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ApStarnet Modbus Datamap

This document is intended for System Installers. It contains the detailed technical information needed to access and setup the ApStarnet.

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Revision History:

Revision	Date	Comment
		Pre-release history
00A	06/10/16	First draft of Modbus Memory Map.
01	4/1/17	AJT Doc reviewed and updated to improve based on possible implementation method
01B	13/2/17	AJT Added register allocation. See 700-979.
01C	27/4/17	AJT Added mode -3. Multi Slave TabEx.
01D	25/8/17	In line with release 3.67.1.15
01E	12/10/18	Added description of 1128-1171. Added section 6.4.3.3 to describe the control registers for an HDLC slave
01F	10/12/18	Updated section 2.5 to include the LED timeout times for lower baud rates. Update sections 6.4.1 and 6.4.2 with references to Multi Slave. Added ESP 19.2kBaud as option 11 of 1003.
01G	19/12/18	ApStarnet v4.67.1.18 Addition of Mode -4 which is a TabEx Master which scans from slave 0 to (Number of Partners-1) Updated MultiSlave to allow the start address to be 0 Updated description of register 1001
01H	7/2/19	Added ESP stats 1130 and 1131. ESP now updates 1102.
01J	26/3/19	Modbus RTU now sets the port LED yellow if the last reply was an exception. Removed Modbus baud rates above 38,400 as they have too many errors. Added 1114 as an ESP error counter.
01K	24/6/19	Added TCP/IP statistics in tables 624 to 634.
01L	7/7/20	Added 511 bit 4: set while there are Serial Flash Memory CRC errors. Added 635: count of serial flash memory writes. Added 636: number of serial flash readback CRC errors

1 Contents

2 ApStarnet Modbus Memory Map

ApStarnet is a communications device capable of converting between Modbus and HDLC/ESP. It is intended to replace the Starnet product. ApStarnet makes available all of the functionality of the original device. Data from a modern PLC is collated using a data map accessible using the Modbus TCP/IP or RTU protocol. The same address map is provided via the USB port although Serial Modbus is used for this access route.

ApStarnet has lots of data to maintain. All data is available using Word Reads. Some data can be written to but may be read only and will not change. Some data ranges cannot be written to at all. There are separate data areas for the ApStarnet and each of the communications Links. The device address is used to specify the target data area.

The data areas are split as follows:

	Modbus TCP/IP Unit Identifier	Serial Modbus Device Address
ApStarnet Data	16 (0x10)	**16 (0x10)**
Communications port 1 data	17 (0x11)	**17 (0x11)**
Communications port 2 data	18 (0x12)	**18 (0x12)**
Communications port 3 data	19 (0x13)	**19 (0x13)**
Communications port 4 data	20 (0x14)	**20 (0x14)**

2.1 ApStarnet Data Summary

This data relates to the ApStarnet as a whole.

- Address 100 - ApStarnet Settings
- Address 500 - ApStarnet Info
- Address 600 - ApStarnet Statistics
- Address 700 – Data Table Allocations
- Address 9000 - Scratchpad

2.2 Communications Port Data Summary

This data relates to one communications port. A separate set of data is available at the 4 devices station addresses (17-20) used for the four ports.

- Address 1000 - Link Settings
- Address 1100 - Link Statistics (separate definitions for HDLC and ESP)
- ~~Address 1200 - Status Flags~~
- Address 1900 – User Control Registers
- Address 2000 - User Control Output Data Array
- Address 3000 - User Control Input Data Array
- Address 4000 – Table Exchange Output Data Arrays
- Address 4100 – Table Exchange Input Data Arrays
- Address 4200 – Table Exchange Controls & Status

2.3 Modbus Functions

The following Modbus functions are implemented on TCP/IP and USB

3, Read Holding Registers
4, Read Input Registers
6, Write Single Register
16, Write Multiple Registers

The Holding Registers and the Input Registers access the same data map. There is no difference in how these two functions work.

Additional Information

Max Register Read or Write Length is 123

Modbus register addressing is defined as 1 to 65536. In the low level comms the address offset from 1 is used. So this document refers to the Modbus Address (range 1 to 65536). The tables below contain the Modbus addresses (1-65536).

2.4 Principles of Operation

HDLC and ESP links are configured to operate as masters (Primary, Control) or slaves (Secondary, Tributary). Data is transferred to or from ApStarnet to other HDLC and ESP devices. The data in ApStarnet can be read or written to by a PLC via Modbus or Ethernet connections.

At present there is no limitation to the number of ports, protocol or speed of each of the ports.

The main types of data exchange are available:

- User Control Mode (Special Function Mode)
- Table Exchange Mode
    - Multi Drop
    - Broadcast without Response
    - Broadcast with Response

HDLC must be used in 4 wire mode. HDLC protocol primary ports are left enabled all the time. Between messages “flag” characters are transmitted to allow the other end to use the signal to generate DPLL baud rate clocks. HDLC Secondaries disable their transmit once they see a message coming from the primary. This allows HDLC to operate with multiple slaves.

For ESP the port is disabled (tri-stated) after a message is transmitted. This allows ESP to be used in 2 wire or 4 wire operation.

2.4.1 Master Free Running

The master cycles round each of the partners that are configured and:

- Checks if there is a partner message in the transmit queue. If not a new message is added to the end of the queue.
- If there is a partner message in the transmit queue which has not started transmission, and overwrite is enabled, then the data in the message is updated without the message losing it's position in the queue.
- There can only be up to 1 message per partner in the transmit queue at any time.

2.4.2 Master User Control

Similar to Free Running but new messages and data updates are only performed when the send control is active.

2.4.3 Master Transmit Queue

When a reply is received or times out, the next message in the transmit queue is sent. Before sending the message the ESP Terminator or HDLC Sequence is updated with the latest value. If there is no message in the transmit queue then the link sits idle until a new message appears in the queue.

2.4.4 Slave Free Running

The slave code:

- Checks if there is a reply message in the transmit queue. If not a new message is added to the queue.
- If there is a message in the transmit queue which has not started transmission, and overwrite is enabled, then the data in the message is updated
- There can only be up to 1 message in the transmit queue

2.4.5 Slave User Control

Similar to Free Running but a new message and data update is only performed when the send control is active.

2.4.6 Slave Transmit Queue

When a message is received the message in the transmit queue is sent. If there is no message in the transmit queue then a zero length HDLC message or and ESP Ack is sent. Before sending the message the ESP Terminator or HDLC Sequence is updated with the latest value.

2.4.7 Multi Slave Free Running

The slave cycles round each of the partners that are configured and:

- Checks if there is a partner reply message in the transmit queue. If not a new message is added to the end of the queue.
- If there is a partner reply message in the transmit queue which has not started transmission, and overwrite is enabled, then the data in the message is updated without the message losing it's position in the queue.

2.4.8 Multi Slave User Control

Similar to Multi Slave Free Running but new messages and data updates are only performed when the send control is active.

2.4.9 Multi Slave Transmit Queue

When a message is received the reply message from the relevant partner is sent. If there is no message in the transmit queue then a zero length HDLC message or and ESP Ack is sent. Before sending the message the ESP Terminator or HDLC Sequence is updated with the latest value.

2.5 LEDs

ApStarnet has 6 multicolour LEDs. They operate as follows:

For Not Receiving (Red On), Not Sending (Yellow On) and Receiving (Green On), the timeout is 5s for most baud rates, 6s for 4800, 8s for 2400 and 12s for 1200.

LED	Power	Ethernet	Master Port	Slave Port
Off	No power	No connection	Not configured or Not sending	Not configured
Red On	Power from USB only	PLC Control Timed out	No partners replying	Not receiving
Yellow On		TCP/IP Timeout	Some partners replying	Receiving but not sending (or Modbus RTU is replying with an exception)
Yellow 3 Flashes			User Tx data (2000) has not been written to so cannot be sent	User Tx data (2000) has not been written to so cannot be sent
Yellow 4 Flashes			TabEx Tx data (4000) has not been written to so cannot be sent	TabEx Tx data (4000) has not been written to so cannot be sent
Green On	Fully powered	Receiving PLC control commands	All partners replying	Sending Messages
Red 2 flashes		No network detected	Configuration error. See register 1009	Configuration error. See register 1009
Red 3		Network cable removed		
Red 4		No DHCP detected		
Red 5		Waiting for IP address		
RYG Cycle	PC Connected to USB			

3 Modbus TCP/IP

Modbus over TCP/IP allows standard Modbus messages to be sent across a TCP/IP network such as Ethernet.

ApStarnet is a Modbus Server. This means that it is a passive device that responds to messages from a client. It is up to the client to initiate all data transfers. Up to 20 Modbus requests can be sent at the same time either from different IP addresses or from different ports within each IP address. Each port of an IP address can only action 1 message at a time.

> For example if ApStarnet is accessed from the Modbus Poll program then only one read at a time can be actioned as only one port is used to access the ApStarnet. Starting a second and third instance of the Modbus Poll program then multiple ports are created allowing 3 parallel accesses to ApStarnet. If 3 or more Modbus Poll programs are started on another PC then another 3 or more parallel access paths are possible into ApStarnet. All in all, 20 separate programs can be accessing the ApStarnet data at one time, plus 1 channel used by a program accessing ApStarnet data via the USB port, plus up to 4 Modbus connections using the RS485 ports and Modbus RTU.

When ApStarnet is first connected to the network it is allocated an IP address either from the fixed address defined in the settings or allocated by the DHCP server. An address allocated by DHCP address should be fixed. Ie the same unit is always allocated the same IP address. This will allow a PLC to know exactly which ApStarnet it is accessing for a given IP address. As a confirmation, a PLC should always read and check the MAC address which can be read in registers 508 to 510.

The control system can read the ApStarnet MAC address from the ApStarnet to verify that the expected ApStarnet is connected. The IP address and the ApStarnet MAC address can also be read via the ApStarnet USB port.

All Modbus TCP/IP messages have a MBAP header that replaces the header and checksum that are part of a normal Modbus message. The standard header contains the Slave Address. This is replaced with the Unit Identifier. The Unit Identifier is used to define which area of ApStarnet is being addressed.

MBAP Header (Big Endian Data Order = High Byte Low Memory)

Byte	Description	Range	Comments
0&1	Transaction Identifier	0-65535	Echoed by ApStarnet
2&3	Protocol Identifier	0	0 identifies Modbus. Message ignored if this is not 0.
4&5	Message Length		The size of the combined unit identifier, function code and data message following the header
6	Unit Identifier	16-20	16: (0x10) ApStarnet Registers 17-20: (0x11-0x14) Communication ports 1 to 4.

All Modbus TCP/IP messages use port 502 (configurable).

4 USB

ApStarnet will appear as a standard COM port on the PC. An .inf file may have to be selected the first time the USB port is connected.

4.1 Modbus via USB

The USB com port can be used as a MODBUS port with Modbus device address 0x10 (16) for ApStarnet registers and addresses 0x11-0x14 (17-20) for communications ports 1 to 4.

5 ApStarnet Registers

ApStarnet registers are accessed via Modbus station address 0x10.

There are a number of settings that are defined for the whole unit and statistics that relate to the whole unit rather that the individual ports. These configuration registers and statistics are defined here.

5.1 ApStarnet Settings

Theses settings define how the ApStarnet operates. All of them are read/write and are retained through a power cycle. Only the date and time are changed by ApStarnet although the Link Control registers may be modified after a power cycle.

Register	Description	Range	Comments
100	Day	1-31	Set the date and time. Not retained through a power down.
101	Month	1-12	
102	Year	0-99	
103	Hour	0-23	
104	Minute	0-59	
105	Second	0-59	
~~106~~	~~Link 1 Control~~	~~0-2~~	~~0 = No transmissions~~ ~~1 = Transmission enabled while PLC in control but disabled by a PLC Control Timeout or GembusHub power cycle (ie changes to 0 on a timeout or power cycle) Must be written to 1 or 2 to restart the link~~ ~~2 = Transmission auto enabled after a link recovery or power cycle.~~
106	Port 1 Control		0 = Port disabled 1 = Port enabled until power cycled then port auto disables (changes to 0) 2 = Port enabled and stays enabled after a power cycle
107	Port 2 Control	0-2	As above
108	Port 3 Control	0-2	As above
109	Port 4 Control	0-2	As above
110	Modbus TCPIP Port	502	Default for Modbus TCP/IP is 502. Changing this value causes an automatic restart of the Ethernet port, this can be up to 4 seconds.
111	PLC Control Timeout time (ms)	0-65535	R/W. PLC Control Timeout time in ms. If no Ethernet or RS485 Modbus message is received within this time then the Link Dependant PLC Control Timeout Action (1008) is taken. Timeout time must be non zero to enable this feature.
112	~~PLC Control Timeout Action~~ Replaced by link dependant 1008		

113	Define IP Address	0-1	Define how the IP address is obtained. 0 Get IP address from DHCP 1 Use the fixed IP details defined below Changing this value causes an automatic restart of the Ethernet port, this can be up to 4 seconds.
114	Fixed IP Address byte 1	0-255	Only relevant if "Define IP Address" is set to 1. ApStarnet address eg 192.168.1.2 Changing this value when a fixed address is specified causes an automatic restart of the Ethernet port, this can be up to 4 seconds.
115	Fixed IP Address byte 2	0-255	
116	Fixed IP Address byte 3	0-255	
117	Fixed IP Address byte 4	0-255	
118	Router Address byte 1	0-255	Only relevant if "Define IP Address" is set to 1. Router address eg 192.168.1.1 Messages not within the Net Mask are sent to the router. Changing this value when a fixed address is specified causes an automatic restart of the Ethernet port, this can be up to 4 seconds.
119	Router Address byte 2	0-255	
120	Router Address byte 3	0-255	
121	Router Address byte 4	0-255	
122	Net Mask byte 1	0-255	Only relevant if "Define IP Address" is set to 1. The mask for the addresses on this network eg 255.255.255.0 Messages not within the Net Mask are sent to the router. Changing this value when a fixed address is specified causes an automatic restart of the Ethernet port, this can be up to 4 seconds.
123	Net Mask byte 2	0-255	
124	Net Mask byte 3	0-255	
125	Net Mask byte 4	0-255	
126	Limit Client IP addresses		Allows the IP addresses that are allowed to connect to be limited. 0x0000 = All client IP address are accepted bit 0 set = Accept IP addresses in range 0 bit 1 set = Accept IP addresses in range 1 etc bit 15 set = Accept IP addresses in range 15 NB This is checked on each read write attempt
127	Range 0, Byte A	0-255	Only relevant if bit 0 of "Limit Client IP Addresses" is set. Range 0, The first to last addresses acceptable in the range A.B.C.D to A.B.C.E. eg 192.168.1.10 to 10 eg 192.168.1.10 to 19
128	Range 0, Byte B	0-255	
129	Range 0, Byte C	0-255	
130	Range 0, Byte D	0-255	
131	Range 0, Byte E	0-255	
132	Range 1, Byte A	0-255	Only relevant if bit 1 of "Limit Client IP Addresses" is set. Range 1, The first to last addresses acceptable in the range A.B.C.D to A.B.C.E.
133	Range 1, Byte B	0-255	
134	Range 1, Byte C	0-255	
135	Range 1, Byte D	0-255	
136	Range 1, Byte E	0-255	
	Etc		
202	Range 15, Byte A	0-255	Only relevant if bit 15 of "Limit Client IP Addresses" is set. Range 15, The first to last addresses acceptable in the range A.B.C.D to A.B.C.E.
203	Range 15, Byte B	0-255	
204	Range 15, Byte C	0-255	
205	Range 15, Byte D	0-255	
206	Range 15, Byte E	0-255	
207	LED Test	0-4	0: No testing 1: All six status LEDs Green 2: All six status LEDs Red 3: All six status LEDs Yellow 4: All six status LEDs cycle

5.2 ApStarnet Info

These registers are read only.

Register	Description	Range	Comments
500	Version byte 1	1-4	1 is a development version 2 is a alpha site release 3 is a beta site release 4 is a full release
501	Version byte 2	67	67 Identifies ApStarnet
502	Version byte 3	0-255	Major change count
503	Version byte 4	0-255	Minor change count. Reset after a major change.
504	Software Checksum (LSW)		Allows code verification against the release paperwork
505	Software Checksum (MSW)		
506	For future use		If writing to, write a 0 to maintain future compatibility
507	For future use		If writing to, write a 0 to maintain future compatibility
508-510	Mac Address	6 bytes of 0-255	Mac Address typically written in Hexadecimal eg 00-04-A3-12-34-56. Stored as: 0x0400, 0x12A3, 0x5634
511	Status flags		Bit 0: Date and time update required Bit 1: Network cable not present Bit 2: Ethernet Timeout Bit 3: Not used Bit 4: Set while there are CRC errors on the Serial Flash chip. Occasional blips can be ignored. Bit 5: Bit 6: Bit 7: Bit 8: Bit 9: Bit 10: Bit 11: Bit 12: Bit 13: Bit 14: Bit 15:

512	More Status flags		Bit 0: Bit 1: Bit 2: Bit 3: Bit 4: Bit 5: Bit 6: Bit 7: Bit 8: Bit 9: Bit 10: Bit 11: Bit 12: Bit 13: Bit 14: Bit 15:
513	ApStarnet IP Address		The IP address used for the ApStarnet. This may have been allocated by the DHCP or have been fixed in the ApStarnet settings.
514	ApStarnet IP Address		
515	ApStarnet IP Address		
516	ApStarnet IP Address		
517	Router IP address		The IP address of the router as defined in the fixed ApStarnet settings or as informed by the DHCP.
518	Router IP address		
519	Router IP address		
520	Router IP address		
521	Net Mask		The Net Mask for this network as defined in the fixed ApStarnet settings or as informed by the DHCP.
522	Net Mask		
523	Net Mask		
524	Net Mask		
525	Power LED		Each register is split into high and low bytes. Low byte: 0 = LED off 1 = Green - see high byte for number of flashes 2 = Yellow - see high byte for number of flashes 3 = Red - see high byte for number of flashes 4 = Slow 3 way cycle (1s each): G, Y, R 5 = Fast 3 way cycle (500ms each): G, Y, R 6 = 4 way cycle (500ms each): G, Y, R, Off 7 = 2 way cycle (500ms each): Y, G 8 = 2 way cycle (500ms each): Y, R High byte only applies if low byte is 1, 2 or 3: 0 = Solid colour 1 = Not used 2-10 = The number of flashes (300ms on, 200ms off, 1s between sequences) 11 = Slow flash (1s on, 1s off) 12 = Fast flash (100ms on, 100ms off) NB Not all options are used by ApStarnet.
526	Network LED		
527	Port 1 LED		
528	Port 2 LED		
529	Port 3 LED		
530	Port 4 LED		

5.3 ApStarnet Statistics

Write the registers to zero to reset them.

Register	Description	Range	Comments
600	Ethernet Tx Count	0-65535	
601	Ethernet Rx Count	0-65535	
602	Ethernet Tx Errors	0-65535	
603	Ethernet Rx Errors	0-65535	
604	Controlling device timeout	0-65535	Number of times that there has been no message from the PLC via the Ethernet port or a RS485 Modbus port for the PLC Control Timeout period. NB Only increments once for each loss of control
605	ApStarnet Power On counter	0-65535	Retained and incremented after a power cycle.
606	ApStarnet Watchdog count	0-65535	Increments every 100ms to confirm link connection
607	Run Time Errors		If incrementing then report back to supplier.
608	Modbus Format Errors		
609	Modbus Address Errors		
610	Modbus Length Errors		
611	Modbus CRC Errors		
612	Modbus Illegal Function Exceptions (Exception 1)		
613	Modbus Illegal Address Exceptions (Exception 2)		
614	Modbus Illegal Value Exceptions (Exception 3)		
615	Modbus Write Exceptions (Exception 4)		
616	Modbus Buffer Errors		
617	Modbus Replies		
618	Ethernet Invalid Clients Accesses		A client with an IP address not in the defined IP address range has accessed this device, The message was ignored.
619-622	The invalid IP address trying to access ApStarnet		
623	Rejected Connection Port		The port the Invalid IP has tried to connect to. Normally this will be the Modbus port. Added in ApStarnet version 4.60.1.10
624	Modbus TCP/IP Active connections		The number of Modbus connections that are currently active
625	Modbus TCP/IP Rx while Tx errors		Indicates that the client is not waiting for a reply before sending the next request
626	Modbus TCP/IP Total Connections		Increments each time a connection is made
627	Modbus TCP/IP Transmits		Number of messages transmitted
628	Modbus TCP/IP Retransmits		Number of messages that were not ACKed and had to be retransmitted
629	Modbus TCP/IP		Number of ACKed transmissions (and

	Total ACKs		retransmissions)
630	Modbus TCP/IP Receives		Number of messages received
631	Modbus TCP/IP Timeouts		Number of TCP/IP timeouts
632	Modbus TCP/IP Connections Closed		Number of times a connection has been closed
633	Modbus TCP/IP Connections Aborted		Number of times a connection has been aborted
634	Modbus TCP/IP New IPs		Number of times the IP address of ApStarnet has been changed by the DHCP
635	Serial Flash Chip writes		The number of writes to the serial flash chip. This will update when non volatile configuration is changed. Also updated when run time errors occur.
636	Serial Flash CRC Errors		The number of CRC errors on the data read back from the serial flash chip. If this is incrementing every 10s or so then there is a hardware fault on the flash chip.

5.4 Data Table Allocation

These setting define how the memory is allocated. All of the settings are read/write and are retained through a power cycle.

There isn't enough memory to provide register space for all the possible configurations of ApStarnet. So the data tables for User Control (2000-3999), Broadcast and Table Exchange (4000-4031, 4100-4131) are allocated automatically by ApStarnet based on 777 tables for User Data and 111 tables for Tx and Rx of each active partner. On larger systems these defaults will use too much memory and at this point the Table Allocation tables below will have to be used to set the max number of registers needed for each partner.. Up to 8192 registers can be allocated from the data pool.

- This area is allocated across all 4 links and registers 700-979 define how much of this area is allocated to each port's User and Table Exchange areas for each partner.
- Only the relevant allocations are used. eg if configured for User Control the Table Exchange allocation tables are ignored.
- Table allocation is not dynamic. If one of these registers is changed then all 4 links may be affected. This may cause data read commands to return Illegal Data Address errors until new data is written to the relevant registers (2000-4131)
- An allocation of 0 will use a default allocation of 777 for the User Data areas
- An allocation of 0 will use a default allocation of 111 for the table exchange areas

When table allocations move then the relevant data area is marked as invalid and any access to the data is blocked until the data area has been written to (eg Modbus write or incoming message). The data areas are split in 66 blocks: User Tx, User Rx, 32 Tx blocks each starting from 4000-4031, 32 Rx blocks each starting from 4100-4131. NB Addresses 4000-4031 and 4100-4131 are 64 separate memory areas which run in parallel and each area can be up to 111 tables long.

Register	Description	Range	Comments
700	Port 1 Send User Control Data (from 2000)	0-1000	Allocated only if user control mode Default 777
701	Port 1 Receive User Control Data (from 3000)	0-1000	Allocated only if user control mode Default 777
702	Port 1 Broadcast/Tx to Primary Allocation (Length from 4000)	0-111	Allocated if Broadcast mode or address is 1-31 Default 111
703	Port 1 Rx from Primary Allocation (Length from 4100)	0-111	Allocated only if address is 1-31 Default 111
704	Port 1 Secondary 1 Tx Allocation (Length from 4001)	0-111	Allocated only if Table Exchange Mode Default 111
705	Port 1 Secondary 1 Rx Allocation (Length from 4101)	0-111	Allocated if TabEx or Broadcast with Response Default 111
702+2x	Port 1 Secondary x Tx Allocation (Length from 4002)	0-111	Allocated only if Table Exchange Mode Default 111
702+2x	Port 1 Secondary x Rx Allocation (Length from 4102)	0-111	Allocated if TabEx or Broadcast with Response Default 111
…	…		
764	Port 1 Secondary 31 Tx Allocation (Length from 4031)	0-111	Allocated only if Table Exchange Mode Default 111
765	Port 1 Secondary 31 Rx Allocation (Length from 4131)	0-111	Allocated if TabEx or Broadcast with Response Default 111
766-769	Spare	0	Write 0

Add 70 to each of the above for the port 2 settings, 140 for port 3 and 210 for port 4

Register	Description	Range	Comments
770-839	Port 2 setting: Same as port 1		Same as port 1
840-909	Port 3 setting: Same as port 1		Same as port 1
910-979	Port 3 setting: Same as port 1		Same as port 1

Allocation Statistics

Register	Description	Range	Comments
980	Tables used by port 1		Updated when tables are allocated
981	Tables used by port 2		
982	Tables used by port 3		
983	Tables used by port 4		
984	Unused or Unavailable Tables	Signed number	A positive value indicates that there are spare tables that could be allocated. A negative value is the number of tables that could not be allocated.

6 Communications Port Registers

These registers are repeated for each of the 4 ports. A different unit address (0x11-0x14) is used for each port (1-4).

6.1 Link Settings

Define the parameters for how the link operates. These settings are retained through a power cycle. See register 106 about how the link can be recovered. If new settings are invalid the error code in 1009 reports the failure.

HDLC Limitations

Due to processor loading no more than two 180K HDLC links can be selected. 180k HDLC can only be selected on ports 1 and 3. Additionally, again due to processor loading, if two 180K HDLC ports are selected then ports 2 and 4 cannot be set to 48K HDLC.

Register	Description	Range	Comments
1000	Port Number	1-4	Read Only. Identifies the hardware port that is being configured. A write to this register with the wrong value will cause the whole message to be ignored.
1001	Port Address	0-31	**MultiSlave (mode -3)** - Defines the first slave address (can be 0). **TabEx Master (mode -4)** - Set to 0. **Other Modes** - Set to 0 to define port as HDLC Primary/ESP Control - For ESP ports set to 1-14 to define the tributary address - For HDLC ports set to 1-31 to define the secondary address
1002	Link Partners	1-31	Only relevant for Masters and Multi Slave. The number of partner devices on the link 1 to 31 for primary (HDLC) 1 to 15 for control (ESP) - For MultiSlave this defines the number of partners responded to, starting from Port Address
1003	Channel Type	0-18	0: Not in use 1: HDLC 48k NRZI (not if two 180k selected) 2: HDLC 48k FM0 (not if two 180k selected) 3: HDLC 48k FM1 (not if two 180k selected) 4: HDLC 180k NRZI (port 1 and/or 3 only) 5: HDLC 180k FM0 (port 1 and/or 3 only) 6: HDLC 180k FM1 (port 1 and/or 3 only) 7: ESP 1.2k 8: ESP 2.4k 9: ESP 4.8k 10: ESP 9.6k 11: ESP 19.2k

			12: Modbus RTU 1.2k 13: Modbus RTU 2.4k 14: Modbus RTU 4.8k 15: Modbus RTU 9.6k 16: Modbus RTU 19.2k 17: Modbus RTU 38.4k ~~18: Modbus RTU 57.6k~~
1004	Transmit mode		>= 0 queue mode (bit 15 not set) <0 overwrite mode (bit 15 set) In queue mode all data is transmitted. In overwrite mode pending messages are cancelled and the new data is transmitted.
1005	Receive mode		>= 0 queue mode (bit 15 not set) <0 overwrite mode (bit 15 set) In queue mode all data is received. In overwrite mode messages waiting to be received are replaced by newer messages.
1006	Interface mode		**+3**: HDLC User Control Mode - With individual frame acknowledge **+2**: HDLC Broadcast - With Response **+1**: HDLC Broadcast - Without Response **0**: HDLC/ESP User Control Mode. - HDLC up to 777 words. - ESP up to 111 words. **-1**: HDLC/ESP Table Exchange Mode - Free Running **-2**: ESP Table Exchange Mode - User Control Mode **-3**: HDLC/ESP Table Exchange Multi Slave - Free Running replying to slave addresses Port Address to (Port Address + Link Partners – 1) **-4**: HDLC/ESP Table Exchange Master - Free Running scanning slaves from 0 to (Link Partners – 1)
1007	~~Table exchange mode table allocation~~	Ignored	Superseded by registers 700-979
1008	PLC Control Timeout Action		0 = Broadcast/Table Exchange keeps running 1 = Broadcast/Table Exchange data is invalidated. Registers must be written to before data can be read or sent
1009	HDLC/ESP Settings status	Bit 0 Bit 1 Bit 2 Bit 3 Bit 4	1000: Invalid Port number Must be 1 to 4 1001: Invalid Port Address 1002: Invalid number of Partners 1003: Invalid Type 1003: 180K Restriction Due to processor loading ports 2 and 4 cannot be set to 180K.

		Bit 5 Bits 6 Bits 7-15	1006: Invalid interface mode 1003: 48K restriction Can't have a 48K port if two 180K ports selected Not Used
1010	*Wiring Options (future)*		*0 = 4 wire point to point – No tri-stating. HDLC slave uses incoming clock to generate transmit clock* *1 = 4 wire multi drop – Master keeps transmitting, Slave tri states. HDLC slave uses incoming clock to generate transmit clock* *2 = 2 wire – Master and Slave both tri-state. HDLC slave uses internal clock for transmissions.*

6.2 Link Statistics

Some of these registers are used by some or all of the protocols. Write the registers to zero to reset them.

Register	Description	Protocol	Comments
1100 1101	Frames sent	Common	Count of frames sent but not necessarily acknowledged. Includes Modbus transmissions
1102	Number of frames acknowledged	Common	This is the number of frames which have been transmitted and acknowledged by the addressed partner.
1103	Number of message acknowledgements	HDLC	The number of messages which have been transmitted and acknowledged by the addressed partner.
1104	ACKs Sent	ESP	Number of ESP Ack or HDLC messages sent without any data
1105	Frames received	Common	Frames received but not yet processed
1106 1107	Frames processed	Common	Frames received and copied into the database. NB Zero length messages are received but not processed
1108	Nak Replies	ESP	Number of Nak replies sent or received
1109	Last partner with Nak reply	ESP	
1110	CRC Errors	Common	The total number of CRC failures encountered in frames received from the addressed partner.
1111	Last partner with CRC error	Common	
1112	Timeouts primary only	Common	The number of timeouts during communications with the addressed partner (Does not include CRC errors)
1113	Last partner with timeout	Common	
1114	Number of receives aborted	Common	HDLC: Number of receives aborted is interpreted as aborted when the length of the data field of the incoming data is incorrect. ESP: EOT character received terminating a message
1115	Last partner where receive was aborted	Common	
1116	Number of sequence failure	HDLC	Number of frames received out of sequence from addressed partner, these frames are discarded.
1117	Last partner address to have sequence failure	HDLC	
1118	Number of Rx queue full conditions	HDLC	Number of times that messages have not been accepted because the receive queue is full
1119	Last partner with Rx queue full	HDLC	
1120	Number of data re transmissions	HDLC	Total number of times a frame has been re transmitted
1121	Last partner address to require re transmission	HDLC	
1122	Number of times link re connected	HDLC	Number of times the addressed partner has been reconnected by receipt or transmission of an SNRM (set normal response mode) frame.

1123	Last partner address to re connect	HDLC	
1124	Number of resource failures	Common	A resource failure occurs when all message buffers have been used.
1125	Underruns	Common	Interrupt system could not process the sending of bytes quickly enough
1126	Overruns	Common	More bytes were received than could be processed by the interrupt system.
1127	Overflows	Common	The received message was bigger than the receive buffer
1128	Tx Timeouts	Common	Number of times it took too long to transmit a message
1129	Last partner address with Tx Timeout	Common	
1130	ENQ messages	ESP	Number of ENQ messages sent by master or received by slave
1131	Last ENQ message address	ESP	The address of the last device with an ENQ message
1132-1139	For future use		
1140	Activity of primary or Address 0		A changing number indicates that the primary address is active
1141-1171	Activity of Addresses 1-31		A changing number indicates that the address is active

6.3 User controlled data transfer mode

When configured in 1006 for User Control the following registers allow Send and Receive operations to be performed in a similar way to the Special Functions.

NB Any data that is sent to or received from a partner using the Multi Component mode should be treated with care as ApStarnet does not implement Multi Component Mode.

- Data sent to a Multi Component partner should add the Message Id Code to the start of the data and increment the data length by 1.
- Data received from a Multi Component partner has the Message Id Code at the start of the data. The actual data length is 1 less than the number of words received.

ASIDE: Send and receive operations have been split so that they can be performed at the same time to allow processing of queued Rx messages.

6.3.1 Sending Data under User Control

Only 1 send to a partner can be queued at a time. Several messages to different partners can be queued up.

Read 1900. If 1900 is 0 then a new Send message can be constructed.
Write the data to be sent into the 2000 block. Or data from the 2000 or 3000 block on any port can be sent.
Write the "Send Data" controls to the 1900 to 1904 registers. NB Write to all 5 registers in a single write or write 1900 last.
Read back 1900-1906. When 1900 changes to 0 the message has been queued. Check 1905 and 1906 to make sure the correct length was written. NB The Send Command is completed when the message is added to the transmit queue. Actual transmission will not occur until the message reaches the front of the queue.

Register	Description	Range	Comments
1900	Send Command	0-1	Registers 1900-1904 should only be written to if 1900 is 0. 0 = Idle (Ready for next write) 1 = Send in Direct Mode
1901	Partner Address	0-31	Address 0-31 (only relevant for master, ignored by slave)
1902	Transmit Register	2000-2999 *3000-3999*	Transmit registers. See 1904, any Transmit or Receive area from any of the 4 ports can be used. Useful if passing data through.
1903	Message Length	0-777	Number of tables to transmit
1904	Source Port for Transmit Data	0-4	0 = this port 1-4 = use registers from port 1-4
Status			
1905	Send error status		Read Only (writes ignored). Non zero if there is an error with the Send request. See next section for details.
1906	Data Transmitted	0-777	Read Only (writes ignored). Number of registers sent. Does not confirm data was acknowledged or copied into partners data tables.
1907	Transmissions pending		Read Only (writes ignored). The number of messages queued for transmission.

1908	Waiting for Ack		Read Only (writes ignored). The number of frames in the transmission queue waiting for an Ack
1909	Reserved		Read Only (writes ignored).

6.3.2 Receive Data Under User Control

Data is received by ApStarnet and is queue internally waiting for a Receive to be performed on the relevant partner address. Registers 1917 and 1918 allow the oldest queued message to be seen although any partner address can be checked.

Write the "Read Data" controls to the 1910 to 1913 registers. NB Write to all 4 registers in a single write.
When 1910 changes to 0 the read has completed. Check 1915 and 1916 to see how many registers have been read.
Read the data from the 3000 block
Read 1917 to see if another Receive is needed and read the oldest message partner address in 1918 if Rx messages are pending in the queue.

Register	Description	Range	Comments
1910	Receive	0-1	Registers 1910-1913 should only be written to if 1910 is 0. 0 = Idle (Receive completed) 1 = Receive in Direct mode
1911	Partner Address	0-31	Bits 0-6: Address 0-31 (only relevant for master, ignored by slave)
1912	Receive Register	3000-3999	Port specific receive registers. 2000-3999 allowed.
1913	Message Length	0-777	Max number of tables to receive
1914	Reserved	0	For future use Write as 0

1915	Receive error status		Read Only. 0 = Success. 1: Multi frame message part received, waiting for rest of message 2: No data from partner 3: Not enough register space 4: Frame order error 5: In Q mode the previous data has not been read by Ethernet
1916	Data received	0-777	Read Only (writes ignored). Number of registers sent or Number of registers received
1917	Rx Messages in Queue		Read Only (writes ignored). Number of queued Rx messages still to be received.
1918	Oldest Partner in Rx Queue	0-31	Read Only (writes ignored). Only relevant if 1907 is non zero The partner address of the oldest Receive data block in the Rx queue.
1919	Reserved		Read Only (writes ignored).

6.3.3 Send/Receive Error Status

Transfer Status		Notes
Bit	**Description**	
0	Fatal error any of bits 5-15 on	
1	Dest/Source not ready	Non Fatal errors
2	Link re connected after failure	
3	Not Used	
4	Previous send unacknowledged/no data received	
0,5	Link Failed	Usually buffer full
0,6	Message pending transmission	
0,7	Not ready for send/receive	
0,8	Port not configured	
0,9	Hardware failure	
0,10	Receive length exceeds limit	
0,11	Invalid source/destination data area specified	
0,12	Direct mode length > 777	
	Multi mode total length not acceptable	
0,13	same as 11	
0,14	Internal error	
15	Not used	

The result of the requested data exchange are reflected in the above bits.

6.3.4 Transmission Data

These registers are only accessible if configured for User Control Mode.

When the register allocation changes due to changes to registers 700-979, 1001, 1002, 1003 or 1006 then data will not be transmitted to a partner until the data has been written to from one of the Modbus ports.

Register	Description	Range	Comments
2000-2999	Data to be sent		A block of up to 1000 registers (see register 700) is allocated as an area where data to be sent can be stored, prior to it being transferred to the required partner. The content of the message should be written into this area

6.3.5 Received Data

These registers are only accessible if configured for User Control Mode.

When the register allocation changes due to changes to registers 700-979, 1001, 1002, 1003 or 1006 then data cannot be read by Modbus until the data has been received into this area.

Register	Description	Range	Comments
3000-3999	Data received		Received data. Up to 1000 registers (see 701) Data should be read out of this area after a Receive function has completed.

6.4 Table exchange mode

Blocks of data are configured to be exchanged between the unit and any attached partners. This was referred to as Table exchange mode in the original Starnet documentation.

6.4.1 Table Exchange Output Array

Up to 111 tables are available to be transmitted to each of 31 Secondaries. See 702-764
Only the configured number of partners and registers are accessible.

When the register allocation changes due to changes to registers 700-979, 1001, 1002, 1003 or 1006 then data will not be transmitted to a partner until the data has been written to from one of the Modbus ports.

For multi slave the registers 4000 to 4031 are the data areas used to send data back to the master. These registers should be written to by the Modbus device.

Register	Description	Comments
4000	Start of up to 111 registers for broadcasting Start of up to 111 registers to primary Start of up to 111 registers to secondary 0	HDLC or ESP
4001	Start of up to 111 registers to secondary 1	HDLC or ESP
4002	Start of up to 111 registers to secondary 2	HDLC or ESP
4003	Start of up to 111 registers to secondary 3	HDLC or ESP
4004	Start of up to 111 registers to secondary 4	HDLC or ESP
4005	Start of up to 111 registers to secondary 5	HDLC or ESP
4006	Start of up to 111 registers to secondary 6	HDLC or ESP
4007	Start of up to 111 registers to secondary 7	HDLC or ESP
4008	Start of up to 111 registers to secondary 8	HDLC or ESP
4009	Start of up to 111 registers to secondary 9	HDLC or ESP
4010	Start of up to 111 registers to secondary 10	HDLC or ESP
4011	Start of up to 111 registers to secondary 11	HDLC or ESP
4012	Start of up to 111 registers to secondary 12	HDLC or ESP
4013	Start of up to 111 registers to secondary 13	HDLC or ESP
4014	Start of up to 111 registers to secondary 14	HDLC or ESP
4015	Start of up to 111 registers to secondary 15	HDLC or ESP
4016	Start of up to 111 registers to secondary 16	HDLC Only
4017	Start of up to 111 registers to secondary 17	HDLC Only
4018	Start of up to 111 registers to secondary 18	HDLC Only
4019	Start of up to 111 registers to secondary 19	HDLC Only
4020	Start of up to 111 registers to secondary 20	HDLC Only
4021	Start of up to 111 registers to secondary 21	HDLC Only
4022	Start of up to 111 registers to secondary 22	HDLC Only
4023	Start of up to 111 registers to secondary 23	HDLC Only
4024	Start of up to 111 registers to secondary 24	HDLC Only
4025	Start of up to 111 registers to secondary 25	HDLC Only
4026	Start of up to 111 registers to secondary 26	HDLC Only
4027	Start of up to 111 registers to secondary 27	HDLC Only
4028	Start of up to 111 registers to secondary 28	HDLC Only
4029	Start of up to 111 registers to secondary 29	HDLC Only
4030	Start of up to 111 registers to secondary 30	HDLC Only
4031	Start of up to 111 registers to secondary 31	HDLC Only

6.4.2 Table Exchange Input Array

Read 112 tables and the last table is the number of tables that are valid. NB 111 tables must be allocated to allow the reading of 112 tables.
Up to up to 111 tables received from each of 31 Secondaries

When the register allocation changes due to changes to registers 700-979, 1001, 1002, 1003 or 1006 then data cannot be read by Modbus until the relevant data block has received data via HDLC/ESP.

For multi slave the registers 4100 to 4131 are the data areas where data from the master is stored. These registers should be read by the Modbus device.

Register	Description	Comments
4100	Start of up to 111 registers from primary Start of up to 111 registers from secondary 0	HDLC or ESP
4101	Start of up to 111 registers from secondary 1	HDLC or ESP
4102	Start of up to 111 registers from secondary 2	HDLC or ESP
4103	Start of up to 111 registers from secondary 3	HDLC or ESP
4104	Start of up to 111 registers from secondary 4	HDLC or ESP
4105	Start of up to 111 registers from secondary 5	HDLC or ESP
4106	Start of up to 111 registers from secondary 6	HDLC or ESP
4107	Start of up to 111 registers from secondary 7	HDLC or ESP
4108	Start of up to 111 registers from secondary 8	HDLC or ESP
4109	Start of up to 111 registers from secondary 9	HDLC or ESP
4110	Start of up to 111 registers from secondary 10	HDLC or ESP
4111	Start of up to 111 registers from secondary 11	HDLC or ESP
4112	Start of up to 111 registers from secondary 12	HDLC or ESP
4113	Start of up to 111 registers from secondary 13	HDLC or ESP
4114	Start of up to 111 registers from secondary 14	HDLC or ESP
4115	Start of up to 111 registers from secondary 15	HDLC or ESP
4116	Start of up to 111 registers from secondary 16	HDLC Only
4117	Start of up to 111 registers from secondary 17	HDLC Only
4118	Start of up to 111 registers from secondary 18	HDLC Only
4119	Start of up to 111 registers from secondary 19	HDLC Only
4120	Start of up to 111 registers from secondary 20	HDLC Only
4121	Start of up to 111 registers from secondary 21	HDLC Only
4122	Start of up to 111 registers from secondary 22	HDLC Only
4123	Start of up to 111 registers from secondary 23	HDLC Only
4124	Start of up to 111 registers from secondary 24	HDLC Only
4125	Start of up to 111 registers from secondary 25	HDLC Only
4126	Start of up to 111 registers from secondary 26	HDLC Only
4127	Start of up to 111 registers from secondary 27	HDLC Only
4128	Start of up to 111 registers from secondary 28	HDLC Only
4129	Start of up to 111 registers from secondary 29	HDLC Only
4130	Start of up to 111 registers from secondary 30	HDLC Only
4131	Start of up to 111 registers from secondary 31	HDLC Only

6.4.3 Table Exchange Control and Status

These registers replicate the functionality of the U tables. There are 4 per Tributary.

The Tx Control register, 4200, 4204 etc bits 0-6 & 15 are retained through a power down.

6.4.3.1 HDLC Broadcast Controls (1006 Interface Mode = 1:Master, 2:Master)

4200-4203 are the controls for Broadcast and Broadcast with Response

Register	Description
4200	Tx Controls Bit 15: Poll Bit. Send 0 length message if nothing to send so Secondary can reply (Broadcast with response only) (retained through a power cycle) Bit 14: Sync Bit. Not implemented Bit 13: Interlock. Not implemented Bits 12-8: Not used Bits 7 to 0: Tx Length Number of words to transmit (0-111) (retained through a power cycle)
4201	Broadcast With Response Only (Interface Mode 2) Response Request Bits 15-8: Not used Bits 7-0: Req Addr The Secondary to request a response from. If set to 0 then a round robin method is used
4202	Broadcast With Response Only (Interface Mode 2) Rx Status – Read only Bits 15-8: Address Address of the secondary that has replied Bits 7-0: Rx Length Number of words received in last reply
4203	Status Bits (For the secondary that has replied) – Read only To be defined

NB Order of data has been changed from Starnet Special Function to allow 4200 and 4201 to be written by a single write. 4202 and 4203 are read only.

6.4.3.2 HDLC Exchange Controls (1006 Interface Mode = -1:Master, -4 Master)

4200 to 4327. HDLC controls for each secondary allocated at 4 tables per secondary.
e.g. Secondary Address 2 starts at address 4200 + Addr * 4 = 4200 + 2*4 = 4208. There are 4 tables for each secondary. The Rx Status is updated for replies to relevant Broadcast with response messages.

Register	Description
Base + 0	Tx Controls (Mode -3 or -1) Bit 15: Poll Bit. Send 0 length message if nothing to send so Secondary can reply (retained through a power cycle) Bit 14: Sync Bit. Not implemented Bit 13: Interlock. Not implemented Bits 12-8: Not used Bits 7 to 0: Tx Length Number of words to transmit (0-111) (retained through a power cycle)
Base + 1	Bits 15-0: Not used
Base + 2	Rx Status– Read only Bits 15-9: Not used Bit 8: NewRx Set when data received. Automatically cleared when data has been read. Bits 7-0: Rx Length Number of words received
Base + 3	Status Bits – Read only To be defined

NB Order of data registers has been changed from Starnet Special Function to match 4200 to 4203

6.4.3.3 HDLC Slave Controls (1006 Interface Mode = -3:Slave, -1:Slave, 1:Slave, 2:Slave)

4200-4203 are the controls for replying to a Broadcast with Response or Table Exchange Master
Multi slave uses these register definitions but in tables 4200-4327 depending on the slave address.

Register	Description
4200	Tx Controls Bit 15: Poll Bit. Not relevant to the slave Bit 14: Sync Bit. Not implemented Bit 13: Interlock. Not implemented Bits 12-8: Not used Bits 7 to 0: Tx Length Number of words to transmit (0-111) (retained through a power cycle)
4201	Bits 15-0: Not used
4202	Rx Status – Read only Bits 15-9: Not used Bit 8: NewRx Set when data received. Automatically cleared when data has been read. Bits 7-0: Rx Length Number of words received in last message
4203	Status Bits (For the secondary that has replied) – Read only To be defined

NB Order of data has been changed from Starnet Special Function to allow 4200 and 4201 to be written by a single write. 4202 and 4203 are read only.

6.4.3.4 "ESP Tributary" Exchange Controls (1006 Interface Mode = -3,-2, -1 or 2)

When ApStarnet is configured as a tributary then registers 4200 to 4203 are used to control the operation of the tributary.
Multi slave uses these register definitions but in tables 4200-4327 depending on the slave address.

Register	Description
4200	Tx Controls (retained through a power cycle) Bits 7 to 0: Tx Length Number of words to transmit (0-111). If set to zero then an Ack is sent in reply to any incoming message.
4201	User Controls (Interface Mode = -2) Bit 0: Not used
4202	Rx Status – Read only Bits 15-9: Not used Bit 8: NewRx Set when data received. Automatically cleared when data has been read. Bits 7-0: Rx Length Number of words received
4203	Status Bits – Read only To be defined

NB Order of data has been changed from Starnet Special Function to allow 4200 and 4201 to be written by a single write. 4202 and 4203 are read only.

6.4.3.5 "ESP Control" Exchange Controls (1006 Interface Mode = -2 or -1)

4204 to 4327. ESP controls for each tributary allocated at 4 tables per tributary.
e.g. Tributary 2 starts at address 4200 + Addr * 4 = 4200 + 2*4 = 4208.
Tributaries 1 to 15 allowed.

Register	Description
Base + 0	Tx Controls (retained through a power cycle) Bits 7 to 0: Tx Length Number of words to transmit (0-111). If set to 0 then there is no link activity to this partner. To poll the partner at least 1 word has to be sent.
Base + 1	Table Exchange User Control (Interface Mode = -2) Bit 0: Send Req Set by controlling device to request transmission in TabEx User Control Mode. Cleared once message queued.
Base + 2	Rx Status – Read only Bits 15-9: Not used Bit 8: NewRx Set when data received. Automatically cleared when data has been read. Bits 7-0: Rx Length Number of words received
Base + 3	Status Bits – read Only To be defined

NB Order of data has been changed from Starnet Special Function to allow 4200 and 4201 to be written by a single write. 4202 and 4203 are read only.

6.5 Development Data

Data useful for debugging faults during and after development. It is not expected that these tables will normally be accessed. If read then access using station address 16.

Register	Description	Comments
7000	Run Time Error Count	Indication of how many run time errors are occurring
7001	Run Time Error Line Number	The line number in the file of the run time error
7002-7009	Run Time Error File Name	Up to 16 characters of the file name for the last run time error.

6.6 Scratchpad

A free area of 512 non-volatile registers on device 16, address 9000 is available for general usage. Any data written to these registers will be maintained across a power cycle. Data can be read and written freely although registers that will change more that 1 million times should be avoided as the NV ram may start to fail.

Register	Description	Comments
9000 to 9511	For general data storage	Non-volatile scratchpad memory. Not used by ApStarnet but made available for attached devices to freely read and write any data required.