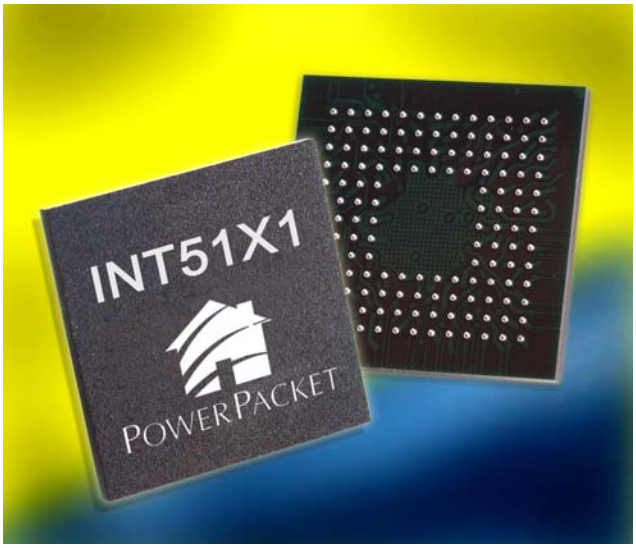
D A T A S H E E T

INT51X1

Integrated Powerline MAC/PHY Transceiver with USB and ETH Integrated Bridges

Features

- **Single-chip powerline networking controller with integrated MII/GPSI, USB 1.1 and Ethernet interfaces**
- **Up to 14 Mbps data rate on the powerline**
- **Integrated 10-bit ADC, 10-bit DAC and AGC Control**
- **Selectable MDI/SPI PHY management interface**
- **General purpose 8-wire serial PHY data interface**
- **Implements Intellon's PowerPacket™ technology which is fully compliant with the *HomePlug 1.0.1 Specification***
- **Orthogonal Frequency Division Multiplexing (OFDM) with patented signal processing techniques for high data reliability in noisy media conditions**
- **Intelligent channel adaptation maximizes throughput under harsh channel conditions**
- **Integrated Quality of Service (QoS) features such as prioritized random access, contention-free access, and segment bursting**
- **56-bit DES Link Encryption with key management for secure powerline communications**
- **EEPROM interface for fast access to configuration parameters**
- **3.3 V signaling, 5 V tolerant interface**
- **Support for three status LEDs**
- **144-pin µBGA package**



Applications

- **Shared broadband Internet access using standard in-home/SOHO powerlines**
- **Internet Appliances**
- **PC file and application sharing**
- **Peripheral and printer sharing**
- **Networked gaming**
- **Security/Surveillance**
- **Audio and Video Streaming**
- **Voice over IP Call**
- **Expanding the coverage of Wireless LANs**

CONTENTS

1. General Description

The INT51X1 IC is an integrated powerline MAC/PHY/AFE transceiver providing *No New Wires®* communications to any room, over any wire, at speeds of up to 14 Mbps. The INT51X1 alternately provides three interfaces, via pinout options:

- INT51X1 (USB Option): A USB Network Model Communications Class Device (ref. Universal Serial Bus Class Definitions for Communication Devices, Version 1.1) interconnection to a USB host (ref. Universal Serial Bus Specification Revision 1.1). The INT51X1 (USB Option) is selected by connecting MODE0 (pin D2) to VDD_IO through 10KΩ and connecting MODE1 (pin D3) to VSS.

- INT51X1 (PHY Option): An MII (IEEE 802.3u 1995, Paragraph 22) or GPSI PHY interface for interconnection to microcontrollers or Ethernet controllers. The INT51X1 (PHY Option) is selected by connecting MODE0 (pin D2) to VSS and connecting MODE1 (pin D3) to VDD_IO through 10KΩ.

- INT51X1 (Host/DTE Option): An MII Host/DTE interface (IEEE 802.3u 1995, Paragraph 22) for interconnection to an Ethernet PHY. The INT51X1 (Host/DTE Option) is selected by connecting MODE0 (pin D2) to VDD_IO through 10KΩ and connecting MODE1 (pin D3) to VDD_IO through 10KΩ.

The IC implements Intellon's patented PowerPacket OFDM technology and is fully compliant with the *HomePlug 1.0.1 Specification*. Specifically tailored to reliably deliver up to 14 Mbps over the difficult powerline communication environment, the IC combats deep attenuation notches, noises sources, and multi-path fading by allocating usable frequencies according to the signal to noise ratio (SNR). Synchronization is achieved in low SNR channels without the use of pilot carriers. The MAC implements a CSMA/CA scheme with prioritization and automatic repeat request (ARQ) for reliable delivery of Ethernet packets via packet encapsulation. A 10-bit analog-to-digital converter (ADC) and a 10-bit digital-to-analog converter (DAC) are fully integrated for simplified design. The ADC and DAC feature sample rates of 50 MBPS, independent of on-chip voltage references, and low power operation.

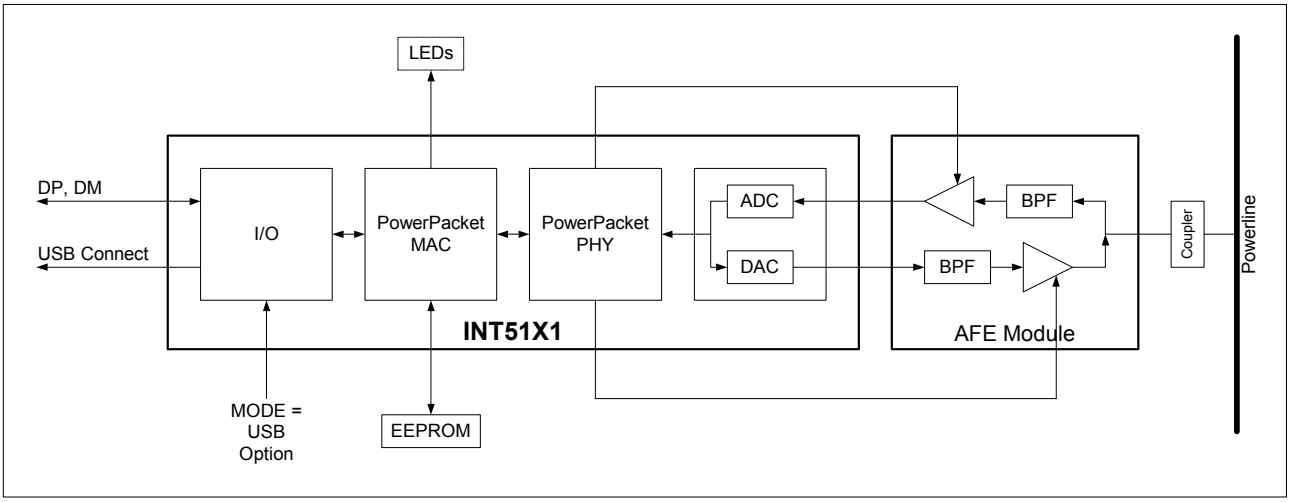
Built-in Quality of Service (QoS) features provide the necessary bandwidth for multimedia payloads including voice, data, audio, and video. A four-level prioritized random access method exists with strict adherence to priority. Segment bursting on the powerline minimizes the demands on the receiver resources and maximizes the throughput of the network while still providing excellent latency response and jitter performance. The IC's contention-free access capability extends this concept of segment bursting to allow the transmission of multiple frames over the powerline without relinquishing the control of the medium. Utilizing contention-free access, a single station may act as a controller for the entire network.

The IC operates on a 1.5V core and 3.3V IO power supplies, offers 5V I/O tolerance, and is packaged in a 144-pin μBGA.

2. USB Option

INT51X1 (USB Option): A USB Network Model Communications Class Device (ref. Universal Serial Bus Class Definitions for Communication Devices, Version 1.1) interconnection to a USB host (ref. Universal Serial Bus Specification Revision 1.1).

2.1. System Block Diagram



2.2. USB Compliance

When optioned for the USB interface, the electrical characteristics and timing of the INT51X1 fully conform with the Universal Serial Bus Specification, Revision 1.1, for self-powered applications.

When configured for either self-powered or bus-powered applications, the INT51X1 (USB Option) reports a MaxPower value of 0x00.

2.3. USB Packets

USB packets are processed only when optioned for INT51X1 (USB Option).

2.3.1. USB Configuration

2.3.1.1. USB Endpoints

USB Endpoints

Endpoint	Type	Direction	Size (bytes)	Description
EP0	control	IN/OUT	32	default endpoint, used for standard and vendor requests
EP1	bulk	IN	64	data input
EP2	bulk	OUT	64	data output
EP3	interrupt	IN	8	interrupt data from chip

EP0, the default endpoint, is used for all standard USB requests and INT51X1 (USB Option) specific requests. The INT51X1 (USB Option) specific requests are implemented according to the USB Communication Device Class Specification 1.1 (CDC).

EP1 is used to process raw Ethernet data from the USB device to the PC. The maximum length of a Ethernet data packet is 1518 bytes (including VLAN tag). Following the Ethernet data packet (the last two valid octets in the last

USB packet) is a 12-bit Frame Length field containing the length of the Ethernet data packet. Bits 0-7 of the 1st octet of the Frame Length field map to bits 0-7 of the Ethernet frame length, bits 0-3 of the 2nd octet of the Frame Length field map to bits 8-11 of the Ethernet frame length, and bits 4-7 of the 2nd octet are reserved. Therefore, the actual length of the data passed from the USB device to the PC for a maximum length Ethernet data packet is 1520 (including VLAN tag) and the Frame Length field will contain 1518. Each Ethernet packet is terminated with a USB short packet. If the Ethernet packet size is a multiple of the endpoint size, a zero packet has to be sent by the USB device. If no data is available the device answers to IN tokens with NAKs.

EP2 is used to process Ethernet data from the PC to the USB device. The maximum length of a Ethernet data packet is 1518 bytes. Preceding the Ethernet data packet (the 1st two octets on the 1st USB packet) is a 12-bit Frame Length field containing the length of the Ethernet data packet. Bits 0-7 of the 1st octet of the Frame Length field map to bits 0-7 of the Ethernet frame length, bits 0-3 of the 2nd octet of the Frame Length field map to bits 8-11 of the Ethernet frame length, and bits 4-7 of the 2nd octet are reserved. Therefore, the actual length of the data passed from the PC to the USB device for a maximum length Ethernet data packet is 1520 (including VLAN tag) and the Frame Length field will contain 1518. Each Ethernet packet is terminated with a USB short packet. If the Ethernet packet size is a multiple of the endpoint size a zero packet has to be sent. If no data is available no OUT tokens are sent by the PC.

EP3 is an interrupt endpoint. EP3 is polled every 2 ms by the PC. If no interrupt data is available the device sends NAKs in response to the IN tokens from the PC. If the device has detected an interrupt condition it sends the interrupt data.

2.3.1.2. USB Descriptors

USB descriptors are used to identify a USB device. The USB bus driver requests these descriptors and the operating system loads the correct device drivers.

The following device descriptors conform to the USB specification version 1.1 and the CDC specification 1.1 from January 1999.

Note that the following descriptors are not customizable for a given product. The INT51X1 (USB Option) will always report the same idVendor, idProduct, etc.

2.3.1.2.1. Device Descriptor

The device descriptor describes basic device properties. Each descriptor starts with a length and a type field. This enables easy descriptor parsing.

```
bLength                 : 0x12
bDescriptorType         : 0x01
bcdUSB                  : 0x0100
bDeviceClass            : 0x02          // CDC
bDeviceSubClass         : 0x00
bDeviceProtocol         : 0x00
bMaxPacketSize0         : 0x20
idVendor                : 0x09E1        // Intellon Vendor ID from USB (2529 decimal)
idProduct               : 0x5121        // Intellon Product ID
bcdDevice               : 0x0100
iManufacturer           : 0x01          // index of string descriptor
iProduct                : 0x02          // index of string descriptor
iSerialNumber           : 0x03          // index of string descriptor
bNumConfigurations      : 0x01
```

2.3.1.2.2. Configuration Descriptor

The configuration descriptor requested by the operating system consists of the USB configuration descriptor, the interface descriptor, the class specific (CDC) descriptor and Endpoint descriptors.

USB Configuration Descriptor

```
bLength                 : 0x09
bDescriptorType         : 0x02
wTotalLength            : 0x0039        // sizeof(Configuration_Descriptor)
                                        // 2byteslength
bNumInterfaces          : 0x01
```

bConfigurationValue	: 0x01	
iConfiguration	: 0x00	
bmAttributes	: 0x40	
MaxPower	: 0x00	

Interface Descriptor

bLength	: 0x09	
bDescriptorType	: 0x04	
bInterfaceNumber	: 0x00	
bAlternateSetting	: 0x00	
bNumEndpoints	: 0x03	
bInterfaceClass	: 0x02	// CDC
bInterfaceSubClass	: 0x06	// Ethernet Networking Control Model
bInterfaceProtocol	: 0x00	
iInterface	: 0x00	

CDC Class Descriptor

bLength	: 0x12	
bDescriptorType	: 0x24	// CS Interface
bDescriptorSubtype	: 0x00	// header
bcdCDC	: 0x0110	// CDC 1.1 Specification
bFunctionLength	: 0x0D	
bDescriptorType	: 0x24	// CS Interface
bDescriptorSubtype	: 0x0F	// Ethernet Networking Functional Desc
iMACAddress	: 0x03	// index of the MAC address
bmEthernetStat	: 0x01000000	// RCV_OVERRUN only
wMaxSegmentSize	: 0x05EA	
wNumberMCFilters	: 0x0080	// not supported
bNumberPowerFilters	: 0x00	// no power filters

2.3.1.2.3. Endpoint Descriptors

Endpoint 1, Bulk IN

bLength	: 0x07
bDescriptorType	: 0x05
bEndpointAddress	: 0x81
bmAttributes	: 0x02
wMaxPacketSize	: 0x0040
bInterval	: 0x00

Endpoint 2, Bulk OUT

bLength	: 0x07
bDescriptorType	: 0x05
bEndpointAddress	: 0x02
bmAttributes	: 0x02
wMaxPacketSize	: 0x0040
bInterval	: 0x00

Endpoint 3, Interrupt, polling interval 2 ms

bLength	: 0x07
bDescriptorType	: 0x05
bEndpointAddress	: 0x83
bmAttributes	: 0x03
wMaxPacketSize	: 0x0008
bInterval	: 0x02

2.3.1.3. String Descriptors

The string descriptors contain unicode strings which describe additional properties of the device. Some strings become visible to the user during the installation process.

Note that the following descriptors (except MAC Address) are not customizable for a given product. The INT51X1 (USB Option) will always report the same Manufacturer description, Product description, etc.

2.3.1.3.1. Index 0

Language ID: English standard

```
bLength                 : 0x04
bDescriptorType         : 0x03
DescriptorContents      : 0x0409
```

2.3.1.3.2. Index 1

Manufacturer description

```
bLength                 : 0x12
bDescriptorType         : 0x03
DescriptorContents      : "Intellon"
```

2.3.1.3.3. Index 2

Product description

```
bLength                 : 0x2A
bDescriptorType         : 0x03
DescriptorContents      : "USB-Powerline Bridge"
```

2.3.1.3.4. Index 3

MAC Address

```
bLength                 : 0x1A
bDescriptorType         : 0x03
DescriptorContents      : "nnnnnnnnnnnn"        // from MAC µProcessor
```

2.3.2. USB Interface Protocol

Endpoint 0 is used for USB control. Each control request consists of a setup packet, an optional data phase and an acknowledgement. The control requests are divided into standard requests, INT51X1 (USB Option) requests and class specific requests. The Request Type is self-explanatory. The other control requests are class specific requests which conform to the CDC specification.

2.3.2.1. CDC Conform Control Requests

The CDC Conform Control Requests are class specific requests. In accordance with the CDC, the commands SEND_ENCAPSULATED_COMMAND and GET_ENCAPSULATED_RESPONSE are used to transmit the requests. Each defined data structure starts with a function code. The function code identifies the operation. Some of the requests need input and output parameters. Input parameters are transmitted with a SEND_ENCAPSULATED_COMMAND and output parameters are transmitted with a GET_ENCAPSULATED_RESPONSE. If a request or function is unknown to the USB firmware, the requested operation failed, or it has bad parameters, the INT51X1 (USB Option) signals the error with a STALL in the acknowledge phase.

2.3.2.1.1. Write USB Register Value in the USB Host

SETUP (SEND_ENCAPSULATED_COMMAND)				
Request Type	**Request**	**Value**	**Index**	**Length**
0x21 CDC Class Host Out to Device	0x00 Send encapsulated command	0x00	0x00	sizeof(USBIF_SET_USB_REG_OUT)

This command is used together with the data structure USBIF_SET_USB_REG_OUT to set a register in the USB State Machine Controller. The data structure is transmitted in the data phase of the setup request.

```
typedef struct _USBIF_SET_USB_REG_OUT
{
UCHAR FunctionCode;                     // = USBIF_FUNC_SET_USB_REG (0x03)
```

```
UCHAR RegAddress;
UCHAR Data;
} USBIF_SET_USB_REG_OUT;
```

If the operation fails the request is stalled by the device.

2.3.2.1.2. Read USB Register Value from the USB Host

SETUP (SEND_ENCAPSULATED_COMMAND)				
Request Type	**Request**	**Value**	**Index**	**Length**
0x21 CDC Class Host Out to Device	0x00 Send encapsulated command	0x00	0x00	sizeof(USBIF_GET_USB_REG_OUT)

This command is used to request the value of a register from the USB State Machine Controller. If the operation fails the request is stalled by the device.

```
typedef struct _USBIF_GET_USB_REG_OUT
{
UCHAR FunctionCode;                    // = USBIF_FUNC_GET_USB_REG (0x04)
UCHAR RegAddress;
} USBIF_GET_USB_REG_OUT;
```

SETUP (GET_ENCAPSULATED_RESPONSE)				
Request Type	**Request**	**Value**	**Index**	**Length**
0xA1 CDC Class Device In to Host	0x01 Get encapsulated response	0x00	0x00	sizeof(USBIF_GET_USB_REG_IN)

This command is used to receive the value of a register from the USB State Machine Controller. If the operation fails the request is stalled by the device.

```
typedef struct _USBIF_GET_USB_REG_IN
{
UCHAR FunctionCode;                    // = USBIF_FUNC_GET_USB_REG (0x04)
UCHAR Data;
} USBIF_GET_USB_REG_IN;
```

2.3.2.1.3. Read Version Information from USB Host

SETUP (SEND_ENCAPSULATED_COMMAND)				
Request Type	**Request**	**Value**	**Index**	**Length**
0x21 CDC Class Host Out to Device	0x00 Send encapsulated command	0x00	0x00	sizeof(USBIF_HW_VERSION_INFO_OUT)

This command is used to request a read version information operation. If the operation fails the request is stalled by the device.

```
typedef struct _USBIF_HW_VERSION_INFO_OUT
{
UCHAR FunctionCode;                    // = USBIF_FUNC_VERSION_INFO (0x05)
} USBIF_HW_VERSION_INFO_OUT;
```

SETUP (GET_ENCAPSULATED_RESPONSE)				
Request Type	**Request**	**Value**	**Index**	**Length**
0xA1 CDC Class Device In to Host	0x01 Get encapsulated response	0x00	0x00	sizeof(USBIF_HW_VERSION_INFO_IN)

This command is used to receive the version information. If the operation fails the request is stalled by the device.

```
typedef struct _USBIF_HW_VERSION_INFO_IN
{
unsigned char FunctionCode;                    // USBIF_FUNC_VERSION_INFO (0x05)
unsigned short BootLoaderVersion;
unsigned short BoardVersion;
unsigned short BoardSubVersion;
unsigned short ProductionYear;
unsigned char ProductionWeek;
unsigned char MAC_Address[6];
} USBIF_HW_VERSION_INFO_IN;
```

2.3.3. Ethernet Parameters

Set Ethernet Packet Filter Request from USB Host

SETUP				
Request Type	Request	Value	Index	Length
0x21 CDC Class Out to Device	0x43 Set Ethernet packet filter	Filter	0x00	0x00

This request is defined by the CDC specification. The packet filter value is a bitmap with the following contents:

Packet Filter Values

Bit Position	Description
D4	PACKET_TYPE_MULTICAST 1: All multicast packets enumerated in the device's multicast address list are forwarded up to the host. (required) 0: Disabled. The ability to disable forwarding of these multicast packets is optional.
D3	PACKET_TYPE_BROADCAST 1: All broadcast packets received by the networking device are forwarded up to the host. (required) 0: Disabled. The ability to disable forwarding of broadcast packets is optional.
D2	PACKET_TYPE_DIRECTED 1: Directed packets received containing a destination address equal to the MAC address of the networking device are forwarded up to the host (required) 0: Disabled. The ability to disable forwarding of directed packets is optional.
D1	PACKET_TYPE_ALL_MULTICAST 1: ALL multicast frames received by the networking device are forwarded up to the host, not just the ones enumerated in the device's multicast address list (required) 0: Disabled.
D0	PACKET_TYPE_PROMISCUOUS: 1: ALL frames received by the networking device are forwarded up to the host (required) 0: Disabled.

2.3.3.1.1. Get Ethernet Statistics Request from USB Host

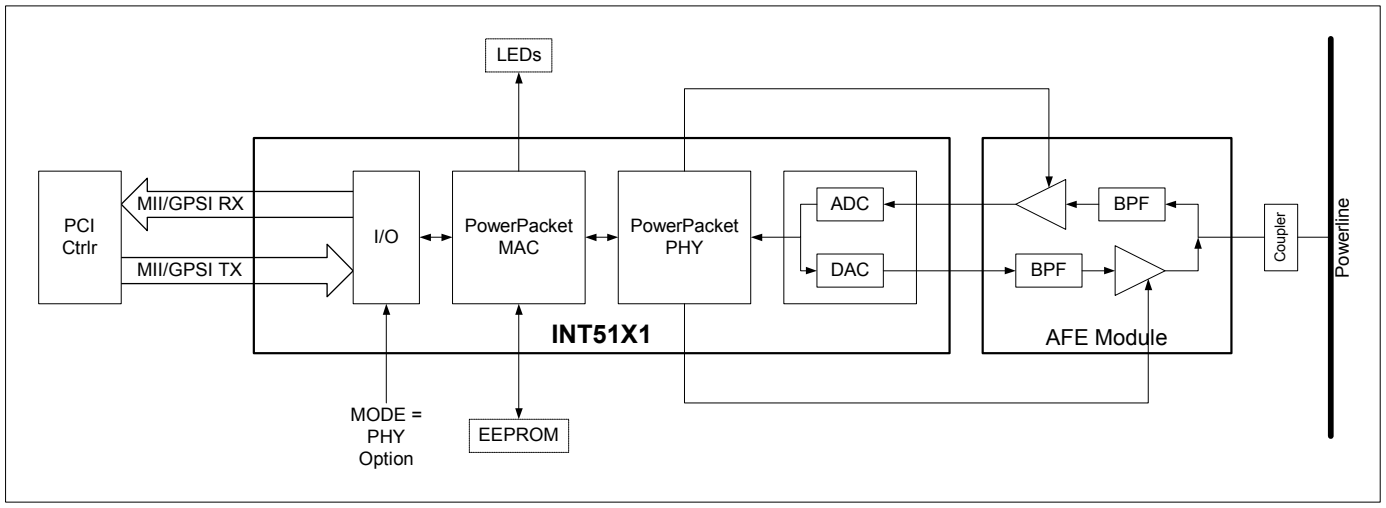
SETUP				
Request Type	**Request**	**Value**	**Index**	**Length**
0xA1 CDC Class In to Device	0x44 Get Ethernet statistic	Feature Selector	0x00	4

This request is defined by the CDC specification. Only the Feature Selector RCV_OVERRUN (0x19) is supported.

3. PHY Option

INT51X1 (PHY Option): An MII (IEEE 802.3u 1995, Paragraph 22) or GPSI PHY interface for interconnection to microcontrollers or Ethernet controllers.

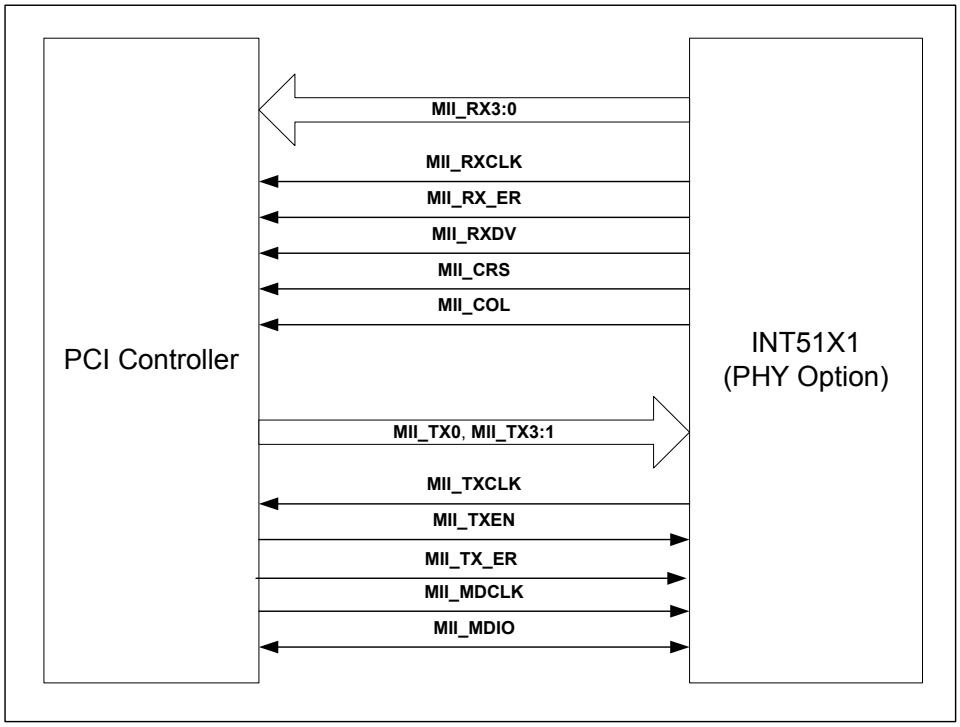
3.1. System Block Diagram



3.2. MII PHY Interface

MII is an industry standard, multi vendor, interoperable interface between the MAC and PHY sub-layers. It provides a simple interconnection between the PowerPacket MAC and IEEE802.3 Ethernet MAC controllers from a variety of sources. The MII consists of separate 4-bit data paths for transmit and receive data along with carrier sense and collision detection. Data is transferred between the MAC and PHY over each 4-bit data path synchronous with a clock signal supplied to the MAC by the PowerPacket MAC. The MII interface also provides a two-wire bi-directional serial management data interface. This interface provides access to the status and control registers in the PowerPacket MAC. Further details of the MII can be found in the IEEE 802.3u Standard.

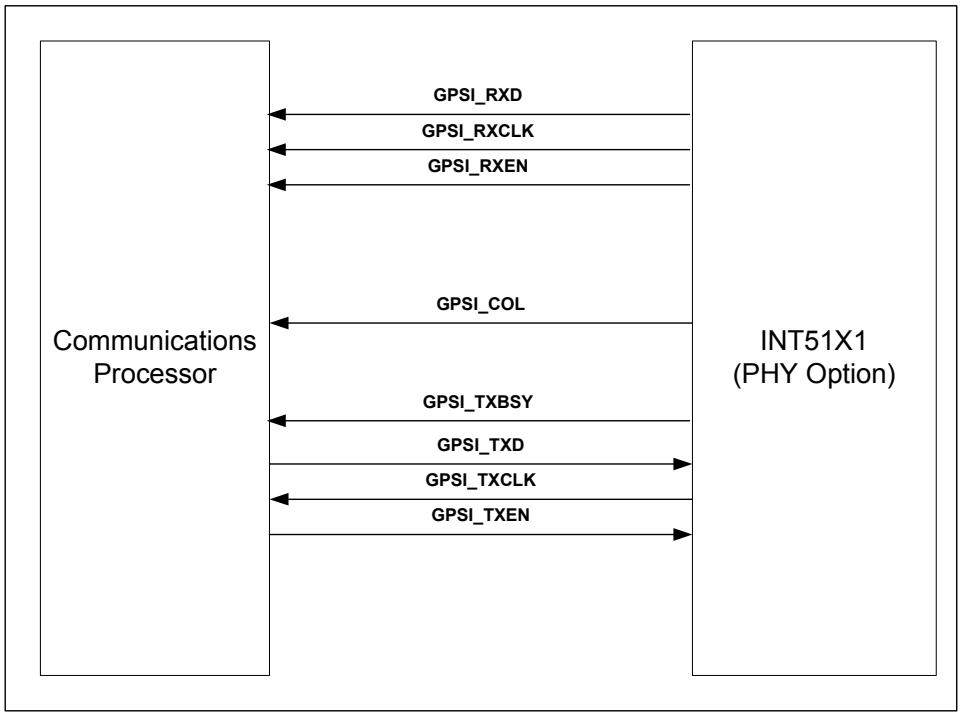
MII Interface to INT51X1 (PHY Option)



3.3. GPSI PHY Interface

The General Purpose Serial Interface (GPSI) is a flexible, bi-directional serial interface to the PowerPacket MAC. It provides a straightforward interface to a communications controller through a synchronous serial data stream for transmit and receive data. The GPSI also provides an industry supported serial peripheral interface for status and control data.

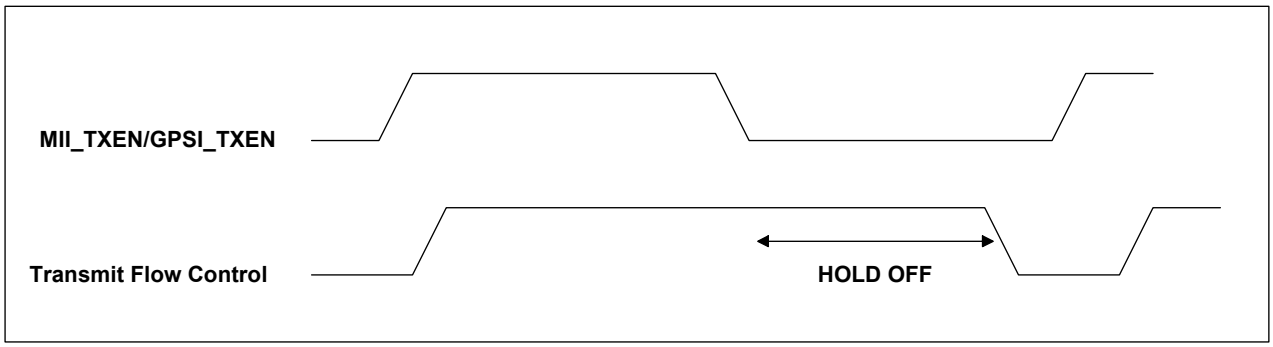
GPSI PHY Interface to INT51X1 (PHY Option)



3.4. Transmit Flow Control

The transmit flow control signal, **MII_CRS** (MII_GPSI_N set high) or **GPSI_TXBSY** (MII_GPSI_N set low), is used to signal the MII or GPSI host that the INT51X1 (PHY Option) has buffers available and is ready to receive a packet for subsequent transmission to the powerline. While transmit buffers are unavailable, the transmit flow contol signal is held high. The transmit flow control signal will go low whenever the INT51X1 (PHY Option) has a buffer available.
On host transmit, the INT51X1 (PHY Option) asserts the transmit flow control signal some time after MII_TXEN/GPSI_TXEN becomes active, and drops the transmit flow control signal after MII_TXEN/GPSI_TXEN goes inactive AND when the INT51X1 (PHY Option) is ready to receive another packet from the MII or GPSI host for transmission. When the transmit flow control signal falls, the host may assert MII_TXEN/GPSI_TXEN again if there is another packet to send. The transmit flow control signal can extend past the end of the packet by an arbitrary amount of time when the INT51X1 (PHY Option) internal TX buffers are full.

Transmit Flow Control Signal Timing Diagram



3.5. Frame Structure

The frame structure transmitted on the MII or GPSI interface is the following sequence of fields:

<interframe gap> <preamble> <SFD> <data><FCS>

The preamble (0x55555555555555), Start Frame Delimiter (SFD) (0xD5) and Frame Check Sequence (FCS) are stripped by the PowerPacket MAC on transmit from host (the preamble, SFD and FCS are not transmitted on the medium) and prepended by the PowerPacket MAC on receive to the host. The data field is assumed to follow the Ethernet format as defined in IEEE 802.3 including the 4-byte FCS field.

3.6. Configuration Registers

3.6.1. Register Access

The IEEE 802.3u mandated management data registers for control and status are accessible via the Management Data Interface (MDI). These registers are also accessible via the industry supported serial peripheral interface. The MDI Port will only respond to addresses 0xbXX000 when the XX field (MSBits of the MDI address) match the state of the MDI_ADRSEL1 and MDI_ADRSEL0 input signals. These registers can also be accessed from the SPI Slave port when the MDI_SPIS_N select line has been tied low to select the SPI Slave port.

3.6.2. Register Summary

Configuration Register Summary

Register Address MDI (Binary) XX matches MDI_ADRSEL1:0 inputs	Register Address SPI (Binary)	Register Name	MII Mandated
XX000 00000	00000	Control Register	X
XX000 00001	00001	Status Register	X

Register Address 0: Control Register – 2 bytes

Bit	Name	Description
15	Reset	When set TRUE, Control and Status registers are set to default states and full PHY and MAC reset processes are executed (data communication will be interrupted). TRUE value returned until reset process completes. The reset process completes within 0.5sec from assertion of Reset.
14	Loopback	When set TRUE, loopback process is entered (no transmission or reception on PLC medium). All transmitted data is looped back with a delay less than 5.12μsec. Resetting to FALSE (default) resumes normal operation.
13	Speed Selection	Set TRUE (100 MBS) when MII mode selected and FALSE (10 MBS) when GPSI selected by the MII_GPSI_N pin.
12	Auto-Negotiation Enable	Ignored and always FALSE (0).
11	Power Down	When set TRUE, all transmit and receive processing is disabled. When FALSE (default), resume normal operation.
10	Isolate	When set TRUE, all transmit and receive processing is disabled and high impedance is presented on MII_RXCLK/GPSI_RXCLK, MII_RX[3:0], MII_RX_ERR/GPSI_RXD, MII_RXDV/GPSI_TXBSY, MII_CRS/GPSI_RXEN, MII_COL/GPSI_COL and MII_TXCLK/GPSI_TXCLK. When FALSE (default), resume normal operation.
9	Restart Auto-Negotiation	Ignored and defaulted to FALSE

Bit	Name	Description
8	Duplex Mode	When in MII mode (MII_GPSI_N=1), Duplex Mode will always read FALSE (0) indicating half duplex. When in GPSI mode (MII_GPSI_N=0), Duplex Mode will always read TRUE (1) indicating full duplex.
7	Collision Test	When set TRUE, MII_COL/GPSI_COL is asserted within 5.12 μsec in response to assertion of MII_TXEN/GPSI_TXEN.
6:0	Reserved	Ignored and always 0.

Register Address 1: Status Register – 2 bytes

Bit	Name	Description
15	100BASE-T4	Returns FALSE.
14	100BASE-X Full Duplex	Returns FALSE.
13	100BASE-X Half Duplex	Returns TRUE when MII mode selected and FALSE when GPSI selected by the MII_GPSI_N pin.
12	10 Mbps Full Duplex	Returns FALSE when MII mode selected and TRUE when GPSI selected by the MII_GPSI_N pin.
11	10 Mbps Half Duplex	Returns FALSE
10:8	Reserved	Returns FALSE
7	Reserved	Returns FALSE
6	MF Preamble Suppression	Returns FALSE (not able to receive Management Data without preamble).
5	Auto-Negotiation Complete	Returns FALSE.
4	Remote Fault	Returns FALSE.
3	Auto-Negotiation Ability	Returns FALSE.
2	Link Status	Returns PL link validity, e.g. TRUE if link is recognized.
1	Jabber Detect	Returns FALSE.
0	Extended Capability	Returns FALSE (no extended register set exists).

3.6.3. SPI Slave Configuration Register Address

The SPI Slave port uses a sixteen bit field consisting of a 6-bit Command, a 5-bit reserved and a 5-bit address field to control access to the two configuration registers detailed above.

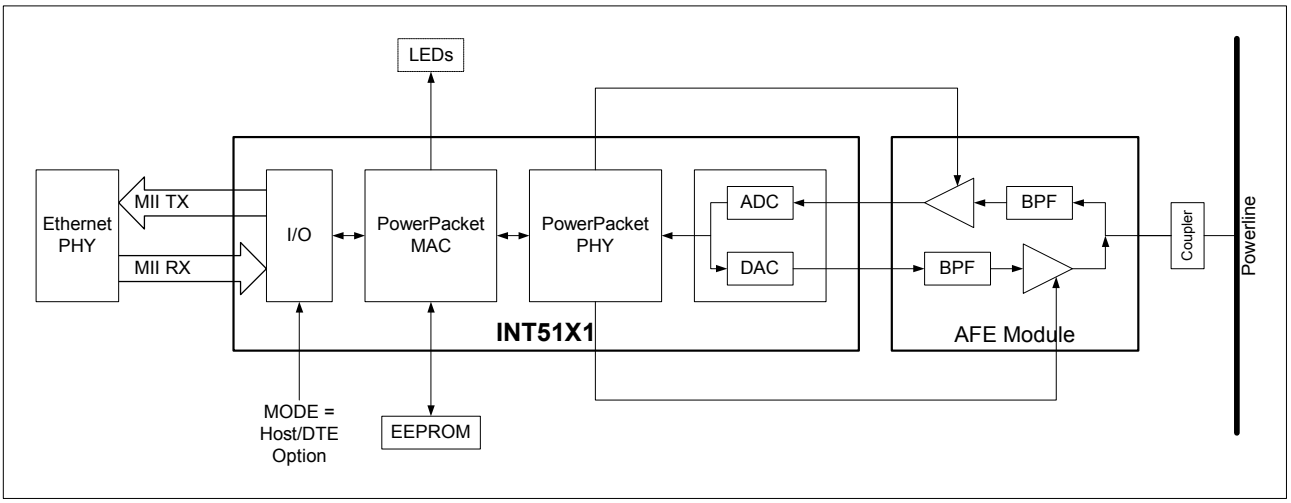
SPI Slave Command Summary

Register Function	Command Bit						Reserved Bit					Address Bit				
	5	4	3	2	1	0	4	3	2	1	0	4	3	2	1	0
Write Control Reg	L	L	L	L	H	L	H	L	L	L	L	L	L	L	L	L
Read Control Reg	L	L	L	L	H	H	H	L	L	L	L	L	L	L	L	L
Write Status Reg	L	L	L	L	H	L	H	L	L	L	L	L	L	L	L	H
Read Status Reg	L	L	L	L	H	H	H	L	L	L	L	L	L	L	L	H

4. Host/DTE Option

INT51X1 (Host/DTE Option): An MII Host/DTE interface (IEEE 802.3u 1995, Paragraph 22) for interconnection to an Ethernet PHY.

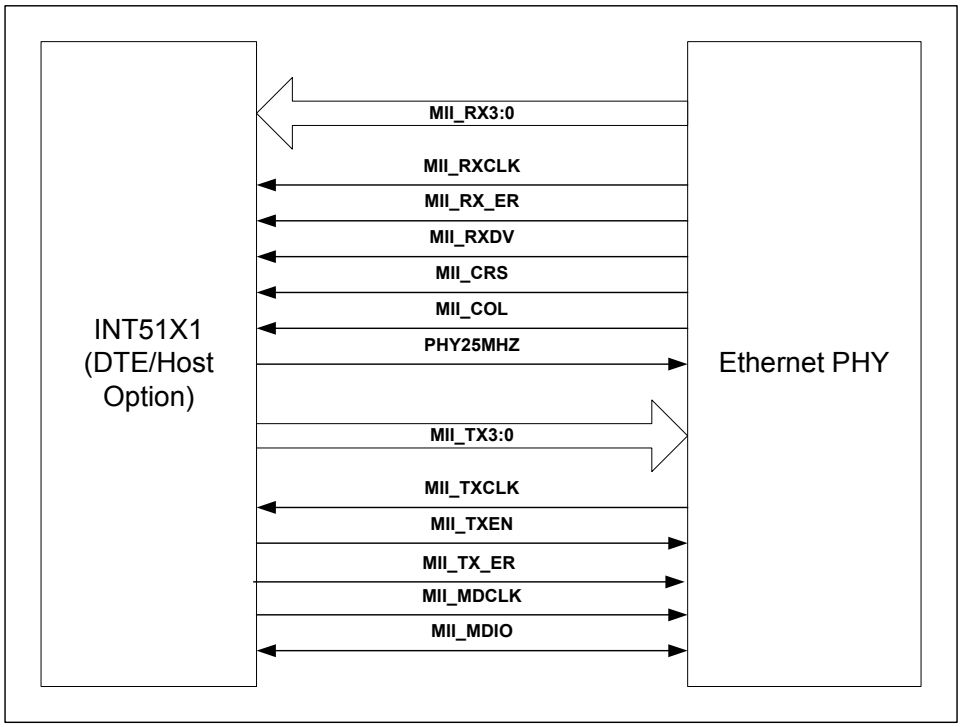
4.1. System Block Diagram



4.2. MII Host/DTE Interface

MII is an industry standard, multi vendor, interoperable interface between the MAC and PHY sub-layers. It provides a simple interconnection between the INT51X1 (Host/DTE Option) and Ethernet PHYs from a variety of sources. The MII interface consists of separate 4-bit data paths for transmit and receive data along with carrier sense and collision detection. Data is transferred between the MAC and PHY over each 4-bit data path synchronous with a clock signal supplied to the INT51X1 (Host/DTE Option) by the Ethernet PHY. The MII interface also provides a two-wire bi-directional serial management data interface. This interface provides access to the status and control registers in the Ethernet PHY. Further details of the MII can be found in the IEEE 802.3u Standard.

MII Interface to INT51X1 (Host/DTE Option)



4.3. Frame Structure

The frame structure transmitted on the MII is the following sequence of fields:

<interframe gap> <preamble> <SFD> <data><FCS>

The data field is assumed to follow the Ethernet format as defined in IEEE 802.3 including the 4-byte FCS field.

5. Reset Control

The INT51X1 (USB Option) and the INT51X1 (PHY Option) support a soft reset function. Soft reset starts when the host writes the MDI Control register reset bit to a one. Soft reset is complete when the INT51X1 clears the Control register reset bit. All logic in the INT51X1 (USB Option) except the USB block and the DAC/ADC clock generation logic will be initialized by a soft reset. All logic in the INT51X1 (PHY Option) except the DAC/ADC clock generation logic and the MII/GPSI clock generation logic will be initialized by a soft reset.

6. User Protocol Interface

6.1. HomePlug MAC Management

HomePlug MAC Management entries (MME) may appear in any frame processed by the INT51X1.

Frame Format

	Field	Length	Definition
	DA	6 octets	IEEE formated destination address
	SA	6 octets	IEEE formatted source address
HomePlug MAC Management Entries (MMEs)	METYPE	2 octets	0x887B (IEEE assigned Ethertype) The presence of the MAC Management Information field is indicated when the first two bytes following the SA of a frame has the value 0x887B.
	MCTRL	1 octet	MAC Control Field The 8-bit MAC Control field indicates the number of MAC data entries contained in the MAC Management Information field.
	MEHDR	1 octet	First MAC Management Entry Header
	MELEN	1 octet	First MAC Management Entry Length The MAC Entry Length field contains the length in octets of the MMENTRY field. If MMENTRY does not exist, MELEN is set to zero. This field provides for transparent extension of MAC management, without rendering older equipment obsolete. If a frame is received with an METYPE value that is not understood, the receiver can still properly parse the frame and process its contents, ignoring what it does not understand.
	MMENTRY	N octets	First MAC Management Entry Data
	• • •		
	MEHDR	1 octet	Last MAC Management Entry Header
	MELEN	1 octet	Last MAC Management Entry Length
	MMENTRY	N octets	Last MAC Management Entry
	Ethertype	2 octets	Optional Ethertype
	Data	N octets	Optional payload data

MAC Control Field (MCTRL)

Field	Bit Number	Bits	Definition
RSVD	7	1	Reserved.
NE	6-0	7	Number Of MAC Data Entries The 7-bit Number of MAC Entries field indicates the number of MAC data entries (defined as a MAC Entry Header and MAC Entry Data pair) following in the MAC Management Information Field.

MAC Entry Header Field (MEHDR)

Field	Bit Number	Bits	Definition
MEV	7-5	3	MAC Entry Version The 3-bit MAC Entry Version field indicates the version in use for interpretation of MAC Entries. Transmitter shall set to all zeros for this version, receiver shall decode and discard the entire MAC Management Information Field if MEV≠0b000.
METYPE	4-0	5	MAC Entry Type The 5-bit MAC Entry Type field defines the MAC entry command or request which follows. The combination of the METYPE and MDATA form a MAC entry.

The table below defines METYPE fields and the manner in which they are used by the MAC. The "M1 Interface" column indicates whether the METYPE appears on the M1 interface. The "Prepend to host MSDU" column indicates whether the METYPE is allowed to be inserted at the front of a host MSDU that is being processed for transmission by the MAC. "Only" in this column indicates that this METYPE is only used in conjunction with an MSDU.

NOTE: The M1 interface is defined as the "host" interface to the INT51X1. In the INT51X1 (USB Option), the host is the entity on the other side of the USB interface. In the INT51X1 (PHY Option), the host is the entity on the other side of the MII PHY interface (typically an ethernet controller or microprocessor). In the INT51X1 (Host/DTE Option), the host is any entity on the other side ot the MII Host/DTE interface (assuming the PHY is connected to an ethernet subnetwork, the host is any device on the ethernet subnetwork).

MAC Entry Type Field (METYPE)

METYPE Value	Interpretation	M1 Interface	Prepend to host MSDU
0 0000	Request Channel Estimation	No	Allowed
0 0001	Channel Estimation Response	No	Allowed
0 0010	Vendor Specific	Yes	Allowed
0 0011	Replace Bridge Address	No	Only
0 0100	Set Network Encryption Key	Yes	Allowed
0 0101	Multicast With Response	No	Only
0 0110	Confirm Network Encryption Key	Yes	Allowed
0 0111	Request Parameters and Statistics	Yes	Allowed
0 1000	Parameters and Statistics Response	Yes	Allowed
0 1001-0 1111	Reserved METYPE on transmit, skip entire layer management entry on receive	No	Allowed
1 0000-1 1000	Undefined manufacturer-specific METYPE space. Never transmitted on medium.	Only	No
1 1001	Set Local Parameters	Only	No
	Set Local Parameters Control	Only	No
	Set Local Parameters Response	Only	No
1 1010	Network Statistics	Only	No
	Network Statistics Extended	Only	No
1 1011	Reserved	Only	No
1 1100	Performance Statistics	Only	No
1 1101	Set Local Overrides	Only	No
	Set Local Overrides RAM & EEPROM	Only	No
1 1110	Bridging Characteristics (Network)	Only	No
	Bridging Characteristics (Local)	Only	No
1 1111	Set Transmit Characteristics	Only	No

In summary:

- MMEs with METYPE values of 0x00 to 0x0F are allowed on the powerline medium
- MMEs with METYPE values of 0x10 to 0x1F are not allowed on the powerline medium

- Frames containing MMEs with METYPE values of 0x00, 0x01, 0x03 and 0x05 will not appear in any frame passed to the host on the M1 interface
- Frames containing MMEs with METYPE values of 0x19 to 0x1F will not appear in any frame on the powerline
- The host must ensure that no frames containing MMEs with METYPE values of 0x10 to 0x18 appear on the M1 interface

6.1.1. MAC Management Entries (MMEs)

6.1.1.1. Request Channel Estimation (METYPE – 0x00)

Request Channel Estimation is a one-byte MME indicating the channel estimation version capability of the requestor, which causes the receiving station to return a Channel Estimation.

This MME is described for information only and will not appear on the host M1 interface.

Request Channel Estimation (METYPE – 0x00)

Field	Byte	Bit Number	Bits	Definition
CEV	0	7-4	4	Channel Estimation Version The 4-bit Channel Estimation Version field indicates the channel estimation version level capability of the station transmitting the request. CEV is set to all zeros for the INT51X1.
RSVD		3-0	4	Reserved on transmit, ignore on receive

6.1.1.2. Channel Estimation Response (METYPE – 0x01)

Channel Estimation Response is a variable length MME sent by a device after receiving a Channel Estimation Request MME. This sequence is part of the channel estimation control.

This MME is described for information only and will not appear on the host M1 interface.

Channel Estimation Response (METYPE – 0x01)

Field	Byte	Bit Number	Bits	Definition
CERV	0	7-4	4	Channel Estimation Response Version The 4-bit Channel Estimation Response Version field indicates the response version in use. CERV is set to all zeros for the INT51X1.
RSVD		3-0	4	Reserved on transmit, ignored on receive
	1	7-5	3	
RXTMI		4-0	5	Receive Tone Map Index The 5-bit Receive Tone Map Index field contains the value to be associated with the Source Address of the station returning the Channel Estimation Response. The station receiving this response inserts the Receive Tone Map Index value in the TMI field of the Start of Frame delimiter when transmitting to the responder.
VT[79-0]	2	7-0	8	Valid Tone Flags [7-0] Valid Tone Flags indicate whether a specific tone is valid (VT[x]=0b1) or invalid (VT[x]=0b0).
	3	7-0	8	Valid Tone Flags [15-8]
	4	7-0	8	Valid Tone Flags [23-16]
	5	7-0	8	Valid Tone Flags [31-24]
	6	7-0	8	Valid Tone Flags [39-32]
	7	7-0	8	Valid Tone Flags [47-40]
	8	7-0	8	Valid Tone Flags [55-48]
	9	7-0	8	Valid Tone Flags [63-56]
	10	7-0	8	Valid Tone Flags [71-64]
	11	7-0	8	Valid Tone Flags [79-72]

Field	Byte	Bit Number	Bits	Definition
RATE	12	7	1	FEC Rate The FEC Rate bit indicates whether the convolutional coding rate is ½ (RATE=0b0) or ¾ (RATE=0b1).
BP		6	1	Bridge Proxy Bridge Proxy indicates that the tone map is being proxied for the following DAs. NBDAS and BDAn only exist if BP=0b1.
MOD		5-4	2	Modulation Method 00: ROBO Modulation 01: DBPSK Modulation 10: DQPSK Modulation 11: Reserved on transmit, ignore on reception
VT[83-80]		3-0	4	Valid Tone Flags [83-80]
RSVD	13	7	1	Reserved on transmit, ignore on receive
NBDAS		6-0	7	Number Bridged Destination Addresses The Number Bridged Destination Addresses and Bridged Destination Addresses only exist if BP=0b1. NBDAS indicate the number of proxied DA, and BDAn contains the addresses. Up to 16 BDAs are included in the Channel Estimation Response for the INT51X1. NOTE: The INT51X1 (Host/DTE Option) will store up to 32 BDAs for use in its address filtering function.
BDA1	14-19	--	48	Bridged Destination Address #1
• • •				

6.1.1.3. Vendor Specific Parameters (METYPE – 0x02)

Vendor Specific field is a variable length MME that allows vendor specific extensions to the HomePlug 1.0.1 Specification. The first 3 bytes of the entry should be an IEEE assigned Organizationally Unique Identifier (OUI).

Vendor Specific Parameters Field (METYPE – 0x02)

Field	Byte	Bit Number	Bits	Definition
OUI	0	7-0	8	OUI [23-16]
	1	7-0	8	OUI [15-8]
	2	7-0	8	OUI [7-0]
Vendor Defined	3-255	--	--	Vendor Defined

6.1.1.4. Replace Bridge Address (METYPE – 0x03)

The Replace Bridge Address MME contains a 6-byte MAC Original Destination Address of a device which may be on another medium and accessed via a bridge and a 6-byte MAC Original Source Address of a device which may be on another medium and accessed via a bridge. The station receiving this MAC Entry reconstructs the original MSDU using the ODA and OSA contained in this entry. The ODA and OSA Fields (6 bytes each) are in IEEE 48-bit MAC address format.

This MME is described for information only and will not appear on the host M1 interface.

Replace Bridge Address Field (METYPE – 0x03)

Field	Byte	Bit Number	Bits	Definition
ODA[47-0]	0	7-0	8	Original Destination Address, first octet
	1	7-0	8	Original Destination Address, second octet
	2	7-0	8	Original Destination Address, third octet

Field	Byte	Bit Number	Bits	Definition
	3	7-0	8	Original Destination Address, fourth octet
	4	7-0	8	Original Destination Address, fifth octet
	5	7-0	8	Original Destination Address, sixth octet
OSA[47-0]	6	7-0	8	Original Source Address, first octet
	7	7-0	8	Original Source Address, second octet
	8	7-0	8	Original Source Address, third octet
	9	7-0	8	Original Source Address, fourth octet
	10	7-0	8	Original Source Address, fifth octet
	11	7-0	8	Original Source Address, sixth octet

6.1.1.5. Set Network Encryption Key (METYPE – 0x04)

When received from the powerline, this entry will only be parsed by the INT51X1 if the frame containing it was encrypted with the receiving devices's default encryption key and was successfully decrypted. The default encryption key cannot be set from the powerline.

Set Network Encryption Key Field (METYPE – 0x04)

Field	Byte	Bit Number	Bits	Definition
EKS	0	7-0	8	Encryption Key Select The one-byte EKS field is associated with the Network Encryption Key. Encrypted data transport uses the EKS value to indicate which NEK is to be used for decryption.
NEK	1	7-0	8	Network Encryption Key, first octet The 64-bit Network Encryption Key field contains the key that is to be stored locally in non-volatile storage and is to be used for subsequent encryption under control of EKS.
	2	7-0	8	Network Encryption Key, second octet
	3	7-0	8	Network Encryption Key, third octet
	4	7-0	8	Network Encryption Key, fourth octet
	5	7-0	8	Network Encryption Key, fifth octet
	6	7-0	8	Network Encryption Key, sixth octet
	7	7-0	8	Network Encryption Key, seventh octet
	8	7-0	8	Network Encryption Key, eight octet

NOTE: The network encryption key is saved and usable after receipt of the Set Network Encryption Key MME. If a device using an INT51X1 contains an EEPROM, the network encryption key is also automatically stored in a nonvolatile manner and reloaded after power cycling. The EEPROM is required for both the INT51X1 (USB Option) and INT51X1 (Host/DTE Option). However, it is optional for the INT51X1 (PHY Option). In the case of the INT51X1 (PHY Option), it is required that the host store the network encryption key in a nonvolatile manner and reload the network encryption key after power cycling (see Initialization below).

6.1.1.6. Multicast With Response (METYPE – 0x05)

Multicast With Response is a 6-byte MME containing the actual multicast destination address. The DA contained in the layer management MAC frame is the unicast proxy for the multicast and will generate an ACK/NACK/FAIL response if requested.

This MME is described for information only and will not appear on the host M1 interface.

6.1.1.7. Confirm Network Encryption Key (METYPE – 0x06)

The Confirm Network Encryption Key MME is transmitted in response to the proper reception and execution of a Set Network Encryption Key MME. This entry shall be encrypted with the Network Encryption Key received in the Set Network Encryption Key command causing the response. This is a zero-byte (null) entry and is indicated by the METYPE only. MELEN is set to zero.

The host of a powerline interface using either the INT51X1 (USB Option) or INT51X1 (PHY Option) is responsible for generating the appropriate Confirm Network Encryption Key MME. The INT51X1 (Host/DTE Option) will generate this MME automatically upon receipt of a valid Set Network Encryption Key MME.

6.1.1.8. Request Parameters and Statistics (METYPE – 0x07)

The Request Parameters and Statistics MME is a zero-byte (null) entry and results in the return of the Parameters and Statistics Response MME to the originator.

6.1.1.9. Parameters and Statistics Response (METYPE – 0x08)

Parameters and Statistics Response is a 22-byte MME containing various station specific parameters and traffic statistics useful for diagnostic purposes. All of the statistics counters are reset at power up and via host level write to zero. The counters roll over without indication.

Parameters and Statistics Response Field (METYPE – 0x08)

Field	Byte	Bit Number	Bits	Definition
TXACK[15-0]	0	7-0	8	Transmit ACK Counter [15-8] The 16-bit Transmit ACK Counter increments when an ACK is received after transmitting a PHY Frame with response expected.
	1	7-0	8	Transmit ACK Counter [7-0]
TXNACK[15-0]	2	7-0	8	Transmit NACK Counter [15-8] The 16-bit Transmit NACK Counter increments when a NACK is received after transmitting a PHY Frame with response expected.
	3	7-0	8	Transmit NACK Counter [7-0]
TXFAIL[15-0]	4	7-0	8	Transmit FAIL Counter [15-8] The 16-bit Transmit FAIL Counter increments when a FAIL is received after transmitting a PHY Frame with response expected.
	5	7-0	8	Transmit FAIL Counter [7-0]
TXCLOSS[15-0]	6	7-0	8	Transmit Contention Loss Counter [15-8] The 16-bit Transmit Contention Loss Counter increments when the station defers to another transmitting station with the same transmit priority during the Contention Window.
	7	7-0	8	Transmit Contention Loss Counter [7-0]
TXCOLL[15-0]	8	7-0	8	Transmit Collision Counter [15-8] The 16-bit Transmit Collision Counter increments when a Collision is inferred to have occurred, after transmitting a PHY frame for which a response is expected.
	9	7-0	8	Transmit Collision Counter [7-0]
TXCA3LAT[15-0]	10	7-0	8	Transmit CA3 Latency Counter [15-8] The 16-bit Transmit CA3 Latency Counter contains the cumulative total of number of milliseconds from receipt of a CA3 priority transmit request to successful transmit completion or transmit timeout. Subsequent Collisions do not affect this metric.
	11	7-0	8	Transmit CA3 Latency Counter [7-0]
TXCA2LAT[15-0]	12	7-0	8	Transmit CA2 Latency Counter [15-8] The 16-bit Transmit CA2 Latency Counter contains the cumulative total of number of milliseconds from receipt of a CA2 priority transmit request to successful transmit completion or transmit timeout. Subsequent Collisions do not affect this metric.

Field	Byte	Bit Number	Bits	Definition
	13	7-0	8	Transmit CA2 Latency Counter [7-0]
TXCA1LAT[15-0]	14	7-0	8	Transmit CA1 Latency Counter [15-8] The 16-bit Transmit CA1 Latency Counter contains the cumulative total of number of milliseconds from receipt of a CA1 priority transmit request to successful transmit completion or transmit timeout. Subsequent Collisions do not affect this metric.
	15	7-0	8	Transmit CA1 Latency Counter [7-0]
TXCA0LAT[15-0]	16	7-0	8	Transmit CA0 Latency Counter [15-8] The 16-bit Transmit CA0 Latency Counter contains the cumulative total of number of milliseconds from receipt of a CA0priority transmit request to successful transmit completion or transmit timeout. Subsequent Collisions do not affect this metric.
	17	7-0	8	Transmit CA0 Latency Counter [7-0]
RXBP40[31-0]	18	7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [31-24] The 32-bit Receive Cumulative Bytes per 40-symbol Packet Counter contains the cumulative total of number of bytes within a received 40-symbol packet for each validly received PHY frame. The number of bytes is based on the tone map and modulation characteristics.
	19	7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [23-16]
	20	7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [15-8]
	21	7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [7-0]

6.1.1.10. Set Local Parameters (METYPE – 0x19)

The Set Local Parameters family of MMEs are Intellon Private. Intellon Private is used to denote an MME that is Intellon unique and available for user activation. The frame containing these MMEs will not be transmitted to the medium.

Set Local Parameters Basic is a 6-byte MME used to set the MAC address of the local station and is compatible with the INT5130. The MA[47-0] is in IEEE 48-bit MAC address format. This MME is typically used when an EEPROM is not present (see Configuration EEPROM and Initialization below). Upon receipt of this MME, the INT51X1 will use the specified address unless another address was previously loaded either from EEPROM or previous Set Local Parameters family MME.

Set Local Parameters Basic (METYPE – 0x19)

Field	Byte	Bit Number	Bits	Definition
MA	0	7-0	8	MAC Address, first octet
	1	7-0	8	MAC Address, second octet
	2	7-0	8	MAC Address, third octet
	3	7-0	8	MAC Address, fourth octet
	4	7-0	8	MAC Address, fifth octet
	5	7-0	8	MAC Address, sixth octet

6.1.1.11. Network Statistics (METYPE – 0x1a)

The Network Statistics family of MMEs are Intellon Private. Intellon Private is used to denote an MME that is Intellon unique and available for user activation. The frame containing these MMEs will not be transmitted to the medium.

Network Statistics Basic is a 187-byte MME used to access network information from the local device including device ID and transmit statistics (40-symbol byte capacity, FAILs received, drops recorded and current destination MAC address) for each of the tone maps including the ROBO tone map and is compatible with the INT5130.

The BYTES40_ROBO and BYTES40_n (B_{40}) can be used to determine the current transmit data rate, in MHz, (R_{TX}) by using the following simple formula:

$$R_{TX} = \frac{B_{40}}{42}$$

Network Statistics Basic (METYPE – 0x1a)

Field	Byte	Bit Num	Bits	Definition
NETW_CTRL	0	7	1	Action Control: Frame from host: When TRUE from host, return basic network statistics. When FALSE from host, clear basic network statistics (all following values in frame are ignored by INT51X1). Frame from INT51X1: Always returns FALSE.
		6-0	7	IC_ID (read only) 0b0000000: INT5130A1 0b0000001: INT51X1 (USB Option) 0b0000010: INT51X1 (PHY Option) 0b0000011: INT51X1 (Host/DTE Option) 0b0000100: INT5130A2 0b0000101 – 0b1111111: Reserved
BYTES40_ROBO	1	7-0	8	Bytes in 40 symbols in ROBO [7-0] Represents the length, in bytes, that 40 symbols can carry based on the ROBO channel estimation.
	2	7-0	8	Bytes in 40 symbols in ROBO [15-8]
FAILS_ROBO	3	7-0	8	Fails Received in ROBO [7-0] Represents the number of FAIL responses received for segments transmitted in ROBO.
	4	7-0	8	Fails Received in ROBO [15-8]
DROPS_ROBO	5	7-0	8	Frame Drops in ROBO [7-0] Represents the number of frames dropped while attempting to transmit in ROBO.
	6	7-0	8	Frame Drops to in ROBO [15-8]
NETW_DA_1	7-12	--	48	Address of network DA #1 A value of 0x010000000000 indicates that the node does not exist and all remaining data for this address are invalid.
BYTES40_1	13	7-0	8	Bytes in 40 symbols for DA #1 [7-0] Represents the length, in bytes, that 40 symbols can carry based on the latest channel estimation results from DA #1.
	14	7-0	8	Bytes in 40 symbols for DA #1 [15-8]
FAILS_1	15	7-0	8	Fails Received from DA #1 [7-0] Represents the number of FAIL responses received from DA #1 for segments transmitted to DA #1.
	16	7-0	8	Fails Received from DA #1 [15-8]

Field	Byte	Bit Num	Bits	Definition
DROPS_1	17	7-0	8	Frame Drops to DA #1 [7-0] Represents the number of frames dropped while attempting to transmit to DA #1.
	18	7-0	8	Frame Drops to DA #1 [15-8]
• • •				
NETW_DA_15	175-180	--	48	Address of network DA #15 A value of 0x010000000000 indicates that the node does not exist and all remaining data for this address are invalid.
BYTES40_15	181	7-0	8	Bytes in 40 symbols for DA #15 [7-0] Represents the length, in bytes, that 40 symbols can carry based on the latest channel estimation results from DA #15.
	182	7-0	8	Bytes in 40 symbols for DA #15 [15-8]
FAILS_15	183	7-0	8	Fails Received from DA #15 [7-0] Represents the number of FAIL responses received from DA #15 for segments transmitted to DA #15.
	184	7-0	8	Fails Received from DA #15 [15-8]
DROPS_15	185	7-0	8	Frame Drops to DA #15 [7-0] Represents the number of frames dropped while attempting to transmit to DA #15.
	186	7-0	8	Frame Drops to DA #15 [15-8]

Network Statistics Extended is a 199-byte MME used to access the basic network information from the local device including device ID and transmit statistics (40-symbol byte capacity, FAILs received, drops recorded and current destination MAC address) for each of the tone maps including the ROBO tone map as well as accessing the states of the six transmit buffers in the INT51X1.

The TX buffer state fields reflect a snapshot of the buffers at the time of building the Network Statistics Extended MME—these fields cannot be cleared by the host.

Network Statistics Extended (METYPE – 0x1a)

Field	Byte	Bit Num	Bits	Definition
NETW_CTRL	0	7	1	Action Control: Frame from host: When TRUE from host, return extended network statistics. When FALSE from host, clear extended network statistics except for transmit buffer states (all following values in frame are ignored by INT51X1). Frame from INT51X1: Always returns TRUE.
		6-0	7	IC_ID (read only) 0b0000000: INT5130A1 0b0000001: INT51X1 (USB Option) 0b0000010: INT51X1 (PHY Option) 0b0000011: INT51X1 (Host/DTE Option) 0b0000100: INT5130A2 0b0000101 – 0b1111111: Reserved
BYTES40_ROBO	1	7-0	8	Bytes in 40 symbols in ROBO [7-0] Represents the length, in bytes, that 40 symbols can carry based on the ROBO channel estimation.
	2	7-0	8	Bytes in 40 symbols in ROBO [15-8]
FAILS_ROBO	3	7-0	8	Fails Received in ROBO [7-0] Represents the number of FAIL responses received for segments transmitted in ROBO.
	4	7-0	8	Fails Received in ROBO [15-8]
DROPS_ROBO	5	7-0	8	Frame Drops in ROBO [7-0] Represents the number of frames dropped while attempting to transmit in ROBO.
	6	7-0	8	Frame Drops to in ROBO [15-8]
NETW_DA_1	7-12	--	48	Address of network DA #1 A value of 0x010000000000 indicates that the node does not exist and all remaining data for this address are invalid.
BYTES40_1	13	7-0	8	Bytes in 40 symbols for DA #1 [7-0] Represents the length, in bytes, that 40 symbols can carry based on the latest channel estimation results from DA #1.
	14	7-0	8	Bytes in 40 symbols for DA #1 [15-8]
FAILS_1	15	7-0	8	Fails Received from DA #1 [7-0] Represents the number of FAIL responses received from DA #1 for segments transmitted to DA #1.
	16	7-0	8	Fails Received from DA #1 [15-8]
DROPS_1	17	7-0	8	Frame Drops to DA #1 [7-0] Represents the number of frames dropped while attempting to transmit to DA #1.
	18	7-0	8	Frame Drops to DA #1 [15-8]
• • •				
NETW_DA_15	175-180	--	48	Address of network DA #15 A value of 0x010000000000 indicates that the node does not exist and all remaining data for this address are invalid.
BYTES40_15	181	7-0	8	Bytes in 40 symbols for DA #15 [7-0] Represents the length, in bytes, that 40 symbols can carry based on the latest channel estimation results from DA #15.
	182	7-0	8	Bytes in 40 symbols for DA #15 [15-8]

Field	Byte	Bit Num	Bits	Definition
FAILS_15	183	7-0	8	Fails Received from DA #15 [7-0] Represents the number of FAIL responses received from DA #15 for segments transmitted to DA #15.
	184	7-0	8	Fails Received from DA #15 [15-8]
DROPS_15	185	7-0	8	Frame Drops to DA #15 [7-0] Represents the number of frames dropped while attempting to transmit to DA #15.
	186	7-0	8	Frame Drops to DA #15 [15-8]
TX_BFR_0_STATE	187	7	1	Buffer in use (1) or buffer available (0) If buffer not in use, all other fields should be ignored.
		6-5	2	Priority CA3: 11 CA2: 10 CA1: 01 CA0: 00
		4-0	5	MSDU length [11-7] Represents TX frame length excluding DA, SA, encryption Pad and ICV—Includes EKS, IV and MAC Layer Management.
	188	7-4	4	Sequence number [3-0]
		3-0	4	Transmit tone map index Maps to the 16 statistics occurring earlier in this MME.
• • •				
TX_BFR_5_STATE	197	7	1	Buffer in use (1) or buffer available (0) If buffer not in use, all other fields should be ignored.
		6-5	2	Priority CA3: 11 CA2: 10 CA1: 01 CA0: 00
		4-0	5	MSDU length [11-7] Represents TX frame length excluding DA, SA, encryption Pad and ICV—Includes EKS, IV and MAC Layer Management.
	198	7-4	4	Sequence number [3-0]
		3-0	4	Transmit tone map index Maps to the 16 statistics occurring earlier in this MME.

6.1.1.12. Performance Statistics (METYPE – 0x1c)

The Performance Statistics MME is Intellon Private. Intellon Private is used to denote a MAC entry that is Intellon unique and available for user activation. The frame containing this MME will not be transmitted to the medium.

Performance Statistics is a 123-byte MME, compatible with the INT5130, used to retrieve or clear information from the local device including delay, jitter, extended latencies, and extended parameters and statistics for increased precision (see Parameter and Statistics MME above).

Performance Statistics (METYPE – 0x1c)

Field	Byte	Bit Num	Bits	Definition
PERF_CTRL	0	7	1	When TRUE, return performance statistics, When FALSE, clear performance statistics (all values in the following bytes are ignored by INT51X1).
		6-0	7	Reserved
MAX_DELAY	1	7-0	8	Maximum Delay (in msec) [7-0] A statistic logged by the VoIP master node representing the total delay from initial downlink to final uplink. D_{MAX} is computed as follows: $$D_{MAX} = t_{RXFUL} - t_{TXDL}$$ where: t_{TXDL} is the time when the initial downlink frame was delivered from the master's host, and t_{RXFUL} is the time when the final uplink has been delivered to the master node.
	2	7-0	8	Maximum Delay [15-8]
MAX_DELAY_JITTER_CA3	3	7-0	8	Maximum Delay Jitter CA3 [7-0] Maximum delay jitter, J_{DMAX} (expressed in 1/16 msec), is a transmitter logged set of statistics (J_{DMAX} for each of CAP0, CAP1, CAP2 and CAP3 priorities) representing the mean deviation (smoothed absolute value) of the difference of delay latencies (L_D) for two consecutive frame transmissions (reference interarrival jitter definition in RFC1889, "RTP: A Transport Protocol for Real-Time Applications"). J_{DMAX} for unused priorities are set to zero. J_{DMAX} is computed as follows: $$_nJ_{DMAX} = {}_{n-1}J_{DMA} + \frac{\left|{}_nL_D - {}_{n-1}L_D\right| - {}_{n-1}J_{DMAX}}{16}$$ for $n = 1$ to the total number of frames transmitted, $_0J_{DMAX} = 0$, $_0L_D = 0$, and where: n is the transmitted frame number (ranging from 1 to the total number of frames transmitted) and $_nL_D$ is the delay latency for transmitted frame n.
	4	7-0	8	Maximum Delay Jitter CA3 [15-8]
MAX_DELAY_JITTER_CA2	5	7-0	8	Maximum Delay Jitter CA2 [7-0]—see definition above
	6	7-0	8	Maximum Delay Jitter CA2 [15-8]
MAX_DELAY_JITTER_CA1	7	7-0	8	Maximum Delay Jitter CA1 [7-0]—see definition above
	8	7-0	8	Maximum Delay Jitter CA1 [15-8]
MAX_DELAY_JITTER_CA0	9	7-0	8	Maximum Delay Jitter CA0 [7-0]—see definition above
	10	7-0	8	Maximum Delay Jitter CA0 [15-8]

Field	Byte	Bit Num	Bits	Definition
MAX_LATENCY_CA3	11	7-0	8	Maximum Latency CA3 (in msec) [7-0] A transmitter logged statistic representing the maximum latency L_{MAX} for unused priorities are set to zero. L_{MAX} is computed as follows: $${}_{n}L_{MAX} = MAX\left({}_{n}L, {}_{n-1}L_{MAX}\right)$$ for $n = 1$ to total number of frames transmitted, ${}_{0}L_{MAX} = 0$, and where: n is the transmitted frame number (ranging from 1 to the total number of frames transmitted) and ${}_{n}L$ is the delay latency for transmitted frame n.
	12	7-0	8	Maximum Latency CA3 [15-8]
MAX_LATENCY_CA2	13	7-0	8	Maximum Latency CA2 [7-0]—see definition above
	14	7-0	8	Maximum Latency CA2 [15-8]
MAX_LATENCY_CA1	15	7-0	8	Maximum Latency CA1 [7-0]—see definition above
	16	7-0	8	Maximum Latency CA1 [15-8]
MAX_LATENCY_CA0	17	7-0	8	Maximum Latency CA0 [7-0]—see definition above
	18	7-0	8	Maximum Latency CA0 [15-8]
LATENCY_BIN1_CA0	19	7-0	8	Latency Bin #1 CA0 [7-0]—latencies between 0 and 1 msec for CA0
	20	7-0	8	Latency Bin #1 CA0[15-8]
LATENCY_BIN2_CA0	21	7-0	8	Latency Bin #2 CA0 [7-0]—latencies between 1 and 2 msec for CA0
	22	7-0	8	Latency Bin #2 CA0 [15-8]
LATENCY_BIN3_CA0	23	7-0	8	Latency Bin #3 CA0 [7-0]—latencies between 2 and 5 msec for CA0
	24	7-0	8	Latency Bin #3 CA0 [15-8]
LATENCY_BIN4_CA0	25	7-0	8	Latency Bin #4 CA0 [7-0]—latencies between 5 and 10 msec for CA0
	26	7-0	8	Latency Bin #4 CA0 [15-8]
LATENCY_BIN5_CA0	27	7-0	8	Latency Bin #5 CA0 [7-0]—latencies between 10 and 20 msec for CA0
	28	7-0	8	Latency Bin #5 CA0 [15-8]
LATENCY_BIN6_CA0	29	7-0	8	Latency Bin #6 CA0 [7-0]—latencies between 20 and 40 msec for CA0
	30	7-0	8	Latency Bin #6 CA0 [15-8]
LATENCY_BIN7_CA0	31	7-0	8	Latency Bin #7 CA0 [7-0]—latencies between 40 and 80 msec for CA0
	32	7-0	8	Latency Bin #7 CA0 [15-8]
LATENCY_BIN8_CA0	33	7-0	8	Latency Bin #8 CA0 [7-0]—latencies between 80 and 160 msec for CA0
	34	7-0	8	Latency Bin #8 CA0 [15-8]
LATENCY_BIN9_CA0	35	7-0	8	Latency Bin #9 CA0 [7-0]—latencies between 160 and 320 msec for CA0
	36	7-0	8	Latency Bin #9 CA0 [15-8]
LATENCY_BIN10_CA0	37	7-0	8	Latency Bin #10 CA0 [7-0]—latencies greater than 320 msec for CA0
	38	7-0	8	Latency Bin #10 CA0 [15-8]
LATENCY_BIN1_CA1 – LATENCY_BIN10_CA1	39 – 58	--	--	See bin definitions above
LATENCY_BIN1_CA2 – LATENCY_BIN10_CA2	59 – 78	--	--	See bin definitions above
LATENCY_BIN1_CA3 – LATENCY_BIN10_CA3	79 – 98	--	--	See bin definitions above
RST_CNT	99 –	7-0	8	Restart Counter [7-0]

Field	Byte	Bit Num	Bits	Definition
	100	7-0	8	Restart Counter [15-8]
TXACK [31-16]	101-102	7-0	8	Transmit ACK Counter [23-16]
		7-0	8	Transmit ACK Counter [31-24]
TXNACK [31-16]	103-104	7-0	8	Transmit NACK Counter [23-16]
		7-0	8	Transmit NACK Counter [31-24]
TXFAIL [31-16]	105-106	7-0	8	Transmit FAIL Counter [23-16]
		7-0	8	Transmit FAIL Counter [31-24]
TXCOLL [31-16]	107-108	7-0	8	Transmit Collision Counter [23-16]
		7-0	8	Transmit Collision Counter [31-24]
TXCLOSS [31-16]	109-110	7-0	8	Transmit Contention Loss Counter [23-16]
		7-0	8	Transmit Contention Loss Counter [31-24]
TXCA3LAT [31-16]	111-112	7-0	8	Transmit CA3 Latency Counter [23-16]
		7-0	8	Transmit CA3 Latency Counter [31-24]
TXCA2LAT [31-16]	113-114	7-0	8	Transmit CA2 Latency Counter [23-16]
		7-0	8	Transmit CA2 Latency Counter [31-24]
TXCA1LAT [31-16]	115-116	7-0	8	Transmit CA1 Latency Counter [23-16]
		7-0	8	Transmit CA1 Latency Counter [31-24]
TXCA0LAT [31-16]	117-118	7-0	8	Transmit CA0 Latency Counter [23-16]
		7-0	8	Transmit CA0 Latency Counter [31-24]
RXBP40 [63-32]	119-122	7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [39-32]
		7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [47-40]
		7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [55-48]
		7-0	8	Receive Cumulative Bytes per 40-symbol Packet Counter [63-56]

6.1.1.13. Set Local Overrides (METYPE – 0x1d)

The Set Local Overrides family of MMEs are Intellon Private. Intellon Private is used to denote a MAC entry that is Intellon unique and available for user activation. The frame containing these MMEs will not be transmitted to the medium.

The Set Local Overrides Basic MME is compatible with the INT5130. Set Local Overrides Basic is a 14-byte MME which updates run-time variables only including maximum transmit timers, maximum receive timers, aging timers, fail timers, contention free timers and VLAN priority mappings to HomePlug priorities.

Set Local Overrides Basic (METYPE – 0x1d)

Field	Byte	Bit Number	Bits	Definition
MAXC3TMR	0	7-0	8	Maximum CAP 3 Transmit Timer [15-8] Default is 8 msec.
	1	7-0	8	Maximum CAP 3 Transmit Timer [7-0]
MAXNCFTMR	2	7-0	8	Maximum Non-Contention-Free Transmit Timer [15-8] Default is 1 sec.
	3	7-0	8	Maximum Non-Contention-Free Transmit Timer [7-0]
MAXRXTMR	4	7-0	8	Maximum Receive Reassembly Timer [15-8] Default is 1 sec.
	5	7-0	8	Maximum Receive Reassembly Timer [7-0]
ESTAGETMR	6	7-0	8	Tone Map Estimation Aging Timer (ms) [15-8] Default is 5 sec. Bit 15 must be set to zero.
	7	7-0	8	Tone Map Estimation Aging Timer [7-0]

Field	Byte	Bit Number	Bits	Definition
FAILTMR	8	7-0	8	Fail Resend Timer [15-8] Default is 10 msec.
	9	7-0	8	Fail Resend Timer [7-0]
CFFRMTMR	10	7-0	8	Contention-Free Frame Timer [15-8] Default is 30 msec.
	11	7-0	8	Contention-Free Frame Timer [7-0]
VLAN_PRIO7	12	7-6	2	VLAN Tag Priority 7 maps to CAP 0bXX Default is CAP3.
VLAN_PRIO6		5-4	2	VLAN Tag Priority 6 maps to CAP 0bXX Default is CAP3.
VLAN_PRIO5		3-2	2	VLAN Tag Priority 5 maps to CAP 0bXX Default is CAP2.
VLAN_PRIO4		1-0	2	VLAN Tag Priority 4 maps to CAP 0bXX Default is CAP2.
VLAN_PRIO3	13	7-6	2	VLAN Tag Priority 3 maps to CAP 0bXX Default is CAP1.
VLAN_PRIO2		5-4	2	VLAN Tag Priority 2 maps to CAP 0bXX Default is CAP1.
VLAN_PRIO1		3-2	2	VLAN Tag Priority 1 maps to CAP 0bXX Default is CAP0.
VLAN_PRIO0		1-0	2	VLAN Tag Priority 0 maps to CAP 0bXX Default is CAP0.

Set Local Overrides RAM & EEPROM is a 20-byte MME which updates both run-time (RAM) variables and EEPROM variables each time this entry is processed by the INT51X1. Variables include maximum transmit timers, maximum receive timers, aging timers, fail timers and VLAN priority mappings to HomePlug priorities.

Set Local Overrides RAM & EEPROM (METYPE – 0x1d)

Field	Byte	Bit Number	Bits	Definition
MAXC3TXTMR	0	7-0	8	Maximum CAP 3 Transmit Timer (ms) [15-8] Default is 8 msec.
	1	7-0	8	Maximum CAP 3 Transmit Timer [7-0]
MAXC2TXTMR	2	7-0	8	Maximum CAP 2 Transmit Timer (ms) [15-8] Default is 250 ms.
	3	7-0	8	Maximum CAP 2 Transmit Timer [7-0]
MAXC1_0TXTMR	4	7-0	8	Maximum CAP 1 & CAP 0 Transmit Timer (ms) [15-8] Default is 1 sec.
	5	7-0	8	Maximum CAP 1 & CAP 0 Transmit Timer [7-0]
MAXC3RXTMR	6	7-0	8	Maximum CAP3 Receive Reassembly Timer (ms) [15-8] Default is 20 msec.
	7	7-0	8	Maximum CAP3 Receive Reassembly Timer [7-0]

Field	Byte	Bit Number	Bits	Definition
MAXC2RXTMR	8	7-0	8	Maximum CAP2 Receive Reassembly Timer (ms) [15-8] Default is 250 ms.
	9	7-0	8	Maximum CAP2 Receive Reassembly Timer [7-0]
MAXC1_0RXTMR	10	7-0	8	Maximum CAP 1 & CAP 0 Receive Reassembly Timer (ms) [15-8] Default is 1 sec.
	11	7-0	8	Maximum CAP 1 & CAP 0 Receive Reassembly Timer [7-0]
ESTAGETMR	12	7-0	8	Tone Map Estimation Aging Timer (ms) [15-8] Default is 5 sec. Bit 15 must be set to zero.
	13	7-0	8	Tone Map Estimation Aging Timer [7-0]
BRIDGELISTTMR	14	7-6	2	Bridge List Aging Timer (≈sec) [15-14] (most significant 2 bits ignored) Default is 0x0125 ≈ 5 minutes Max Value 0x3FFF ≈ 4.5 hours Min Value 0x000a ≈ 10 sec (values below 10 will be rounded up to 10) See Optimizing the Bridge List Aging Timer below.
		5-0	6	Bridged List Aging Timer [13-8]
	15	7-0	8	Bridged List Aging Timer [7-0]
FAILTMR	16	7-0	8	Fail Resend Timer (ms) [15-8] Default is 10 msec.
	17	7-0	8	Fail Resend Timer [7-0]
VLAN_PRIO7	18	7-6	2	VLAN Tag Priority 7 maps to CAP 0bXX Default is CAP3.
VLAN_PRIO6		5-4	2	VLAN Tag Priority 6 maps to CAP 0bXX Default is CAP3.
VLAN_PRIO5		3-2	2	VLAN Tag Priority 5 maps to CAP 0bXX Default is CAP2.
VLAN_PRIO4		1-0	2	VLAN Tag Priority 4 maps to CAP 0bXX Default is CAP2.
VLAN_PRIO3	19	7-6	2	VLAN Tag Priority 3 maps to CAP 0bXX Default is CAP1.
VLAN_PRIO2		5-4	2	VLAN Tag Priority 2 maps to CAP 0bXX Default is CAP1.
VLAN_PRIO1		3-2	2	VLAN Tag Priority 1 maps to CAP 0bXX Default is CAP0.
VLAN_PRIO0		1-04	2	VLAN Tag Priority 0 maps to CAP 0bXX Default is CAP0.

6.1.1.14. Bridging Characteristics (METYPE – 0x1e)

The Bridging Characteristics family of MMEs are Intellon Private. Intellon Private is used to denote a MAC entry that is Intellon unique and available for user activation. The frame containing these MMEs will not be transmitted to the medium.

Bridging Characteristics Network and Bridging Characteristics Local are variable-length MMEs, compatible with the INT5130, used to retrieve information on the local device's view of the bridges on the powerline network and the local device's list of addresses for which it is acting as a bridge, respectively. These MMEs should occur only once per frame for proper execution by the INT51X1.

Two types of bridge tables are kept by the INT51X1. Bridging Characteristics Network information refers to the table of bridges learned through HomePlug's bridge reporting process (part of the automatic channel estimation process) and the destination addresses that can be reached through these bridges. Bridging Characteristics Local information refers to the list of addresses learned by an INT51X1 that is serving as a bridge.

The INT51X1 can support, with active tone maps, up to 15 bridges. A bridge can provide bridging services for a maximum of 16 devices. The aggregate total number of devices for which bridging services can be provided is 64. This allows great flexibility in network topology—four bridges can bridge for 16 devices each (64 aggregate), 15 bridges can bridge for 4 devices each (60 aggregate), etc.

Bridge tables are aged based on the BRIDGELISTTMR (see Set Local Overrides above).

Bridging Characteristics Network (greatest length MME shown) (METYPE – 0x1e)

Field	Byte	Bit Number	Bits	Definition
BRIDGE_CTRL	0	7	1	Local (0) or Network Bridge (1) information
		6	1	From host: Return bridging characteristics (1) or set bridging characteristics (0)
		5-4	2	Reserved
		3-0	4	First Bridge Number - bridges 0 –14 Each MME allows access to two bridges out of a possible 15, therefore, 8 MMEs are required to access the entire bridge table. When setting bridging characteristics and First Bridge number is zero, the entire bridge table is cleared before the following values are set. If the First Bridge number is non-zero, only the 1 or 2 bridge entries are set—no clearing occurs.
BRIDGE_1_DA	1-6	--	48	Address of bridge #1 If 0x010000000000 returned, bridge is not known to exist. If set by host to 0x000000000000, the rest of MME (including both bridge entries) is ignored.
BP1_DAS	7	7-0	8	Number of bridge #1 proxied DA's supported (maximum is 16)
BP1_BDA1	8-13	--	48	Proxied Bridge #1 Bridged Destination Address #1
• • •				
BP1_BDA16	98-103	--	48	Proxied Bridge #1 Bridged Destination Address #16
BRIDGE_2_DA	104-109	--	48	Address of bridge #2 If 0x010000000000 returned, bridge is not known to exist. If set by host to 0x000000000000, the rest of MME (the 2nd bridge entry) is ignored.
BP2_DAS	110	7-0	8	Number of bridge #2 proxied DA's supported (maximum is 16)
BP2_BDA1	111-116	--	48	Proxied Bridge #2 Bridged Destination Address #1

Field	Byte	Bit Number	Bits	Definition
• • •				
BP2_BDA16	201-206	--	48	Proxied Bridge #2 Bridged Destination Address #16

Bridging Characteristics Local (greatest length MME shown) (METYPE – 0x1e)

Field	Byte	Bit Number	Bits	Definition
BRIDGE_CTRL	0	7	1	Local (0) or Network Bridge (1) Information
		6	1	From host: Return bridging characteristics (1) or set bridging characteristics (0)
		5-0	6	Reserved
HPROX_DAS	1	7-0	8	Number of host proxied DA's supported by the bridge application (maximum is 16)
HPBDA1	2-7	--	48	Host Proxied Bridged Destination Address #1
• • •				
HPBDA16	92-97	--	48	Host Proxied Bridged Destination Address #16

6.1.1.15. Set Transmit Characteristics (METYPE – 0x1f)

The Set Transmit Characteristics MME is Intellon Private. Intellon Private is used to denote a MAC entry that is Intellon unique and available for user activation. The frame containing this MME will not be transmitted to the medium.

Set Transmit Characteristics is a 3-byte MME compatible with the INT5130. All run-time transmit characteristics persist until updated by the next Set Transmit Characteristics MME. The EEPROM data is updated only if NO_EE_SAVE is FALSE.

Set Transmit Characteristics (METYPE – 0x1f)

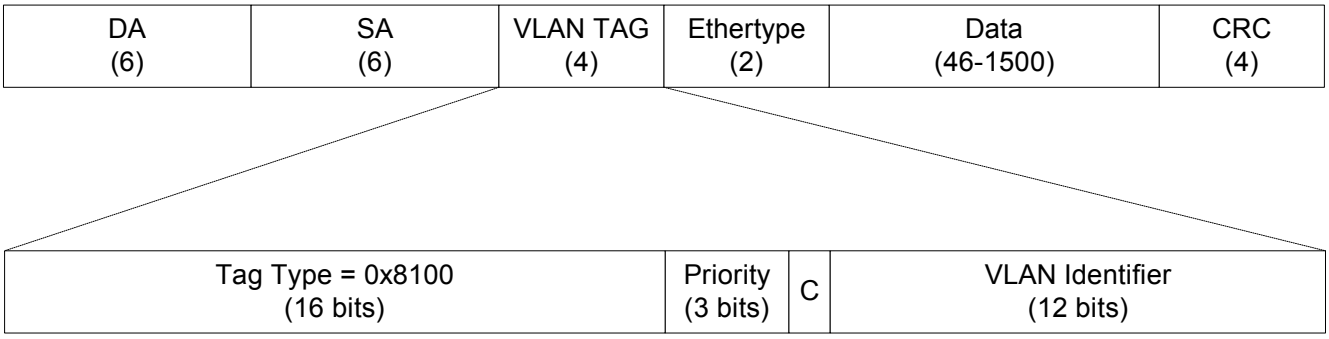
Field	Byte	Bit Num	Bits	Definition
LCO	0	7	1	Local Consumption Only Do not transmit subsequent frames to medium if LCO=0b1.
ENCF		6	1	Encryption Flag Encrypt subsequent frames if ENCF=0b1
TXPRIO		5-4	2	Transmit Priority Transmit subsequent frames with priority CA3, CA2, CA1 or CA0 (11, 10, 01 or 00)
RESPEXP		3	1	Response Expected Mark subsequent frames to receive response (ACK, NACK, FAIL) if RESPEXP=0b1
TX_CONT_FREE		2	1	Transmit Contention Free Mark subsequently transmitted frames as contention free if TX_CONT_FREE=0b1
CF_PRIO		1	1	Contention Free Transmit Override Priority Transmit subsequent contention free frames with priority set to CA2 (0b1) or set to CA3 (0b0).
RSVD		0	1	Reserved

Field	Byte	Bit Num	Bits	Definition
RETRY_CTRL	1	7-6	2	Retry Control Transmit subsequent frames with no retries (00), one retry only (01) or normal retries based on specification (10). Value of (11) is reserved.
RSVD		5-4	2	Reserved
NO_DFLT_ENC_RX		3	1	Disable Default Encryption Receive If TRUE (0b1) received frames will not be processed if the frame was encrypted with the default encryption key (EKS = 0).
NO_UNENC_RX		2	1	Disable Unencrypted Receive If TRUE (0b1) received frames will not be processed if the frames was not encrypted.
BACKPRESSURE		1	1	INT51X1 (Host/DTE Option) Enable Backpressure If TRUE (0b1), the INT51X1 (Host/DTE Option) will exert backpressure to the Ethernet network by generating “Jam Packets.”
NO_EE_SAVE		0	1	Disable EEPROM Save If TRUE (0b1) the data in this entry will not be saved to the EEPROM.
TXEKS	2	7-0	8	EKS to be used for encryption if ENCF=0b1

6.2. VLAN Tagging Support

A VLAN tag is an IEEE optional 4 Byte field inserted into a Ethernet frame between the SA and Ethertype fields. This tag can be used as a frame-specific means of setting priority. Setting the priority by VLAN tag only affects the specific frame containing the VLAN tag—untagged frames are transmitted using the priority set by the Set Transmit Characteristics MME. If MMEs are included in a frame with a VLAN tag, the MMEs must appear after the VLAN tag.

VLAN Tag Structure



7. Initialization and EEPROM

7.1. Initialization

The INT51X1 (USB Option) and INT51X1 (Host/DTE Option) are required to be initialized by the configuration EEPROM. The INT51X1 (PHY Option) is initialized either by the configuration EEPROM or by receiving a specific sequence of MAC Management entries (in a single frame or multiple frames) conveyed from its MII/GPSI host. An example of the single frame initialization sequence is depicted below. The initialization sequence of MAC Management entries must occur prior to the INT51X1 (PHY Option) device's ability to transmit or receive frames on the powerline.

Single Initialization Sequence Frame

Field	Length	Definition
DA	6 Bytes	Destination Address Set to 0xFF FF FF FF FF FF The universal broadcast address.
SA	6 Bytes	Source Address Set to 0xXX XX XX XX XX XX X is the 48-bit local MAC address.
Ethertype	2 bytes	Ethertype Set to 0x887B (assigned to Intellon Corporation by IEEE)
MCTRL	1 byte	MAC Control Field Set to 0x05 Five MMEs follow.
		Set Local Parameters MME
MEHDR	1 byte	Set to 0x19 Set Local Parameters MME.
MELEN	1 byte	Set to 0x06 Six bytes of Entry Data follow.
MMENTRY	6 bytes	Set to 0xXX XX XX XX XX XX X is the 48-bit local MAC address retrieved/determined by the host.
		Set Network Encryption Key MME (default key)
MEHDR	1 byte	Set to 0x04 Set Network Encryption Key MME.
MELEN	1 byte	Set to 0x09 Nine bytes of Entry Data follow.
MMENTRY	1 byte	Set to 0x00 0x00 is used as the default Encryption Key Select (EKS) value as defined in the HomePlug 1.0.1 Specification.
MMENTRY	8 bytes	Set to 0xDD DD DD DD DD DD DD DD User determined default Encryption Key.
		Set Network Encryption Key MME (network key)

Field	Length	Definition
MEHDR	1 byte	Set to 0x04 Set Network Encryption Key MME.
MELEN	1 byte	Set to 0x09 Nine bytes of Entry Data follow.
MMENTRY	1 byte	Set to 0x01 0x01 is used as the network Encryption Key Select (EKS) value as defined in the HomePlug 1.0.1 Specification.
MMENTRY	8 bytes	Set to 0xNN NN NN NN NN NN NN NN User determined network Encryption Key.
		Set Transmit Characteristics MME
MEHDR	1 byte	Set to 0x1F Set Transmit Characteristics MME.
MELEN	1 byte	Set to 0x03 Three bytes of Entry Data follow.
LCO	1bit	Set to 0b0 Subsequent frames are NOT for local consumption only and will be sent over the powerline medium.
ENCF	1bit	Set to 0b1 Subsequent frames will be encrypted
TXPRIO	2 bits	Set to 0b01 Subsequent frames will be transmitted with priority CA1.
RESPEXP	1bit	Set to 0b1 Subsequent frames will be marked to request receive response.
TX_CONT_FREE	1bit	Set to 0b0 Subsequent frames will NOT be sent contention free.
CF_PRIO	1 bit	Set to 0b0 Subsequent contention free frames will be transmitted at priority CA3.
RSVD	1 bit	Set to 0b0 Reserved.
RETRY_CTRL	2 bits	Set to 0b10 Subsequent frames are transmitted with normal retries based on the HomePlug 1.0.1 Specification
RSVD	2 bits	RESERVED Must be set to 0b00
NO_DFLT_ENC_RX	1bit	Set to 0b0 The device will process received frames encrypted with the default encryption key (EKS=0)
NO_UNENC_RX	1bit	Set to 0b1 Received frames must be encrypted to be processed.
BACKPRESSURE	1bit	Set to 0b1 The INT51X1 (Host/DTE Option) will send “Jam Packets” to exert backpressure on the Ethernet host network.

Field	Length	Definition
NO_EE_SAVE	1bit	Set to 0b0 These settings will be saved to EEPROM, if present. (It is recommended that this setting be used for initialization only.)
TXEKS	1 byte	Set to 0x01 EKS to be used for encryption if ENCF = 0b1. 0x00 is defined as the default key select and 0x01 is defined as the network key select as specified by the HomePlug 1.0.1 Specification.
		Set Local Overrides RAM & EEPROM MME
MEHDR	1 byte	Set to 0x1D Set Local Overrides RAM & EEPROM MME.
MELEN	1 byte	Set to 0x14 Twenty bytes of Entry Data follow.
MAXC3TXTMR	1 byte	Set to 0x00 Maximum CAP 3 Transmit Timer value of 8 msec.
	1 byte	Set to 0x08
MAXC2TXTMR	1 byte	Set to 0x00 Maximum CAP 2 Transmit Timer value of 250 msec.
	1 byte	Set to 0xFA
MAXC1_0TXTMR	1 byte	Set to 0x03 Maximum CAP 1 & CAP 0 Transmit Timer value of 1 sec.
	1 byte	Set to 0xE8
MAXC3RXTMR	1 byte	Set to 0x00 Maximum CAP3 Receive Reassembly Timer value of 20 msec.
	1 byte	Set to 0x14
MAXC2RXTMR	1 byte	Set to 0x00 Maximum CAP2 Receive Reassembly Timer value of 250 msec.
	1 byte	Set to 0xFA
MAXC1_0RXTMR	1 byte	Set to 0x03 Maximum CAP 1 & CAP 0 Receive Reassembly Timer value of 1 sec.
	1 byte	Set to 0xE8
ESTAGETMR	1 byte	Set to 0x13 Tone Map Estimation Aging Timer value of 5 secs.
	1 byte	Set to 0x88
BRIDGELISTTMR	1 byte	Set to 0x04 Bridge List Aging Timer value of 20 mins (0x0125 for 5 mins). See Optimizing the Bridge List Aging Timer below.
	1 byte	Set to 0x94
FAILTMR	1 byte	Set to 0x00 Fail Resend Timer value of 10 msec.
	1 byte	Set to 0x0A
VLAN_PRIO7	2 bits	Set to 0b11 VLAN Tag Priority 7 maps to CAP3
VLAN_PRIO6	2 bits	Set to 0b11 VLAN Tag Priority 6 maps to CAP3

Field	Length	Definition
VLAN_PRIO5	2 bits	Set to 0b10 VLAN Tag Priority 5 maps to CAP2
VLAN_PRIO4	2 bits	Set to 0b10 VLAN Tag Priority 4 maps to CAP2
VLAN_PRIO3	2 bits	Set to 0b10 VLAN Tag Priority 3 maps to CAP1
VLAN_PRIO2	2 bits	Set to 0b10 VLAN Tag Priority 2 maps to CAP1
VLAN_PRIO1	2 bits	Set to 0b00 VLAN Tag Priority 1 maps to CAP0
VLAN_PRIO0	2 bits	Set to 0b00 VLAN Tag Priority 0 maps to CAP0
FCS	4 Bytes	Frame Check Sequence field as described in the IEEE Std. 802.3. The external MAC controller normally generates this field.

7.2. Configuration EEPROM

When optioned for INT51X1 (USB Option) or INT51X1 (Host/DTE Option), the configuration EEPROM is required to store and maintain the MAC address and default encryption key. When optioned for INT51X1 (PHY Option), the configuration EEPROM is optional (see Initialization below if EEPROM is not present). The EEPROM must be Atmel AT93C46, programmed in 8-bit mode, or equivalent.

EEPROM Configuration

Field	Byte Addr	Bit Number	Bits	Definition	Defaults
Vcode[15-0]	0	7-0	8	Validity Code [15-8] (0x77 = Valid)	0x77
	1	7-0	8	Validity Code [7-0] (0x77 = Valid)	0x77
MA[47-0]	2	7-0	8	MAC Address, first octet	User Determined
	3	7-0	8	MAC Address, second octet	
	4	7-0	8	MAC Address, third octet	
	5	7-0	8	MAC Address, fourth octet	
	6	7-0	8	MAC Address, fifth octet	
	7	7-0	8	MAC Address, sixth octet	
DEK[63-0]	8	7-0	8	Default Encryption Key, first octet	
	9	7-0	8	Default Encryption Key, second octet	
	10	7-0	8	Default Encryption Key, third octet	
	11	7-0	8	Default Encryption Key, fourth octet	
	12	7-0	8	Default Encryption Key, fifth octet	
	13	7-0	8	Default Encryption Key, sixth octet	
	14	7-0	8	Default Encryption Key, seventh octet	
	15	7-0	8	Default Encryption Key, eight octet	
EKS	16	7-0	8	Encryption Key Select	0x01
NEK[63-0]	17	7-0	8	Network Encryption Key, first octet	User Determined
	18	7-0	8	Network Encryption Key, second octet	
	19	7-0	8	Network Encryption Key, third octet	
	20	7-0	8	Network Encryption Key, fourth octet	
	21	7-0	8	Network Encryption Key, fifth octet	
	22	7-0	8	Network Encryption Key, sixth octet	
	23	7-0	8	Network Encryption Key, seventh octet	
	24	7-0	8	Network Encryption Key, eight octet	
LCO	25	7	1	Local Consumption Only[1]	0b0

Field	Byte Addr	Bit Number	Bits	Definition	Defaults
ENCF		6	1	Encryption Flag[1]	0b1
TXPRIO		5-4	2	Transmit Priority[1]	0b01
RESPEXP		3	1	Response Expected[1]	0b1
TX_CONT_FREE		2	1	Transmit Contention Free[1]	0b0
CF_PRIO		1	1	Contention Free Transmit Override Priority[1]	0b0
RSVD		0	1	Reserved[1]	0b0
RETRY_CTRL	26	7-6	2	Retry Control[1]	0b10
RSVD		5-4	2	Reserved[1]	0b00
NO_DFLT_ENC_RX		3	1	Disable Default Encryption Receive[1]	0b0
NO_UNENC_RX		2	1	Disable Unencrypted Receive[1]	0b1
BACKPRESSURE		1	1	INT5141 Enable Backpressure[1]	0b1
NO_EE_SAVE		0	1	Disable EEPROM Save	0b0
TXEKS	27	7-0	8	EKS[1]	0x01
MAXC0TXTMR	28	7-0	8	Maximum CAP 0 Transmit Timer (ms) [7-0]	0xE8
	29	7-0	8	Maximum CAP 0 Transmit Timer [15-8]	0x03
MAXC1TXTMR	30	7-0	8	Maximum CAP 1 Transmit Timer (ms) [7-0]	0xE8
	31	7-0	8	Maximum CAP 1 Transmit Timer [15-8]	0x03
MAXC2TXTMR	32	7-0	8	Maximum CAP 2 Transmit Timer (ms) [7-0]	0xFA
	33	7-0	8	Maximum CAP 2 Transmit Timer [15-8]	0x00
MAXC3TXTMR	34	7-0	8	Maximum CAP 3 Transmit Timer (ms) [7-0]	0x08
	35	7-0	8	Maximum CAP 3 Transmit Timer [15-8]	0x00
MAXC3RXTMR	36	7-0	8	Maximum CAP3 Receive Reassembly Timer (ms)[7-0]	0x14
	37	7-0	8	Maximum CAP3 Receive Reassembly Timer [15-8]	0x00
MAXC2RXTMR	38	7-0	8	Maximum CAP2 Receive Reassembly Timer (ms)[7-0]	0xFA
	39	7-0	8	Maximum CAP2 Receive Reassembly Timer [15-8]	0x00
MAXC1_0RXTMR	40	7-0	8	Maximum CAP 1 & CAP 0 Receive Reassembly Timer (ms)[7-0]	0xE8
	41	7-0	8	Maximum CAP 1 & CAP 0 Receive Reassembly Timer [15-8]	0x03
ESTAGETMR	42	7-0	8	Tone Map Estimation Aging Timer (ms) [7-0]	0x88
	43	7-0	8	Tone Map Estimation Aging Timer [15-8]	0x13
BRIDGELISTTMR	44	7-0	8	Bridge List Aging Timer (≈1/4 sec) [7-0] Note: This number has been multiplied by 4 by the chip. (0x1250 = 20 mins, 0x0494 = 5 mins) See Optimizing the Bridge List Aging Timer below.	0x50
	45	7-0	8	Bridged List Aging Timer [15-8]	0x12
FAILTMR	46	7-0	8	Fail Resend Timer (ms) [7-0]	0x0A
	47	7-0	8	Fail Resend Timer [15-8]	0x00
VLAN_PRIO7	48	7-6	2	VLAN Tag Priority 7	0b11
VLAN_PRIO6		5-4	2	VLAN Tag Priority 6	0b11
VLAN_PRIO5		3-2	2	VLAN Tag Priority 5	0b10
VLAN_PRIO4		1-0	2	VLAN Tag Priority 4	0b10
VLAN_PRIO3	49	7-6	2	VLAN Tag Priority 3	0b01
VLAN_PRIO2		5-4	2	VLAN Tag Priority 2	0b01
VLAN_PRIO1		3-2	2	VLAN Tag Priority 1	0b00
VLAN_PRIO0		1-0	2	VLAN Tag Priority 0	0b00
RST_CNT	50	7-0	8	Restart Counter [7-0]	0x00
	51	7-0	8	Restart Counter [15-8]	0x00
RSVD	52 – 127	7:0	8	Reserved	0xFF

Field	Byte Addr	Bit Number	Bits	Definition	Defaults

NOTE:
1. Please refer to the Set Transmit Characteristics MME above for further explanation.

7.3. Optimizing the Bridge List Aging Timer

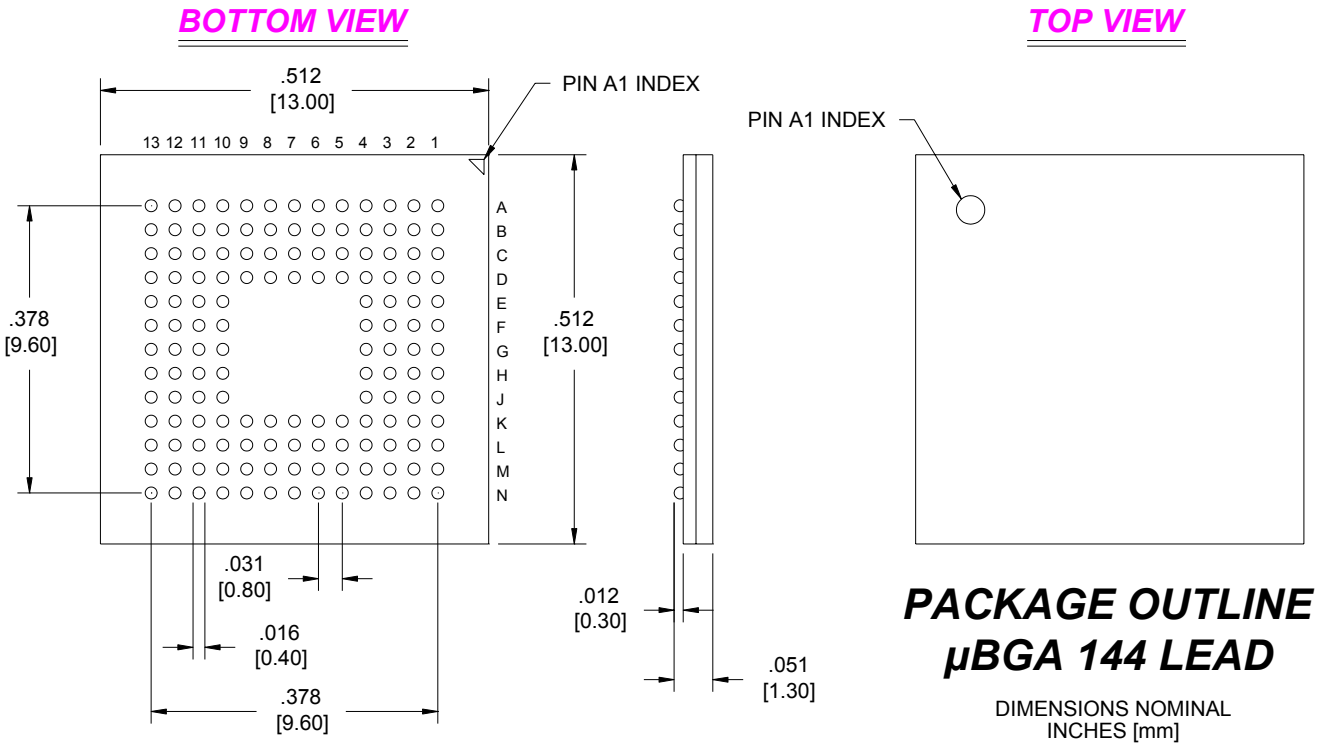
The bridge list aging timer controls the duration of a host proxied DA entry in the local bridge table (see Bridging Characteristics Local above). The duration of this timer can be optimized by understanding the traffic characteristics of its host application, e.g. normal PC running standard Internet Protocol (IP) based network protocol stack, router running Router Information Protocol (RIP or RIP2).

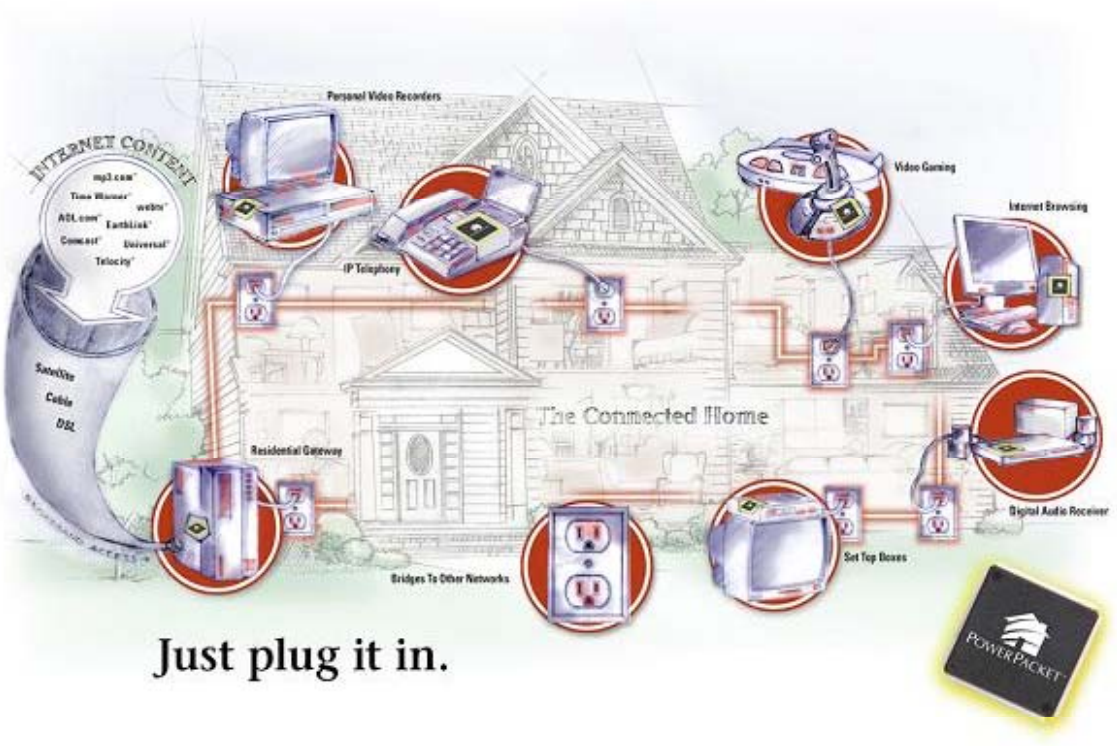
The goal of the bridge list aging timer is to reflect the active network topology and adjust to changes in that topology under all network traffic conditions. Under high traffic conditions, the duration of the timer is not critical. However, under low traffic conditions (web surfing, night time, etc.), the traffic generated by a host may be limited to the inherent protocol traffic, e.g. Address Resolution Protocol (ARP) requests and responses, RIP broadcasts, which occurs at a low rate. The bridge list aging timer should be long enough such that bridge table entries are not removed prematurely.

ARP traffic occurs every 10 minutes (typical) and RIP broadcasts occur every 30 seconds (typical). Therefore, to optimize the bridge list aging timer, set the value to 20 minutes if the host is a normal PC (this value is shown as the suggested value in the Initialization and Configuration EEPROM sections above) or set the value to 5 minutes or less if the host is a router. The optimal timing for each device may be device specific. These settings will optimize the topology awareness aspect of the bridge table aging timer to respond to the needs of the network.

8. Specifications

8.1. Physical Dimensions





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