eyePower Limited

John de Mierre House, 20 Bridge Road,

Haywards Heath, RH16 1UA, UK

eyePower PDU Technical Manual

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SAFETY NOTICE

End users must be made aware that power outlets are remote controlled

This unit is not certified for safety isolation of the electrical supply

Overview

eyePower Limited have produced intelligent mains unit for many years. Formerly sold by Bryant Unlimited, the original SMU offered 12 outlets, sequenced on at intervals of 600 milliseconds. The SMR had 10 outlets sequenced after a GPI low input, with a GPI output that can be linked to start another SMR unit. The CMU sequenced on like the SMU but has two mains inputs, switching when main supply fails to the reserve supply without interruption to equipment operation.

Serial RS422 control was introduced with SMS and CMS units that allow total flexibility for stand-alone applications and live access to control power outlets. Standalone operation is based on a proprietary macro programming language to switch outlets with customised order and delay, GPIs can be input or output with different macro routines for different scenarios. Macro editing or live control is possible with Windows™ software supplied by Bryant Unlimited, free for a single unit or cost option to control multiple units. The serial protocol is also available for integration with third party systems.

Based on this proven technology, the eyePower range of Mains Distribution Units adds a plethora of new features such as overall and individual current measurement, environmental monitoring, optional Ethernet connectivity and local reporting using the front panel OLED display. Outlets are increased to 14 even on dual supply PDUs.

The reader should note the difference between live control of the unit and what the unit will do on its own, possibly with GPI connections. Live control is usually from a PC or management system with checking of outlet status, monitoring overall and outlet current, inlet voltage and switching outlets on or off. Stand-alone macro operation uses the contents of the unit's memory to determine sequence order and delays at power-up or when there are GPI changes. However, a PC is still required to program the stand-alone parameters before the unit enters service. The unit ships with a basic on/off sequence triggered by the front panel soft switch.

The macro language was an inspired solution to meet eyePower's different customer requirements. The language offers total flexibility which may at first appear relatively complex, but the average user will program the unit using the free software supplied. They will not know that their sequence on, and off, have been programmed as a list of macro commands. For the advanced user the unit's potential is unlocked with the ability to dynamically change how the unit responds. For example, a unit might sequence on, shut down some outlets on UPS failure, and restore them in a completely different order to the original sequence. Even this restore sequence might be changed depending how far the load shedding has gone.

Macro commands are basically two types – those that cause a change such as switching an outlet and those that influence program flow by responding to a GPI. The instruction set is discussed briefly after the protocol for live commands, but experimentation with the eyePower software and an eyePower PDU would be more of an education. Please note there are some areas of live control relevant to macro setup such as writing to unit memory and checking progress through a macro program.

The full serial command set may appear daunting, but many users only need a limited number of commands. eyePower Limited are always available to offer technical advice.

1. Serial Control Background

eyePower serial control is a mixture of RS422 and RS485 standards, in a way much used by broadcast equipment. A single controller, typically computer, outputs commands as balanced RS422 data on a twisted pair, which is connected to all eyePower PDU. Individual eyePower PDUs are targeted using unique addresses at the start of every serial command.

Units share another twisted pair for replies, using RS485 techniques to either send a reply or turn high impedance allowing others to talk. In true RS485, all PDU share a single pair and timing of the shared bus is more of an issue, with the controller also needing an RS485 interface. However, in this case the mains units are simply communicating as for RS422, selectively switching off their transmission. The computer can therefore use a normal RS422 interface with separate TX/RX pairs.

2. Serial Control Electrical

Industry standard, high performance RS422/485 driver chips are used inside the mains units, allowing a large number of units to be controlled from the same controller. The controller RS422 port and cabling will be specified by the end user, making it difficult to predict how many units may be controlled on the same bus. With good quality data cabling such as CAT5e, one may expect many tens of units to be controlled from the same bus. The unit does not loop through serial data, which might lead to disconnection of the bus when a unit is removed. Instead, fan-out strips should be used, or control cables looped in the mating D connectors. The topology of this wiring will also affect performance for large numbers of units.

As the eyePower PDU transmission drivers are high impedance unless transmitting, a replying eyePower PDU should easily be able to drive the return data pair to the controller despite other units connected to the same line. It is the controller that must drive the potentially difficult receive load of many units, with an input impedance of 12kOhms for each unit. Typically, one would expect to drive only 32 such loads from a PC RS422 port, but experience has shown that this specification, intended for much higher data rates, allows more load at the 9600 baud rate used by eyePower.

Good practice suggests both data pairs should be terminated with 110 Ohms at their extreme ends. However, modern driver chips running well below their maximum data rates do not usually benefit from their fitting, although installers should be mindful of EMC compliance.

Regardless of the number of units that will function on a single bus, the user may wish to limit units and associated data traffic to improve response times. In this case multiple controllers and bus wiring are used, each with a smaller number of units operating a higher data refresh rate.

Computers have extremely tolerant RS232 ports and it will usually be possible to connect a PC RS232 port directly to a single eyePower PDU serial port, using only ground, one TX and one RX pin. This will be useful for testing or unit configuration on relatively short cables but is not recommended for permanent, multi-drop installations.

3. Ethernet Connectivity

The eyePower PDU is fitted with an Ethernet interface module. All of the commands in the protocol detailed below can be sent over TCP using the inbuilt Serial Bridge to a dedicated port number, allowing control and monitoring of units across both LAN and WAN networks. Please note that when using the Serial Bridge, the unit will be targeted using its IP Address and port (1243 default), which can be enabled and set using the eyePower Windows™ software. The multi-drop address is used as described below, however, the addresses are fixed at 250 (FA hex) for the relay processor and 251 (FB hex) for the measurement processor. The Ethernet interface also offers a web interface and will support SNMP in a future firmware release.

4. Serial Protocol Overview

The protocol must be robust as accidental de-powering of vital equipment is unacceptable. However, in-built error correction would be too great an overhead for an inherently reliable interface and only error checking is used. Complete commands or replies are covered by a single checksum byte.

If a communications error is determined at the mains unit, it will not respond or change state. The controller should be designed to timeout when the unit does not respond and then retry. This approach is to avoid multiple units trying to report an error simultaneously. However, addresses FA/FB used for IP control do have additional processing to return NAK for invalid requests, the logic being that multi-drop is not in use and any perceived error is not going to be a legitimate command for another multi-drop unit. The response times for eyePower PDUs will depend on the command, for example, status requests are fast (20-30ms) but memory writing is slower (200ms for 16 bytes). Response times will also depend on the user’s equipment although serial ports on most PCs will return a response within a similar time, whether the serial port is integral or an external USB converter. Where serial data is bridged, for example across TCP/IP networks, the timeout may need to be lengthened because of the link delay.

Although corrupted commands will be ignored, the unit will respond with a NAK (Negative AcKnowledge) to illegal commands with good basic formatting and checksum, typical examples would be a command that is not followed by the correct number of configuration bytes

If the controller detects a communications error in a unit's response, it is suggested the controller retries the command.

Serial interface parameters for locally connected RS422 rather than Ethernet bridge are,

Baud rate	9600
Parity	None
Data bits	8
Stop bit	1

which should result in very few problems with a properly engineered system. eyePower Limited's own PC software has the ability to step the baud rate to 115200, if this is of interest where wiring supports this rate then further details can be provided.

The protocol is not human readable, i.e. for use on a terminal program. This would increase the number of characters to be transmitted where (for example) a single character/byte can report the status of 8 outlets if there is no requirement for terminal control.

The inherent problem with such protocols that allow any byte value for data is how to define start and end of message. STX (02 hex) and ETX (03 hex) are standard but these must be distinguished from 02H or 03H as actual data. DLE (10H) is known as the Data Link Exception (or Escape) character, with STX or ETX preceded by DLE.

Where the data itself is 10H, two DLE's are transmitted.

Hence a typical command or eyePower PDU response looks like this,

DLE	**STX**	**ADDRESS**	**COMMAND**	**MESSAGE BODY**	**CHECK**	**DLE**	**ETX**
10H	**02H**	**xxH**	**xxH**		**xxH**	**10H**	**03H**

eyePower PDUs are fitted with two different processors (Ethernet has a third but ignore that one) to increase reliability even though the firmware could have been combined in a single, cheaper processor. One processor manages relays, environmental monitoring and GPIs. The second processor makes voltage and current measurements while operating the front panel OLED display. Each processor is accessed with a different address after STX, the measurement processor is automatically 128 higher than the address set for the relay processor.

The relay address will be between 0 and 121 decimal (00 and 79 hex), although 0 is intended for new units from the factory to avoid accidental operation when added to a system. This can be changed on installation, as explained below. Other addresses are reserved.

The relay or measurement processor command byte will be one of the commands listed below, which also details the message body for each case.

The single byte checksum is simply an addition of all bytes starting at unit address and including the message body, with any overflow discarded. Any DLE-DLE embedded in the message body are treated in their un-encoded form, i.e. a single 10H.

Note the coding of 10H as DLE-DLE includes all of the message from address to checksum inclusive.

Where a PDU receives an invalid command, and responds with a NAK (Not AcKnowledged), the received message is echoed with DLE-NAK after the command and replacing any message body. The checksum is incremented by 25H.

DLE	STX	ADDRESS	COMMAND	DLE	NAK	CHECK	DLE	ETX
10H	02H	xxH	xxH	10H	15H	xxH	10H	03H

Invalid commands always receive a NAK response when connecting TCP over Ethernet. However, on a wired RS422 connection, NAK is not sent for all invalid messages as the invalid message might be intended for another unit on the multi-drop wiring. Note from 2001 to 2017, to software versions 1.4.3, NAK was sent without a DLE prefix. We are not aware that anyone implemented a check for NAK, but the old method was flawed in the rare case where the message body could be 15H.

For all commands summarised below, only the command and message body are described. Unit address is always required, although there are some commands that are not address specific and the address will be ignored whatever its value.

Note that a unit responding to a command will not accept a second command until it has completed transmission of its reply. Until the reply is complete, any data transmitted by the controller is discarded. Although other units will accept the second command, the preferred method of control is to complete a command and receive a reply before issuing further commands to the same or other units.

5. Changing Unit Memory Settings - Relay Processor

As noted above the eyePower PDU can be controlled 'live' or as a stand-alone unit running its own macro code. This macro code is held in the relay processor's non-volatile memory and accessed using the following commands,

To read memory values,

Read memory	**11H**
Start location	Most significant byte, see appendix B
Start location	Least significant byte
Number of bytes to read	xxH

where the eyePower PDU will reply,

Read memory	11H
Start location MSB	Should be as command
Start location LSB	Should be as command
Number of bytes read	Should be as command
Memory values	

and to write to memory,

Write memory	**12H**
Start location	Most significant byte, see appendix B
Start location	Least significant byte
Number of bytes to write	xxH
Memory values	

with the eyePower PDU reply being values read back from the memory. This confidence reading is slower but more reliable than echoing the original command,

Write memory	12H
Start location MSB	Should be as command
Start location LSB	Should be as command
Number of bytes written	Should be as command
Memory values read back	Should be as command

Memory access is limited to 16 memory bytes at a time. The unit will transmit a NAK if this is exceeded and perform no function.

NAK will also be sent if an attempt is made to change the unit's unique serial number, or to change the multi-drop address, which are both held in memory. The serial number is factory set and may not be changed. The multi-drop address is changed with a separate command that ensures the address of the correct unit is changed.

Some memory locations below address 20H can be changed, for example changeover settings. Memory locations 20H to 01FFH are used for the macros that determine stand-alone operation.

The same 11H/12H commands are also used to access memory of the measurement processor, used for Ethernet settings and unit / designation strip naming.

Setting Multi-Drop Address

Multi-drop addresses are set in the non-volatile memory to avoid physical address switches and thus improve flexibility and reliability. The multi-drop address must be set by software, based on confirming the unit's unique four-byte serial number. The address is used to target serially connected units, use of the Ethernet option as a serial bridge overrides the address setting, targeting is then via IP address.

There are a number of commands related to address settings, some of which follow from experience of awkward installations where other manufacturers' equipment has been set to the same address and conflicts have occurred. When writing controlling software, these commands do not all have to be used but they should offer a complete system integrity check if required.

It is possible to automatically detect all connected units hence the inability to look at a physical address switch is not an issue. In fact, even physical switches can be difficult to check if they are on a modular card, or hidden from view in the back of a crowded equipment rack.

To read an eyePower PDU unique serial number,

Read serial no. and address	**21H**

and the unit set to the transmitted pre-amble address will give reply,

Read serial no. and address	21H
Serial number	4 bytes

There is the opportunity for multiple units to respond if set to the same address. Units will normally be delivered from the factory with address 00H, although complete systems may be shipped with address 01H onwards.

To echo a serial number thought to be available,

Echo serial no. and address	**22H**
Serial number	4 bytes

and regardless of transmitted pre-amble address the unit if available will reply with its actual address and

Echo serial no. and address	22H
Serial number	4 bytes

with front panel LED display set to flash orange, indicating the unit has received a 22H command. This flashing can be stopped by re-powering, or by cease poll command.

To change multi-drop address,

Change address	**23H**
Serial number	4 bytes
Multi-drop address	1 byte

and the unit will reply,

Change address	23H
Serial number	4 bytes

The address in the reply pre-amble should be the new address and is read back from memory after writing.

Note replies to 21H/22H/23H are all the same, but are for a given address, a given serial number, change of address for a given serial number.

The easiest way to configure the address of a new unit may be to connect this alone to a PC and use the software supplied by eyePower Limited. As an alternative, your custom software can poll for units, using the command 24H.

Poll serial nos. and addresses	**24H**

Only units corresponding to the pre-amble multi-drop address will respond. When 24H is received by the targeted eyePower PDU, each determines a random time in 100 millisecond steps up to seven seconds that it will respond as for command 21H. The units will continue to randomly respond like this until individually instructed to be silent with 25H which must specify the address as standard and the unique serial number,

Cease serial number poll	**25H**
Serial number	4 bytes

The relatively long seven seconds reduces the chance of data collision. However, the controller will still need to filter garbled responses, which should diminish as individual units are silenced.

Command 24H may be useful for solving installation problems where two units have been given the same multi-drop address in error.

To poll all units, command 26H works the same as 24H but the address part of the command is ignored and all units will respond. For a large system this may result in a lot of data collision.

To silence all units, a single 27H is used with the address part of the command again ignored. 27H will also silence units responding to a 24H command.

While a unit is polling its serial number, it will receive commands as normal, and reply. However, the reply may be lost if another unit randomly sends its address information at the same time.

This polling method is intended to be a tool rather than a sophisticated implementation of data collision and negotiation. Although units share a return data pair to the controller they can not ‘hear’ each other and this simple polling approach is meant to solve occasional installation configuration problems.

To assist in unit identification, any unit sending poll data flashes its LED display to orange. As for the serial number echo command, this is cancelled when a cease poll command is received by the unit.

6. Real Time Control - Relay Processor

To check the status of the eyePower PDU,

Status **31H**

and that address will respond,

Status	31H
Change relay, unit alarm, relay 9-14	Changed over, alarm, expected state of relays
Relay 1-8	Expected state of relays
Misc out	Direction and output state of GPI
Cycle Timer, Type 227, outlet 9-14	Cycle Timer, type 227, measured state of relay output
Outlet 1-8	Measured state of relay output
Supplies input, fuse 9-14	Supplies input, measured state of fuse (pre relay)
Fuse 1-8	Measured state of fuse
Misc in	GPIs disabled, front panel on/off, options, GPI inputs
Macro address	Current macro code address
Macro timer	Two byte word macro command timer 0.1 second steps
Changeover detail main	Initially bit1 (=2) backfeed over voltage varistors intact
Changeover detail backup	As above, other bits will be more internal test results

which can be summarised,

128	64	32	16	8	4	2	1
Changed Over	Unit Alarm	Relay 14	Relay 13	Relay 12	Relay 11	Relay 10	Relay 9
Relay 8	Relay 7	Relay 6	Relay 5	Relay 4	Relay 3	Relay 2	Relay 1
GPI4 Set	GPI4 Out	GPI3 Set	GPI3 Out	GPI2 Set	GPI2 Out	GPI1 Set	GPI1 Out
1 = Cycle Timer running*	1 = Dual Input 227	Outlet 14	Outlet 13	Outlet 12	Outlet 11	Outlet 10	Outlet 9
Outlet 8	Outlet 7	Outlet 6	Outlet 5	Outlet 4	Outlet 3	Outlet 2	Outlet 1
Backup Fuse	Main Fuse	Fuse 14	Fuse 13	Fuse 12	Fuse 11	Fuse 10	Fuse 9
Fuse 8	Fuse 7	Fuse 6	Fuse 5	Fuse 4	Fuse 3	Fuse 2	Fuse 1
1 = GPI Disabled	1 = On/off Switch on	1 = Change Fitted	1 = No Out Relays	GPI4	GPI3	GPI2	GPI1
Current macro code address which is physical address divided by 2 – see separate section							
High byte of macro timer word							
Low byte of macro timer word 0.1 second counter							
Changeover useable status main							
Changeover useable status backup							

* See relay commands 69H & 6AH for more information, added June 2016.

Output relays on/off and outlet/fuse mains sense are provided for fourteen outlets. Logic ‘1’ means the relay is meant to be on for Relay *x* and that power is sensed for Outlet or Fuse *x*. Earlier designs only sensed mains post relay but this would not detect a failed fuse where the relay is off. eyePower senses mains both post fuse and post relay for each outlet.

Fourteen outlets leaves two spare bits in each of the relay state, fuse sense and outlet sense words of two bytes each. Spare bits of relay state are used to indicate position of the changeover relay if fitted and whether the local unit alarm is operating. Spare bits of fuse sense are used for the internal power supply, (two supplies for changeover), that are fused on the front panel. One of the spare bits of output sense is used to indicate a type 227 unit which is dual supply with a split 7+7 outlet distribution, ie not a changeover. The most significant bit of output sense is used to indicate whether a cycle timer is running.

The third byte is what state the GPI direction and state are meant to be for outputs. GPIx Out is ‘1’ for output or ‘0’ for input. For outputs, GPIx Set is ‘1’ for a +5V output or ‘0’ for a 0V output.

The eighth byte gives measured GPI values, ‘0’ for 0V and ‘1’ for a voltage present. Although obviously useful for GPI set as an input, this might also be used to detect a GPI output that is being driven (and certainly should not be) by an external voltage. The GPIs are protected with series 1k resistors, which allows connection of +24V D.C. The user would have to work quite hard for this ‘read back’ of a GPI output not to be correct. Note that GPI are fitted with weak 100k pull-up resistors, hence inputs are ‘1’ with no connection.

Other values in the eighth byte indicate GPIs globally disabled/inhibited, position of the front panel rocker switch, whether the unit is changeover with dual input, whether output relays have been replaced by failsafe bypass wiring.

Current macro address is useful to monitor macro routine progression. In January 2014 the 16 bit counter to the next macro command was added to this standard status response. Although available using 51H, returning this 0.1 second resolution counter with the standard status command also allows regular updates to monitor time to the next macro command or whether halted with timer at zero.

The last two status (useable) bytes were added January 2014 for advanced detail most applicable to changeover units. Initially only the second bit (value 2) is used to indicate backfeed protection varistors are present without failed internal fusing. These varistors are not fitted to single inlet units.

Use of those last bytes is being expanded to flag error conditions for voltage, current, sensors etc. so the control system knows to check for more detail. It is likely that two bits will also flag if TCP messages are failing authentication, and whether such failures have locked out remote control.

To change the status of the eyePower PDU, affecting all relays and GPIs,

Control	**32H**
Relay 9-14	State of relays, two most significant bits not applied
Relay 1-8	State of relays
Misc out	Direction / state of GPI

where the controller software must be careful to maintain previous bit settings on outputs that are not to be changed. The response is the same as for 31H, with no delay to allow for output sensing to reflect the change. This allows a fast response but does mean the controller should continue polling status to reflect the change request.

Although the two most significant status bits, what would otherwise be relays 15/16, indicate changeover and unit alarm (buzz/flash) operation, 32H will control neither the changeover nor set/cancel the alarm. Another powerful command, cautiously undocumented here, allows tuning of changeover parameters and detailed control of local alarm which would normally be cancelled on the front panel if enabled. For more details and suitably cautionary advice please contact eyePower Limited.

A quick turn off for all power outlets, reply is same as message sent,

All off	**33H**

Note that use of the 32H or 33H command will halt any active macro program, although the address returned as the last byte of the status reply will be unchanged. Macro operation is halted because there is an obvious conflict with live changes. However, keeping the macro interrupts for GPI will still allow macros to restart on GPI changes.

To change individual relay settings or to change GPI settings without knowing the relay settings as required by 32H,

Outlet on	**34H**
Outlet number	Individual outlet number 1-14 less 1 ie 0-13
Optional GOTO	Single byte macro address (half real memory address)
Outlet off	**35H**
Outlet number	Individual outlet number 1-14 less 1 ie 0-13
Optional GOTO	Single byte macro address (half real memory address)
GPI settings	**36H**
As for 32H	Direction / state of GPI

These three commands reply as for 31H. The default operation for 34H and 35H is to not halt macro routines, thereby allowing outlets 1-12 for example to be under macro control and outlets 13/14 to be switched serially without halting the macro programming.

If continuing with macro operation is not required for 34H/35H then optionally an extra byte can be added to these two commands which is the macro address (divided by two as normal) to jump to after setting the outlet on or off. If this optional byte is 0 then running macros will continue just as if the byte were missing, a value of 1 stops the macro as happens with 32H, any other value will jump to that address but 2 is reserved for the optional web server so it can be seen the web GUI was used to stop a running macro. It is noted elsewhere that otherwise invalid GOTO addresses less than 10H are useful as parking addresses to show why a macro was terminated.

Changeover units can be interrogated with **39H** which will reply with the following bytes,

Msg Byte	Default/ E2P Loc		
0		Macro jump location if supply changes A to B	
1		Macro jump location if supply changes B to A	
2	32 / 0AH	Maximum dead time supply A before considered failed	
3	32 / 0BH	Maximum dead time supply B before considered failed	
4	02 / 0CH	A/B phase limit for "in phase" change, multiples of 3.6 degrees @50Hz	
5	01 / 0DH	Delay after both supplies good, in 10 sec steps, before auto change to preferred	
6	01 / **0FH**	Preference setting A, B or neither	
7		Measured dead time supply A	
8		Measured dead time supply B	
9		Phase A/B	
10		Phase B/A	
11		Time in 10 sec steps (max 254) that both supplies have been available	
12		Period supply A high byte	Period measurements are the number
13		Period supply A low byte	of 5kHz clocks over 20 mains cycles.
14		Period supply B high byte	Diagnostic only, to read frequency use
15		Period supply B low byte	the display processor 41H.

Bytes 0-6 are settings, 7-15 are live readings. Settings for macro jump can be defined in the macro program itself, bytes 2-6 showing a default factory value (decimal) are read from EEPROM (E2P) when the unit starts and can be altered with the memory write command. EEPROM changes will only take effect when the unit is repowered. Note the discontinuity in EEPROM locations, 0EH is historically used for alarm enable of unit beep and flash. Command 3AH can be used to change the live settings for bytes 0-6, without affecting the default values at power on.

Dead time of the supply refers to mains voltage below a value fixed in eyePower's hardware. This time is measured in 0.2 millisecond samples and is typically 17 samples for a 230V supply, representing time passing through mains zero crossing. The default setting of 32 is therefore a conservative point to consider a supply as failed and initiate changeover.

The phase limit is used to decide whether an in-phase change is possible. The corresponding live measurement is the smaller of phase A/B and phase B/A. Again sampling is every 0.2 msec, 100 samples per 50Hz cycle, so each step is 3.6 degrees and default acceptance is about 7 degrees.

Delay before auto change is 10 seconds by default, ie both supplies must have been good for 10 seconds before auto change to preferred supply. Where A or B preference is set with non-sync change allowed, the non-sync change will occur one minute after sync change is allowed. Hence for default 10 seconds, during the time 10-70 seconds after good supplies, sync change will occur if possible. Only at 70 seconds will non-sync change be initiated. This involves briefly opening all relays to minimise the chance of arcing between supplies A and B. This is inherently more risky than a synchronous change.

The preference setting is

1	Prefer A, will return to A after pre-set time, only if sync change possible
2	Prefer B, detail as 1
3	No preference, will stay on A or B unless it fails
4	Prefer A, will try sync return to A after pre-set time, one minute later non-sync
5	Prefer B, detail as 4

The live A/B preference setting can be changed using command 3AH. This offers options beyond 1-5 above and these are used to force a change without having to set a preference.

11H	Switch to A, sync only
12H	Switch to B, sync only
14H	Switch to A, try sync and then use non-sync
15H	Switch to B, try sync and then use non-sync

For all options 11H-15H, the counter for both supplies good is initially reset to zero. The change delay (byte 5 in the table above) is the amount of time allowed to perform a synchronous change (11H/12H) before giving up, or to perform a sync change if possible before changing asynchronously (14H/15H). The extra one minute does not apply for these commands. If either supply fails during timing, the instruction is abandoned.

The unit will echo the 3AH command for setting, but status 39H should be used to track change success. After timeout or change, preference is set to 3 (no pref) even if there was a preference before.

Command 3AH is used by sending pairs, as required, of byte to change (from the table, starting with 0) and a second byte for the new value. Consider the order of data sent, for example set the timer before the preference. Hence forcing non-sync change to B after 2 minutes (0CH) would be,

STX+Address	3AH	05H	0CH	06H	15H	Checksum+ETX

As a general point, it is intended that macros are used for stand-alone operation and not continually modified to perform tasks that a controller can perform. However, custom applications may benefit from an external controller stopping, re-starting or re-directing macro program flow. Live changes to macro GPI interrupts, GPI inhibits or counters may also be useful (read macro section for more detail). For example, a unit may be set to load shed when the mains fails, acting on the GPI from a UPS. However, if the mains outage is for maintenance and the UPS can cover the planned outage period, live changes to the GPI response could disable the usual load shed. This could then be re-enabled afterwards.

The current address of the executing macro is returned with the 31H status command. For more detailed information,

GPI1 interrupt status	**41H**

with response,

GPI1 interrupt status	41H
GPI1 low interrupt	Macro address for GPI1 low, 00H for disabled
GPI1 high interrupt	Macro address for GPI1 high
GPI1 inhibit time H	High byte of inhibit timer word
GPI1 inhibit time L	Low byte of inhibit timer

Inhibit timer is 0.1 second intervals left until GPI interrupts will work if set

Changes can be made,

GPI1 int change	**45H**
GPI1 low interrupt	Macro address for GPI1 low, 00H for disabled
GPI1 high interrupt	Macro address for GPI1 high
GPI1 inhibit time H	High byte of inhibit timer word
GPI1 inhibit time L	Low byte of inhibit timer

with response as for 41H to reflect changes.

GPI2, GPI3 and GPI4 equivalents are 42H/46H, 43H/47H, 44H/48H

It is also possible to check the two counters and the 0.1 second interval macro timer,

Counter status	**51H**

with response,

Counter status	51H
Counter1	Byte value
Counter2	Byte value
Macro timer H	High byte of macro timer word
Macro timer L	Low byte of macro timer word

and changes to the counters can be made,

Counter change	**52H**
Counter1	Byte value
Counter2	Byte value

with reply as for 51H. The macro timer, for example the time left before a relay turns on, may be read using 51H but not changed with 52H. It is not the intention that macro timings be affected by an external controller, which should use the live control commands for complex operations.

The currently running or stopped macro code can be re-started at a new macro address,

GOTO address	**61H**
Address	Single byte macro address (half real memory address)

which will respond as for the standard status command 31H where the last byte should be the new address. To halt a program the new address could be any one of the illegal macro addresses 00H to 0FH. This will be accepted and reflected in the status but the program will not try to execute. Use of any address 00H to 0FH allows the external controller to keep track of why the macro program has been stopped.

Two one byte commands are used to disable then re-enable GPIs to allow completion of a particular request without interruption when GPIs are disabled.

Disable GPIs	**62H**
Enable GPIs	**63H**

To check or change the front panel switch interrupt settings and status, **71H** (check) and **72H** (change) work in the same way as 41H and 45H for GPI1. The front panel switch can be programmed to operate relays when switched on and/or off, or simply programmed to do nothing.

From relay firmware version 1.4.4, new commands were added to simplify power cycling a specific outlet. This has been implemented using 14 cycle timers, which act as an overlay on top of the existing outlet control signals.

To check the values of the 1 second interval cycle timers,

Cycle timer status	**69H**

and that address will respond,

Cycle timer status	69H
Timer 1	1 Byte
..	
Timer 14	1 Byte

Total length of data in message body after 69H is 14 bytes.

To initiate a single channel's cycle timer,

Cycle outlet	6AH
Outlet number	Individual outlet number 1-14 less 1 ie 0-13
Cycle period	Single byte cycle period in seconds up to maximum 255 seconds (FFH)

and that address will echo the command back.

The front panel channel LED will flash Red/Green alternately to show that the channel has an active cycle timer running.

As mentioned above, the cycle timers are an overlay on top of the standard outlet control. The timer does not itself turn a relay on and off, but rather inhibits any relay 'on' control signal from switching the relay on for the length of the timer signal. If a relay is set to on, setting a cycle timer will turn off the outlet relay and as long as the relay remains set to on, then the relay will turn back on at the end of the cycle timer period. However, if the outlet is switched off during the cycle timer period, either by serial/TCP command, web browser control or macro, the outlet will remain off at the end of the cycle timer period. Obviously if an outlet relay is off when a cycle timer is activated, it will have no effect, but if the channel is turned on, then the relay will not turn on until the cycle timer period has ended.

It should be noted that the when a cycle timer is running, the unit status response to relay command 31H will report the channel's relay state as it would be normally (on or off). The measured state of the outlet will be off. In normal circumstances, a relay state 'on' with an outlet state 'off' would denote a failed relay. The response to the relay status command 31H has been modified so that bit 7 of Byte 4 is set to 1 if any cycle timers are running. The specific channel(s) that have a cycle timer running can be found using command 69H detailed above.

The final relay processor command is 81H, used to retrieve environmental readings in a similar way to 31H for relay and fuse state monitoring.

Read environment	**81H**
Read/reset	Byte value 1=read, 2=no read & reset min/max, 3=read then reset

While 31H returns the direction and state of GPIs, along with the state of the front panel rocker switch, command 81H reports the state low/high but not the direction assuming this is already known. However, 81H additionally returns GPI changes low/high or high/low which may be useful to catch events or for fault finding.

81H reports the voltage in 0.1V steps of the main, unregulated 12V nominal power supply. For a given load the difference between minimum and maximum voltage can be used to determine the health of the linear power supply reservoir capacitors and data will be published in due course. The power supply is deliberately simple and this information aids monitoring of the only wearing component in a way that a cheap switched mode supply would not offer. Because eyePower relays are turned on with greater power than used to keep relays on, saving energy and component wear, these PSU minimum and maximum readings will depend not only on the number of relays powered but whether they have remained powered since min/max reset.

There are plans to report the same 12V rail connected to the optional Ethernet board, in case of fault, and the voltage of any PoE present. These two values and their min/max read FFH for now.

Internal temperature in degrees C, along with min and max are given. If present, live/min/max for one wire temperature or combined temp/humidity sensors are given. Reading is FFH for no sensor present, otherwise **the value is signed, with the 8th bit being set denoting a negative reading**. The reply to 81H read or read/reset is below, reset only just echoes the command.

Read environment	81H
Read/reset	Byte value 01/03
GPI now	Byte with bits 3x most significant unused / rocker switch / GPI4-1
GPI has low to high	Byte with bit for rocker switch or GPI set if 0->1 since last reset
GPI has high to low	Byte with bit for rocker switch or GPI set if 1->0 since last reset
12V unreg on main board	3 bytes live/min/max 0.1V steps
12V unreg Ethernet board	3 bytes will be live/min/max but FFH for now
PoE Ethernet board	3 bytes will be live/min/max but FFH for now
Internal temperature deg C	3 bytes live/min/max
1-Wire temperature	3 bytes live/min/max
1-Wire humidity	3 bytes live/min/max

The reply above is for a basic 1-Wire configuration with no more than a single temperature or temp/humidity sensor. Firmware version 1.4.3 onwards supports a maximum 16 external sensors which extends the basic reply for each additional sensor live/min/max, giving 81H a variable length reply. See the eyePower Windows™ software user manual for sensor configuration and fixing the sensor order in memory.

7. Macro Programming - Relay Processor

As outlined in the overview, eyePower PDUs uses a high level macro programming language to control how the unit responds at power up, and how GPI inputs are processed. Each command consists of two bytes - the first being the action such as turn on outlet 1, the second byte is typically the delay that will be applied before the action. This delay can be varied between 0.1 and 6300 seconds. However, for commands controlling program flow the second byte is the memory address the unit should jump to. The commands are listed in the appendix including delay calculations, but some examples are given below to explain basic operation.

Although some guidance is given below on macro programming, those intending to write their own software to upload macros should use the free Windows™ software provided with new units. Experimentation with this software and its examples will allow a much better understanding than any number of written examples.

The two bytes for a command are held in sequential memory addresses starting at 20H. This allows 240 macro commands (480 bytes) in what remains of 512 bytes of memory beyond the first 20H or 32 bytes. Given that each command starts at an even address, 20H, 22H, 24H etc, the 'goto' address is always referred to as the physical memory location of each command divided by two. This number is then used in macros that redirect the program. Clearly the lowest such value should be 10H given macro memory starts at 20H. This allows one address byte to access 512 memory locations as command pairs.

When the unit is first powered, it looks at physical address 20H for its first macro command. All power outlets will be off. All GPI will be set as inputs, but the unit will not know what to do if they change. The front panel switch works like a GPI input and similarly must be programmed to have any action, although units ship from the factory with on/off switching as standard.

The LEDs on the front of the unit require no instruction to start and automatically display the following,

LED	
Off	Outlet meant to be off, fuse good, no outlet power detected
Flash green	Outlet meant to be off, outlet power detected
Green	Outlet meant to be on, outlet power detected
Red	Fuse fail
Flash red	Outlet meant to be on, fuse good, no outlet power detected

For a unit that will only ever operate under computer control, the simplest macro program would place a STOP command, 00H in memory location 20H. STOP ends macro execution and is one of the few commands that does not make use of the second command byte. The unit will not respond to GPI inputs and will not sequence on automatically. Only live serial control will make the unit provide any power at its outlets.

Another simple program would emulate a Bryant SMU which is the most basic sequential mains unit, but with a modified order and timings for the sequence on. For example,

Actual Mem	Macro Address	First Byte	Second Byte	Macro
20H	10H	20H	05H	Turn on outlet 1 after 0.5 seconds delay
22H	11H	21H	45H	Turn on outlet 2 after 5 seconds delay
24H	12H	29H	85H	Turn on outlet 10 after 50 seconds delay
26H	13H	24H	C5H	Turn on outlet 5 after 500 seconds delay
		2xH	xxH	Turn on other outlets
		00H	00H	STOP

The macro language also includes a GOTO command, but no sub-routine using GOSUB. Tracking sub-routines using GOSUB is considered too complex for the user.

A simple program using GOTO,

Actual Mem	Macro Address	First Byte	Second Byte	Macro
20H	10H	25H	05H	Turn on outlet 6 after 0.5 seconds delay
22H	11H	15H	0AH	Turn off outlet 6 after 1.0 seconds delay
24H	12H	01H	10H	GOTO macro address 10H

would flash a light connected to outlet 6 with 0.5 seconds off, 1 second on.

The examples so far have included 2xH to turn an outlet on, 1xH to turn it off. The delay for these commands cannot be commuted even if the outlet is already in the correct state. However, imagine a unit that has slowly sequenced on and only just started a long off sequence, before once again receiving a GPI to switch back on again. If it restarts the on sequence, it will be waiting for a number of specified delays where the outlet is already on anyway.

To quickly pass over a 1xH/2xH type command where the outlet is already in the correct state, use 3xH (off) and 4xH (on) to apply the same delay as before only if the outlet needs to be changed. Otherwise, the program moves on to the next command. For safety, the outlet status will be re-affirmed in software but with zero delay.

Clearly, other triggers are required than simply powering the mains unit. Externally these are four GPIs and internally there are two counters and the front panel soft switch. If enabled, the GPIs or soft switch operate as high level interrupts, i.e. when triggered the macro program will divert to another part of the program. This means a macro command currently executing will be aborted and the program will start at the point associated with the GPI or switch. The current command must be aborted because most of the commands allow long delays which if completed would cause very unreliable operation. We have used the word interrupt because a GPI change will interrupt the current macro code, aborting a delay if necessary. However, for those aware of ‘interrupt routines’ which on completion return to the point of interrupt, that is not the case here.

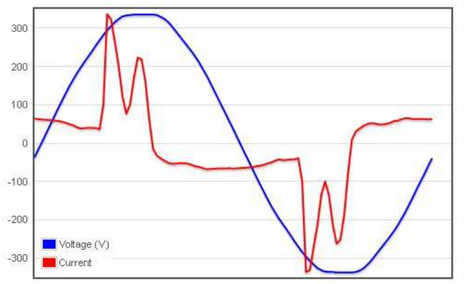
The counters are included to allow a unit to re-sequence a maximum number of times for example before requiring a reset. This would be possible using one GPI to control the sequence, the other GPI for reset. The counters are one byte, which are loaded with a number to count up or down. If the counter reaches its maximum (FFH) or minimum (00H) value, program execution branches to the second byte of the increment/decrement command. Unlike the GPI interrupt, the counter re-direction of the program will occur following a macro command and is quite predictable.

There should be no need for interrupt timers that count real time. These are effectively built into the power control commands.

8. Real Time Control - Measurement Processor

Please remember to communicate with the measurement processor at the address set for the relay processor +128.

Not only is the measurement processor extremely powerful, it has control over a number of very accurate analogue to digital converters. There is a vast amount of data available and applications will no doubt develop over time. Where a measurement is not shown below, for example maximum voltage, it is because there are different kinds of maximum voltage that require discussion with the end user. Some products oversimplify the measurements they provide.



It is possible to read raw measurement data from eyePower, the details are beyond the scope of this document but can be discussed with integrators. The graphs in eyePower Windows software and the integrated web server use this facility.

To access all voltage and current measurements calculated within eyePower, noting eyePower can measure 2000V peaks,

Read all V/I	**41H**

with reply

Read all V/I	41H
Main live/neutral RMS	0.1V steps, 2 bytes needed for >255V
Backup live/neutral RMS	0.1V steps, 2 bytes*
Main live/neutral peak	0.1V steps, 2 bytes
Backup live/neutral peak	0.1V steps, 2 bytes*
Main neutral/earth RMS	0.1V steps, 2 bytes
Backup neutral/earth RMS	0.1V steps, 2 bytes*
Bus live/neutral RMS	0.1V steps, 2 bytes
DC offset	10mV steps, 2 bytes signed
Main frequency	0.01Hz steps, 2 bytes
Backup frequency	0.01Hz steps, 2 bytes*
Outlet 1 current RMS	0.001A steps, 2 bytes maximum 65A
..	
Outlet 14 current RMS	0.001A steps, 2 bytes
Total current RMS	0.001A steps, 2 bytes
Main supply leakage	0.001A steps, 2 bytes
Backup supply leakage	0.001A steps, 2 bytes*
	*FFFF hex for single supply unit

Other figures such as crest factor can be derived from these measurements. Total length of data in message body after 41H is 54 bytes.

Power measurements in Watts are returned with a single command, each measurement uses 2 bytes. The most significant bit is a flag which is not set for measurements of 0.1W, or set for measurements to 1W resolution. The 0.1W or 1W range is determined internally by eyePower depending on load. There is no exact figure for auto-ranging as eyePower uses an elegant ranging algorithm that can adapt part way through a cycle of mains.

Read all Watts	**42H**

with reply

Read all Watts	42H
Outlet 1 W	2 bytes
..	
Outlet 14 W	2 bytes
Total W	2 bytes

Further processed data extraction is available on request. Note also no detail has been given to access environmental sensors but this follows the standard protocol structure.

APPENDIX A – Summary of Serial Control Codes for Relay Processor

All numbers hexadecimal. Other parameters required listed in detailed information.

Memory Access

11 Read memory
12 Write to memory

Setting Multi-Drop Address

21 Read serial number for given address
22 Echo serial number for given serial number
23 Change address for given serial number
24 Poll serial numbers of all units with given address
25 Silence poll for unit with serial number
26 Poll all units, regardless of address
27 Silence poll for all units

Power and GPI

31 Check inlet/outlet presence and GPI status
32 Change relay and GPI settings
33 Turn off all outlets
34 Turn on individual outlet
35 Turn off individual outlet
36 Change GPI settings
39 Check supply frequency, changeover measurements - advanced users
3A Adjust changeover control - advanced users

GPI Interrupts

41 Check GPI1 interrupt status
42 Check GPI2 interrupt status
43 Check GPI3 interrupt status
44 Check GPI4 interrupt status
45 Change GPI1 interrupt
46 Change GPI2 interrupt
47 Change GPI3 interrupt
48 Change GPI4 interrupt

Macro Counters

51 Check macro counters
52 Change macro counters

Macro Re-direction

61 GOTO macro location, including stop
62 GPI disable to allow routine completion
63 GPI enable

Cycle Timers

69 Cycle timer status
6A Initiate single channel's cycle timer

Front Panel Switch Interrupt

71 Check front panel switch interrupt status, same format as 41H GPI1
72 Change front panel switch interrupt, same format as 45H GPI1

Environmental

81 Read/reset misc environment - internal DC rails, switches, GPIs, internal temp, 1 wire

APPENDIX B – Memory Map for Relay Processor

From	To	Use	Comment
0000	0003	Unique serial number MSB to LSB	Can not be changed by user.
0004		Multi drop address	00H reserved for new units and single unit Windows control software.
0005	001F	Reserved except	
000A	000F	Changeover settings	See command 39H
0020	01FF	Macro programming	Each macro uses two memory locations. At power on, unit starts execution at 20H. Macros affecting flow (eg GOTO) do not use least significant bit for address, i.e. 20H written as 10H with actual memory address shifted right one bit.
0200	03FF		Reserved for settings including 1-Wire (R) addresses

All memory locations may be read using command 11H.

The first memory location that can be written using command 12H is 0010H.

The multi drop address cannot be changed by memory write command 12H and must be changed by reference to unit's unique serial number using command 23H.

Memory locations 0010 to 001F are no longer available to the user.

Advanced developers may want to read, possibly also write, to the memory locations containing outlet and external 1-Wire sensor names. Contact eyePower Limited to discuss your requirements.

APPENDIX C – Summary of Macro Codes for Relay Processor

00*	STOP, with macro address halting at memory location that contains 00
01	GOTO address in second byte (actual address divided by 2)
02	WAIT for time in second byte
03*	Disable GPIs, allows current routine to complete before processing GPI changes
04*	Enable GPIs
05*	Reset all GPI interrupt addresses and inhibit counters, ie disable all

1x	Outlet x+1 off after delay in second byte
2x	Outlet x+1 on after delay in second byte
3x	Outlet x+1 off after delay, no delay if outlet already off
4x	Outlet x+1 on after delay, no delay if outlet already on
51	All outlets off after delay in second byte
52	All outlets on after delay in second byte

60*	Set GPI1 as low output
61*	Set GPI1 as high output
62	Set interrupt macro address for GPI1 low, also sets GPI as input
63	Set interrupt macro address for GPI1 high, also sets GPI as input
64	GPI1 inhibit for time in second byte

7x, 8x, 9x as for 6x but GPI2, GPI3, GPI4

A0	Load counter 1 with value in second byte
A1	Decrement counter 1 (no underflow) and branch to second byte address if 00H
A2	Increment counter 1 (no overflow) and branch to second byte address if FFH

Bx as for Ax but counter 2

Cx	Changeover settings for advanced users, not detailed here

D2	Set interrupt macro address for front panel switch on
D3	Set interrupt macro address for front panel switch off
D4	Front panel switch inhibit for time in second byte

Time delays for 02, 1x, 2x, 3x, 4x, 51, 52, 64, 74, 84, 94 and D4 use bits 0-5 for delay of zero to 63. Bits 6 and 7 then set multiple, i.e.

Bit7	Bit6	
0	0	0 to 6.3 seconds in 0.1 second multiples
0	1	0 to 63 seconds in 1 second multiples
1	0	0 to 630 seconds in 10 second multiples
1	1	0 to 6300 seconds in 100 second multiples

Commands with * do not use the second byte.

Commands ‘set interrupt’ should contain the macro address in the second byte, i.e. real memory address divided by two. Set second byte as 00H to disable the interrupt.

APPENDIX D – Summary of Serial Control Codes for Measurement Processor

All numbers hexadecimal. Other parameters required listed in detailed information.

Memory Access

Used for network settings, unit name, outlet names, 1-Wire™ sensor names

11 Read memory
12 Write to memory

Raw measurement data

31 Read raw waveform data - advanced users, not detailed here

Processed data

41 Read supply voltages, outlet currents, overall current, earth leakage current
42 Read individual outlet and total Watts

APPENDIX E – Serial and GPI Connections

Serial connections for an eyePower PDU are industrial RS422/485 balanced, unlike a PC which provides the same data but as unbalanced RS232. For fixed installations or multiple eyePower PDUs, the PC should be fitted with an RS422 port or converter. However, the standard PC RS232 port should suffice for one-to-one programming or live control over a short distance with eyePower Software.

Computers have extremely tolerant RS232 ports and it will usually be possible to connect a PC RS232 port directly to an eyePower PDU serial port, using only ground, one TX and one RX pin.

The rear of the eyePower PDU is equipped with a single D9 chassis socket. This was selected over the RJ45 connector to allow breakout of the GPI connections if required. For those wanting to use commercially available RJ45 leads, custom wireable D9/RJ45 adaptor modules are recommended.

The connector pinout is,

1 GND
2 TXA(-)
3 RXB(+)
4 GPI1
5 GPI3
6 GPI4
7 TXB(+)
8 RXA(-)
9 GPI2

where TX/RX are data from/to the unit respectively.

For unbalanced connection to a standard PC serial port, wire the following cable,

PC End Free D9 Socket			SMS End Free D9 Plug	
RX	2	-------------	2	TXA(-)
TX	3	-------------	8	RXA(-)
GND	5	-------------	1	GND

This assumes PC has D9 rather than D25 connection.