byte Count	Sub req Byte Count	Ref Type	.....
Dimension	1	1	1	1	1	
Value	xx	20	16	15	6	

.....	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7
	2	2	2	2	2	2	2
	xx						
	Num-Chan	EvType	EvNum	Time		Parameter	

On the contrary, the following message (still valid) does not return a valid event both for the address (it is not an event starting register) and for the dimension (different from 7)[2)]:

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count
Dimension	1	1	1	1	2	2	2
Value	xx	20	7	6	2	11	6

1) Part of an event is still available, by reading a shorter number of registers.
2) This situation is not well explained in the Modbus Technical reference.

4.4.5. Reading a group of consecutive events (reading a block of registers)

In order to minimize the communication overhead during event memory buffer transmission, it is helpful to require event blocks, where each block contains the maximum number of events that can be sent by a single Modbus message. The Modbus function 20 allows to transmit up to 250 bytes, a single event block can contain up to 250/14 = 17 events in standard form or 250/22 = 11 events in extended form.

The easier way to request an event block is to use a single Sub request starting at the beginning of the first event in the block and having as many registers as 7 * number of events in a standard form or 11 * number of events in an extended form.

The request for event 18 to 34 in standard form is:

Field	Address	Function	Byte Count	Ref Type	File Number	Req Address	Reg Count
Dimension	1	1	1	1	2	2	2
Value	xx	20	7	6	2	3+7*17	7*17

If all the 17 events are stored, the Modbus board answers with a following message:

Field	Address	Function	Byte Count	Sub req Byte Count	Ref Type	Data 1	....	Data 7*17
Dimension	1	1	1	1	1	2		2
Value	xx	20	14*17 +2	14*17+1	6	6		6

5. Abbreviations

Abbreviation	Description
FUPLA	Function block Programming Language; Function Plan; Function Chart
GPS	Global Positioning System
HMI	Human-Machine Interface
IEC	International Electrotechnical Commission
LON	Local Operating Network
LTC	Local Time Clock
RHMI	Remote Human-Machine Interface as control unit
UTC	Universal Time Clock

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