1.- ORION ITALIA SERIES MODBUS PROTOCOL.

The ORION ITALIA SERIES implement a subset of the AEG Modicon Modbus serial communication standard. Many devices support this protocol directly with suitable interface card, allowing direct connection of relays. The Modbus protocol is hardware-independent; that is, the physical layer can be any of variety of standard hardware configurations, this includes RS232, RS422, RS485, fibber optics, etc. The ORION ITALIA RELAYS include rear terminals that can be RS232 or RS485 ports. Modbus is a single master multiple slave protocol suitable for a multi-drop configuration as provided by RS485 hardware. In this configuration up to 32 slaves can be daisy-chained together on a single communication channel.

The VPR-A - ORION ITALIA Relay is always a Modbus slave. It cannot be programmed as a Modbus master. The Modbus protocol exists in two versions: Remote Terminal Unit (RTU, binary) and ASCII. Only the RTU version is supported by the Orion Italia Relay. Monitoring, programming and control functions are possible using read and write register commands.

2.- ELECTRICAL INTERFACE.

The hardware or electrical interface is any of the following:

a. Two two-wire RS485 for Com2 and Com3 rear terminals connector.

b. One RS232 for Com1 rear terminal connector.

In a two-wire RS485 link, data flow is bi-directional. RS232 port uses 3-pin Rx for receive data, Tx for Transmit data and signal ground. Different ports Com1, Com2 and Com3 can be used at the same time. Data flow is half duplex. That is, data is never transmitted and received at the same time.

In RS485 lines should be connected in a daisy chain configuration (avoid star connections) with terminating resistors and capacitors installed each end of the link, i.e. at the master end and the slave farthest from the master. That value of the terminating resistors should be equal to the characteristic impedance of the line. This is approximately 120 Ohms for standard 24 AWG twisted pair wire. The value of the capacitors should be 1 nF. Shielded wire should always be used to minimize noise. Polarity is important in RS485 communications. See figure below for more details.

3.- DATA FRAME FORMAT AND DATA RATE.

One data frame of an asynchronous transmission to or from a Orion Italia Relay consists of 1 start bit, 8 data bits, not parity and 1 stop bit (8N1). This produces a 10 bit frame. This is important for the correct transmission of the data.

The rear RS485 communication ports of the Orion Italia Relay supports operation at 1200,2400,4800, 9600 and 19200 baud.

4.- DATA PACKET FORMAT.

A complete request/response consists of the following bytes transmitted as separate data frames:

Master Query Message:

SLAVE ADDRESS	(1 byte)
FUNCTION CODE	(1 byte)
DATA	(variable number of bytes depending on FUNCTION CODE)
CRC	(2 bytes)

Slave Response Message:

SLAVE ADDRESS	(1 byte)
FUNCTION CODE	(1 byte)
DATA	(variable number of bytes depending on FUNCTION CODE)
CRC	(2 bytes)

A message is terminated when no data is received for a period of 3½ character transmission times. Consequently, the transmitting device must not allow gaps between bytes larger than this interval (about 3ms at 9600 baud).

Slave Address: This is the first byte of every message. This byte represents the user-assigned address of the slave device that is to receive a message sent by the master. Each slave device must be assigned a unique address, and only the addressed slave will respond to a message that starts with its address. In a master query message the SLAVE ADDRESS represents the address of the slave to which the request is being sent. In a slave response message the SLAVE ADDRESS is a confirmation representing the address of the slave that is sending the response. A master query message with a SLAVE ADDRESS of 0 indicates a broadcast command. All slaves on the communication link will take action based on the message, but no one will respond to the master.

Function Code: This is the second byte of every message. Modbus defines function codes of 1 to 127. The Orion Italia Relay implements some of this functions. See section 7 for details of the function codes supported by the Orion Italia Relay Series Modbus Protocol. In a master query message the FUNCTIONS CODE tells the slave what action to perform. In a slave response message, if the FUNCTION CODE sent from the slave is the same as the FUNCTION CODE sent from the master then the slave performed the function as requested.

Data: This will be a variable number of bytes on the FUNCTION CODE. This may include actual values, setpoints or addresses sent by the master to the slave or by the slave to the master. See section 7 for a description of the Orion-supported functions and the data required for each.

CRC: This is a two byte error checking code. CRC is sent LSByte first followed by the MSByte. The RTU version of Modbus includes a two byte CRC-16 (16 bit cyclic redundancy check) with every message. The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (11000000000000101B). The 16 bit remainder of the division is appended to the end of the message, MSByte first. The resulting message including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred. If a Orion Modbus slave device receives a message in which an error is indicated by the CRC-16 calculation, the slave device will not respond to the message. A CRC-16 error indicates that one or more bytes of the message were received incorrectly and thus the entire message should be ignored in order to avoid the slave device performing any incorrect operation. The CRC-16 calculation is an industry standard method used for error detection. An algorithm is included in section 5 CRC-16 algorithm to assist programmers in situations where no standard CRC-16 calculation routines are available.

5.- CRC-16 ALGORITHM

Once the following algorithm is completed, the working register "A" will contain the CRC value to be transmitted. Note that this algorithm requires the characteristic polynomial to be reverse bit ordered. The most significant bit of the characteristic polynomial is dropped, since it does not affect the value of the remainder. The following symbols are used in the algorithm:

Symbols:

-->	data transfer
A	16 bit working register
Alow	low order byte of A
Ahigh	high order byte of A
CRC	16 bit CRC-16 value
i,j	loop counter
(+)	logical EXCLUSIVE-OR operator
N	total number of data bytes
Di	i-th data byte (i=0 to N-1)
G	16 bit characteristic polynomial =1010000000000001(binary) with MSbit dropped and bit order reversed
shr(x)	right shit operator (the LSbit of x is shifted into a carry lag, a '0' is shifted into the MSbit of x, all other bits are shifted right one location)

Algorithm:

1.	**FFFF(hex) --> A**	
2.	**O --> i**	
3.	**O --> j**	
4.	**Di (+) Alow --> Alow**	
5.	**j + 1 --> j**	
6.	**shr (A)**	
7.	**Is there a carry ?**	**No: go to step 8**
		Yes: G (+) A --> A and continue
8.	**Is j = 8 ?**	**No: go to 5**
		Yes: continue
9.	**i + 1 --> i**	
10.	**Is i = N ?**	**No: go to 3**
		Yes: continue
11.	**A ----> CRC**	

6.- MESSAGE TIMING

Communication message synchronization is maintained by timing constraints. The receiving device must measure the time between the reception of characters. If three and one half character times elapse without a new character or completion of the message, then the communication link must be reset (i.e. all slaves start listening for a new query message from the master). Thus at 1200 baud a delay of greater than 3.5 x 1/1200 x 10 = 29.2 ms cause the communication link to be reset. At 9600 baud a delay of greater than 3.5 x 1/9600 x 10 = 3.6 ms will cause the communication link to be reset. Most master query messages will be responded to in less than 50 ms. The maximum time for the Orion Italia Relays to return a slave response message for any function code will never exceed 1 second.

7.- SUPPORTED FUNTION CODES

The second byte of every message is the function code. Modbus defines function codes of 01h to 7Fh. The Orion Italia Relay Modbus protocol supports some of these functions, as summarized in Table No. 1

TABLE No. 1

FUNCTION CODE MODBUS PROT. (HEX)	***FUNCTION CODE ORION ITALIA (HEX)***	***DEFINITION***
03	03	READ SETPOINTS or ACTUAL VALUES
04	04	READ SETPOINTS or ACTUAL VALUES
05	05	EXECUTE OPERATION
06	06	STORE SINGLE SETPOINTS
10	10	STORE MULTIPLES SETPOINTS

Since some programmable logic controllers only support function codes 03h (or 04h) and 10h, most of the above Modbus commands can be performed by reading from or writing to special addresses in the Orion Italia Relay memory map using these function codes.

7.1.- FUNCTION CODE 03H or 04H - READ SETPOINTS OR ACTUAL VALUES.

Modbus implementation: Read Holding Registers

Orion Italia Relay implementation: Read Actual Values or Setpoint

The Orion Italia Relay implementation of Modbus views "holding registers" as any setpoint or actual values register in the Orion Italia Relay memory map. Registers are 16 (two byte) values transmitted high order byte first. Thus all Orion Italia Relay setpoints and actual values in the memory map are sent as two byte registers. This function code allows the master to read one or more consecutive setpoints or actual values from addressed slave device.

The slave response to these function codes is the slave address, function code, a count of the number of data bytes to follow, the data itself and the CRC. Each data item is sent as a two byte number with the high order byte sent first. The CRC is sent as a two byte number with the low order byte sent first.

MESSAGE FORMAT EXAMPLE:

Request to read 4 register values starting address 0102h from slave device 1.

Master query message	Example(hex)	
SLAVE ADDRESS	01	query message for slave 01 = 01h
FUNCTION CODE	03	read Setpoints
DATA STARTING ADDRESS-high order	01	data starting at address 0102h
DATA STARTING ADDRESS-low order byte	02	
NUMBER OF REGISTERS-high order byte	00	4 register value = 4 word total
NUMBER OF REGISTER-low order byte	04	
CRC-low order byte	E4	CRC calculated by the master
CRC-high order byte	35	

If the function code or the address of any of the requested data is illegal, the slave will **not** respond the message. Otherwise, the slave will respond as follows:

Slave response message	Example (hex)	
SLAVE ADDRESS	01	response message from slave 1 = 01h
FUNCTION CODE	03	read Setpoints
BYTE COUNT	08	4 register values = 8 bytes total
DATA #1-high order byte	00	register value in address 0102= 0064h
DATA #1-low order byte	64	
DATA #2-high order byte	00	register value in address 0103=0064h
DATA #2-low order byte	64	
DATA #3-high order byte	03	register value in address 0104=03E8h
DATA #3-low order byte	E8	
DATA #4-high order byte	00	register value in address 0105=0064h
DATA #4-low order byte	64	
CRC-low order byte	40	CRC calculated by the slave
CRC-high order byte	42	

7.2.- FUNCTION CODE 05H - EXECUTE OPERATION

Modbus implementation: Force Single Coil
Orion Italia Relay implementation : Execute Operation

This function code allows the master to request a VPR-A to perform specific command operation. The commands Number Listed in the table 2: Commands; correspond to operations codes for function code 05h.

The Slave Response to this function is to echo the entire master transmission.

TABLE 2. COMMANDS

ACTION	*COMMAND (HEX)*
No Action	00
Remote Reset	01
Set Clock	05
Clear All Events	09
Set Aux1	20
Set Aux2	21
Set Aux3	22
Set Aux4	23
Set Aux5	24
Set Aux6	25

MESSAGE FORMAT EXAMPLE:
Request to Remote Reset VPR-A Relay.

Master query message	Example(hex)	
SLAVE ADDRESS	01	Query message for slave 01 = 01h
FUNCTION CODE	05	Execute Operation
OPERATION CODE-high order	00	Reset Relay Command
OPERATION CODE-low order byte	01	
NUMBER OF REGISTERS-high order byte	FF	Perform Function
NUMBER OF REGISTER-low order byte	00	
CRC-low order byte	DD	CRC calculated by the master
CRC-high order byte	FA	

Slave response message	Example (hex)	
SLAVE ADDRESS	01	Message from slave 01 = 01h
FUNCTION CODE	05	Execute Operation
DATA STARTING ADDRESS-high order	00	Reset Relay Command
DATA STARTING ADDRESS-low order byte	01	
NUMBER OF REGISTERS-high order byte	FF	Perform Function
NUMBER OF REGISTER-low order byte	00	
CRC-low order byte	DD	CRC calculated by theSlave
CRC-high order byte	FA	

7.3.- FUNCTION CODE 06H - STORE SINGLE SETPOINTS

Modbus implementation: Preset Single Register
Orion Italia Relay implementation : Store Single Setpoints

This function code allows the master to store single setpoints into the memory map of the VPR-A.
The Slave Response to this function is to echo the entire master transmission.

MESSAGE FORMAT EXAMPLE:
Request slave device 01h to write the value 0190h at setpoint address 0102h

Master query message	Example(hex)	
SLAVE ADDRESS	01	query message for slave 01 = 01h
FUNCTION CODE	06	Store Single Setpoints
DATA STARTING ADDRESS-high order	01	Setpoint Address 0102h
DATA STARTING ADDRESS-low order byte	02	
NUMBER OF REGISTERS-high order byte	01	Data for Address 0102h = 0190h
NUMBER OF REGISTER-low order byte	90	
CRC-low order byte	28	CRC calculated by the master
CRC-high order byte	0A	

Slave response message	Example (hex)	
SLAVE ADDRESS	01	Message from slave 01 = 01h
FUNCTION CODE	06	Store Single Setpoints
DATA STARTING ADDRESS-high order	01	Setpoint Address 0102h
DATA STARTING ADDRESS-low order byte	02	
NUMBER OF REGISTERS-high order byte	01	Data Stored in Address 0102h = 0190h
NUMBER OF REGISTER-low order byte	90	
CRC-low order byte	28	CRC calculated by the Slave
CRC-high order byte	0A	

7.4.- FUNCTION CODE 10H -STORE MULTIPLE SETPOINTS

Modbus implementation: Preset Multiple Register
Orion Italia Relay implementation : Store Multiple Setpoints

This function code allows the master to modify the contest of a one or more consecutive setpoint in the addressed slave device. Setpoint registers are 16 bit (two byte) values transmitted high order byte first.
The VPR-A Setpoint data starts at address 0100h.

To store the value of one or more setpoints in the internal memory of the VPR-A, the following steps shall be realized:
a) First shall be read setpoint group to modify with function 03h or 04h.
b) Then, modify the values of setpoints according to memory map.
c) Send setpoint group back to relay with function 10h.

The VPR-A response to this function code is to echo the slave address, function code, starting address, the number of setpoints stored, and the CRC.

MESSAGE FORMAT AND EXAMPLE:

Request slave device 11h to write the value 0190h at setpoint address 0102h, and the value 012Ch at setpoint address 0103h.

Master query message	Example (hex)
SLAVE ADDRESS	11 query for slave 11h
FUNCTION CODE	10 store multiple setpoint values
DATA STARTING ADDRESS-high order byte	01 data starting at address 0102
DATA STARTING ADDRESS-low order byte	02
NUMBER OF SETPOINTS-high order byte	00 2 setpoint values = 2 word
NUMBER OF SETPOINTS-low order byte	02
BYTE COUNT	04 4 byte of data
DATA #1-high order byte	01 data for address 0102h=012Ch
DATA #1-low order byte	2C
DATA #2-high order byte	01 data for address 0103h=012Ch
DATA #2-low order byte	2C
CRC-low order byte	9E CRC calculated by the master
CRC-high order byte	46

If the function code or the address or value of any of the data, is illegal, the slave will not respond to the message. Otherwise, the slave will respond as follows:

Master query message	Example (hex)
SLAVE ADDRESS	11 Message from slave 11h
FUNCTION CODE	10 store multiple setpoint values
DATA STARTING ADDRESS-high order byte	01 data starting at address 0102h
DATA STARTING ADDRESS-low order byte	02
NUMBER OF SETPOINTS-high order byte	00 2 setpoint values = 2 word
NUMBER OF SETPOINTS-low order byte	02
CRC-low order byte	E1 CRC calculated by the slave
CRC-high order byte	5E

8.- MEMORY MAP INFORMATION

The data stored in the VPR-A is grouped generally on Setpoints, Actual Values and Product ID. Setpoints can be read and written by a master computer. Actual Values & Product ID are read only. All data is stored as two bytes values (16 bit Word). Addresses are listed in hexadecimal. Data values (Setpoint ranges, increments, factory value) are in decimal.

See Memory Map below.

VPR-A - MODBUS MEMORY MAP

Add (Hex)	MODBUS REG. ADD (Dec)	Size	Description	Unit	Range	Step	Initial Value	Format	Read/ Write
Product ID									
0000	300001	1 W	Product Code	---	---	---	17	F2	R
0001	300002	1 W	Product Model	---	---	---	1	F2	R
0002	300003	1 W	Version Number	---	---	---	1.02	F6	R
0003	300004	1 W	Product Language	---	---	---	1	F24	R
Commands									
0080	400129	1 W	Command Operation Code	---	---	---	---	F23	R/W
TimeSet									
0090	400145	3 W	Date & Time Preset Data	---	---	---	---	F8	R/W
Common Setpoints									
0100	400257	1 W	Access Code	---	111~999	1	111	F10	R/W
0101	400258	1 W	System Setup	BitField	---	---	1028	F9	R/W
0102	400259	1 W	VT Nominal Secondary	V	55~254	1	100	F2	R/W
0103	400260	1 W	VT Primary Volts	KV	0.10~650	0.01/0.1/1	10.00	F6	R/W
0104	400261	1 W	AUX1 Relay Config	BitField	---	---	2	F11	R/W
0105	400262	1 W	AUX2 Relay Config	BitField	---	---	2	F11	R/W
0106	400263	1 W	AUX3 Relay Config	BitField	---	---	2	F11	R/W
0107	400264	1 W	AUX4 Relay Config	BitField	---	---	2	F11	R/W
0108	400265	1 W	AUX5 Relay Config	BitField	---	---	2	F11	R/W
0109	400266	1 W	AUX6 Relay Config	BitField	---	---	2	F11	R/W
010A	400267	1 W	AUX1 Relay Reset Time	Sec	0.0 ~ 6500	0.1	5.0	F4	R/W
010B	400268	1 W	AUX2 Relay Reset Time	Sec	0.0 ~ 6500	0.1	5.0	F4	R/W
010C	400269	1 W	AUX3 Relay Reset Time	Sec	0.0 ~ 6500	0.1	5.0	F4	R/W
010D	400270	1 W	AUX4 Relay Reset Time	Sec	0.0 ~ 6500	0.1	5.0	F4	R/W
010E	400271	1 W	AUX5 Relay Reset Time	Sec	0.0 ~ 6500	0.1	5.0	F4	R/W
010F	400272	1 W	AUX6 Relay Reset Time	Sec	0.0 ~ 6500	0.1	5.0	F4	R/W
0110	400273	1 W	Event Recorder Config	BitField	---	---	31	F14	R/W
0111	400274	1 W	Digital Inputs Config	BitField	---	---	0	F12	R/W
0112	400275	1 W	Input 1 Function		0~7	1	7	F13	R/W
0113	400276	1 W	Input 2 Function		0~7	1	0	F13	R/W
0114	400277	1 W	Input 3 Function		0~7	1	0	F13	R/W
0115	400278	1 W	Input 4 Function		0~7	1	0	F13	R/W
0116	400279	1 W	Reserved						R/W
0117	400280	1 W	Reserved						R/W
0118	400281	1 W	Reserved						R/W
0119	400282	1 W	Reserved						R/W
011A	400283	1 W	Reserved						R/W
011B	400284	1 W	Reserved						R/W
011C	400285	1 W	Reserved						R/W
011D	400286	1 W	Reserved						R/W
011E	400287	1 W	Slave Address	---	1~247	1	1	F2	R/W
011F	400288	1 W	Com1 (RS-232) Baud Rate	Baud	0~4	1	3	F17	R/W
0120	400289	1 W	Com2 (RS-485) Baud Rate	Baud	0~4	1	3	F17	R/W
0121	400290	1 W	Com3 (RS-485) Baud Rate	Baud	0~4	1	3	F17	R/W
Protections Setpoints									
0180	400385	1 W	Undervoltage 1 Relays	---	0~63	1	0	F15	R/W
0181	400386	1 W	Undervoltage 1 Level	%VT	15~100	1	95	F2	R/W
0182	400387	1 W	Undervoltage 1 Dropout	%VT	15~100	1	97	F2	R/W
0183	400388	1 W	Undervoltage 1 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
0184	400389	1 W	Undervoltage 1 Curve	---	0~1	1	0	F16	R/W
0185	400390	1 W	Phases for U/V 1 Operation	---	0~2	1	0	F25	R/W
0186	400391	1 W	Minimun Operation Level for U/V 1	%VT	0~100	1	0	F2	R/W
0187	400392	1 W	Undervoltage 2 Relays	---	0~63	1	0	F15	R/W
0188	400393	1 W	Undervoltage 2 Level	%VT	15~100	1	95	F2	R/W
0189	400394	1 W	Undervoltage 2 Dropout	%VT	15~100	1	97	F2	R/W
018A	400395	1 W	Undervoltage 2 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
018B	400396	1 W	Undervoltage 2 Curve	---	0~1	1	0	F16	R/W
018C	400397	1 W	Phases for U/V 2 Operation	---	0~2	1	0	F25	R/W
018D	400398	1 W	Minimun Operation Level for U/V 2	%VT	0~100	1	0	F2	R/W
018E	400399	1 W	Undervoltage 3 Relays	---	0~63	1	0	F15	R/W
018F	400400	1 W	Undervoltage 3 Level	%VT	15~100	1	95	F2	R/W
0190	400401	1 W	Undervoltage 3 Dropout	%VT	15~100	1	97	F2	R/W
0191	400402	1 W	Undervoltage 3 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
0192	400403	1 W	Undervoltage 3 Curve	---	0~1	1	0	F16	R/W
0193	400404	1 W	Phases for U/V 3 Operation	---	0~2	1	0	F25	R/W

VPR-A - MODBUS MEMORY MAP

Add (Hex)	MODBUS REG. ADD (Dec)	Size	Description	Unit	Range	Step	Initial Value	Format	Read/ Write
0194	400405	1 W	Minimun Operation Level for U/V 3	%VT	0~100	1	0	F2	R/W
0195	400406	1 W	Overvoltage 1 Relays	---	0~63	1	0	F15	R/W
0196	400407	1 W	Overvoltage 1 Level	%VT	1~150	1	105	F2	R/W
0197	400408	1 W	Overvoltage 1 Dropout	%VT	1~150	1	103	F2	R/W
0198	400409	1 W	Overvoltage 1 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
0199	400410	1 W	Phases for O/V 1 Operation	---	0~3	1	0	F25	R/W
019A	400411	1 W	Overvoltage 2 Relays	---	0~63	1	0	F15	R/W
019B	400412	1 W	Overvoltage 2 Level	%VT	1~150	1	105	F2	R/W
019C	400413	1 W	Overvoltage 2 Dropout	%VT	1~150	1	103	F2	R/W
019D	400414	1 W	Overvoltage 2 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
019E	400415	1 W	Phases for O/V 2 Operation	---	0~3	1	0	F25	R/W
019F	400416	1 W	Overvoltage 3 Relays	---	0~63	1	0	F15	R/W
01A0	400417	1 W	Overvoltage 3 Level	%VT	1~150	1	105	F2	R/W
01A1	400418	1 W	Overvoltage 3 Dropout	%VT	1~150	1	103	F2	R/W
01A2	400419	1 W	Overvoltage 3 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
01A3	400420	1 W	Phases for O/V 3 Operation	---	0~3	1	0	F25	R/W
01A4	400421	1 W	Unbalance 1 Relays	---	0~63	1	0	F15	R/W
01A5	400422	1 W	Unbalance 1 Level	%	1~99	1	10	F2	R/W
01A6	400423	1 W	Unbalance 1 Dropout	%	1~99	1	8	F2	R/W
01A7	400424	1 W	Unbalance 1 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
01A8	400425	1 W	Unbalance 2 Relays	---	0~63	1	0	F15	R/W
01A9	400426	1 W	Unbalance 2 Level	%	1~99	1	10	F2	R/W
01AA	400427	1 W	Unbalance 2 Dropout	%	1~99	1	8	F2	R/W
01AB	400428	1 W	Unbalance 2 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
01AC	400429	1 W	Phase Reversal Relays	---	0~63	1	0	F15	R/W
01AD	400430	1 W	Phase Reversal Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
01AE	400431	1 W	Frequency 1 Relays	---	0~63	1	0	F15	R/W
01AF	400432	1 W	Frequency 1 Mode	---	0~2	1	0	F26	R/W
01B0	400433	1 W	Frequency 1 Level	Hz or Hz/s	0.05~9.99	0.01	1.00	F6	R/W
01B1	400434	1 W	Frequency 1 Dropout	Hz or Hz/s	0.01~5.00	0.01	0.50	F6	R/W
01B2	400435	1 W	Frequency 1 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
01B3	400436	1 W	Frequency 2 Relays	---	0~63	1	0	F15	R/W
01B4	400437	1 W	Frequency 2 Mode	---	0~2	1	0	F26	R/W
01B5	400438	1 W	Frequency 2 Level	Hz or Hz/s	0.05~9.99	0.01	1.00	F6	R/W
01B6	400439	1 W	Frequency 2 Dropout	Hz or Hz/s	0.01~5.00	0.01	0.50	F6	R/W
01B7	400440	1 W	Frequency 2 Delay	Sec	0.05~600	0.01/0.1/1	1.00	F6	R/W
			Actual Values						
0200	300513	3 W	Relay Date & Time	---	---	---	---	F8	R
0203	300516	1 W	Front Panel Leds Status	BitField	---	---	---	F18	R
0204	300517	1 W	Front Panel Leds Blink Status	BitField	---	---	---	F18	R
0205	300518	1 W	Output Relays Status	BitField	---	---	---	F20	R
0206	300519	1 W	Digital Inputs Status	BitField	---	---	---	F21	R
0207	300520	1 W	Status Flags	BitField	---	---	---	F22	R
0208	300521	1 W	Pickup Flags	BitField	---	---	---	F22	R
0209	300522	2 W	Phase AB RMS Voltage	V	---	---	---	F4	R
020B	300524	2 W	Phase BC RMS Voltage	V	---	---	---	F4	R
020D	300526	2 W	Phase CA RMS Voltage	V	---	---	---	F4	R
020F	300528	2 W	3Vo Voltage	V	---	---	---	F4	R
0211	300530	1 W	Frequency	Hz	---	---	---	F6	R
0212	300531	2 W	Phase AN RMS Voltage	V	---	---	---	F4	R
0214	300533	2 W	Phase BN RMS Voltage	V	---	---	---	F4	R
0216	300535	2 W	Phase CN RMS Voltage	V	---	---	---	F4	R
0218	300537	1 W	Phase Sequence	---	---	---	---	F27	R
0219	300538	1 W	Phase AB Unbalance	%	---	---	---	F4	R
021A	300539	1 W	Phase BC Unbalance	%	---	---	---	F4	R
021B	300540	1 W	Phase CA Unbalance	%	---	---	---	F4	R
021C	300541	2 W	Voltage Average	V	---	---	---	F4	R
021E	300543	1 W	Reserved	---	---	---	---	---	R
021F	300544	1 W	Reserved	---	---	---	---	---	R
0220	300545	1 W	Reserved	---	---	---	---	---	R
0221	300546	1 W	Reserved	---	---	---	---	---	R
0222	300547	1 W	Reserved	---	---	---	---	---	R
			Events						
0600	301537	1 W	Last Event Number	---	---	---	---	F2	R
0601	301538	3 W	Last Event Clear Date & Time	---	---	---	---	F8	R

VPR-A - MODBUS MEMORY MAP									
Add (Hex)	MODBUS REG. ADD (Dec)	Size	Description	Unit	Range	Step	Initial Value	Format	Read/ Write
0610	401553	1 W	Selected Event Number	---	1~65535	1	1	F2	R/W
0611	301554	3 W	Selected Event Date & Time	---	---	---	---	F8	R
0614	301557	2 W	Selected Event Phase AB RMS Voltage	V	---	---	---	F4	R
0616	301559	2 W	Selected Event Phase BC RMS Voltage	V	---	---	---	F4	R
0618	301561	2 W	Selected Event Phase CA RMS Voltage	V	---	---	---	F4	R
061A	301563	2 W	Selected Event Phase 3Vo Voltage	V	---	---	---	F4	R
061C	301565	1 W	Selected Event Frequency	Hz	---	---	---	F6	R

VPR-A DATA FORMATS			
Format Code	**Type**	**Value**	**Definition**
F1	**Integer**		**Signed Integer Value**
			Example: -123 saved as -123
F2	**Integer**		**Unsigned Integer Value**
			Example: 123 saved as 123
F3	**Integer**		**Signed Integer Value with 1 decimals**
			Example: -1.0 saved as -10
F4	**Integer**		**Unsigned Integer Value with 1 decimals**
			Example: 1.0 saved as 10
F5	**Integer**		**Signed Integer Value with 2 decimals**
			Example: -1.00 saved as -100
F6	**Integer**		**Unsigned Integer Value with 2 decimals**
			Example: 1.00 saved as 100
F7	**Floating Point**		**(4 Byte) Floating Point Value**
			4-byte floating-point format The memory layout of 4-byte floating-point numbers is: 31 30 23 22 0 S | Exponent | Mantissa The value of the number is: $(-1)^S * 2^{(Exponent-127)} * 1.Mantissa$ Zero is represented by 4 bytes of zeros. The precision of the float operators (+, -, *, and /) is approximately 7 decimal digits.
F8	**Clock**		**Date & Time Format**
			1st Word: bits 15–7: **Event Cause (Only for Events Date & Time Register) Otherwise NOT USED** (0~512) See Events List; bits 6–0: **YEAR** (00~99) Ex. 00 = 2000, 01=2001 ... **2nd Word**: bits 15–14: **Not Used**; bits 13–10: **MONTH** (1~12); bits 9–5: **DAYS** (1~31/30/29/28) Depending on the Month & Year; bits 4–0: **HOURS** (00~23) **3th Word**: bits 15–10: **MINUTES** (00~59); bits 9–0: **SECONDS** (00.0~59.9)
F9	**16 Bits BitMap**		**System Setup Register Format**
		Bit 0 ~ Bit 1	**System Frequency:** 0 = 50hz, 1 = 60hz
		Bit 2 ~ Bit 4	**VT Connection:** 0 = None, 1 = Wye-Wye, 2 = Delta-Delta, 3 = Delta-Wye, 4 = Open Delta
		Bit 5 ~ Bit 9	**Not Used**
		Bit 10	**Out of Service on AUX6 ?:** 0 = No, 1 = Yes
		Bit 11 ~ Bit 15	**Not Used**
F10	**Integer**		**Unsigned Integer Access Code Value Register Format**
			Example: 111 saved as 111 **(only digits 1~9 accepted, digit 0 is NOT ALLOWED)**
F11	**16 Bits BitMap**		**Outputs Relays Configuration Register Format**
		Bit 0 ~ Bit 7	**Relay Pulse Time:** (only applicable if relay type is set as PULSED) **Range:** 0.1~10.0 seconds **Format F4**
		Bit 8 ~ Bit 9	**Relay Type:** 0 = "LATCHED", 1 = "PULSED", 2 = "AUTORESET"
		Bit 10	**Relay Non Operation State:** 0 = "DE-ENERGIZED", 1 = "ENERGIZED"
		Bit 11 ~ Bit 15	**Not Used**
F12	**16 Bits BitMap**		**Digital Input Configuration Register Format**
		Bit 0 ~ Bit 1	**INPUT 1 SET ON:** 0 = "CONTACT CLOSED", 1 = "CONTACT OPEN"
		Bit 2 ~ Bit 3	**INPUT 2 SET ON:** 0 = "CONTACT CLOSED", 1 = "CONTACT OPEN"
		Bit 4 ~ Bit 5	**INPUT 3 SET ON:** 0 = "CONTACT CLOSED", 1 = "CONTACT OPEN"
		Bit 6 ~ Bit 7	**INPUT 4 SET ON:** 0 = "CONTACT CLOSED", 1 = "CONTACT OPEN"

VPR-A DATA FORMATS			
Format Code	**Type**	**Value**	**Definition**
		Bit 8 ~ Bit 15	**Not Used**
F13	**Integer**		**Digital Input Functions**
		0	NONE
		1	ACTIVATE AUX1
		2	ACTIVATE AUX2
		3	ACTIVATE AUX3
		4	ACTIVATE AUX4
		5	ACTIVATE AUX5
		6	ACTIVATE AUX6
		7	EXTERNAL RESET
F14	**16 Bits BitMap**		**Events Recorder Configuration Register Format**
		Bit 0	UnderVoltage Protections Events { 0 = Off , 1 = On }
		Bit 1	OverVoltage Protections Events { 0 = Off , 1 = On }
		Bit 2	Unbalance Protections Events { 0 = Off , 1 = On }
		Bit 3	Frequency Protections Events { 0 = Off , 1 = On }
		Bit 4	System Events { 0 = Off , 1 = On }
		Bit 5	Output Relays Events { 0 = Off , 1 = On }
		Bit 6	Digital Inputs Events { 0 = Off , 1 = On }
		Bit 7 ~ Bit 15	Not Used
F15	**Integer**		**Output Relay Selection**
		Bit 0	AUX.1 OUTPUT RELAY
		Bit 1	AUX.2 OUTPUT RELAY
		Bit 2	AUX.3 OUTPUT RELAY
		Bit 3	AUX.4 OUTPUT RELAY
		Bit 4	AUX.5 OUTPUT RELAY
		Bit 5	AUX.6 OUTPUT RELAY
F16	**Integer**		**Protection Curve Definition Format**
		0	DefiniteTime
		1	Inverse
F17	**Integer**		**BaudRate Definitions**
		0	1200 Bps
		1	2400 Bps
		2	4800 Bps
		3	9600 Bps
		4	19200 Bps
F18	**16 Bits BitMap**		**Led Status Register Format**
		Bit 0	Status of Output Aux 1
		Bit 1	Status of Output Aux 2
		Bit 2	Status of Output Aux 3
		Bit 3	Status of Output Aux 4
		Bit 4	Status of Output Aux 5
		Bit 5	Status of Output Aux 6 (Service)
		Bit 6	Memory
		Bit 7	Pickup 27
		Bit 8	Pickup 27R
		Bit 9	Pickup 59
		Bit 10	Pickup 46
		Bit 11	Pickup 81
		Bit 12 ~ Bit 15	NOT USED
F19	**16 Bits BitMap**		**Not Used**
F20	**16 Bits BitMap**		**Output Relays Status Register**
		Bit 0	Aux1 Output Relay { 0 = "Energized" , 1 = "De-energized" }
		Bit 1	Aux2 Output Relay { 0 = "Energized" , 1 = "De-energized" }
		Bit 2	Aux3 Output Relay { 0 = "Energized" , 1 = "De-energized" }
		Bit 3	Aux4 Output Relay { 0 = "Energized" , 1 = "De-energized" }
		Bit 4	Aux5 Output Relay { 0 = "Energized" , 1 = "De-energized" }
		Bit 5	Aux6 (Service) Output Relay { 0 = "Energized" , 1 = "De-energized" }
		Bit 6 ~ Bit 15	Not Used
F21	**16 Bits BitMap**		**Digital Input Status Register**
		Bit 0	Digital Input 1 { 0 = "OPEN" , 1 = "CLOSE" }
		Bit 1	Digital Input 2 { 0 = "OPEN" , 1 = "CLOSE" }
		Bit 2	Digital Input 3 { 0 = "OPEN" , 1 = "CLOSE" }
		Bit 3	Digital Input 4 { 0 = "OPEN" , 1 = "CLOSE" }
		Bit 4 ~ Bit 15	Not Used
F22	**16 Bits BitMap**		**Status & Pickup Flags Format**
		Bit 0	UnderVoltage 1 Protection { 0 = OFF , 1 = ON }
		Bit 1	UnderVoltage 2 Protection { 0 = OFF , 1 = ON }

VPR-A DATA FORMATS			
Format Code	**Type**	**Value**	**Definition**
		Bit 2	UnderVoltage 3 Protection { 0 = OFF , 1 = ON }
		Bit 3	OverVoltage 1 Protection { 0 = OFF , 1 = ON }
		Bit 4	OverVoltage 2 Protection { 0 = OFF , 1 = ON }
		Bit 5	OverVoltage 3 Protection { 0 = OFF , 1 = ON }
		Bit 6	Unbalance 1 Protection { 0 = OFF , 1 = ON }
		Bit 7	Unbalance 2 Protection { 0 = OFF , 1 = ON }
		Bit 8	Phase Reversal Protection { 0 = OFF , 1 = ON }
		Bit 9	Frequency 1 Protection { 0 = OFF , 1 = ON }
		Bit 10	Frequency 2 Protection { 0 = OFF , 1 = ON }
		Bit 11 ~ Bit 15	Reserved
F23	**Integer**		**Commands Operation Codes**
		0	No Command
		1	Remote Reset
		5	Activate Date & Time Preset Data
		9	Clear All Events
		20	Activate Aux1
		21	Activate Aux2
		22	Activate Aux3
		23	Activate Aux4
		24	Activate Aux5
		25	Activate Aux6
		200	SETPOINTS PushButton Activation
		201	ACTUAL VALUES PushButton Activation
		202	RESET PushButton Activation
		203	PAGE UP PushButton Activation
		204	VALUE UP PushButton Activation
		205	LINE PushButton Activation
		206	PAGE DOWN PushButton Activation
		207	VALUE DOWN PushButton Activation
		208	STORE PushButton Activation
		209	PROG PushButton Activation
F24	**Integer**		**Product Language**
		0	Not Used
		1	English
		2	Russian
F25	**Integer**		**Phases for Protection Operation**
		0	Any One
		1	Any Two
		2	All Three
		3	Homopolar (3Vo)
F26	**Integer**		**Frequency Protection Mode**
		0	O/F + U/F
		1	O/F
		2	U/F
F27	**Integer**		**Phase Sequence**
		0	None
		1	A-B-C
		2	A-C-B

VPR-A Event Cause List :	
0	No Event
1	Events Clear
6	Aux.1 Relay OFF
7	Aux.1 Relay ON
8	Aux.2 Relay OFF
9	Aux.2 Relay ON
10	Aux.3 Relay OFF
11	Aux.3 Relay ON
12	Aux.4 Relay OFF
13	Aux.4 Relay ON
14	Aux.5 Relay OFF
15	Aux.6 Relay ON
16	Aux.6 Relay OFF
17	Aux.6 Relay ON
20	Digital Input 1 Deactive
21	Digital Input 1 Active
22	Digital Input 2 Deactive
23	Digital Input 2 Active
24	Digital Input 3 Deactive
25	Digital Input 3 Active
26	Digital Input 4 Deactive
27	Digital Input 4 Active
100	UnderVoltage 1
101	UnderVoltage 2
102	UnderVoltage 3
103	OverVoltage 1
104	OverVoltage 2
105	OverVoltage 3
106	Unbalance 1
107	Unbalance 2
108	Phase Reversal
109	Frequency 1
110	Frequency 2