PERFORMANCE MOTION DEVICES

MOTION CONTROL AT ITS CORE

C-Motion PRP II

Programming Reference

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Related Documents

Magellan Motion Control IC User Guide

Complete description of the Magellan Motion Control IC features and functions with detailed theory of its operation.

C-Motion Magellan Programming Reference

Descriptions of all C-Motion Magellan Motion Control IC commands, with coding syntax and examples, listed alphabetically for quick reference.

C-Motion Engine Development Tools Manual

Describes the C-Motion Engine Development Tools that allow user application code to be created and compiled on a host PC, then downloaded, executed and monitored on a CME device C-Motion Engine module.

ION/CME N-Series Digital Drive User Manual

Complete description of the ION/CME N-Series Digital Drive including getting started section, operational overview, detailed connector information, and complete electrical and mechanical specifications..

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1. Introduction

1.1 Introduction

This manual documents C-Motion PRP II, which is a software library used to control and monitor various PMD motion control products. PRP stands for PMD Resource Access Protocol, which is the protocol used to communicate with these devices.

There are two other C-Motion versions; C-Motion Magellan and C-Motion PRP. All of these software systems are available in separate SDKs as detailed below:

- **C-Motion Magellan SDK** – an SDK (Software Developer Kit) for creating motion applications using the C/C++ programming language for PMD products that utilize a direct Magellan or Juno formatted protocol.
- **C-Motion PRP SDK** – an SDK for creating PC and downloadable user code for systems utilizing either a PRP (PMD Resource Access Protocol) protocol device or a Magellan/Juno protocol device. C-Motion PRP is also used in motion applications that will use the .NET (C#, VB) programming languages.
- **C-Motion PRP II SDK** – This SDK is similar to C-Motion PRP but is used with ION/CME N-Series ION Digital Drives. Compared to standard C-Motion PRP, C-Motion PRP II supports additional features such as multi-tasking, mailboxes, mutexes, and enhanced event management.

For detailed information on Magellan/Juno protocol C-Motion refer to the *C-Motion Magellan Programming Reference*. For detailed information on C-Motion PRP refer to the *C-Motion PRP Programming Reference*.

1.2 PMD Products and C-Motion Version

The following table shows the C-Motion versions that can be used with each PMD product family:

Product Family	Compatible C-Motion Versions
Magellan ICs	C-Motion Magellan, C-Motion PRP*
Juno ICs	C-Motion Magellan, C-Motion PRP*
ION/CME N-Series	C-Motion PRP II
ION 500	C-Motion Magellan, C-Motion PRP*
ION/CME 500	C-Motion PRP
ION 3000	C-Motion Magellan, C-Motion PRP*
Prodigy PC/104	C-Motion Magellan, C-Motion PRP*
Prodigy/CME PC/104	C-Motion PRP
Prodigy/CME Stand-Alone	C-Motion PRP
Prodigy/CME Machine-Controller	C-Motion PRP

*C-Motion PRP typically only used for .NET support, or if a mix of Magellan/Juno protocol and PRP protocol devices are attached.

1.3 Overview of C-Motion PRP II

C-Motion is PMD's C-language based motion control programming system. It is provided in source code form for easy integration on a wide variety of platforms. Its primary purpose is to provide a C-language API to interface with, and access the resources of, PMD's motion control products.

All PMD products utilize packet-based protocols for communication, so a primary purpose of C-Motion is to translate the information contained in C-language function calls to the proper packet format. This allows C-Motion application developers to avoid having to learn the low level communication formats required by each PMD product.

Within the full PMD product set there are two different packet protocols used. A protocol known as the Magellan/ Juno protocol is used when directly interfacing with PMD Magellan ICs or Juno ICs. PRP (PMD Resource Access Protocol) is the protocol used with products such as ION/CME Digital Drives and Prodigy/CME boards.

Not all C-Motion function calls are translated into packets that will be sent, or received, by a PMD product. Especially for C-Motion PRP or C-Motion PRP II libraries, many function calls are used to manage application execution, memory resources, tasks, or to access resources located within the same device executing the C-Motion engine user code.

1.3.1 Resource Access Virtualization

In addition to handling the details of packet protocol conversion, another important feature of C-Motion is its support for virtualization of resource access.

Whether accessing a Magellan Motion Control IC, a memory block, a digital I/O port, or a CANbus peripheral port, C-Motion calls accept a handle which provides access to that resource independent of its location on a network or even PMD product type.

To instantiate a particular resource handle C-Motion calls are used to establish needed access information. It is this handle that is then provided to downstream C-Motion calls which command, or query, that resource. We will discuss the specifics of initializing access information in more detail later, but what is important about access virtualization is that it makes it easy to re-use previously written code for new machine control projects, or to transport code from prototyping setups to custom-designed production boards.

1.3.2 C-Motion Code Execution

A special and unique capability of the C-Motion PRP system is that it allows application code sequences to be run either from an external host (such as a PC) or from the C-Motion Engine on the device. This is convenient for code development, which is often easier and faster when located on the PC.

When operating on a host PC the C-Motion PRP system converts C-Motion calls to PRP protocol packets and sends them through the network interface to the device. This same C-Motion application code, when re-compiled for operation on the target device's C-Motion Engine (sometimes called CME for short) no longer sends packets in PRP format but instead makes the conversions needed to access the on-device resources from the CME, using the device's internal high speed communication bus.

1.3.3 Communication Networks

Another unique and powerful feature of the C-Motion PRP system is that it allows layered networks to be created. For example if a host PC talks directly to a Prodigy/CME Machine-Controller board via an Ethernet connection this board can in turn have a network of ION/CME units attached through its CAN network interface.

PRP allows both the resources on the Prodigy board and the 'sub network' ION/CME resources to be seamlessly addressed from the PC. Built into the PRP resource accessing scheme is the capability for devices to act as network

gateways, directly processing messages intended for local resources, and passing on messages intended for resources connected by network to the local device.

From the perspective of the C-Motion user code running on the PC access to all resources is automatic. To achieve this, as before, once the location of the devices and resources of the PRP network is established through C-Motion initialization calls, subsequent calls use just a C-language handle, whether the resources is directly-connected, or connected through a network.

In the next chapter we will expand on all of these concepts and give examples of how C-Motion PRP II is used to achieve various common control functions.

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2. PMD Resource Access Protocol (PRP)

In This Chapter

2.1 Introduction

Access to Prodigy/CME boards, ION/CME Drives, and Ethernet-capable ION drives is provided by a protocol called PMD Resource Access Protocol (PRP). PRP may be transmitted via serial, CAN, Ethernet TCP/IP, or SPI (Serial Peripheral Interface). PRP is both a protocol which can be transmitted across various connection interfaces and an architecture for how resources on PRP devices are accessed. A complete understanding of C-Motion PRP II therefore requires an understanding of PRP.

PRP device functions are organized into *resources*; resources process *actions* sent to them. *Actions* can send information, request information, or command specific events to occur. *Addresses* allow access to a specific resource on the device or connected to the device.

A basic communication to a PRP device consists of a 16 bit PRP header and for some communications a message body. The message body, if present, contains data associated with the specified PRP action. The header contains various information used to process the PRP messages including identifiers for the resource type, action type, and resource address. After a PRP communication is sent to a device, a return communication is sent by the PRP device which consists of a response header and an optional return message body. The return message body may contain information associated with the requested PRP action, or it may contain error information if there was a problem processing the requested action.

PRP is a master/slave system. The host functions as the master and initiates communication sequences which the connected device must respond to. The connected device can not initiate messages on its own within the PRP protocol. Note however that some PRP-supported networks, in particular CAN and Ethernet, allow one or more non-PRP protocol connections to be established to support asynchronous communication from the attached device to the host.

In the sections below more information is provided on each of these PRP constructs.

2.2 PRP Resources

There are five different resource types supported by PRP devices. The ***Device*** resource indicates functionality that is addressed to the entire board or digital drive, the ***MotionProcessor*** resource indicates a Magellan Motion Control IC, the ***CMotionEngine*** resource indicates the C-Motion Engine, the ***Memory*** resource indicates RAM or non-volatile RAM (Random Access Memory), and the ***Peripheral*** resource indicates a communications connection.

The following table summarizes the various resource types and their numeric codes as specified in the header.

Name	Code	Description
Device	0	A Prodigy/CME card or ION/CME module
CMotionEngine	1	A C-Motion Engine
MotionProcessor	2	A Magellan Motion Processor
Memory	3	A random access memory
Peripheral	4	A connection to a remote device over a communications channel.

2.3 PRP Actions and Sub-Actions

There are ten different PRP actions including *Command*, which is used to send commands to resources such as the Magellan Motion Processor, *Send* and *Receive*, which are used to communicate using serial, CAN, Ethernet, or SPI, *Read* and *Write*, which are used to access memory-type devices, and *Set* and *Get*, which are used to load or read parameters.

The behavior of an action depends on the resource type to which it is addressed. The same action may take a different set of arguments, return different data, and have different effects depending on its resource type. Many, but not all, actions are only fully specified by adding a *sub-action,* an 8 bit code qualifying the action to take. Finally, a few commands also accept a *sub command,* another 8 bit qualifier of the action to take.

The following table summarizes the various Action types and their numeric codes.

Name	Value	Meaning
NOP	0	No operation
Reset	1	Perform a reset
Command	2	Motion Processor and miscellaneous actions
Open	3	Open an addressable resource
Close	4	Close a remote resource
Send	5	Send data to a stream-like resource
Receive	6	Receive data from a stream-like resource
Write	7	Write data to an indexed resource
Read	8	Read data from an indexed resource
Set	9	Change a setting or operating state
Get	10	Get a setting or operating state
Clear	11	Erases the memory resources

2.4 PRP Addresses

Every resource accessible via PRP is identified by a numeric address. Addresses for Memory, Motion Processor, and C-Motion Engine resources local to a PRP device are fixed numbers. Refer to the user manual for the C-Motion PRP II-based product you are using for a detailed list. Addresses for Peripheral resources and resources on remote PRP devices, that is devices not directly connected to the host, are obtained by PRP actions and are automatically assigned. For more information on automatically assigned see Section 2.6.2, Automatically Assigned Addresses and Peripherals

While these automatically assigned addresses may in practice be predictable, it is important not to assume their values, which may change depending on the state of the device assigning them.

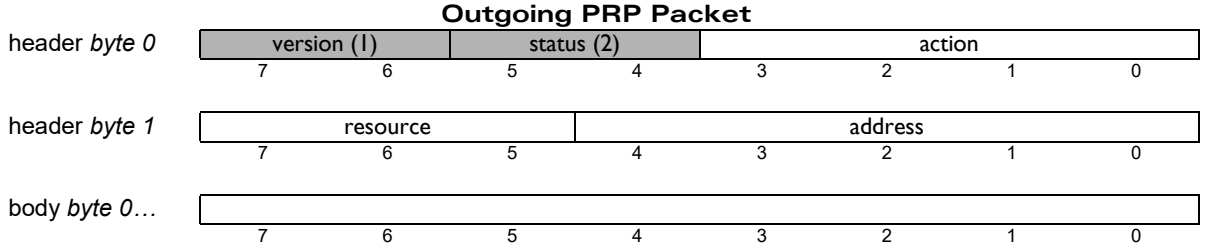
2.5 PRP Packet Structure

2.5.1 Outgoing PRP Packet

The core of the PMD Resource Access Protocol is a header that accompanies all PRP communications. The figure below shows the format of the resource access protocol header. The PRP header is a single 16 bit word divided into five fields. Normally, the PRP header is immediately followed by a message body, but there are certain communications that do not require a message body.

The table below shows the structure of an outgoing PRP packet:

Outgoing PRP Packet



PRP outgoing packet header descriptions:

Version - This two bit field encodes the version of PRP being used. The value of this field for all PRP devices should always be 1 (binary 01) unless documentation included with your PRP device indicates otherwise.

Status code - For PRP communications being sent out by the host, this 2 bit field should contain the value 2.

Action - This 4 bit field contains an action identifier that is used to process PRP messages. See Section 2.3, PRP Actions and Sub-Actions, for a summary of the PRP actions supported by PRP.

Resource - This 3 bit field encodes the specific resource type being addressed. See the table in Section 2.2, PRP Resources, for the summary of resources supported by PRP.

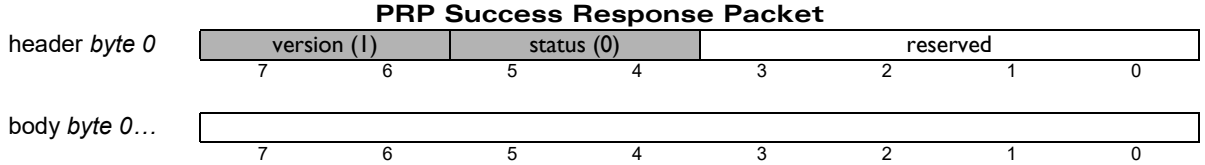
Address - This 5 bit field encodes the address of the particular resource being communicated to. Fixed addresses are used for resources that are local to the PRP device. Automatically assigned addresses are used to access attached devices, and are also used to create peripheral connections, which are communication 'conversations' between the PRP device and another device.

2.5.2 PRP Response Packet

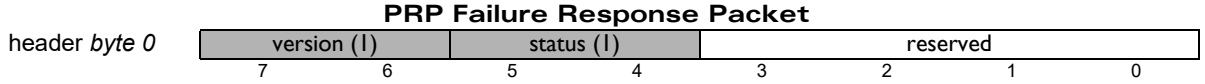
When an outgoing PRP packet is received by the device it responds with a response packet, which consists of at least a one byte (8 bit) header, followed by a message body. The length of the message body depends on the particular action - in some cases no body is required, in some cases a fixed length body is required, and in some cases a variable length body is used. In the case of a variable length body, information on packet length external to PRP is used to determine the length.

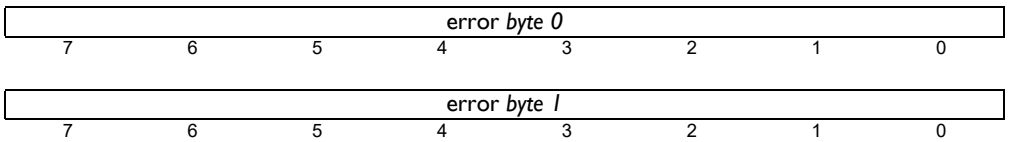
The table below shows the structure of PRP response packets for success and for failure:

PRP Success Response Packet



PRP Failure Response Packet





The version field, as for the outgoing packet, must contain 1.

The bits marked reserved must have a value of zero.

The status field is used to indicate success or failure, a value of zero indicates success, and a message body may follow as specified by the documentation for the particular action to which the PRP device is responding. A **status** value of 1 indicates that an error occurred processing the requested action, and a two byte (16 bit) message body follows specifying the particular error that occurred. The table below summarizes some values that the error code may take. (See the C-Motion PMDecode.h source file for all the possible values.) When used in the C language interface these names should be prefixed by "**PMD_ERR_RP_**," for example, "**PMD_ERR_RP_InvalidAddress**."

Name	Value	Description
Reset	0x2001	The previous command reset the device; action was not processed.
InvalidVersion	0x2002	The version field was incorrect.
InvalidResource	0x2003	No such resource type.
InvalidAddress	0x2004	The address for the specified resource type is not valid.
InvalidAction	0x2005	No such action, or resource not appropriate to specified action.
InvalidSubAction	0x2006	Sub-Action field not valid, or resource not appropriate for sub-action.
InvalidCommand	0x2007	An enumerated option argument is not correct.
InvalidParameter	0x2008	An argument value is not legal, or not supplied.
InvalidPacket	0x2009	A PRP packet was corrupted
Checksum	0x200E	Bad packet checksum value
Magellan error codes	1 – 35	Magellan Motion Processor error codes, documented in the *Magellan Motion Processor User Guide*.

2.6 Using PRP

In the next few sections we will provide examples of important PRP concepts including how to access resources, how to use automatically assigned addresses, and more.

Beyond these examples here is a list of additional useful C-Motion PRP II resources contained in this manual:

- Section 3.8, Alphabetical C-Motion API Reference, provides detailed information on the C-Motion PRP II API, listed alphabetically
- Section 4.2, Alphabetical PRP Action Reference, provides detailed information including packet format for all PRP Actions, listed alphabetically
- Section 3.7, C-Motion to API PRP Table, provides an alphabetically listed table of the C-Motion PRP II API and its corresponding PRP Actions
- Section 4.1, Action Table, provides the same information but in reverse, a table of PRP Actions and the corresponding C-Motion PRP II API
- Appendix A, *PRP Transport*, provides detailed information on the format and process for transporting PRP on Serial, CAN, Ethernet, or SPI

2.6.1 Device Access Basics

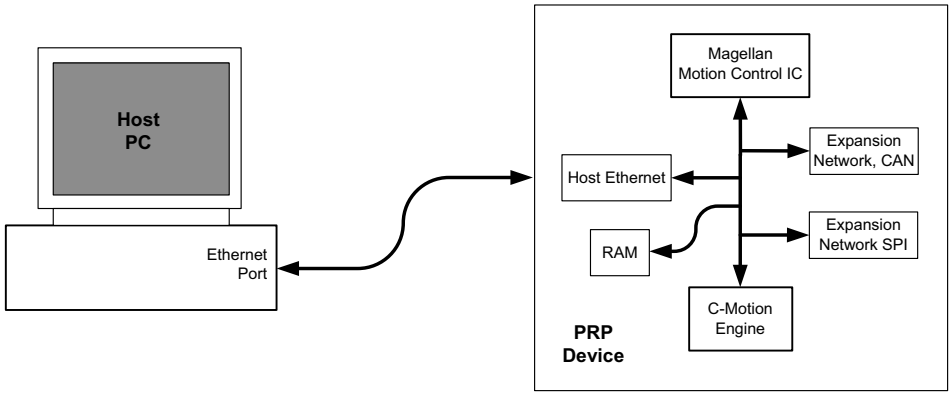


Figure 2-1: Host PC Connected to PRP Device via Ethernet TCP

Accessing resources on PRP devices is straightforward using the C-Motion PRP system. To illustrate this we will begin by showing the C-Motion commands used to achieve this. We will then illustrate how this same function is achieved via PRP-formatted packets.

Example 1: A Host Controller is connected to a PRP device via Ethernet/TCP and sets the position of Axis #3 of the PRP device's onboard Magellan Motion Control IC to a value of 0x123456.

Example in C-Motion

The first step will be to create an Ethernet/TCP peripheral connection and associated C-language handle on the host PC. Then we use this peripheral handle to create a handle to access the Ethernet-connected PRP device. Finally, using this device handle we will open an Axis handle which is used to access all Magellan Motion Control IC commands.

```
PMDDeviceOpenPeriphTCP()*          // Open and get access handle for TCP Peripheral on Host PC
PMDDeviceOpenPeriphDevicePRP()     // Open PRP-based device via this peripheral connection
PMDDeviceOpenAxis()                // Get Magellan Axis handle at axis #3 using PRP device handle
PMDSetPosition()                   // Send SetPosition 0x123456 from PC to Magellan IC
```

**For clarity the content of these example C calls such as handles and other initialization information will not be shown. For complete C-Motion coding examples refer to CMESDK\HostCode\Examples located on the C-Motion PRP II SDK.*

Note that once we have a handle set up we may use it to access the associated resource without re-opening that resource. For example in the above sequence if we want to also set the motion control IC's motion velocity, we would just add a **PMDSetVelocity()** call to the above sequence using the same axis handle as was used to set the position.

Example in PRP

The above example in PRP format looks very different. There are two reasons for this, one of which is that the mnemonic format for PRP packets is different than C language calls. The general PRP packet mnemonic format is:

<Resource ID> <Address> <Action ID> <Message content>

The other reason is that none of the C-Motion initialization calls which create virtual resource access through handles are relevant. So the PRP sequence is a single packet which is sent to the *MotionProcessor* resource, and has an action type of *Command*.

From the table in Section 2.2, PRP Resources, through Section 2.4, PRP Addresses, to communicate with the onboard Magellan Motion Control IC, a PRP message is sent to Resource ID 2 (corresponding to the *MotionProcessor* resource), address 0 (corresponding to the PRP device's onboard Magellan address), and with an action ID of 2 (corresponding to the *Command* action). The message body is loaded with the Magellan packet corresponding to "Set Position, #3 0x123456," which is the 3-word sequence 0x210, 0x0012, 0x3456.

In PRP mnemonics here is this command:

MotionProcessor, Addr 0, Command, 0x0210, 0x0012, 0x3456

Upon processing of this command by the device, the host would receive a PRP response message back. A zero in the status field would indicate that no error occurred. If this is the case the message body will be empty. If an error did occur, then the PRP status field would contain a 1, and the message body would contain the specific error code that occurred.

Example 2: The same Host Controller wants to read the 32 bit word value of address 0x100 of the PRP device's RAM

Example in C-Motion

Here we will send a **PMDMemoryRead()** call to retrieve the memory. From the previous Example #1 sequence we will assume the first two initializations have already been made and now execute the additional needed calls:

```
PMDDeviceOpenMemory()     // takes the device handle and creates a memory resource handle
PMDMemoryRead()           // takes the memory resource handle and returns the requested data
```

Example in PRP

The ID for a *Memory* resource type is 3, and the ID for a *Read* action is 7. The message body contains a sub-action of 0 specifying a 32 bit word read followed by a 0x100 which specifies the address of the desired memory read. Upon successfully processing this command, the host would receive the 32 bit contents of memory location 0x100 in the message body.

So in PRP mnemonics here is this outgoing command:

Memory, Addr 0, Read, 0, 0x100

Note that the PRP *Command* message sent to the Magellan Motion Control IC did not use a sub-action code in the message body, while the *Read* command sent to the RAM did. Whether or not a sub-action is required, and what the codes are for various sub-actions is action-specific, and sometimes resource-specific. Chapter 4, *PRP Action Reference*, provides exact message body information for each PRP action and (if applicable) sub-action.

2.6.2 Automatically Assigned Addresses and Peripherals

The above examples illustrate how C-Motion PRP II is used to gain basic access to on-device resources. In these examples the address of the resource being commanded or queried were local to the device, and therefore had a fixed numerical value.

In the PRP system however there are instances where the device or resource address is not fixed and is assigned dynamically. These occurs in particular when addressing the *Peripheral* resource.

PRP devices support up to four different network connection types; Serial, CAN, Ethernet, and SPI. These communication resources are represented in PRP by a construct called a peripheral connection. A peripheral is a resource (resource ID: 4), and is used to send and receive messages to network connections.

Obtaining access to an on-device serial, CAN, Ethernet, or SPI port is accomplished via the PRP *Open* action. This action opens a peripheral by specifying a sub-action of *PeriphSerial*, *PeriphCANFD*, *PeriphTCP*, *PeriphUDP*, or *PeriphSPI*. The corresponding C-Motion commands are **PMDDeviceOpenPeriphSerial()**, **PMDDeviceOpenPeriphCANFD()**, **PMDDeviceOpenPeriphTCP(), PMDDeviceOpenPeriphUDP()**, and **PMDDeviceOpenPeriphSPI()**.

The addresses of these Peripheral resources are not fixed. Each newly opened peripheral connection receives an automatically assigned address within the PRP response message body. The device that requests the peripheral open

connection must record that provided address for future use, and it is this address that is used in subsequent PRP messages to that peripheral connection.

Note that automatically assigned addresses generally increment by one each time they are assigned, however this should not be assumed.

Opening a new peripheral opens a connection between a PRP device and a specific remote device. It does not open the overall network port. For example if a PRP device has a CAN network with 4 attached devices (each at seperate CAN network addresses), four separate open peripheral function calls must be made, each opening a one-to-one connection between the PRP device and a specific network-attached device.

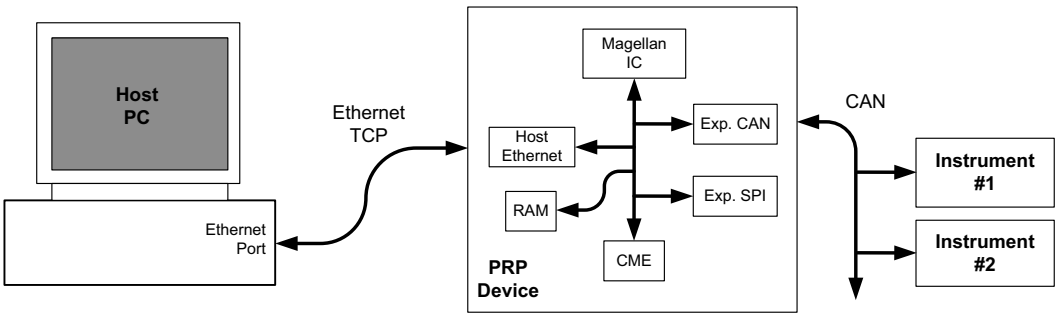


Figure 2-2: Host PC Connected to PRP Device connected to Instruments via CAN Network

Example 1

Figure 2-2 **shows a network configuration. A Host PC is connected via Ethernet TCP to a PRP device, which in turn is connected via a CANFD network to two scientific instruments. The host controller needs to initiate, send and receive a message to/from the CAN-connected instrument.**

Example in C-Motion

The first two steps provide general Ethernet access from the PC to the PRP device, and are the same as from our previous examples.

```
PMDDeviceOpenPeriphTCP()*          // Open TCP Peripheral connection on Host PC
PMDDeviceOpenPeriphDevicePRP()     // Open PRP-based device connection
```

Next we use the device handle created using the open PRP device call to access the Ethernet-connected PRP device and open CANFD peripherals to each instrument. Using this peripheral handle we then send and receive a message:

```
PMDDeviceOpenPeriphCANFD()         // Open CANFD Peripheral connection #1
PMDDeviceOpenPeriphCANFD()         // Open CANFD Peripheral connection #2
PMDPeriphSend()                    // Send a message to the #1 peripheral connection
PMDPeriphReceive()                 // Receive a message from #1
PMDPeriphSend()                    // Send a message to the #2 peripheral connection
PMDPeriphReceive()                 // Receive a message from #2
```

**For clarity the contents of the C calls such as handles and other initialization/parameter information is not shown.*

Example in PRP

As in the examples from the previous section there are no PRP transactions to set up resource or peripheral access handles. So the first step is to open a CANFD peripheral connection on the PRP Device.

Device, Addr 0, Open, PeriphCANFD, <CANFD Parameters for #1>
Device, Addr 0, Open, PeriphCANFD, <CANFD Parameters for #2>
Peripheral, <Assigned Address for #1>, Send, <Message>
Peripheral, <Assigned Address for #1>, Receive, <Message>

Peripheral, <Assigned Address for #2>, Send, <Message>
Peripheral, <Assigned Address for #2>, Receive, <Message>

In the return message body of the first transaction above the automatically assigned address of the opened CANFD peripheral is provided, and this address is used for the subsequent *Send* and *Receive* actions. <CANFD Parameters> here denotes that the message body of the outgoing communication contains formatted information indicating the Node ID.

Upon processing the peripheral receive command the PRP device will wait for a CANFD message to be received. A timeout value can be provided so that the length of this wait period can be limited. Once the message is received the PRP response message contains the received CANFD message.

2.6.3 RS232 & RS485 Peripherals

Most PMD products support both RS232 and RS485 serial communications, although specifying that a serial port should operate as a RS485 network reduces the number of serial ports available. For example PMD's N-Series ION Drive supports separate Serial1 and Serial2 point-to-point RS232 connections but just Serial1 when configured for multidrop RS485 operation.

Opening a point-to-point serial connection is straightforward and uses the C-Motion call **PMDDeviceOpenPeriphSerial()**. In the argument list the port is specified (Serial1, Serial2, or Serial3) along with other parameters such as baud rate, parity, etc.

In PRP protocol this is:

Device, Addr, Open PeriphSerial, <Serial Parameters>

Opening a multi drop RS485 connection however requires two calls, the first to open a serial peripheral connection, and then separate calls for each RS485 connection that is to be created. This second peripheral open uses what is called a multi drop peripheral type. Here is what this call sequence looks like via C-Motion, showing how devices at two separate RS485 network addresses are connected to.

```
PMDDeviceOpenPeriphSerial()          // open serial port peripheral, creating periph handle
PMDPeriphOpenPeriphMultiDrop()       // open multi drop peripheral connection # 1 using
                                     // above serial periph handle. Resultant peripheral handle
                                     // now represents the RS485 connection to the device at the
                                     // first RS485 address
PMDPeriphOpenPeriphMultiDrop()       // open multi drop peripheral connection # 2 using
                                     // original serial periph handle. Resultant peripheral handle
                                     // now represents the RS485 connection to the device at the
                                     // second RS485 address
```

Here is the same sequence in PRP mnemonics:

Device, Addr, Open, PeriphSerial, <Serial Parameters>
Periph, <Assigned Addr>, Open PeriphMultiDrop, <RS485 connection parameters for node #1>
Periph, <Assigned Addr>, Open PeriphMultiDrop, <RS485 connection parameters for node #2>

After these sequences there are two multidrop peripherals which can then be used for communications to and from each connection via standard peripheral *Send* or *Receive* commands.

2.6.4 Remote Attached Devices

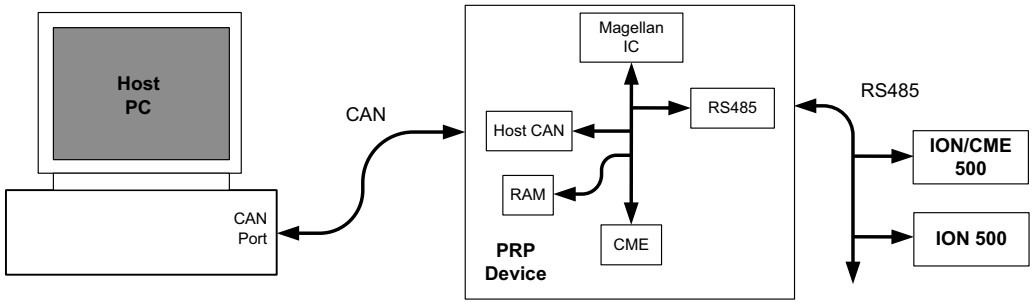


Figure 2-3: Host PC Connected to PRP Device connected to ION/CME and ION 500 via RS485 Network

Before closing our discussion of peripheral connections there is one more especially useful configuration to discuss. In Figure 2-3 a host PC connects to a PRP device which in turns has additional devices connected to it via another network. These additional devices, from the perspective of the PC, are referred to as remote attached devices. With PRP, creating 'bridged' networks like this is not difficult, as this example shows.

Example

A Host PC is connected via CAN to a PRP device, which in turn is connected via RS485 to two devices; an ION/CME 500 (#1) and an ION 500 (#2). The host controller needs to set a destination position, and send a GetVersion command to both of the remote RS485 connected ION Drives.

Example in C-Motion

The first two steps provide general CAN access from the PC to the PRP device, and are similar to our previous examples other than the switch from Ethernet to CAN.

```
PMDDeviceOpenPeriphCANFD()      // Open CANFD Peripheral connection on Host PC
PMDDeviceOpenPeriphDevicePRP()  // Open PRP-based device connection
```

Next we will open a serial peripheral connection so that we can create two RS485 connections, one to each device.

```
PMDDeviceOpenPeriphSerial()       // Open Serial peripheral connection
PMDPeriphOpenPeriphMultiDrop()    // Open multi drop peripheral connection # 1
PMDPeriphOpenPeriphMultiDrop()    // Open multi drop peripheral connection # 2
```

Next we will create device connections via each of these peripherals. This accomplished via either an OpenDevicePRP call (for PRP protocol devices) or an OpenDeviceMP (for Magellan/Juno format devices). In this example the #1 device is an ION/CME and therefore a PRP device, while the #2 device is an ION 500 and therefore a Magellan/Juno protocol device.

```
PMDDeviceOpenPeriphDevicePRP()  // Open PRP device connection for #1 ION (ION/CME 500)
PMDPeriphOpenDeviceMP()         // Open Magellan device connection for #2 ION (ION 500)
```

Finally we create access handles to the motion processor axes for each device and set the destination position command and query the unit version.

```
PMDDeviceOpenAxis()     // Using handle for device #1 get Magellan axis handle
PMDDeviceOpenAxis()     // Using handle for device #2 get Magellan axis handle
PMDSetPosition()        // Set position to 0x123456 to Axis on device #1
PMDSetPosition()        // Set position to 0x234567 to Axis on device #2
PMDGetVersion()         // Query version of Magellan on device #1
PMDGetVersion()         // Query version of Magellan on device #2
```

Example in PRP

Since we don't need commands to create handles to access the Host PC-attached device, the first step is to open a serial peripheral connection, then we create two RS485 peripheral connections, first for device #1 and next for device #2

Device, Addr 0, Open, PeriphSerial, <Serial parameters>
Device, <assigned Addr>, Open, PeriphMultiDrop, <RS485 parameters for #1>
Device, <assigned Addr>, Open, PeriphMultiDrop, <RS485 parameters foir #2>

Next we will create device connections via each of the just-created RS485 peripheral addresses.

Periph, <assigned Addr>, Open, DevicePRP, <Parameters for PRP Device>
Periph, <assigned Addr>, Open, DeviceMP, <Parameters for MP Device>

Finally we send the desired **SetPosition** and **GetVersion** commands to each motion control IC.

MotionProcessor, <device Addr #1>, Command, <SetPosition 0x123456>
MotionProcessor, <device Addr #2>, Command, <SetPosition 0x234567>
MotionProcessor, <device Addr #1>, Command, <GetVersion>
MotionProcessor, <device Addr #2>, Command, <GetVersion>

Note that in the above PRP messages the commands sent to the motion processor resource are not sent as ASCII characters but rather in a packet protocol format. In the mnemonics they are shown in ASCII only for clarity. Magellan IC packet formats are detailed in the *C-Motion Magellan Programming Reference.*

2.6.5 Other Peripheral Types

As it turns out there are some peripheral types that do not strictly function as communication ports, but are still accessed as *Peripheral* resources. These peripheral types are listed in the table below. Note that some of these peripheral types, rather than using *Send* and *Receive* commands, use *Read* and *Write* commands to access their contents.

Peripheral Type (Sub Action Name)	Description
PeriphPRP	PRP Peripherals allow general purpose application-specific communications to occur through an already established PRP channel. This mechanism, often referred to as tunneling, can be convenient for "conversation constrained" network interfaces such as Serial or SPI.
PeriphPIO	Each PRP Device has a single PIO Peripheral which gives access to various bit or word encoded registers. These registers provide read or write access to the unit's Digital I/O bits, analog inputs, encoder-related settings, and more.

3. PMD C-Motion API Reference

3.1 Naming Conventions

Procedures and data type names in the CME library are prefixed with "PMD." This prefix is omitted in the binary protocol documentation below, but must be included in C programs. *C-Motion* is the PMD library for Magellan Motion Processor control, and is a subset of the CME libraries. C-Motion procedures and data type names are also prefixed with "PMD."

3.2 Data Types

PRP resources are represented by opaque C types. "Opaque" means that reading and writing members of the data structures without using the library procedures is not supported. All of these structures must be allocated by the calling program, and are passed to library procedures by using a pointer argument. They must not be freed or otherwise written to until explicitly closed.

These data types include:

- PMDDeviceHandle – There are two types of "device:" an *RP device* is a device that communicates using the PRP protocol, that is, a Prodigy/CME card or an ION/CME module; an MP device is a device that communicates using the Magellan/Juno protocol, that is, a non-CME ION module, non-CME Prodigy card, or other "Magellan attached" device.
- PMDAxisHandle – A control axis of a Magellan Motion Control IC, which may be part of a Magellan attached device or of a PRP device.
- PMDPeriphHandle – A connection to a peripheral device over a particular communication channel. The peripheral data type specifies both the communication channel and any addressing information specific to a remote device, for example a TCP/IP port number or a PC/104 ISA bus base address.
- PMDMemoryHandle – A memory resource on a PRP device or a non-CME Prodigy card.

The include file "PMDtypes.h" defines typedefs for specific integral types that will be used in the prototypes in this manual:

- PMDuint32, PMDint32 – unsigned and signed 32 bit integers
- PMDuint16, PMDint16 – unsigned and signed 16 bit integers
- PMDuint8, PMDint8 – unsigned and signed 8 bit integers

Many bitmask and enumerated types are also defined in this file.

3.3 Return Values

Almost all of the PMD library procedures return an integer of type PMDresult, indicating success (zero) or failure (nonzero). The error values of PMDresult are the same as the PRP error values documented in this manual, and are all

declared in the "PMDecode.h" file. A partial list of these error codes is in Section 2.5.2, PRP Response Packet, for more information.

3.4 C-Motion Engine

The C-Motion Engine is a special purpose computer included in PMD's CME line of products, and connected by a high speed internal bus to the on-board Magellan Motion Processor, memory, and various communication devices. The firmware libraries required for motion control and a framework for application support are already included in the CME device, only the logic specific to a particular application need be programmed into the C-Motion Engine, making development a much quicker task than it would be for a "ground-up" embedded application.

Most of the instruction cycles in the microprocessor hosting the C-Motion Engine are normally available for running the user program, but processing of messages sent and received on communication peripherals is done by the same processor. Heavy message traffic, particularly heavy Ethernet traffic, may therefore reduce the time available for running the user program.

Dynamic memory allocation is supported using "malloc" and "free." Because the dynamic heap is of limited size and is unavoidably subject to fragmentation it is suggested that dynamic allocation be used sparingly, preferably only during initialization. The heap in most CME devices is approximately 7 kilobytes. The heap in N-Series ION devices is approximately 500k.

CME tasks can be aborted using PMDTaskAbort. Do not return from a CME task function.

3.4.1 C-Motion Engine Programming

In many ways the C-Motion engine environment is more restrictive than a PC host environment: code size, data size, and stack size are all more limited (see the User's Guide for your product). The processor running the C-Motion Engine is slower than a typical PC processor, but because of the lack of competing processes it can be much more predictable and quicker to respond.

C-Motion Engine programs are compiled with the GNU C compiler (GCC) provided with the CME SDK. Each example contains a build.bat file that builds the appropriate example. The resulting binary file is then downloaded to the CME device via Pro-Motion or the command-line utility StoreUserCode.exe.

3.4.2 Macros

A number of C preprocessor macros are required as part of a C-Motion Engine user code program. These macros are defined in the "PMDsys.h" file.

USER_CODE_VERSION (MAJOR, MINOR)
USER_CODE_TASK (myProgram)

USER_CODE_VERSION encodes version information in a section of the binary that will be used by the C-Motion Engine runtime code. It should be put once in the main source file at top level (outside of any function definition).

MAJOR and MINOR are user program version numbers, 16 bit constants that will be reported by Pro-Motion. USER_CODE_VERSION must be present even if you don't care to maintain a version number.

USER_CODE_TASK should be used to define the main function of the user code program, its argument is the name of the function, which should accept no arguments and should never return. A user program skeleton follows:

```
#include “C-Motion.h”
#include "PMDsys.h"

// this macro is required at the beginning of a CME user application
USER_CODE_VERSION (1,0)
// UserTCP is the name of the main task function
USER_CODE_TASK (myProgram)
{
…

   while (1) {
   // Handle task events
   }
   PMDTaskAbort(0);
}
```

3.5 Microsoft .NET Programming

3.5.1 Visual Basic Programming

The Visual Basic PMD Library is the interface from Microsoft Visual Basic .NET to the PMD C-Motion library for control of Magellan Motion Control ICs, which is documented in the *Magellan Motion Control IC Programming Reference*. The Visual Basic interface documented in that manual is similar to but not identical to that used for PRP devices. Basic language programming is supported only for Microsoft Windows hosts, C-Motion Engine programming must be done in the C language.

There are two parts to the Visual Basic interface code:

1. C-Motion.dll is a dynamically loadable library of all documented procedures in the PMD host libraries, including all C-Motion procedures.
2. PMDLibrary.vb is Visual Basic source code containing definitions and declarations for DLL procedures, enumerated types, and data structures supporting the use of C-Motion.dll from Visual Basic. PMDLibrary.vb should be included in any Visual Basic project for PRP or Magellan device control.

Both debug and release versions of C-Motion.dll are provided in directories CMESDK\HostCode\Debug and CMESDK\HostCode\Release, respectively. The library input file C-Motion.lib is also provided so that C-Motion.dll may be used with C/C++ language programs. When compiling C/C++ programs to be linked against the DLL the preprocessor symbol PMD_IMPORTS must be defined.

C-Motion.dll must be in the executable path when using it, either from a C or a Visual Basic program. Frequently the easiest and safest way of doing this is to put it in the same directory as the executable file.

PMDLibrary.vb is located in the directory CMESDK\HostCode\DotNet.

3.5.2 Visual Basic Classes

The file PMDLibrary.vb defines a Visual Basic class for each of the opaque data types used in the PMD library: **PMDPeripheral**, **PMDDevice**, **PMDAxis**, and **PMDMemory**. **PMDPeripheral** is inherited by a set of derived classes

for each peripheral type: **PMDPeripheralSerial**, **PMDPeripheralMultiDrop**, **PMDPeripheralPRP**, **PMDPeripheralCAN**, **PMDPeripheralSPI**, and **PMDPeripheralTCP**.

Each class takes care of allocating and freeing the memory used for the "handle" structures used in the C language interface. The first pointer argument to, for example, a **PMDPeriphHandle** in a C language procedure call is not needed because a method call for a particular **PMDPeripheral** object is used instead, and each object manages its own **PMDPeriphHandle**.

The "Open" procedures used in the C language interface are replaced in Visual Basic with constructor methods that take the same arguments in the same order, with the exception that the first pointer argument is not needed. "Close" methods are provided that call the C language "Close" procedures, however these procedures may also be called automatically as part of the finalization process when objects are garbage collected.

The following example demonstrates how to open a peripheral connection to a PRP device accessible by TCP/IP, and to access the resources of that device.

```
Public Class Examples
    Public Sub Example1()

' Allocate and open a peripheral connection to a PRP device using TCP/IP.
' Note that the arguments for the PMDPeripheralTCP object are the same as for the
' C language call PMDDeviceOpenPeriphTCP, except that the first argument for the peripheral
' struct pointer and the second argument for the device are not used.
' The standard .NET class for IP addresses is used instead of a numeric IP address.
' DEFAULT_ETHERNET_PORT is a constant defined in PMDLibrary.vb for the default
' TCP port used for commands by the PRP device.
' 1000 is a timeout value in milliseconds.
Dim periph As New PMDPeripheralTCP(System.Net.IPAddress.Parse("192.168.0.27"), _
                                        DEFAULT_ETHERNET_PORT, _
                                        1000)

' Now allocate and connect a device object using the newly opened peripheral.
' Instead of using two different names the second argument specifies whether a
' PRP device or attached Magellan device is expected.
Dim DevCME As New PMDDevice(periph, PMDDeviceType.ResourceProtocol)

' Once the PRP device is open we can obtain an axis object, which may be used
' for any C-Motion commands. Notice that the enumerated value used to specify the axis is
' called "Axis1" instead of "PMDAxis1" because the enumeration name already includes
' the "PMD" prefix.
Dim axis1 As New PMDAxis(DevCME, PMDAxisNumber.Axis1)

' C-Motion procedures returning a single value become class properties, and may be
' retrieved or set by using an assignment. The "Get" or "Set" part of the name is dropped.
Dim pos As Int32
pos = axis1.ActualPosition

' The following line sets the actual position of the axis to zero.
axis1.ActualPosition = 0

' Properties may accept parameters, for example the CurrentLoop parameter is used to set
' control gains for the current loops, and takes two parameters. This example sets
' the proportional gain for phaseA to 1000
axis1.CurrentLoop(PMDCurrentLoopNumber.PhaseA, _
PMDCurrentLoopParameter.ProportionalGain) = 1000

' C-Motion procedures returning multiple values become Sub methods, and return their
' values using ByRef parameters. The "Get" and "Set" parts of the names are the same as
' in the C language binding.
Dim MPmajor, MPminor, NumberAxes, special, custom, family As UInt16
Dim MotorType As PMDMotorTypeVersion
axis1.GetVersion(family, MotorType, NumberAxes, special, custom, MPmajor, MPminor)

' If the objects opened here are not explicitly closed they will be closed by the
' garbage collector.
  End Sub
End Class
```

Several general points about the translation from C to Visual Basic are shown in the example:

- Argument type and order are the same, except that the initial "handle" pointer argument is not needed. The null device pointer used to indicate that a peripheral is opened on the local device is also not needed.
- "Get/Set" procedures returning a single argument become object properties, with parameters if needed. The property name does not contain "Get" or "Set", or the "PMD" prefix.
- Procedures returning or setting multiple values are implemented as Sub methods, returning values via ByRef parameters. "Get" or "Set" is retained in the names, but the "PMD" prefix is not.
- Enumerated value names do not use the "PMD" prefix, but the enumeration names do.
- Procedures reading or writing array data through C pointers instead take Visual Basic arrays of the appropriate type.

3.5.3 C# Programming

The C# language is very similar to the VB language. A C# PMD program uses the PMDLibrary.dll created by the ClassLibrary project located in CMESDK\HostCode\DotNet\ClassLibrary. An example C# PMD program can be found in CMESDK\HostCode\DotNet\CSTestApp.

3.5.4 Error Handling

Almost all of the PMD C language library procedures return an error code to indicate success or failure. The Visual Basic versions of these procedures instead throw an exception if the wrapped DLL procedures return an error code. The exception message will contain the error number and a short description of the error. The Data member of the exception will contain the error number as an enumeration of type **PMDresult**, associated with the key "PMDresult", so that structured exception handling may be used to appropriately handle errors.

The following example commands a PRP device to reset, and then ignores the expected error return on the next command:

```
dev.Reset()
Try
     Dim major, minor As UInt32
     dev.Version(major, minor)
Catch ex As Exception When ex.Data("PMDresult").Equals(PMDresult.ERR_RP_Reset)
' Ignore the expected error
 End Try
```

Any errors that are not caught will cause the application to display a popup window displaying an error message, including the error number and description, and a stack trace with file names and line numbers. The popup window allows a user to continue, ignoring the error, or to abort the application.

While popup windows are useful for debugging, any application controlling motors should be designed to recover gracefully and safely from any foreseeable error condition, and it is recommended to use Try blocks liberally to make applications more robust.

3.6 PMD Library Procedures

This section documents the PMD C language interface to the library procedures for programming a CME PRP device, both in hosted programs and C-Motion Engine user programs. Most procedure calls are syntactically the same in both environments, but their implementation is of course quite different.

In many cases a PRP action corresponds closely to the action of a library procedure, but this is not invariable. One procedure call may involve a PRP action, or none. Whether PRP is used may depend on whether the procedure call is

executed on the host or in a C-Motion Engine user program, and on whether it is directed at a remote device or the device on which the program itself is running.

There are a few conventions common to many procedures:

- When opening a handle to some object a pointer to an uninitialized instance of the appropriate data type is passed first, and the open procedure will write to it. The initialized data type should not be written to as long as it is in use.
- Most procedures return an integer status code of type PMDresult. A zero indicates success, and a non-zero value failure or error.
- Many procedures that accept a pointer to a PMDDeviceHandle as an argument should be passed a null pointer to indicate the "local" device. For C-Motion Engine user programs the local device is the device hosting the C-Motion Engine. For hosted programs, for example when opening a peripheral, the local device is the host itself.

3.7 C-Motion to API PRP Table

The table below provides an alphabetical listing of the C-Motion API with its corresponding PRP packet content including *Resource, Action,* And *Sub-Action ID*s if applicable. Note that C-Motion calls which do not have corresponding PRP packets are not shown in this table.

For a complete alphabetical list of the C-Motion PRP II API calls refer to Appendix B, Summary List of C-Motion API. For a complete description of the C-Motion Magellan API refer to the *C-Motion Magellan Programming Reference*.]

C-Motion Procedure	PRP Resource	PRP Action	PRP Sub-action
PMDCMETaskGetInfo	CMotionEngine	Get	TaskInfo
PMDCMEGetUserCodeChecksum	CMotionEngine	Get	FileChecksum
PMDCMEGetUserCodeDate	CMotionEngine	Get	FileDate
PMDCMEGetUserCodeName	CMotionEngine	Get	FileName
PMDCMEGetUserCodeVersion	CMotionEngine	Get	FileVersion
PMDCMEStoreUserCode	CMotionEngine	Command	Flash
PMDCMETaskStart	CMotionEngine	Command	TaskControl
PMDCMETaskStop	CMotionEngine	Command	TaskControl
PMDDeviceClose	Device	Close	
PMDDeviceClose	MotionProcessor	Close	
PMDDeviceGetDefault	Device	Get	Default
PMDDeviceGetFaultCode	Device	Get	FaultCode
PMDDeviceGetInfo	Device	Get	Version
PMDDeviceGetSystemTime	Device	Get	SystemTime
PMDDeviceOpenPeriphCANFD	Device	Open	PeriphCANFD
PMDDeviceOpenPeriphCAN	Device	Open	PeriphCAN
PMDDeviceOpenPeriphSerial	Device	Open	PeriphSerial
PMDDeviceOpenMemory	Device	Open	Memory
PMDDeviceOpenPeriphPIO	Device	Open	PeriphPIO
PMDDeviceOpenPeriphPRP	Device	Open	PeriphPRP
PMDDeviceOpenPeriphSPI	Device	Open	PeriphSPI
PMDDeviceOpenPeriphTCP	Device	Open	PeriphTCP
PMDDeviceOpenPeriphUDP	Device	Open	PeriphUDP
PMDDeviceReset	Device	Reset	
PMDCMESetConsole	CMotionEngine	Set	Console

C-Motion Procedure	PRP Resource	PRP Action	PRP Sub-action
PMDDeviceSetDefault	Device	Set	Default
PMDMemoryClose	Memory	Close	
PMDMemoryErase	Memory	Clear	
PMDMemoryRead	Memory	Read	
PMDMemoryWrite	Memory	Write	
PMDPeriphClose	Peripheral	Close	
PMDPeriphOpenDeviceMP	Peripheral	Open	DeviceMP
PMDPeriphOpenPeriphMultiDrop	Peripheral	Open	PeriphMultiDrop
PMDPeriphOpenDevicePRP	Peripheral	Open	DevicePRP
PMDPeriphRead	Peripheral	Read	
PMDPeriphReceive	Peripheral	Receive	
PMDPeriphSend	Peripheral	Send	
PMDPeriphWrite	Peripheral	Write	
PMDDeviceSetSystemTime	Device	Set	SystemTime

3.8 Alphabetical C-Motion API Reference

Arguments

Name	Type
hAxis	pointer to PMDAxisHandle
hDevice	pointer to an open PRP device handle or NULL if local
axis_number	enumeration PMDAxis1 to PMDAxis4

C Syntax

```
PMDresult PMDAxisOpen(PMDAxisHandle *hAxis,
                      PMDDeviceHandle *hDevice,
                      PMDAxis axis_number);
```

C# Syntax

```
Axis axis = new Axis(device, AxisNumber.Axis);
```

VB Syntax

```
Dim axis As New(device, PMDAxisNumber.Axis)
```

Description

PMDAxisOpen is used to obtain a handle to a single control axis of a Magellan Motion Processor, which will be used for all C-Motion procedures. The *hAxis* argument should point to an uninitialized **PMDAxisHandle** struct, which should not be freed or written to as long as the handle is required. The *device* argument should point to an open **PMDDeviceHandle** handle, which may represent either a PMD device or a Magellan attached device. In a C-Motion engine user program, *device* may be null, in which case the Magellan processor on the local device will be opened.

For example, to open the first axis on the local Magellan processor from a CME user program:

```
PMDAxisHandle axis1;
PMDresult result;

result = PMDAxisOpen(&axis1, 0, PMDAxis1);
```

And to open the second axis on a Magellan attached device accessible by CANBus:

```
PMDPeriphHandle periph;
PMDDeviceHandle dev;
PMDAxisHandle axis2;
PMDresult result;

// First open the peripheral connection, CAN_TX, CAN_RX, and CAN_EVENT
//  depend on how the attached device is configured.
result = PMDDeviceOpenPeriphCAN(&periph, 0, CAN_TX, CAN_RX, CAN_EVENT);
// Now open an MP Device on the peripheral
if (PMD_NOERROR == result)
  status = PMDPeriphOpenDeviceMP(&dev, &periph);
// Now we're ready to obtain the axis handle.
if (PMD_NOERROR == result)
  result = PMDAxisOpen(&axis2, &dev, PMDAxis2);
```

PRP Action

None

PMDCMEGetUserCodeChecksum

C-Motion Engine | Host-Based

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
checksum	CRC of the user code that is stored in the CME

C Syntax

```
PMDresult PMDCMEGetUserCodeVersion(PMDDeviceHandle *hDevice,
                                   PMDuint32* checksum);
```

C# Syntax

```
UInt32 value;
value = device.UserCodeChecksum();
```

VB Syntax

```
Dim value as UInt32
value = device.UserCodeChecksum()
```

Description

The function **PMDCMEGetUserCodeChecksum** is used to retrieve the CRC-32 of the user code that is stored in the CME.

PRP Action

Get FileChecksum CMotionEngine

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
date	date of the user code file that is stored in the CME

C Syntax

```
PMDresult PMDCMEGetUserCodeDate(PMDDeviceHandle *hDevice,
                                char* date);
```

C# Syntax

```
String value = device.UserCodeDate();
```

VB Syntax

```
Dim value as String
value = device.UserCodeDate()
```

Description

The function **PMDCMEGetUserCodeDate** is used to retrieve the file date of the user code that is stored in the CME.

PRP Action

Get FileDate CMotionEngine

PMDCMEGetUserCodeName

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
filename	file name of the user code that is stored in the CME

C Syntax

```
PMDresult PMDCMEGetUserCodeName(PMDDeviceHandle *hDevice,
                                char* filename);
```

C# Syntax

```
String value = device.UserCodeName();
```

VB Syntax

```
Dim value as String
value = device.UserCodeName()
```

Description

The function **PMDCMEGetUserCodeName** is used to retrieve the file name of the user code that is stored in the CME.

PRP Action

Get FileName CMotionEngine

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
version	version of the user code that is stored in the CME

C Syntax

```
PMDresult PMDCMEGetUserCodeVersion(PMDDeviceHandle *hDevice,
                                   PMDuint32* version);
```

C# Syntax

```
UInt32 value;
value = device.UserCodeVersion();
```

VB Syntax

```
Dim value as UInt32
value = device.UserCodeVersion()
```

Description

The function **PMDCMEGetUserCodeVersion** is used to retrieve the user-specified version of the user code that is stored in the CME.

PRP Action

Get FileVersion CMotionEngine

PMDCMESetConsole

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
hPeriph	pointer to open peripheral handle to set the console to

C Syntax

```
PMDresult PMDCMESetConsole(PMDDeviceHandle *hDevice,
                           PMDPeriphHandle *hPeriph);
```

C# Syntax

```
device.SetConsole(periph);
```

VB Syntax

```
device.SetConsole(periph)
```

Description

The function **PMDCMESetConsole** is used to set the console peripheral to the one indicated in the *hPeriph* handle. See the PRP action for more information.

PRP Action

Set Console CMotionEngine

Arguments

Name	Type
hDevice	pointer to an open PRP device handle
pdata	pointer to data buffer
length	length of data buffer in bytes

C Syntax

```
PMDresult PMDCMEStoreUserCode(PMDDeviceHandle* hDevice,
                              PMDuint8* pdata,
                              int length);
```

C# Syntax

```
Byte *pdata;
UInt32 length;
device.StoreUserCode(data, length);
```

VB Syntax

```
Dim pdata As Byte()
Dim length as UInt32
device.StoreUserCode(pdata, length)
```

Description

PMDCMEStoreUserCode is used to store a user program in the CME device addressed by the *hDevice* device handle. The *pdata* parameter is a pointer to the data buffer that contains the contents of the binary compiled from the CMESDK. The *length* parameter is the size of the buffer pointed to by the *pdata* parameter. The binary data is sent to the device in multiple PRP packets using the **Command Flash CMotionEngine** action.

PRP Action

Command Flash CMotionEngine

Arguments

Name	Type
hDevice	pointer to an open PRP device handle or NULL if local
tasknumber	task number
infoID	a value of PMDTaskInfo that identifies the information to retrieve
value	a 32 bit value representing the task information

C Syntax

```
PMDresult PMDCMETaskGetInfo(PMDDeviceHandle *hDevice,
                            int tasknumber,
                            PMDTaskInfo infoID,
                            PMDint32* value);
```

C# Syntax

```
UInt32 value;
Byte taskno;
value = device.TaskGetInfo(taskno, PMDTaskInfo.InfoID);
```

VB Syntax

```
Dim taskno as Byte
Dim value as UInt32
value = device.TaskGetInfo(taskno, PMDTaskInfo.InfoID)
```

Description

The function **PMDCMETaskGetInfo** is used to retrieve information about a particular task such as its state, remaining stack space, abort code, or priority.

PRP Action

Get TaskInfo CMotionEngine

Arguments

Name	Type
hDevice	pointer to PMDDeviceHandle

C Syntax

```
PMDresult PMDCMETaskStart (PMDDeviceHandle *hDevice);
```

C# Syntax

```
device.TaskStart();
```

VB Syntax

```
device.TaskStart()
```

Description

PMDCMETaskStart is used to start a user program installed in the C-Motion Engine that is part of the CME device associated with the *hDevice* argument. If *hDevice* is not a PRP device then PMD_ERR_Not_Supported will be returned. If no runnable program is installed then PMD_ERR_UC_NotProgrammed will be returned. If a program is already running, then PMD_ERR_UC_TaskAlreadyRunning will be returned.

PRP Action

Command TaskControl CMotionEngine

Arguments

Name	Type
hDevice	pointer to PMDDeviceHandle

C Syntax

```
PMDresult PMDCMETaskStop(PMDDeviceHandle *hDevice);
```

C# Syntax

```
device.TaskStop();
```

VB Syntax

```
device.TaskStop()
```

Description

PMDCMETaskStop is used to stop any user program currently running in the C-Motion Engine that is part of the PRP device associated with the *hDevice* argument. If *hDevice* is not a CME PRP device then PMD_ERR_Not_Supported will be returned. If no program is currently running, then PMD_ERR_UC_TaskNotCreated will be returned. If no program is installed, then PMD_ERR_UC_NotProgrammed will be returned.

It is the user's responsibility to ensure safety when starting or stopping a user program that controls motors. It is not possible to predict the state of the PRP device or of it's motion processor at the instant that the user program is stopped. PMD strongly recommends that a task be stopped only to correct unrecoverable errors and that the card and any devices that it controls be put immediately into a known safe state using host commands. Because the card resources and the dynamic heap are not in a known state it is not safe to restart a task after stopping it without first resetting the entire device. Stopping a task may cause a mutex timeout in other tasks and host applications accessing the Magellan because the mutex and other resources do not get released when a task is stopped.

PRP Action

Command TaskControl CMotionEngine

Arguments

Name	Type
hDevice	pointer to PMDDeviceHandle

C Syntax

```
PMDresult PMDDeviceClose(PMDDeviceHandle *hDevice);
```

C# Syntax

```
device.Close();
```

VB Syntax

```
device.Close()
```

Description

PMDDeviceClose is used to free any resources used in maintaining the device handle passed as a pointer argument. After closing the device handle, the memory used for ***hDevice*** may be freed or re-used for another device.

PRP Action

Close various

Arguments

Name	Type
hDevice	pointer to an open PRP device handle or NULL if local
defaultcode	enumerated default code
value	pointer to memory area to receive default value
valueSize	maximum size of value area

C Syntax

```
PMDresult PMDDeviceGetDefault(PMDDeviceHandle *hDevice,
                              PMDDefault defaultcode,
                              void *value,
                              unsigned valueSize);
```

C# Syntax

```
UInt32 value32;
device.GetDefault(PMDDefault.code, value32);
```

VB Syntax

```
Dim value32 As UInt32
device.GetDefault(PMDDefault.code, value32)
```

Description

PMDDeviceGetDefault is used to retrieve the value of a *device default*. Device defaults are various non-volatile properties of the PRP device for example the IP address, or whether to run a user program immediately after power up.

hDevice is a pointer to a handle associated with the device to retrieve the value of a *device default*. In C-Motion Engine user programs *hDevice* may be a null pointer, meaning the local device.

default is a numeric default code, please see the description of the **Set DefaultDevice** action in Section 2.4, PRP Addresses for a table of supported default codes and their meaning.

value is a pointer to a data area in which to store the default code, and *valueSize* is the size, in bytes, of the area. The size of a default depends on the particular data type, and is encoded in the upper byte of the default code – a value of zero means one byte, one means two bytes, and *n* means *n – 1* bytes. *valueSize* is required in order to prevent buffer overruns, an error code will be returned if *valueSize* is not large enough to contain the default value.

Two byte default values are generally 16 bit integers, and four byte values 32 bit integers. The *value* pointer must be properly aligned to hold these values.

PRP Action

Get Default Device

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
faultID	a value of PMDFaultCode that identifies the information to retrieve
value	a 32 bit value representing the fault code requested

C Syntax

```
PMDresult PMDDeviceGetFaultCode(PMDDeviceHandle *hDevice,
                                PMDFaultCode faultID,
                                PMDint32* value);
```

C# Syntax

```
UInt32 value;
value = device.GetFaultCode(PMDFaultCode.faultid);
```

VB Syntax

```
Dim value as UInt32
value = device.GetFaultCode(PMDFaultCode.faultid)
```

Description

The function **PMDDeviceGetFaultCode** is used to retrieve any fault codes such as PMDInitFault, PMDException or PMDResetCause. See the PRP action for more information.

PRP Action

Get FaultCode Device

Arguments

Name	Type
hDevice	pointer to an open PRP device handle or NULL if local
infoID	a value of PMDDeviceInfo that identifies the information to retrieve
option	not used
value	a 32 bit value representing the task information requested

C Syntax

```
PMDresult PMDDeviceGetInfo(PMDDeviceHandle *hDevice,
                           PMDDeviceInfo infoID,
                           PMDuint16 option,
                           PMDint32* value);
```

C# Syntax

```
UInt32 value, optionID;
value = device.GetInfo(PMDDeviceInfo.infoID, optionID);
```

VB Syntax

```
Dim value as UInt32
Dim optionID as UInt32
value = device.GetInfo(PMDDeviceInfo.infoID, optionID)
```

Description

The function is used to retrieve information about the device such as its firmware version, logic version and host interface. The requested information is one of **PMDDeviceInfo**.

```
typedef enum {
   PMDDeviceInfo_CMEVersion     = 0, // byte3=mode, byte2=major, byte1=customcode, byte0=minor
   PMDDeviceInfo_LogicVersion   = 1, // 16 bit version
   PMDDeviceInfo_HostInterface  = 2, // one or more of PMDHostInterface
   PMDDeviceInfo_MemorySize     = 3, // with optional parameter set to one of PMDMemoryAddress
   PMDDeviceInfo_Heap           = 5, // with optional parameter set to one of PMDHeap
   PMDDeviceInfo_IPaddress      = 6, // IPv4 address of the device
}  PMDDeviceInfo;
```

The PMDDeviceInfo_CMEVersion infoID returns the firmware version in this format:

byte 3	byte 2	byte 1	byte 1
reserved	major	custom	minor

The PMDDeviceInfo_LogicVersion infoID returns the logic version as a 16 bit value.

The PMDDeviceInfo_HostInterface infoID returns the available host interfaces as one or more of PMDHostInterface.

```
typedef enum {
   PMDHostInterface_Serial          = 1,
   PMDHostInterface_CAN             = 2,
   PMDHostInterface_SPI             = 4,
   PMDHostInterface_Ethernet        = 8,
} PMDHostInterface;
```

The PMDDeviceInfo_Heap infoID returns the heap information specified in the option parameter as one of **PMDHeap**.

```
typedef enum {
   PMDHeap_AvailableBytes           = 0,
   PMDHeap_MinimumAvailableBytes    = 1,
} PMDHeap;
```

The PMDHeap_AvailableBytes returns the total amount of heap space remaining in bytes. There is no guarantee that all of this can be allocated, depending no what sizes are asked for. The PMDHeap_MinimumAvailableBytes option return how close we have come to running out of heap space so far.

PRP Action

Get Info Device

Arguments None

C Syntax

```
PMDuint32 PMDDeviceGetMicroseconds(void);
```

Description The function **PMDDeviceGetMicroseconds** is used to obtain a count of the number of microseconds since the C-Motion Engine was reset, and may be used for timing events. Note that the count is not from the time the user program began to run. The count will wrap around to zero after 0xFFFFFFFF (4294967295) microseconds.

PRP Action None

PMDDeviceGetSystemTime

Arguments

Name	Type
hEvent	pointer to an open PRP device handle or NULL if local
time	pointer to a SYSTEMTIME structure

C Syntax

```
PMDresult PMDDeviceGetSystemTime(PMDDeviceHandle* hDevice,
                                 SYSTEMTIME* time);
```

C# Syntax

```
SYSTEMTIME time;
device.GetSystemTime(time);
```

VB Syntax

```
Dim time as PMD.SYSTEMTIME
device.GetSystemTime(time)
```

Description

PMDDeviceGetSystemTime is used to obtain the date and time from the built-in real-time clock. The time argument is a pointer to a SYSTEMTIME structure which is the same format as the Windows SYSTEMTIME structure. The milliseconds value has an accuracy of approximately 3 milliseconds.

```
typedef struct _SYSTEMTIME {
    WORD wYear;
    WORD wMonth;     // The current month; January is 1.
    WORD wDayOfWeek; // The current day of the week; Sunday is 0, Monday is 1, etc.
    WORD wDay;
    WORD wHour;
    WORD wMinute;
    WORD wSecond;
    WORD wMilliseconds;
} SYSTEMTIME
```

PRP Action

Get Time Device

Arguments None

C Syntax

```
PMDuint32 PMDDeviceGetTickCount(void);
```

Description **PMDDeviceGetTickCount** returns the number of milliseconds from the time the C-Motion Engine from which it is called has been running. The count is maintained with a granularity of 1 milliseconds, and will overflow to zero after 2^{32} milliseconds.

PRP Action None

Arguments

Name	Type
hMemory	pointer to uninitialized PMDMemoryHandle
hDevice	pointer to PMDDeviceHandle
datasize	PMDDataType
memoryaddress	PMDMemoryAddress

C Syntax

```
PMDresult PMDDeviceOpenMemory (PMDMemoryHandle *hMemory,
                               PMDDeviceHandle *hDevice,
                               PMDDataSize datasize,
                               PMDMemoryAddress memoryaddress);
```

C# Syntax

```
PMDMemory memory = new
PMDMemory(deviceRP, PMDDataSize.Size32Bit);
```

VB Syntax

```
Dim mem As New PMDMemory(deviceRP, PMDDataSize.Size32Bit)
```

Description

PMDDeviceOpenMemory is used to obtain a handle to a memory resource such as dual-ported RAM on a Prodigy/CME or non-CME Prodigy card. *hDevice* specifies the device containing the memory, and may have been opened using **PMDPeriphOpenDeviceMP** (for non-CME cards), or **PMDPeriphOpenDevicePRP** (for CME cards). In the case of C-Motion Engine user programs needing to read or write the local memory, *hDevice* should be a null pointer.

The *width* argument indicates the size of the data that are read or written to the memory device. All currently supported memory devices support only 32 bit access, so *width* must be PMDDataSize_32bit. All accesses to the memory must use addresses dword-aligned, ie divisible by four, and use buffer lengths that are also divisble by four.

For all current products *memoryaddress* is one of:

PMDMemoryType_DPRAM

PMDMemoryType_NVRAM

PMDMemoryType_RAM

PRP Action

Open Memory Device

Arguments

Name	Type
hPeriph	pointer to uninitialized PMDPeriphHandle
hDevice	pointer to an open device handle
addressTx	CAN identifier for transmit
addressRx	CAN identifier for receive
addressEvent	CAN identifier for event notification receive

C Syntax

```
PMDresult PMDDeviceOpenPeriphCAN(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDuint32 addressTX,
                                 PMDuint32 addressRX,
                                 PMDuint32 addressEvent;
```

C# Syntax

```
UInt32 addressTX, addressRX, addressEvent;
PMDPeripheral periph = new PMDPeripheralCAN(addressTX, addressRX,
addressEvent);
```

VB Syntax

```
Dim addressTX As UInt32
Dim addressRX As UInt32
Dim addressEvent As UInt32
Dim periph As New PMDPeripheralCAN(addressTX, addressRX, addressEvent)
```

Description

PMDDeviceOpenPeriphCAN is used to open a peripheral connection to a device on a CANBus that uses two or three CAN identifiers for communication, for example a Magellan attached device or a Prodigy/CME card. *hPeriph* should point to an uninitialized PMDPeriphHandle data structure. hDevice should point to an open device handle corresponding to a PRP device, *hDevice* may be a null pointer, which means the local device, either the host or, for C-Motion Engine user programs, the local PRP device.

addressTX is a CAN identifier that will be used for sending outgoing packets. *addressRX* is a CAN identifier that will be used to listen for incoming packets. Currently only 11 bit CAN identifiers are supported.

addressEvent is an optional CAN identifier used for receiving asynchronous event notification packets from a Magellan attached device. If no such event notification is needed then *addressEvent* should be zero.

PRP Action

None

Arguments

Name	Type
hPeriph	pointer to uninitialized peripheral handle
hDevice	pointer to an open PRP device handle or NULL if local
port	ExpCAN or HostCAN port (0-1)
baud	CAN bitrate (one of PMDCANFDBaud)
addressTx	CAN identifier for transmit (0-2047)
addressRx	CAN identifier for receive (0-2047)
addressMode	reserved (0)

C Syntax

```
PMDresult PMDDeviceOpenPeriphCANFD(PMDPeriphHandle* hPeriph,
                                   PMDDeviceHandle* hDevice,
                                   PMDCANPort port,
                                   PMDparam baud,
                                   PMDparam addressTX,
                                   PMDparam addressRX,
                                   PMDparam addressMode);
```

C# Syntax

```
UInt32 addressTX, addressRX;
PMDPeripheral periph = new PMDPeripheralCANFD(PMDCANPort.port,
PMDCANBaud.baud, addressTX, addressRX, 0);
```

VB Syntax

```
Dim addressTX As UInt32
Dim addressRX As UInt32
Dim periph As New PMDPeripheralCANFD(PMDCANPort.port, PMDCANBaud.baud,
addressTX, addressRX, 0)
```

Description

PMDDeviceOpenPeriphCANFD is used to open a peripheral connection to a device on a CANBus that uses two CAN identifiers for communication, for example a Magellan attached device or another CME device. *hPeriph* should point to an uninitialized **PMDPeriphHandle** data structure. *hDevice* should point to either an open device handle corresponding to a PRP device or a null pointer, which means the local device. ***port*** is the local physical CANFD port on the device itself: 0 for ExpCAN, and 1 for HostCAN (if applicable). ***baud*** sets the bitrate of the specified CANcontroller. CANFD supports 2 bitrates during the transmission of a frame: a nominal bitrate and a data bitrate. The nominal bitrate is one of the standard CAN bitrates: 10,000 to 1,000,000 bps. The data bit rate has a range of 1,000,000 to 5,000,000 bps. The low nibble (bits 0-3) of the baud parameter sets the nominal bit rate with a range of 0-7 representing 1Mbps to 10kbps respectively. The second nibble (bits 4-7) sets the data bit rate with a range of 4-7 representing 5Mbps to 1Mbps respectively. The bitrate for the CAN port is set to the bitrate of the last call to **PMDDeviceOpenPeriphCANFD**. All the devices on the bus must be set to the same bitrate. ***addressTX*** is the CAN identifier that will be used for sending outgoing packets. ***addressRX*** is the CAN identifier that will be used to listen for incoming packets. Currently, only 11 bit CAN identifiers are supported. ***addressMode*** is not used and must be set to 0.

```
typedef enum {
    PMDCANBaud1000000        = 0,
    PMDCANBaud800000         = 1,
    PMDCANBaud500000         = 2,
    PMDCANBaud250000         = 3,
    PMDCANBaud125000         = 4,
    PMDCANBaud50000          = 5,
    PMDCANBaud20000          = 6,
    PMDCANBaud10000          = 7
} PMDCANBaud;
typedef enum {
    PMDCANFDDataBaudNone     = 0 << 4,
    PMDCANFDDataBaud5000000  = 4 << 4,
    PMDCANFDDataBaud4000000  = 5 << 4,
    PMDCANFDDataBaud2000000  = 6 << 4,
    PMDCANFDDataBaud1000000  = 7 << 4,
} PMDCANFDDataBaud;
```

PMDCANFDBaud is the logical or of PMDCANBaud and PMDCANFDDataBaud.

PRP Action

Open CANFD Device

Arguments

Name	Type
hPeriph	pointer to uninitialized PMDPeriphHandle
hDevice	pointer to an open PRP device handle

C Syntax

```
PMDresult PMDDeviceOpenPeriphCME(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice);
```

Description

PMDDeviceOpenPeriphCME is used to open a connection to a virtual peripheral using PRP *user packets*. User packets may contain data for user application control and monitoring in any format, but are limited in size to USER_PACKET_LENGTH (250) bytes. User packets are sent as discrete units, they do not constitute a stream.

User packets are transported in PRP packets, that is, they are "tunneled" through PRP, and are a very simple way to establish communication between host programs and C-Motion engine user programs because they do not require opening a separate communication channel, nor implementing a low-level protocol over it.

PMDDeviceOpenPeriphCME is used to open both sides of the user packet channel: On the host side an opened device handle associated with a PRP device must be passed using the *hDevice* argument. On the C-Motion engine side a user program should pass a null pointer as *hDevice*.

The peripheral handle opened by **PMDDeviceOpenPeriphCME** may be used in the same way as other peripheral handles, using **PMDPeriphSend**, **PMDPeriphReceive**, and **PMDPeriphClose**.

When considering the timeout parameter for peripheral send and receive commands for user packets, it is useful to know that the C-Motion Engine can buffer one user packet on the incoming side, and one on the outgoing side. The timeout period is not determined by when something actually reads a user packet, but rather by when it is copied into the appropriate buffer. There are four cases to consider:

1. A host sending user packets to a CME can always send one packet without a timeout, but the *second* packet will time out if a CME user program has not read the first packet in the specified time.
2. A host receiving user packets from a CME will time out if a CME user program has not written a packet to the outgoing buffer by the specified time.
3. A CME sending user packets to a host can always send one packet without a timeout, but the *second* packet will time out if a host program has not read the first packet in the specified time.
4. A CME receiving user packets will time out if a host program has not written a user packet to the incoming buffer in the specified time.

PRP Action

None

Arguments

Name	Type
hPeriph	pointer to uninitialized peripheral handle
hDevice	pointer to a valid device handle
address	16 bit address indicating peripheral channel to open
eventIRQ	device-specific interrupt channel
datasize	data width of the peripheral in bytes

C Syntax

```
PMDresult PMDDeviceOpenPeriphPIO(PMDPeriphHandle* hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDuint16 address,
                                 PMDuint8 eventIRQ,
                                 PMDDataSize datasize);
```

C# Syntax

```
UInt32 address;
PMDPeripheral periph = new PMDPeripheralPIO(address, 0,
PMDDataSize.Size16Bit);
```

VB Syntax

```
Dim address As UInt16
Dim periph As New PMDPeripheralPIO(address, 0, PMDDataSize.Size16Bit)
```

Description

PMDDeviceOpenPeriphPIO is used to open a peripheral handle representing a parallel channel on the indicated device. The nature of the parallel channel is specific to the device being addressed. N-Series ION/CME supports parallel channels used for digital I/O, encoder configuration parameters, and for analog input.

The ***address*** argument indicates the specific parallel channel to be opened, and is device-specific. The ***datasize*** argument indicates the data width of the peripheral to be opened, that is, the number of 8 bit bytes read or written with each operation. Only one data width is normally supported for each type of parallel channel. The ***eventIRQ*** argument indicates the interrupt used for parallel communication, and is not used in N-Series ION/CME.

Consult the appropriate device user manual for details.

PRP Action

Open PIO Device

Arguments

Name	Type
hPeriph	pointer to uninitialized peripheral handle
hDevice	pointer to an open PRP device handle or NULL if local
channel	channel number (1-10)
bufsize	size of buffer in bytes to allocate

C Syntax

```
PMDresult PMDDeviceOpenPeriphPRP(PMDPeriphHandle* hPeriph,
                                 PMDDeviceHandle* hDevice,
                                 PMDparam channel,
                                 PMDparam bufsize);
```

C# Syntax

```
UInt32 channel, bufsize;
PMDPeripheral periph = new PMDPeripheralPRP(channel, bufsize);
```

VB Syntax

```
Dim channel, bufsize As UInt32
Dim periph As New PMDPeripheralPRP(channel, bufsize)
```

Description

PMDDeviceOpenPeriphPRP is used to open a virtual peripheral using PRP packets. It is similar to the CME user packet peripheral accessed via **PMDDeviceOpenPeriphCME** but transfers a stream of bytes rather than a single "user packet" of a fixed size.

A peripheral connection is made using the function **PMDDeviceOpenPeriphPRP**, where *hPeriph* is the peripheral handle that will be assigned, *hDevice* is the device handle of the remote PRP device or NULL to indicate the local device, *channel* is the channel number from 2-10 (1 is reserved for the PRP console) and bufsize is the size of the buffer to allocate. Data are sent and received using **PMDPeriphSend** and **PMDPeriphReceive**.

When a PRP peripheral channel is opened by CME user code two buffers of size *bufsize* bytes each are created, one for sending data and one for receiving data. If the buffer memory cannot be allocated PMD_ERR_Memory will be returned. When a PRP peripheral channel is opened by host software the channel is assigned to the peripheral handle but no PRP "open" command is sent. If the host attempts to send or receive data to a channel that is not opened by the CME a PMD_ERR_NotConnected error is returned.

PRP Action

None

Arguments

Name	Type
hPeriph	pointer to uninitialized PMDPeriphHandle
hDevice	pointer to an open PRP device handle or NULL if local
port	enumerated serial port
baud	enumerated baud rate
parity	enumerated parity
stopbits	enumerated number of stop bits

C Syntax

```
PMDresult PMDDeviceOpenPeriphSerial(PMDPeriphHandle *hPeriph,
                                    PMDDeviceHandle *hDevice,
                                    PMDSerialPort port,
                                    PMDSerialBaud baud,
                                    PMDSerialParity parity,
                                    PMDSerialStopBits stopbits);
```

C# Syntax

```
PMDPeripheral periph = new PMDPeripheralSerial(portnum,
PMDSerialBaud.baud, PMDSerialParity.parity, PMDSerialStopBits.bits);
```

VB Syntax

```
Dim periph As New PMDPeripheralSerial(portnum, PMDSerialBaud.baud, _
                                      PMDSerialParity.parity, PMDSerialStopBits.bits)
```

Description

PMDDeviceOpenPeriphSerial is used to open a peripheral handle representing an open serial line. *hPeriph* should point to an uninitialized **PMDPeriphHandle** data structure. *hDevice* is a device handle which should be associated with a PRP device, *hDevice* may be a null pointer, in which case it means the local device, either the host or, for a C-Motion Engine user program, the local PRP device.

port is the serial port to use, one of PMDSerialPort1 or PMDSerialPort2 or higher for host PCs.

baud is the serial port speed to set, one of PMDSerialBaud9600, PMDSerialBaud19200, PMDSerialBaud57600, PMDSerialBaud115200, PMDSerialBaud230400, or PMDSerialBaud460800.

parity is the parity to use, one of PMDSerialParityNone, PMDSerialParityOdd, or PMDSerialParityEven.

stopbits is the number of stopbits to use, either PMDSerialStopBits1 or PMDSerialStopBits2.

Eight data bits are always used.

In order to open a PMD serial protocol multi-drop peripheral, **PMDPeriphOpenPeriphMultiDrop** should be applied to the peripheral handle opened by **PMDDeviceOpenPeriphSerial**.

PRP Action

Open Serial Device

Arguments

Name	Type
hPeriph	pointer to uninitialized peripheral handle
hDevice	pointer to an open PRP device handle or NULL if local
port	ExpSPI or HostSPI port (0-1)
chipselect	a value of PMDSPIChipSelect (0-4)
spimode	a value of PMDSPIMode (0-3)
datasize	number of bits in an SPI word (4-16)
bitrate	clock frequency as one of PMDSPIBitRate (1-7)

C Syntax

```
PMDresult PMDDeviceOpenPeriphSPI(PMDPeriphHandle* hPeriph,
                                 PMDDeviceHandle* hDevice,
                                 PMDSPIPort port,
                                 PMDSPIChipSelect chipselect,
                                 PMDSPIMode SPImode,
                                 PMDuint8 datasize,
                                 PMDSPIBitRate bitrate);
```

C# Syntax

```
Byte datasize;
PMDPeripheral periph = new PMDPeripheralSPI(SPIPort.port,
PMDSPIChipSelect.chipselect, PMDSPIMode.mode, datasize,
PMDSPIBitRate.bitrate);
```

VB Syntax

```
Dim datasize As Byte
Dim periph As New PMDPeripheralSPI(PMDSPIPort.port,
PMDSPIChipSelect.chipselect, PMDSPIMode.mode, datasize,
PMDSPIBitRate.bitrate)
```

Description

PMDDeviceOpenPeriphSPI is used to open an Expansion or Host SPI peripheral. The ***port*** parameter selects the SPI port: ExpSPI (SPI master) or HostSPI (SPI slave). The ***chipselect*** parameter sets the chip select signal that will be activated during a transaction on the ExpSPI port. Up to 4 chip selects can be opened simultaneously. The possible ***chipselect*** values are 0-4 where 1-4 select the chip select signal to use and a value is of 0 specifies no chip select signal will be used. The ***chipselect*** parameter is not valid for the HostSPI port. Each chip select supports different SPI configurations. The ***datasize*** parameter sets the number of bits in a single word for both ExpSPI and HostSPI. The ***datasize*** field affects the size of the data parameter in the Send and Receive functions. If ***datasize*** is 8 bits or less the `data` parameter is a pointer to an array of bytes. If ***datasize*** is 16 bits or less the `data` parameter for the PMDPeriphSend and PMDPeriphReceive functions is a pointer to an array of 16 bit words. The ***bitrateHz*** parameter specifies the ExpSPI clock frequency as one of **PMDSPIBitRate**. The DIO configuration such as the mux selection and signal direction must be configured separately (see the *ION/CME N-Series Digital Drive User Manual*).

PRP Action

Open SPI Device

Arguments

Name	Type
hPeriph	pointer to uninitialized PMDPeriphHandle
hDevice	pointer to an open PMDDeviceHandle or NULL if local
IPAddress	32 bit IP address
port	16 bit TCP port
timeout	milliseconds

C Syntax

```
PMDresult PMDDeviceOpenPeriphTCP(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDparam IPAddress,
                                 PMDparam port,
                                 PMDparam timeout);
```

C# Syntax

```
System.Net.IPAddress ipaddress;
UInt32 port, timeout;
PMDPeripheral periph = new PMDPeripheralTCP(ipaddress, port, timeout);
```

VB Syntax

```
Dim address As System.Net.IPAddress
Dim portnum, timeout As UInt32
Dim periph As New PMDPeripheralTCP(address, portnum, timeout)
```

Description

PMDDeviceOpenPeriphTCP is used to open a TCP peripheral on the PRP device indicated by *hDevice*. If *hDevice* is a null pointer then the local device, either the host or the PRP device on which a CME user program is running.

If *IPAddress* is nonzero then it is the IP address of a remote Ethernet device to which a connection should be opened. If *IPAddress* is nonzero then the device will listen on the indicated TCP *port* for incoming connections from any device, handle one connection at a time, and resume listening after a remote device closes the connection. In either case, a connection may be closed using **PMDPeriphClose**.

IPAddress must be numeric, PRP devices do not support any kind of name service. An IP address in the familiar dotted quad notation A.B.C.D is equivalent to the 32 bit number (A<<24) + (B<<16) + (C<<8) + D, this conversion may be done using the macro PMD_IP4_ADDR, for example the numeric value of the IP address 192.168.13.42 could be obtained by writing PMD_IP4_ADDR(192, 168, 13, 42).

port is the TCP port number to use for sending or receiving. TCP ports are divided into three ranges:

1. The *well-known* ports from 0 to 1023 are used for standard services, which are not likely to be hosted by user C-Motion Engine applications.
2. The *registered ports* from 1024 to 49151 are used *ad hoc*, and are most likely to be used for user motion control applications,
3. The dynamic ports from 49152 to 65535 are used for temporary applications, and may be useful for user applications that dynamically assign TCP ports.

PRP Action

Open TCP Device

Arguments

Name	Type
hPeriph	pointer to uninitialized PMDPeriphHandle
hDevice	pointer to an open PMDDeviceHandle
IPAddress	32 bit IP address
port	16 bit UDP port

C Syntax

```
PMDresult PMDDeviceOpenPeriphUDP(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDparam IPAddress,
                                 PMDparam port);
```

C# Syntax

```
System.Net.IPAddress ipaddress;
UInt32 port;
PMDPeripheral periph = new PMDPeripheralUDP(ipaddress, port);
```

VB Syntax

```
Dim IPaddress As UInt32
Dim port As UInt32
Dim periph As New PMDPeripheralUDP(IPaddress, port)
```

Description

PMDDeviceOpenPeriphUDP is used to open a UDP peripheral on the PRP device indicated by *hDevice*. If hDevice is a null pointer then the local device, either the host or the PRP device on which a CME user program is running.

If *IPAddress* is nonzero then it is the IP address of a remote Ethernet device to which packets will be sent; the peripheral will be write-only. If *IPAddress* is zero then a UDP port will be opened for listening; the peripheral will be read-only. *IPAddress* must be numeric, PRP devices do not support any kind of name service. An IP address in the familiar dotted quad notation A.B.C.D is equivalent to the 32 bit number (A<<24) + (B<<16) + (C<<8) + D, this conversion may be done using the macro PMD_IP4_ADDR, for example the numeric value of the IP address 192.168.13.42 could be obtained by writing PMD_IP4_ADDR(192, 168, 13, 42).

port is the UDP port number to use for sending or receiving. UDP ports are divided into three ranges:

1. The *well-known* ports from 0 to 1023 are used for standard services, which are not likely to be hosted by user C-Motion Engine applications.
2. The *registered ports* from 1024 to 49151 are used *ad hoc*, and are most likely to be used for user motion control applications,
3. The dynamic ports from 49152 to 65535 are used for temporary applications, and may be useful for user applications that dynamically assign UDP ports.

PRP Action

Open UDP Device

Arguments

Name	Type
hDevice	pointer to PMDDeviceHandle

C Syntax

```
PMDresult PMDDeviceReset(PMDDeviceHandle *hDevice);
```

C# Syntax

```
device.Reset();
```

VB Syntax

```
device.Reset()
```

Description

PMDDeviceReset is used to reset the device. After resetting a CME device, the first valid command sent from a host will return PMD_ERR_RP_Reset.

PRP Action

Reset Device

Arguments

Name	Type
hDevice	pointer to an open PRP device handle or NULL if local
defaultcode	enumerated default code
value	pointer to new default value
valueSize	size of default value

C Syntax

```
PMDresult PMDDeviceSetDefault(PMDDeviceHandle *hDevice,
                              PMDDefault defaultcode,
                              void *value,
                              unsigned valueSize);
```

C# Syntax

```
UInt32 value32;
device.SetDefault(PMDDefault.code, value32);
```

VB Syntax

```
Dim value32 As UInt32
device.SetDefault(PMDDefault.code, value32)
```

Description

PMDDeviceSetDefault is used to change the value of a *device default*. Device defaults are various non-volatile properties of the PRP device, for example the IP address, or whether to run a user program immediately after power up.

hDevice is a pointer to a handle associated with the PRP device being interrogated; in C-Motion Engine user programs *hDevice* may be a null pointer, meaning the local device.

default is a numeric default code, please see the description of the Set DefaultDevice action in Section 2.4, PRP Addresses for a table of supported default codes and their meaning.

value is the data to be stored, and *valueSize* is the size, in bytes, of the area. The size of a default depends on the particular data type, and is encoded in the upper byte of the default code – a value of zero means one byte, one means two bytes, and *n* means *n – 1* bytes. *valueSize* is required as a sanity check, an error code will be returned if *valueSize* is not large enough to contain the default value.

Two byte default values are generally 16 bit integers, and four byte values 32 bit integers. The *value* pointer must be properly aligned to hold these values. It is safe in all cases to make value to be double-word aligned.

PRP Action

Set Default Device

Arguments

Name	Type
hDevice	pointer to open RP device handle or NULL if local
nodeID	desired NodeID to assign to the device
DOsignal	digital output signal that will be set
DIsignal	digital input signal to sample
DIsense	digital input and output signal sense

C Syntax

```
PMDresult PMDDeviceSetNodeID(PMDDeviceHandle *hDevice,
                             PMDuint8 nodeID,
                             PMDuint8 DOsignal,
                             PMDuint8 DIsignal,
                             PMDuint8 DIsense);
```

C# Syntax

```
Byte nodeID, DOsignal, DIsignal, DIsense;
device.SetNodeID(nodeID, DOsignal, DIsignal, DIsense);
```

VB Syntax

```
Dim nodeID, DOsignal, DIsignal, DIsense As Byte
device.SetNodeID(nodeID, DOsignal, DIsignal, DIsense)
```

Description

The function **PMDDeviceSetNodeID** is used to set the NodeID of the interface on the CME device that the command is received on (Serial or CAN). See the PRP action for more information.

PRP Action

Set NodeID Device

Arguments

Name	Type
hDevice	pointer to an open PRP device handle or NULL if local
time	pointer to a SYSTEMTIME structure

C Syntax

```
PMDresult PMDDeviceSetSystemTime(PMDDeviceHandle* hDevice,
                                 SYSTEMTIME* time);
```

C# Syntax

```
SYSTEMTIME time;
device.SetSystemTime(time);
```

VB Syntax

```
Dim time as PMD.SYSTEMTIME
device.SetSystemTime(time)
```

Description

PMDDeviceSetSystemTime is used to obtain the date and time from built-in real-time clock. The time argument is a pointer to a SYSTEMTIME structure which is the same format as the Windows SYSTEMTIME structure.

```
typedef struct _SYSTEMTIME {
    WORD wYear;
    WORD wMonth;     // The current month; January is 1.
    WORD wDayOfWeek; // The current day of the week; Sunday is 0, Monday is 1, etc.
    WORD wDay;
    WORD wHour;
    WORD wMinute;
    WORD wSecond;
    WORD wMilliseconds;
} SYSTEMTIME
```

PRP Action

None

Arguments

Name	Type
hEvent	pointer to uninitialized event handle
eventnumber	a value of PMDEventNumber indicating 1 of 2 possible event inputs
signal	a value of PMDEventSignal that indicates which digital input will cause the event
trigger	a value of PMDEventTrigger that sets the trigger mode

C Syntax

```
PMDresult PMDEventOpenDI(PMDEventHandle* hEvent,
                         PMDEventNumber number,
                         PMDEventSignal signal,
                         PMDEventTrigger trigger);
```

Description

The **PMDEventOpenDI** function is used to setup a digital input event. Events are hardware interrupts from various sources. The CME user code waits for an event to occur using the **PMDEventWait** function.

The *eventumber* parameter specifies which of the 2 possible events to configure. The *signal* parameter sets the digital input to monitor. The *trigger* parameter sets the trigger mode of PMDEventTrigger.

```
typedef enum {
    PMDEventSignal_DI1                  = 0,
    PMDEventSignal_DI2                  = 1,
    PMDEventSignal_DI3                  = 2,
    PMDEventSignal_DI4                  = 3,
    PMDEventSignal_DI5                  = 4,
    PMDEventSignal_DI6                  = 5,
    PMDEventSignal_DI7                  = 6,
    PMDEventSignal_DI8                  = 7,
    PMDEventSignal_HallA                = 8,
    PMDEventSignal_HallB                = 9,
    PMDEventSignal_HallC                = 10,
    PMDEventSignal_PosLimit             = 11,
    PMDEventSignal_NegLimit             = 12,
    PMDEventSignal_Home                 = 13,
    PMDEventSignal_Enable               = 14,
    PMDEventSignal_Brake                = 15,
    PMDEventSignal_QuadA1               = 16,
    PMDEventSignal_QuadB1               = 17,
    PMDEventSignal_Index1               = 18,
    PMDEventSignal_QuadA2               = 20,
    PMDEventSignal_QuadB2               = 21,
    PMDEventSignal_Index2               = 22,
    PMDEventSignal_FaultOut             = 23,
} PMDEventSignal;

typedef enum {
    PMDEventTrigger_Disable             = 0,
    PMDEventTrigger_PosEdge             = 1,
    PMDEventTrigger_NegEdge             = 2,
    PMDEventTrigger_BothEdges           = 3,
} PMDEventTrigger;
```

PRP Action

None

Arguments

Name	Type
hEvent	pointer to uninitialized event handle

C Syntax

```
PMDresult PMDEventOpenMotion(PMDEventHandle* hEvent);
```

Description

The **PMDEventOpenMotion** function is used to setup a motion event from the motion IC such as a motion complete event. This event is triggered by the ***HostInterrupt*** signal of the Motion IC. The CME user code waits for an event to occur using the **PMDEventWait** function. (For more information see the *Host Interrupts* section in the *Magellan Motion Control IC User Guide*).

PRP Action

None

Arguments

Name	Type
hEvent	pointer to uninitialized event handle
timernumber	a value of PMDEventNumber indicating 1 of 4 possible timers
mode	a value of PMDEventMode that sets the timer mode
periodus	period in microseconds

C Syntax

```
PMDresult PMDEventOpenTimer(PMDEventHandle* hEvent,
                            PMDEventNumber timernumber,
                            PMDEventMode mode,
                            PMDparam periodus);
```

Description

The **PMDEventOpenTimer** function is used to setup a high-resolution timer event. There are 4 timers available. The *timernumber* parameter specifies which of the 4 possible timers to configure. The `mode` parameter selects the mode of the timer event: one-time or continuous. The *period* parameter sets the period of the timer in µs. The timer starts counting down from the period value to 0 after the call to **PMDEventOpenTimer**. The event will trigger when the timer reaches 0. If the timer mode is continuous the timer will reload the period value and begin to count down again and the event will repeatedly trigger when the counter reaches 0. The **PMDEventWait** function will return PMD_ERR_ReceiveOverrun if more than one event was missed before the **PMDEventWait** function was called.

PRP Action

None

Arguments

Name	Type
hEvent	pointer to initialized event handle
eventvalue	reserved
timeoutms	timeout in milliseconds

C Syntax

```
PMDresult PMDEventWait(PMDEventHandle* hEvent,
                       PMDparam* eventvalue,
                       PMDparam timeoutms);
```

Description

The **PMDEventWait** function is used to wait for an event created by one of the **PMDEventOpen** functions. The function returns when the event occurs or ***timeoutms*** milliseconds have elapsed. The ***eventvalue*** parameter is reserved for future use and can be set to NULL.

PRP Action

None

Arguments

Name	Type
hMailbox	pointer to uninitialized mailbox handle
hDevice	must be set to NULL
mailboxid	the mailbox number to open
depth	number of items that the mailbox can hold
itemsize	size of a single mailbox item in bytes

C Syntax

```
PMDresult PMDMailboxOpen(PMDMailboxHandle* hMailbox,
                         PMDDeviceHandle* hDevice,
                         PMDparam mailboxid
                         PMDparam depth,
                         PMDparam itemsize);
```

Description

The **PMDMailboxOpen** function is used to create a mailbox for intertask communication. Up to 10 mailboxes can be created. The *mailboxid* parameter is the mailbox number to create, *itemsize* is the size of each item in bytes and depth is the number of items that the mailbox can hold. The maximum depth is 10. Messages are sent and received using **PMDMailboxSend** and **PMDMailboxReceive**.

One or more tasks send messages to the mailbox while another task receives messages from the mailbox. The **PMDMailboxPeek** function receives a message from the mailbox without removing it from the mailbox.

A semaphore can be implemented using a mailbox with a depth of 1 and item size of 0.

PRP Action

None

Arguments

Name	Type
hMailbox	pointer to initialized mailbox handle
pItem	pointer to the item to receive
timeoutms	timeout in milliseconds

C Syntax

```
PMDresult PMDMailboxPeek(PMDMailboxHandle* hMailbox,
                         void* pItem,
                         PMDparam timeoutms);
```

Description

The **PMDMailboxPeek** function is used to receive an item from the mailbox identified by the *hMailbox* parameter without removing it from the mailbox. The *pItem* is a pointer to the item that should be able to receive a block of data of size *itemsize* that was set in the call to **PMDMailboxOpen**. The **PMDMailboxPeek** function will block the calling task if the mailbox is empty. It will return if an item is posted to the mailbox or *timeoutms* elapses.

PRP Action

None

Arguments

Name	Type
hMailbox	pointer to initialized mailbox handle
pItem	pointer to the item to receive
timeoutms	timeout in milliseconds

C Syntax

```
PMDresult PMDMailboxReceive(PMDMailboxHandle* hMailbox,
                            void* pItem,
                            PMDparam timeoutms);
```

Description

The **PMDMailboxReceive** function is used to receive an item from the mailbox identified by the *hMailbox* parameter. The *pItem* is a pointer to the item that should be able to receive a block of data of size `itemsize` that was set in the call to **PMDMailboxOpen**. The **PMDMailboxReceive** function will block the calling task if the mailbox is empty. It will return PMD_ERR_OK if an item is posted to the mailbox or PMD_ERR_Timeout if *timeoutms* elapses.

PRP Action

None

Arguments

Name	Type
hMailbox	pointer to initialized mailbox handle
pItem	pointer to the item to send
timeoutms	timeout in milliseconds

C Syntax

```
PMDresult PMDMailboxSend(PMDMailboxHandle* hMailbox,
                         void* pItem,
                         PMDparam timeoutms);
```

Description

The **PMDMailboxSend** function is used to send an item to the mailbox identified by the *hMailbox* parameter. The *pItem* is a pointer to the item that is of size *itemsize* that was set in the call to **PMDMailboxOpen**. The **PMDMailboxSend** function will block the calling task if the mailbox is full. It will return PMD_ERR_OK if space becomes free or PMD_ERR_Timeout if *timeoutms* elapses.

PRP Action

None

Arguments

Name	Type
hMemory	pointer to an open PMDMemoryHandle

C Syntax

```
PMDresult PMDMemoryClose(PMDMemoryHandle *hMemory);
```

C# Syntax

```
memory.Close();
```

VB Syntax

```
memory.Close()
```

Description

PMDMemoryClose is used to free any resources used in maintaining a handle to a memory resource such as dual-ported RAM. After closing the memory used for the **PMDMemoryHandle** data type may be freed or re-used.

PRP Action

Close various

Arguments

Name	Type
hMemory	pointer to open memory handle

C Syntax

```
PMDresult PMDMemoryErase(PMDMemoryHandle *hMemory);
```

C# Syntax

```
memory.Erase();
```

VB Syntax

```
memory.Erase()
```

Description

The function **PMDMemoryErase** is used to erase the memory indicated by the *hMemory* handle opened with **PMDDeviceOpenMemory**. If the memory is of type PMDMemoryAddress_NVRAM the function may take several seconds to return and will set all the bytes to 0xFF. If the memory is of type PMDMemoryAddress_RAM the function may take several milliseconds to return and will set all the bytes to 0x00.

PRP Action

Clear Memory

Arguments

Name	Type
hMemory	pointer to an open PMDMemoryHandle
data	pointer to data read
offset	memory address
length	memory byte length

C Syntax

```
PMDresult PMDMemoryRead(PMDMemoryHandle *hMemory,
                        void *data,
                        PMDuint32 offset,
                        PMDuint32 length);
```

C# Syntax

```
UInt32 offset, length;
UInt32 values[MaxLength];
memory.Read(values, offset, length);
```

VB Syntax

```
Dim offset, length As UInt32
Dim values(0 To MaxLength)
memory.Read(values, offset, length)
```

Description

PMDMemoryRead is used to read a sequence of bytes from the memory object indicated by the *hMemory* argument. The *data* argument is a pointer to a data buffer for the values read. The *offset* argument is the memory address at which to start reading. The *length* argument is the number of bytes to read.

Each memory device has a data width, for example memory handles opened with a datasize of PMDDataSize32bit have a data width of 4 bytes, or 32 bits. If the *data*, *offset*, or *length* arguments are not aligned to the memory data width then a PMD_ERR_ParameterAlignment error code will be returned. Most CME products support only dword addressable memory resources.

PRP Action

Read Memory

Arguments

Name	Type
hMemory	pointer to an open PMDMemoryHandle
data	pointer to data to write
offset	memory address
length	number of bytes to write

C Syntax

```
PMDresult PMDMemoryWrite(PMDMemoryHandle *hMemory,
                         void *data,
                         PMDuint32 offset,
                         PMDuint32 length);
```

C# Syntax

```
UInt32 offset, length;
UInt32 values[MaxLength];
memory.Write(values, offset, length);
```

VB Syntax

```
Dim offset, length As UInt32
Dim values(0 To MaxLength)
memory.Write(values, offset, length)
```

Description

PMDMemoryWrite is used to write data to the memory resource indicated by the *hMemory* handle. The *data* argument is a pointer to the data to write. The *offset* argument is the memory address at which to start writing. The *length* argument is the number of data units to write depending on the data size.

Each memory device has a data width. For example, memory handles opened with a datasize of PMD_DataSize_32Bit have a data width of 4 bytes, or 32 bits. If the data, offset, or length arguments are not aligned to the memory data width then a PMD_ERR_ParameterAlignment error code will be returned. Most CME products support only dword- addressable memory resources. The N-Series ION writes data in 256 bit blocks (32 dwords). The data pointer can point to an array of up to 8 32 bit values (dwords). The *offset* must be divisible by 8 dwords or PMD_ERR_ParameterAlignment error code will be returned. **PMDMemoryRead** does not have this restriction.

PRP Action

Write Memory

Arguments

Name	Type
hPeriph	pointer to an open PMDPeriphHandle

C Syntax

```
PMDresult PMDPeriphClose(PMDPeriphHandle *hPeriph);
```

C# Syntax

```
memory.Close();
```

VB Syntax

```
peripheral.Close()
```

Description

PMDPeriphClose is used to free resources associated with an open peripheral handle.

The communication channel will be closed, and no input will be accepted on it. Memory used for the peripheral handle may be freed or used for another purpose.

PRP Action

Close various

Arguments

Name	Type
hDevice	pointer to uninitialized PMDDeviceHandle
hPeriph	pointer to PMDPeriphHandle

C Syntax

```
PMDresult PMDPeriphOpenDeviceMP(PMDDeviceHandle *hDevice,
                                PMDPeriphHandle *hPeriph);
```

C# Syntax

```
PMDDevice device = new PMDDevice(periph,
                        PMDDeviceType.MotionProcessor);
```

VB Syntax

```
Dim device As New PMDDevice(peripheral, PMDDeviceType.MotionProcessor)
```

Description

PMDPeriphOpenDeviceMP is used to obtain a handle to a Magellan attached device, for example a non-CME ION module, or a Magellan DK card. A Magellan attached device communicates using the Magellan protocol, and not PRP. The *hDevice* argument should point to an uninitialized PMDDeviceHandle data type, which may not be freed or written to as long as the device handle is in use.

hPeriph should point to an open peripheral connection to the Magellan attached device.

The device handle obtained using this procedure is useful for opening motion processor axis handles, using the **PMDAxisOpen** procedure.

PRP Action

Open MotionProcessor Peripheral

Arguments

Name	Type
hDevice	pointer to uninitialized PMDDeviceHandle
hPeriph	pointer to an open PMDPeriphHandle

C Syntax

```
PMDresult PMDPeriphOpenDevicePRP(PMDDeviceHandle *hDevice,
                                 PMDPeriphHandle *hPeriph);
```

C# Syntax

```
PMDDevice device = new PMDDevice(periph, PMDDeviceType.ResourceProtocol)
```

VB Syntax

```
Dim dev As New PMDDevice(periph, PMDDeviceType.ResourceProtocol)
```

Description

PMDPeriphOpenDevicePRP is used to open a handle to a device that communicates using PRP, that is, a Prodigy/CME card or N-Series ION/CME module. *hPeriph* should be a handle to an open peripheral that is physically connected to a PRP device.

The device handle opened by this procedure may be used for opening motion processor axes, (see **PMDAxisOpen** (p. 29)), or memory resources (see **PMDDeviceOpenMemory** (p. 46), or peripherals on the device (see **PMDDeviceOpenPeriphSerial** (p. 52), **PMDDeviceOpenPeriphTCP** (p. 54), **PMDDeviceOpenPeriphUDP** (p. 55), **PMDDeviceOpenPeriphSPI** (p. 53), and **PMDDeviceOpenPeriphCAN** (p. 47)) .

The device handle is also used to access the C-Motion Engine on the device, for example using **PMDCMETaskStart** or **PMDCMETaskGetInfo**.

PRP Action

Open Device Peripheral

Arguments

Name	Type
hPeriph	pointer to uninitialized PMDPeriphHandle
hParent	pointer to an open handle to serial port peripheral
address	multi-drop address

C Syntax

```
PMDresult PMDPeriphOpenPeriphMultiDrop(PMDPeriphHandle *hPeriph,
                                       PMDPeriphHandle *hPeriphParent,
                                       PMDparam address);
```

C# Syntax

```
UInt32 address;
Peripheral periph = new PeripheralMultiDrop(periph, address);
```

VB Syntax

```
Dim address As UInt32
Dim periph As New PMDPeripheralMultiDrop(periph, address)
```

Description

PMDPeriphOpenPeriphMultiDrop is used to open a peripheral representing a connection on a serial line to a device using the PMD multi-drop serial protocol, either a Magellan attached device or a PRP device. *hParent* must be a pointer to a previously opened peripheral representing the serial line, and address is the multi-drop address. This function can be used to open multiple handles to different CAN nodeIDs on a host PC.

PRP Action

Open MultiDrop Peripheral

Arguments

Name	Type
hPeriph	pointer to an open PMDPeriphHandle
data	buffer for incoming data
offset	byte offset from base address
length	number of data units to read

C Syntax

```
PMDresult PMDPeriphRead (PMDPeriphHandle *hPeriph,
                         void *data,
                         PMDparam offset,
                         PMDparam length);
```

C# Syntax

```
UInt16 data16[MaxLength];
UInt32 offset, length;
periph.Read(data16, offset, length);
```

VB Syntax

```
Dim data16(0 To MaxLength) As UInt16
Dim offset, length As UInt32
periph.read(data16, offset, length)
```

Description

PMDPeriphRead is used to read a stream of bytes from a peripheral with a specified base address, specifically PIO bus peripherals. *hPeriph* should point to an open handle to such a peripheral, for peripherals without an address concept an error code of PMD_ERR_Not_Supported will be returned.

data is a pointer to a buffer for incoming data, *offset* is an increment to add to the base address to give the address to read from, and *length* is the number of datasize elements (specified in **PMDPeriphOpen** call) to read.

PRP Action

Read Peripheral

Arguments

Name	Type
hPeriph	pointer to an open PMDPeriphHandle
data	pointer to incoming data buffer
nReceived	pointer to actual bytes received
nExpected	maximum bytes to receive
timeout	milliseconds to wait

C Syntax

```
PMDresult PMDPeriphReceive(PMDPeriphHandle *hPeriph,
                           void *data,
                           PMDparam *nReceived,
                           PMDparam nExpected,
                           PMDparam timeout);
```

C# Syntax

```
Byte data[MaxLength];
UInt32 expected, received, timeout;
periph.Receive(data, received, expected, timeout);
```

VB Syntax

```
Dim data(0 To MaxLength) As Byte
Dim nReceived, nExpected, timeout As UInt32
periph.Receive(data, nReceived, nExpected, timeout)
```

Description

PMDPeriphReceive is used to read bytes from a peripheral. *hPeriph* should be a pointer to an open peripheral handle, *data* a pointer to a memory buffer for incoming data, and *nExpected* the maximum number of bytes to accept, typically the size of the data buffer.

For peripherals that receive data in packets, such as CANBus, TCP, and UDP, **PMDPeriphReceive** will return after receiving one packet, writing to the data buffer, and writing the actual number of bytes received to *nReceived*. Note that the number of bytes received may be greater than *nExpected*, but at most *nExpected* bytes will be written to the buffer.

For peripherals that do not receive data in packets, such as serial ports, **PMDPeriphReceive** will return after receiving exactly *nExpected* bytes.

PMDPeriphReceive will return PMD_ERR_RP_Timeout if timeout milliseconds elapsed waiting for data. Some ports may timeout before receiving *nExpected* bytes. The *nReceived* parameter will contain the number of bytes received before the timeout. A timeout value of PMD_WAITFOREVER (0xFFFFFFFF) disables the time out. When this function is sent as a PRP command (i.e. remote peripheral access) the maximum timeout is 0xFFFF.

If the peripheral connection has been closed by some external action, for example a TCP connection that has been closed by a peer, then PMD_ERR_NotConnected will be returned. After such an error the peripheral handle must be closed using **PMDPeriphClose**. In the case of a TCP connection, after closing the unconnected peripheral a new peripheral with the same TCP port may be opened using **PMDDeviceOpenPeriphTCP**.

The following example shows how to implement a TCP server that handles a single connection at a time, and reads data until the connection is closed by the peer.

```
    PMDresult status;
    PMDPeriphHandle hPeriphTCP;
    PMDuint32 nReceived;
    unsigned char buffer[PACKETSIZE];
    int open;

while (!0) {
     status = PMDDeviceOpenPeriphTCP(&hPeriphTCP, NULL, 0, TCPPORT, timeout);
     open = 1;
```

Description (cont.)

```
while (open) {
   status = PMDPeriphReceive(&hPeriphTCP, buffer, &nReceived, sizeof(buffer), timeout);
   // As a simple example we just read data. For a more complicated protocol each send
    // and receive operation should include a check of the return value as shown.
    switch (status) {
    default:
        Handle the error;
    case PMD_ERR_NotConnected:
       // The peripheral handle must be closed. It will be re-opened in the outer loop.
        PMDPeriphClose(&hPeriphTCP);
        open = 0;
        break;
    case PMD_ERR_OK:
        Do something useful with the data;
        break;
    }
  }
}
```

PRP Action

Receive Peripheral

Arguments

Name	Type
hPeriph	pointer to an open PMDPeriphHandle
data	pointer to data to send
nCount	number of bytes to send
timeout	milliseconds to wait

C Syntax

```
PMDresult PMDPeriphSend(PMDPeriphHandle *hPeriph,
                        void *data,
                        PMDparam nCount,
                        PMDparam timeout);
```

C# Syntax

```
Byte data[MaxLength];
UInt32 length, timeout;
periph.Send(data, length, timeout);
```

VB Syntax

```
Dim data8(0 To MaxLength) As Byte
Dim nCount, timeout As UInt32
periph.Send(data8, nCount, timeout)
```

Description

PMDPeriphSend is used to send bytes to a peripheral, indicated by the *hPeriph* argument.

nCount bytes are sent from the buffer data. If the data may not be sent in timeout milliseconds then **PMDPeriphSend** will stop trying and return PMD_ERR_Timeout. A *timeout* value of PMD_WAITFOREVER (0xFFFFFFFF) means never stop trying. When this function is sent as a PRP command (i.e. remote peripheral access) the maximum timeout is 0xFFFF.

If the peripheral connection has been closed by some external action, for example a TCP connection that has been closed by a peer, then PMD_ERR_NotConnected will be returned. After such an error the peripheral handle must be closed using **PMDPeriphClose**. In the case of a TCP connection, after closing the unconnected peripheral a new peripheral with the same TCP port may be opened using **PMDDeviceOpenPeriphTCP**. See **PMDPeriphReceive** (p. 77) for example code.

PRP Action

Send Peripheral

Arguments

Name	Type
hPeriph	pointer to an open peripheral handle
data	pointer to data to write
offset	offset from base address
length	number of data units to write

C Syntax

```
PMDresult PMDPeriphWrite(PMDPeriphHandle *hPeriph,
                         void *data,
                         PMDparam offset,
                         PMDparam length);
```

C# Syntax

```
UInt16 data16[MaxLength];
UInt32 offset, length;
periph.Write(data16, offset, length);
```

VB Syntax

```
Dim data16(0 To MaxLength) As UInt16
Dim offset, length As UInt32
periph.Write(data16, offset, length)
```

Description

PMDPeriphWrite is used to write a stream of bytes to a peripheral with a specified base address, specifically PIO bus peripherals. *hPeriph* should point to an open handle to such a peripheral, for peripherals without an address concept an error code of PMD_ERR_Not_Supported will be returned.

data is a pointer to a buffer containing the data to write, *offset* is an increment to add to the base address to give the address for writing, and *length* is the number of datasize elements (specified in **PMDPeriphOpen** call) to write.

PRP Action

Write Peripheral

Arguments

Name	Type
fmt	string
…	arguments to format

C Syntax

```
int PMDprintf(const char *fmt, …);
```

Description

PMDprintf is the primary procedure used for console output, a feature used for progress reporting during development and debugging. The console may be attached to any of the available communication devices at startup using the default settings PMDDefault_DebugIntfType, PMDDefault_DebugIntfAddr, and PMDDefault_DebugIntfPort. The console may be changed at run time to a specified peripheral by using the PRP action **Set Console**. Pro-Motion can also be used conveniently to set the current or default console.

The arguments to **PMDprintf** are the same as to the C standard library *printf*, and the return value is the number of characters printed. Because there is only one console and no file system there is no equivalent to fprintf. In order to send formatted data through a peripheral sprintf should be used to format to a user-supplied buffer, and the buffer sent.

PRP Action

None

Arguments

Name	Type
ch	8 bit integer

C Syntax

```
void PMDputch(int ch);
```

Description

PMDputch is used to print a single character to the console. See also **PMDprintf** (p. 81) for more description of the console.

PRP Action

None

Arguments

Name	Type
str	string

C Syntax

```
void PMDputs(const char *str);
```

Description

PMDputs is used to print a constant string to the console. See also **PMDprintf** (p. 81) for more description of the console.

PRP Action

None

Arguments

Name	Type
UserAbortCode	integer

C Syntax

```
void PMDAbortTask(int UserAbortCode);
```

Description

PMDTaskAbort is used to halt user code execution, it does not return. The argument is a nonzero code that can be used to communicate the cause of a failure to the next invocation of the user program, and can be checked using **PMDTaskGetAbortCode** at the beginning of the user program.

PMDTaskAbort does not perform any cleanup actions, nor does it perform a reset. Any cleanup required to put the device in a safe state must be done by the user program before calling **PMDTaskAbort**.

PRP Action

None. This procedure may be called only from a C-Motion Engine user program.

Arguments

Name	Type
pTask	pointer to task function
name	character string (max 31 chars)
stacksize	size of stack in 32 bit words
taskparam	user specified 32 bit value passed to the task function
priority	a value of PMDTaskPriority

C Syntax

```
int PMDTaskCreate(taskptr pTask,
                  char* name,
                  size_t stacksize,
                  void* taskparam,
                  PMDTaskPriority priority);
```

Description

The function **PMDTaskCreate** is used to create a new user task from within an existing user task. The return value is an assigned task number that can be used to obtain information about the newly created task. Task numbers increment in the order that they are created. A value of -1 means the task could not be created due to a lack of memory or exceeding the maximum number of tasks. Once a task is created and assigned a task number that task number does not get reused if the task is aborted. Each call to **PMDTaskCreate** will increment the task number until all available task numbers have been used regardless of how many have been aborted. **PMDTaskAbort** is used to abort a task. A task number of 0 is reserved to indicate the main function. Therefore, the first call to **PMDTaskCreate** in the main task will return 1 if successful. The ***stacksize*** parameter specifies the amount of memory to allocate for the stack. The stack size should be set according to the number of automatic variables that are used in the task function and functions called from the task. The ***taskparam*** parameter can be used to pass in a 32 bit value or pointer from the calling task to the task being created. The ***priority*** parameter is used to set the priority: low, normal or high. High should only be used for tasks that quickly respond to **PMDEvents**.

Example task function prototype:

```
void MyTask( void* pvTaskParam );
```

PRP Action

None

Arguments None

C Syntax

```
unsigned PMDTaskGetAbortCode();
```

Description **PMDTaskGetAbortCode** is used to retrieve the code left by a previous call to **PMDTaskAbort**, and may be used for communication from one instance of a C-Motion Engine user program to the next. The abort code is volatile, and does not survive a reset or power cycle. After reading the abort code is cleared, and subsequent reads will return zero. Zero is also returned if **PMDTaskAbort** was not called by the previous program. To obtain extended information about other user tasks use **PMDCMETaskGetInfo**.

PMDTaskGetAbortCode is only available to CME user programs.

PRP Action None

Arguments None

Returned Data Task number

Description The function **PMDTaskGetNumber** is used to retrieve the task number of the calling task to be used in functions that require a task number.

C Syntax

```
int PMDTaskGetNumber()
```

Arguments

Name	Type
msec	milliseconds

C Syntax

```
void PMDTaskWait(PMDuint32 msec);
```

Description

The **PMDTaskWait** procedure is used to delay execution of a C-Motion Engine user program for a specified number of milliseconds. The delay is relative to the time the procedure is called, and has a granularity of 1 millisecond.

For a way to arrange a periodic task, see **PMDTaskWaitUntil** (p. 89).

PRP Action

None

Arguments

Name	Type
pPreviousTime	pointer to time in milliseconds
incrms	increment in milliseconds

C Syntax

```
void PMDTaskWaitUntil(PMDuint32 *pPreviousTime, PMDuint32 incrms);
```

Description

The **PMDTaskWaitUntil** procedure is used to wait until a particular specified time and may be used to arrange a periodic task loop. The argument ***pPreviousTime*** should point to a timer count previously returned by **PMDDeviceGetTickCount** or modified by **PMDTaskWaitUntil**. **PMDTaskWaitUntil** will return after the timer tick computed by adding ***incrms*** to the tick value in ****pPreviousTime***. The value in ****pPreviousTime*** will be updated to the current time.

If the time computed by adding ***incrms*** to ****pPreviousTime*** is in the past then **PMDTaskWaitUntil** will return immediately and will not update ****pPreviousTime***. If this case is likely, it must be checked explicitly using **PMDDeviceGetTickCount**.

For example:

```
PMDuint32 lastTime, thisTime;
PMDuint32 incrTime = 32;

lastTime = PMDDeviceGetTickCount();
while (!0) {

   Do some useful job

   thisTime = PMDDeviceGetTickCount();
   if ((lastTime + incrTime < thisTime) &&
       (lastTime + incrTime > lastTime)) {
          Report a time budget overrun
        lastTime = thisTime;
    }
    PMDTaskWaitUntil(*lastTime, incrTime);   // wait for up to 32 milliseconds
}
```

PRP Action

None

Arguments

Name	Type
hDevice	pointer to PMDDeviceHandle
hEvent	pointer to event struct
timeout	milliseconds, up to 0xFFFE

C Syntax

```
PMDresult PMDWaitForEvent(PMDDeviceHandle *hDevice,
                          PMDEvent *hEvent,
                          PMDuint32 timeout);
```

VB Syntax

```
Dim EventStruct As PMDEvent
Dim timeout As UInt32
device.WaitForEvent(EventStruct, timeout)
Dim axis As PMDAxis
Dim EventMask As UInt16
axis = EventStruct.axis
EventMask = EventStruct.EventMask
```

Description

PMDWaitForEvent is used to check for any reported asynchronous events raised by the device indicated by *hDevice*. The device must be a Magellan device.

If an asynchronous event notification is received for any of the Magellan axes of the motion processor attached to the device then the function returns and the axis and event status register are written to members of the *hEvent* struct. This struct has at least these members:

PMDAxis axis;

PMDuint16 eventStatus;

which indicate the axis and events responsible for the notification. If no event notifications have been received within timeout milliseconds, then PMD_ERR_Timeout is returned, and *hEvent* is not written. A *timeout* value of PMD_WAITFOREVER will block the task until the event occurs.

Asynchronous event notification is an optional Magellan feature described in the *Magellan Motion Processor User's Guide*. The conditions causing an event notification are programmable, using commands described in the *Magellan Motion Processor Programming Reference*. The **PMDWaitForEvent** function handles all the necessary function calls to deal with the event except for the **PMDClearInterrupt** function. Not all peripheral types support event notification, in particular serial communication does not. **PMDWaitForEvent** is supported by the local Magellan and Magellan attached devices opened with **PMDDeviceOpenPeriphCAN**.

PRP Action

None

4. PRP Action Reference

This section describes each action and sub-action, with the binary encoding of all arguments. Some aspects of action processing are common to all commands:

- Many PRP actions require a *sub-action* in addition to the action and resource, this is an 8 bit unsigned quantity that immediately follows the PRP outgoing header. Not all actions use a sub-action.
- All multi-byte argument values are encoded in little endian order: The least significant byte is sent first, and the most significant last. A 32 bit quantity is sent as bytes 0, 1, 2, and then 3, the most significant byte.
- Signed arguments are sent as twos-complement integers.

4.1 Action Table

The table below provides a listing of available PRP packets including *Resource*, *Action*, and *Sub-Action* if applicable along with the corresponding C-Motion API calls.

For a complete alphabetical list of the C-Motion PRP II API refer to Section 3.8, Alphabetical C-Motion API Reference. For a complete description of the C-Motion Magellan API refer to the *C-Motion Magellan Programming Reference.*

PRP Resource	PRP Action	PRP Sub-action	C-Motion Procedure
MotionProcessor	Command		*Any C-Motion Magellan Commands*
MotionProcessor	Close		PMDDeviceClose
Device	Open	PeriphCAN	PMDDeviceOpenPeriphCAN
Device	Open	PeriphCANFD	PMDDeviceOpenPeriphCANFD
Device	Open	Memory	PMDDeviceOpenMemory
Device	Open	PeriphSerial	PMDDeviceOpenPeriphSerial
Device	Open	PeriphPIO	PMDDeviceOpenPeriphPIO
Device	Open	PeriphSPI	PMDDeviceOpenPeriphSPI
Device	Open	PeriphTCP	PMDDeviceOpenPeriphTCP
Device	Open	PeriphUDP	PMDDeviceOpenPeriphUDP
Device	Get	Default	PMDDeviceGetDefault
Device	Get	ResetCause	PMDDeviceGetResetCause
Device	Get	Version	PMDDeviceGetInfo
Device	Get	SystemTime	PMDDeviceGetSystemTime
Device	Get	FaultCode	PMDDeviceGetFaultCode
Device	Set	Console	PMDDeviceSetConsole
Device	Set	Default	PMDDeviceSetDefault
Device	Set	SystemTime	PMDDeviceSetSystemTime
Device	Reset		PMDDeviceReset
Device	Close		PMDDeviceClose
Peripheral	Receive		PMDPeriphReceive
Peripheral	Send		PMDPeriphSend
Peripheral	Read		PMDPeriphRead

PRP Resource	PRP Action	PRP Sub-action	C-Motion Procedure
Peripheral	Write		PMDPeriphWrite
Peripheral	Open	DevicePRP	PMDPeriphOpenDevicePRP
Peripheral	Open	DeviceMP	PMDPeriphOpenDeviceMP
Peripheral	Open	PeriphMultiDrop	PMDPeriphOpenPeriphMultiDrop
Peripheral	Close		PMDPeriphClose
CMotionEngine	Command	Flash	PMDCMEStoreUserCode
CMotionEngine	Command	TaskControl	PMDCMETaskStart
CMotionEngine	Command	TaskControl	PMDCMETaskStop
CMotionEngine	Get	TaskInfo	PMDCMETaskGetInfo
CMotionEngine	Get	TaskState	PMDCMEGetTaskState
CMotionEngine	Get	FileName	PMDCMEGetUserCodeName
CMotionEngine	Get	FileDate	PMDCMEGetUserCodeDate
CMotionEngine	Get	FileChecksum	PMDCMEGetUserCodeChecksum
CMotionEngine	Get	FileVersion	PMDCMEGetUserCodeVersion
Memory	Clear		PMDMemoryErase
Memory	Close		PMDMemoryClose
Memory	Read	Dword	PMDMemoryRead
Memory	Write	Dword	PMDMemoryWrite

4.2 Alphabetical PRP Action Reference

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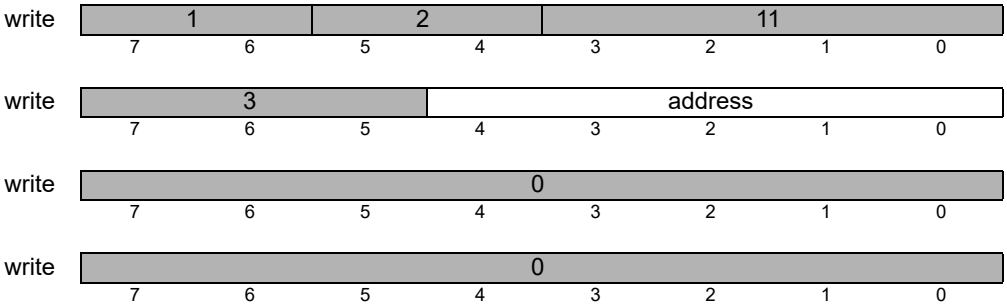
Coding

Action	Sub-action	Resource
11	-	3

Arguments None

Returned Data None

Packet Structure



Description

The **Clear Memory** action erases the memory addressed. If the addressed memory is NVRAM it may take a few seconds to respond.

C Syntax

```
PMDresult PMDMemoryErase(PMDMemoryHandle *hMemory);
```

Close *various*

Coding

Action	Sub-action	Resource
4	-	various

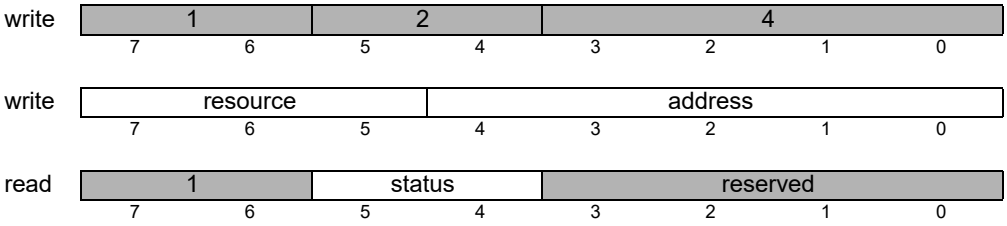
Arguments

None

Returned Data

None

Packet Structure



Description

The **Close** action may be used to free any resource that was originally returned by an **Open** action. After closing, such a resource no longer exists and will signal an error if an action is addressed to it.

Close will close an open TCP connection if applied to a TCP peripheral. For reasonably sized networks that are static it may never be necessary to use **Close**. It is an error to send a **Close** action to a resource that was not returned by **Open**.

C Syntax

```
PMDresult PMDPeriphClose(PMDPeriphHandle *hPeriph);
PMDresult PMDDeviceClose(PMDDeviceHandle *hDevice);
PMDresult PMDMemoryClose(PMDMemoryHandle *hMemory);
```

Coding

Action	Sub-action	Resource
2	2	1

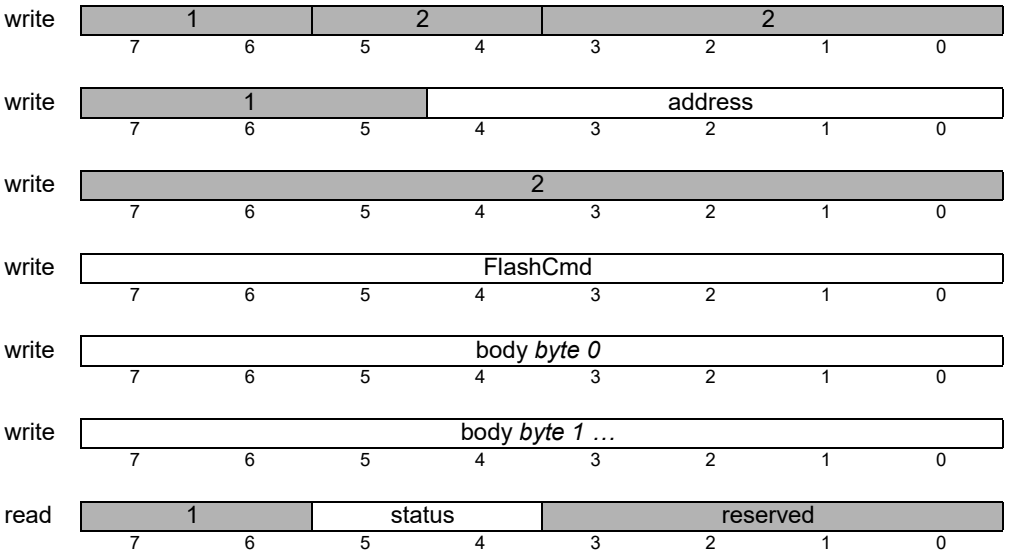
Arguments

Name	Encoding	Instance
FlashCmd	1	FlashStart
	2	FlashData
	3	FlashEnd

Returned Data

None

Packet Structure



Description

The **Command Flash CMotionEngine** action is used to install a user program in a C-Motion Engine. The flash process proceeds in three steps, each with a separate value of the *FlashCmd* argument. In addition to *FlashCmd*, this action may include many bytes of message body, depending on the step.

If any step of the flash procedure gives an error response then the procedure must be restarted from the beginning. No actions may be sent between flash procedure actions. The steps, in order of execution, are:

1. *FlashStart*: The body bytes are a four byte length of the flash image, least significant byte first. If this step is successful the user program flash is erased. The length may be specified as zero, in which case no new user program is installed, and no further steps need be taken.

1 *FlashData*: The body bytes are sequential parts of the entire flash image, in order.

2 *FlashEnd*: There are no body bytes. This action verifies the checksum of the program image received. If it finishes successfully then a new user program has been installed and may be run using the **Command Task CMotionEngine** action.

C Syntax

```
PMDresult PMDCMEStoreUserCode (PMDDeviceHandle *hDevice,
                               PMDuint8* pdata,
                               int length);
```

Coding

Action	Sub-action	Resource
2	1	1

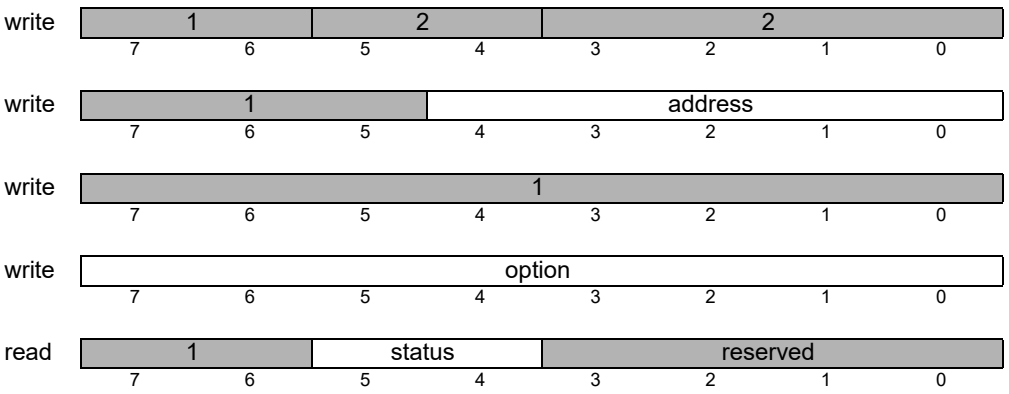
Arguments

Name	Encoding	Instance
option	1	start
	2	stop

Returned Data

None

Packet Structure



Description

The **Command TaskControl CMotionEngine** action is used to start or stop a C-Motion Engine user program. The two cases are distinguished by the argument option.

If *option* is start, then if no user program is installed this action will return PMD_ERR_UC_NotProgrammed. If a user program is already running then PMD_ERR_UC_TaskAlreadyRunning will be returned.

If *option* is stop, then any running user program will be stopped. If no user program is currently running in the C-Motion Engine then this action will return PMD_ERR_UC_TaskNotCreated.

It is the user's responsibility to ensure safety when starting or stopping a user program that controls motors. It is not possible to predict the state of the PRP device or of its motion processor at the instant that the user program is stopped. PMD strongly recommends that a task be stopped only to correct unrecoverable errors and that the PRP device and any devices that it controls be put immediately into a known safe state using host commands. Because the card resources and the dynamic heap are not in a known state it is not safe to restart a task after stopping it without first resetting the entire device.

C Syntax

```
PMDresult PMDCMETaskStart(PMDDeviceHandle *pDevice);
PMDresult PMDCMETaskStop(PMDDeviceHandle *pDevice);
```

Coding

Action	Sub-action	Resource
2	-	2

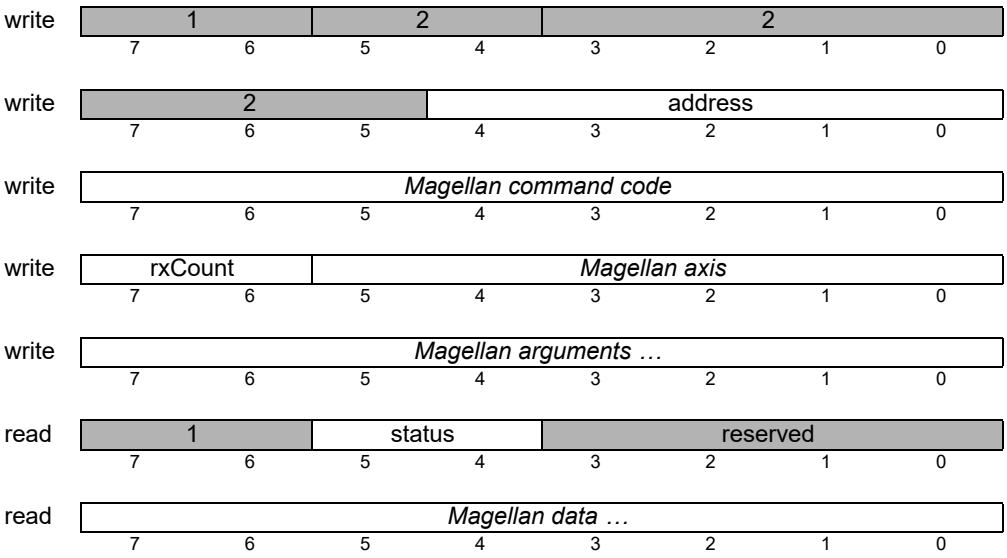
Arguments

Magellan command and arguments
rxCount, 2 bit count of words returned

Returned Data

Magellan return data

Packet Structure



Description

The **Command** action directed to a ***MotionProcessor*** resource sends a Magellan protocol command to the motion processor indicated by the address field. A sub-action field is not used, instead a Magellan protocol command packet follows the header immediately.

Magellan commands are documented in the *Magellan Motion Processor Programming Reference,* with the addition of the rxCount parameter. A Magellan protocol packet consists of at least one 16 bit command word, followed by zero to three argument words. The first byte of the command word is an opcode for the Magellan command. The remaining bits 0 – 5 are the Magellan axis addressed. The second byte of command word comprises two fields, bits 6 and 7 are the rxCount field, the number of words that are expected as returned values from the command. Each command takes a fixed number of arguments and returns a fixed number of return data. The arguments and data are encoded as little-endian quantities, 16 bit words are sent most significant byte first, followed by the most significant byte, 32 bit words are sent in order of significance, starting with the least significant word, and ending with the least significant word.

If the status field of the return packet PRP header is zero then the return data of the Magellan command follow. If the Magellan motion processor reports an error then the status field of the return header will be 1 (error), and the Magellan error code will follow. Magellan error codes are documented in the *Magellan Motion Processor Programming Reference,* and do not overlap with any PRP or PMD C library error codes. The error code will not be encoded as a big-endian value.

C Syntax

All C-Motion command procedures use this action. See the *Magellan Motion Processor Programming Reference* for documentation of C-Motion commands and C language syntax.

Coding

Action	Sub-action	Resource
10	2	0

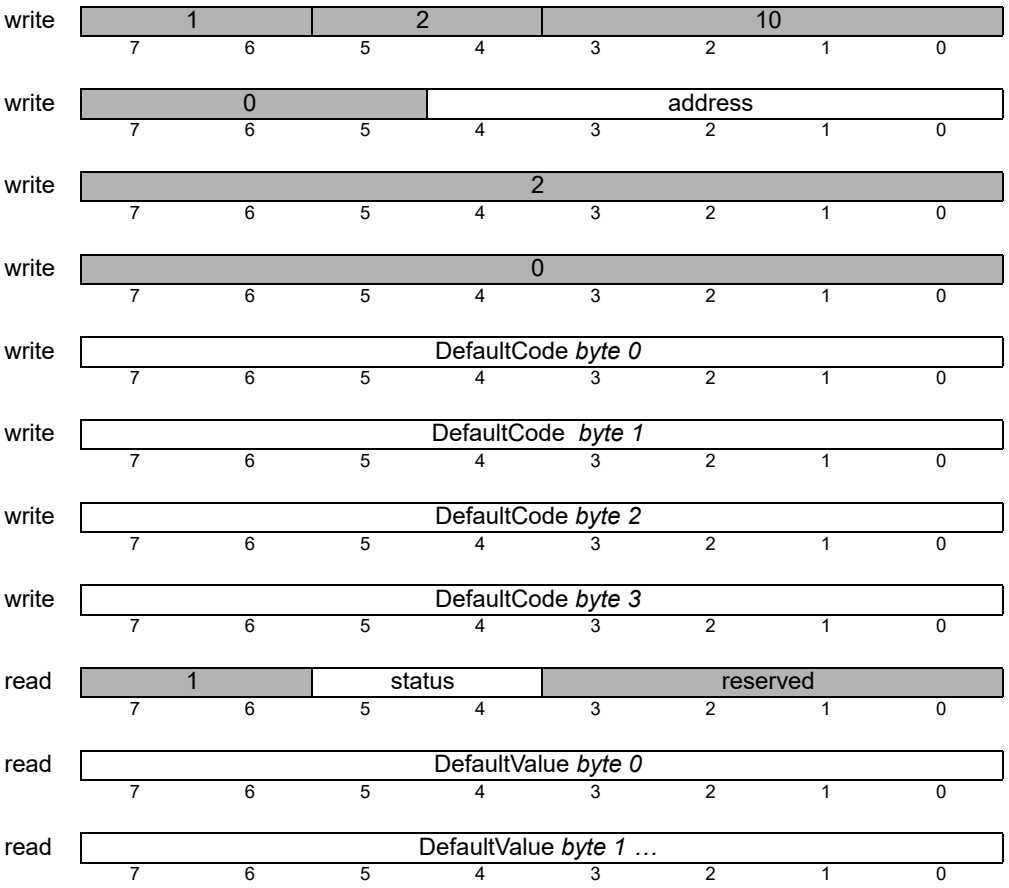
Arguments

Name	Type	meaning
DefaultCode	unsigned 32 bit	default identifier

Returned Data

Name	Type	meaning
DefaultValue	varies	varies – see Set ValueDefault

Packet Structure



Description

The **Get Default Device** action is used to retrieve the value of a device default. Device defaults are various non-volatile properties of the PRP device, for example the IP address, or whether to run a user program immediately after power up. The length of ***DefaultValue*** depends on the particular data type, and is encoded in the upper byte of ***DefaultCode***. A length value of one means two bytes, three means four bytes. Please see the description of **Set Default Device** (p. 140) for a table of supported default codes and their meaning.

C Syntax

```
PMDresult PMDDeviceGetDefault(PMDDeviceHandle *hDevice,
                              PMDDefault defaultcode,
                              void *value,
                              unsigned valueSize);
```

Coding

Action	Sub-action	Resource
10	14	0

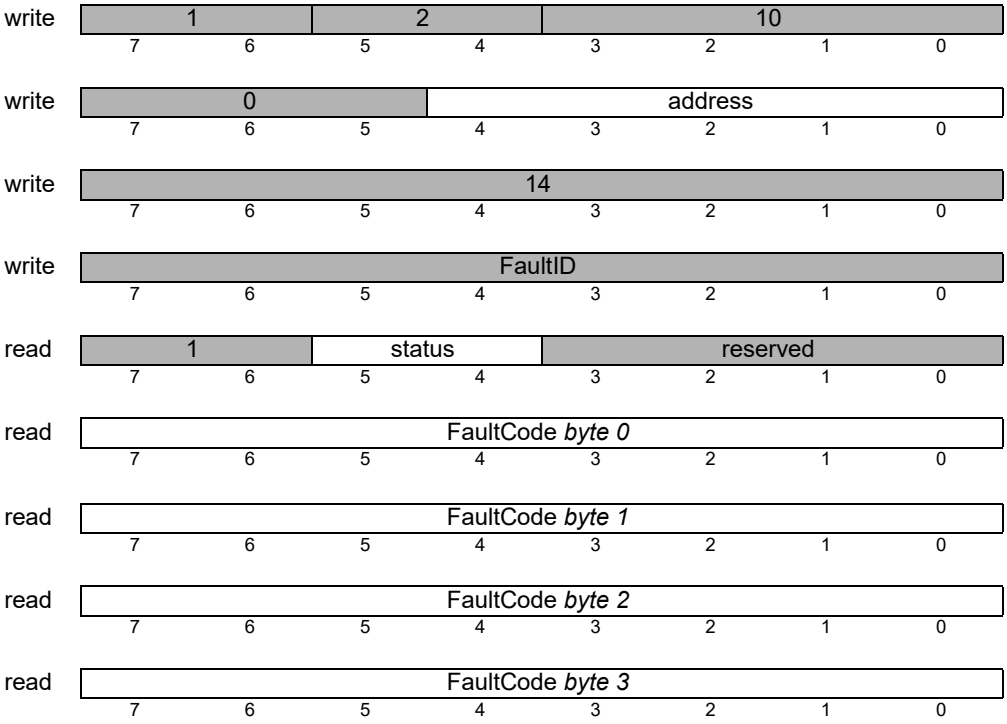
Arguments

Name	Type	Encoding	Instance
FaultID	unsigned 32 bit	0	ResetCause
		1	Initialization
		2	Exception

Returned Data

Name	Type	Encoding	Instance
ResetCause	unsigned 32 bit	0x00000200	Software reset
		0x00000400	Exception
		0x00000800	System watchdog
		0x00001000	Hardware reset
		0x00002000	Undervoltage
InitFault	unsigned 32 bit	0x00000000	No fault
		0x00000001	Boot firmware CRC error
		0x00000002	Main firmware CRC error
		0x00000020	Magellan initialization error
		0x00000100	Internal PIO fault
		0x00000200	Cannot determine model
		0x00000400	Hardware initialization fault
		0x00000800	Memory allocation failure
Exception	unsigned 32 bit	0	None
		1	NMI
		2	HardFault
		3	MemManage
		4	BusFault
		5	UsageFault
		16	StackOverflow
		17	UserTaskReturned

Packet Structure



Get FaultCode Device (cont.)

Description

The **Get FaultCode Device** action retrieves various fault codes from the CME device addressed. The type of fault code returned depends on the *FaultID* requested. A *FaultID* of ResetCause will return the reset cause. A *FaultID* of *PMDFaultCode_Initialization* will return any combination of PMDInitFault.

C Syntax

```
PMDDeviceGetFaultCode(PMDDeviceHandle *hDevice,
                      PMDuint32 FaultID,
                      PMDuint32* FaultCode);
```

Coding

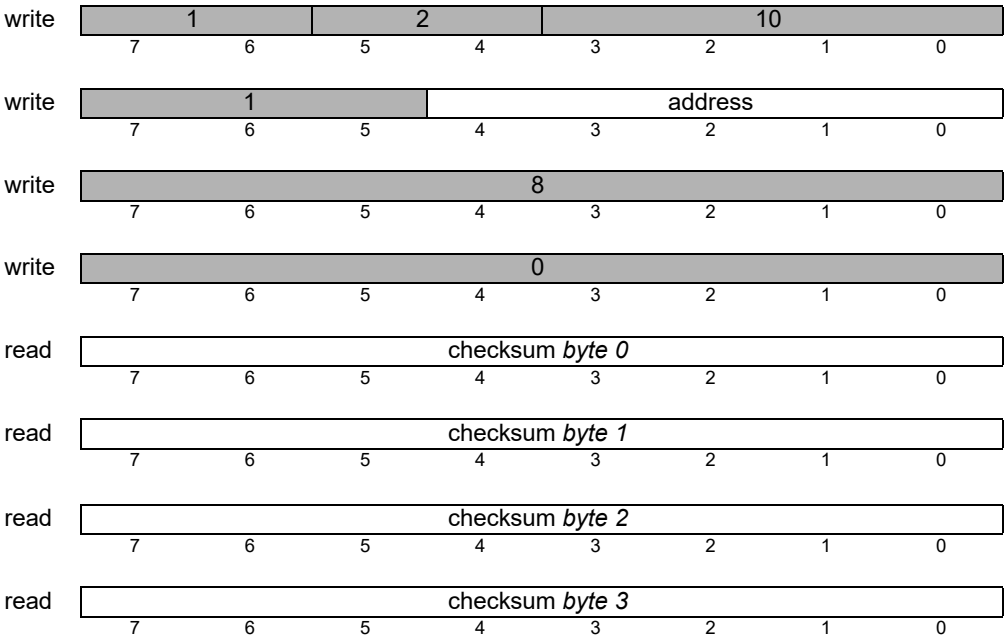
Action	Sub-action	Resource
10	8	1

Arguments None

Returned Data

Name	Type
checksum	unsigned 32 bit

Packet Structure



Description

The **Get FileChecksum CMotionEngine** action retrieves the CRC of the file that has been downloaded. The CRC polynomial is CRC-32 (0x04C11DB7).

C Syntax

```
PMDresult PMDCMEGetUserCodeChecksum(PMDDeviceHandle *hDevice,
                                    PMDuint32* checksum);
```

Coding

Action	Sub-action	Resource
10	7	1

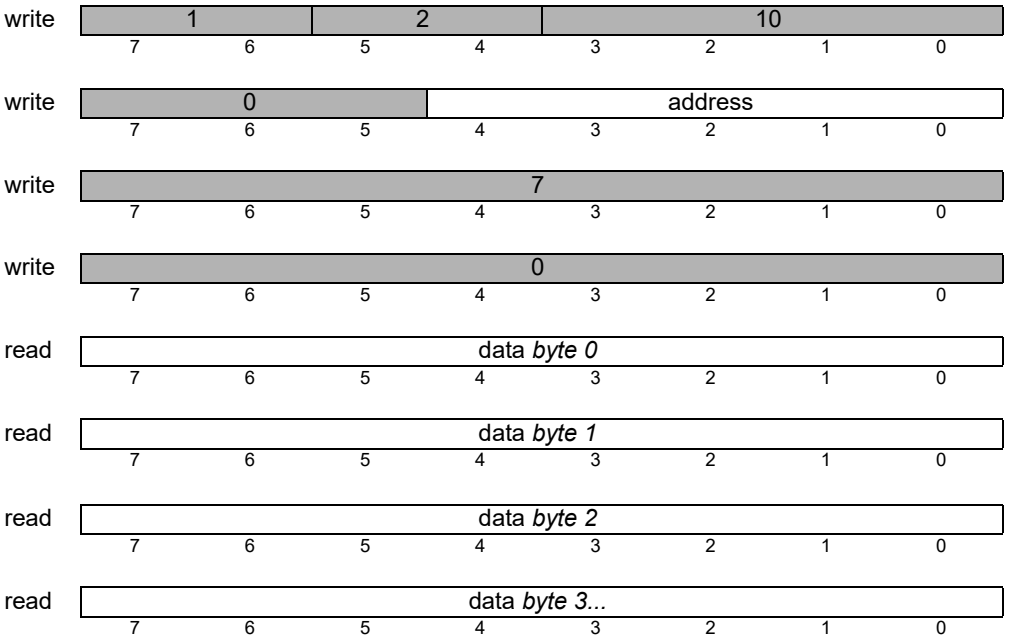
Arguments

None

Returned Data

Name	Type
date	pointer to a string with a minimum size of 20 bytes

Packet Structure



Description

The **Get FileDate CMotionEngine** action retrieves the date of the file that has been downloaded. The returned string contains the date and time in the universal full date/time pattern. For example: 2009-06-15T13:45:30

C Syntax

```
PMDresult PMDCMEGetUserCodeDate(PMDDeviceHandle *hDevice,
                                char* date);
```

Coding

Action	Sub-action	Resource
10	6	1

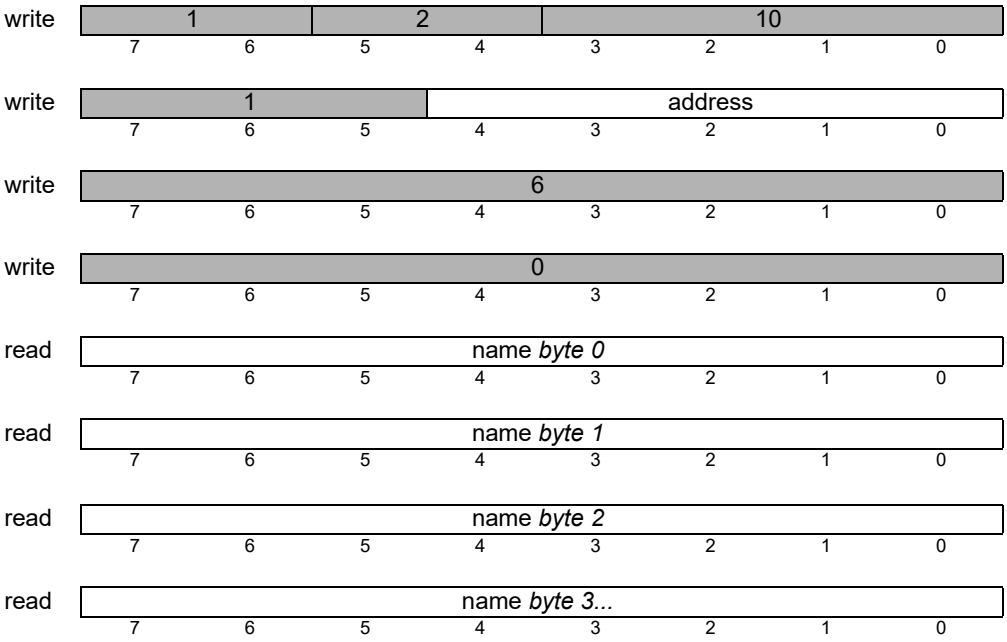
Arguments

None

Returned Data

Name	Type
name	pointer to a string with a minimum size of 256 bytes

Packet Structure



Description

The **Get FileName CMotionEngine** action retrieves the name of the file that has been downloaded. The returned string contains the file name of the main source file without the folder structure. For example: "MoveARM.c".

C Syntax

```
PMDresult PMDCMEGetUserCodeName(PMDDeviceHandle *hDevice,
                                char* name);
```

Coding

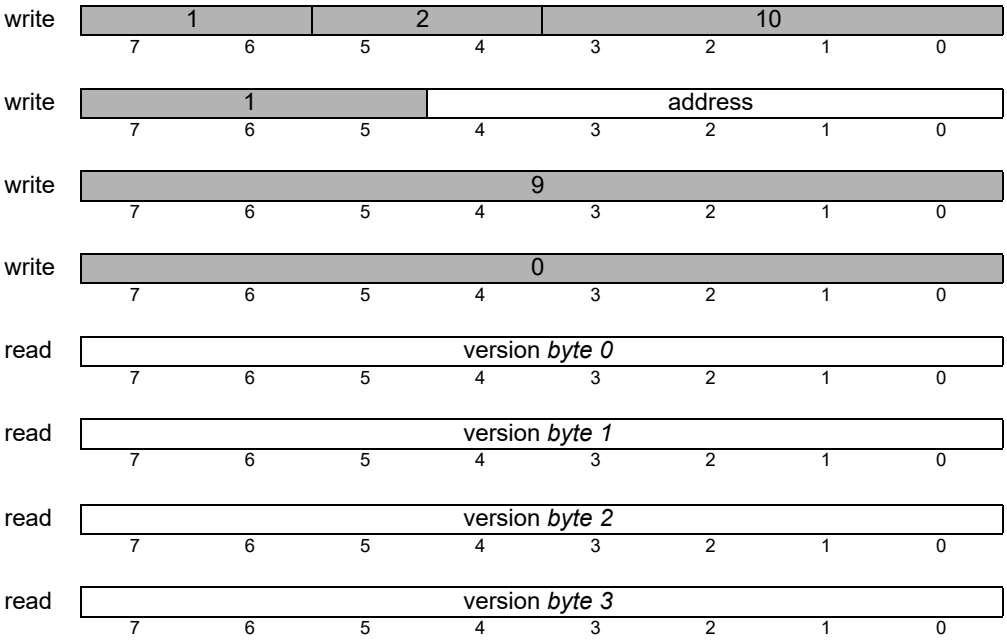
Action	Sub-action	Resource
10	9	1

Arguments None

Returned Data

Name	Type
version	unsigned 32 bit

Packet Structure



Description

The **Get FileVersion CMotionEngine** action retrieves the version of the file that has been downloaded. The version is set using the macro:

```
USER_CODE_VERSION(MAJOR_VERSION,MINOR_VERSION)
```

The returned 32 bit version is stored as (major << 16 | minor).

C Syntax

```
PMDresult PMDCMEGetUserCodeVersion(PMDDeviceHandle *hDevice,
                                   PMDuint32* version);
```

Coding

Action	Sub-action	Resource
10	1	0

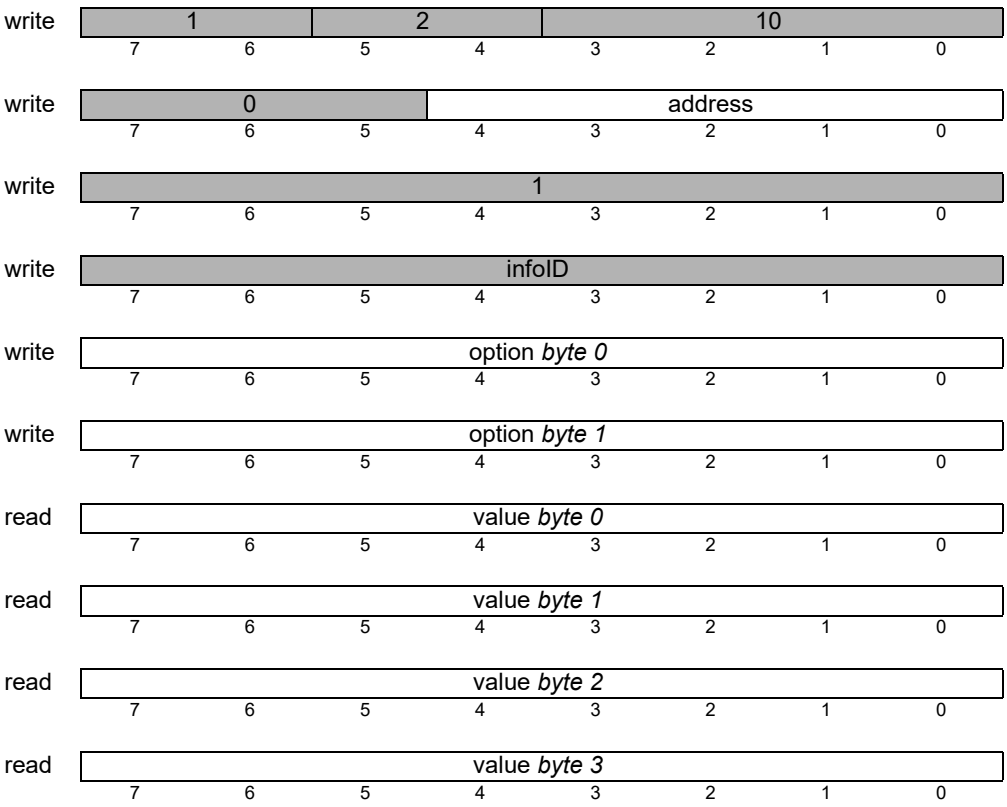
Arguments

Name	Type	Range	Encoding
infoID	unsigned 8 bit	0	CMEVersion
		1	LogicVersion
		2	HostInterface
		3	MemorySize
		5	Heap
		6	IPaddress
option	unsigned 16 bit	0-2	See Description

Returned Data

Name	Type	Range	Encoding
CMEVersion	unsigned 32 bit	0-0xFFFFFFFF	CME firmware version
LogicVersion	unsigned 32 bit	0-0xFFFF	CME logic version
HostInterface	unsigned 32 bit	0-0xF	Available host interfaces
MemorySize	unsigned 32 bit	0-0xFFFFFFFF	See Description
Heap	unsigned 32 bit	0-0xFFFFFFFF	See Description
IPaddress	unsigned 32 bit	0-0xFFFFFFFF	IPaddress of the device

Packet Structure



Description

The **Get Info Device** action is a request to a PRP device to return information about the device such as its firmware version, logic version and host interface. The requested information is one of PMDDeviceInfo.

Description (cont.)

The CMEVersion *infoID* returns the firmware version in this format:

byte 3	byte 2	byte 1	byte 0
reserved	major	custom	minor

The LogicVersion *infoID* returns the logic version as a 16 bit value.

The HostInterface *infoID* returns the available host interfaces as one or more of PMDHostInterface.

The MemorySize *infoID* returns the total memory size of the type of memory specified by the option parameter. The available options are one of PMDMemoryAddress.

These memories are separate from the heap memory and are accessed via the Read Memory and Write Memory commands.

The Heap *infoID* in combination with an option word of 0 returns the total amount of heap space remaining in bytes. There is no guarantee that all of this can be allocated, depending on what sizes are asked for. The Heap *infoID* in combination with an option word of 1 returns how close the heap has come to running out of space so far.

Coding

Action	Sub-action	Resource
10	5	1

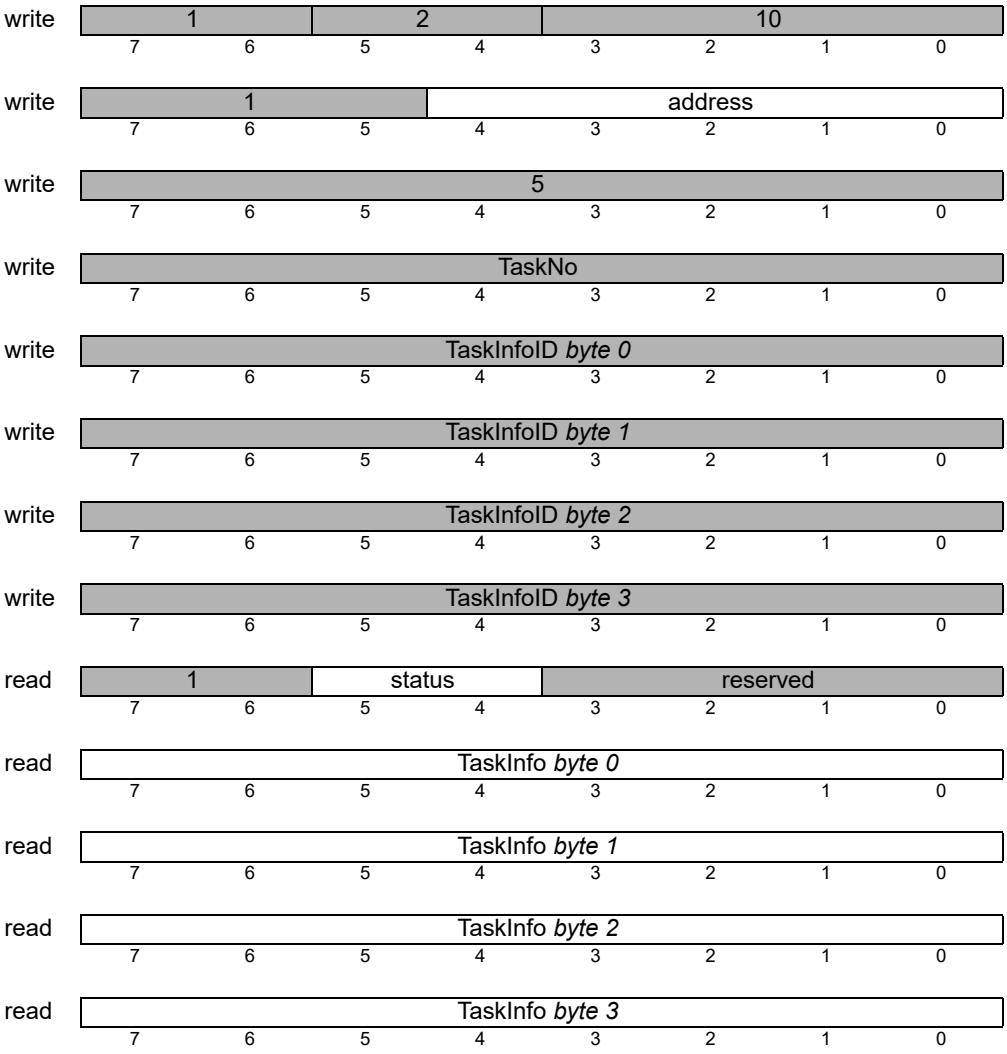
Arguments

Name	Type	Encoding	Instance
TaskNo	unsigned 8 bit		Task number
TaskInfoID	unsigned 32 bit	0	TaskState
		1	AbortCode
		2	StackRemaining
		3	StackSize
		4	Priority

Returned Data

Name	Type	Encoding	Instance
TaskState	unsigned 32 bit	0	no program
		1	not started
		2	running
AbortCode	unsigned 32 bit		user defined abort code
StackRemaining	unsigned 32 bit		remaining stack space in 32 bit words
StackSize	unsigned 32 bit		stack size in 32 bit words
Priority	unsigned 32 bit		one of PMDTaskPriority

Packet Structure



Get TaskInfo CMotionEngine (cont.)

Description

The **Get TaskInfo CMotionEngine** action retrieves the current state of the specified task in the CMotionEngine user program. The *TaskNo* parameter is 0-based. Specifying a *TaskNo* of 0 returns the information requested for the main task. A *TaskNo* of 1 returns the information requested for the first task created from the main task. To obtain the task number of the calling task **PMDTaskGetNumber** can be used.

C Syntax

```
PMDresult PMDCMETaskGetInfo(PMDDeviceHandle *hDevice,
                            int TaskNo,
                            PMDTaskInfo infoID,
                            PMDint32* value);
```

Coding

Action	Sub-action	Resource
10	13	0

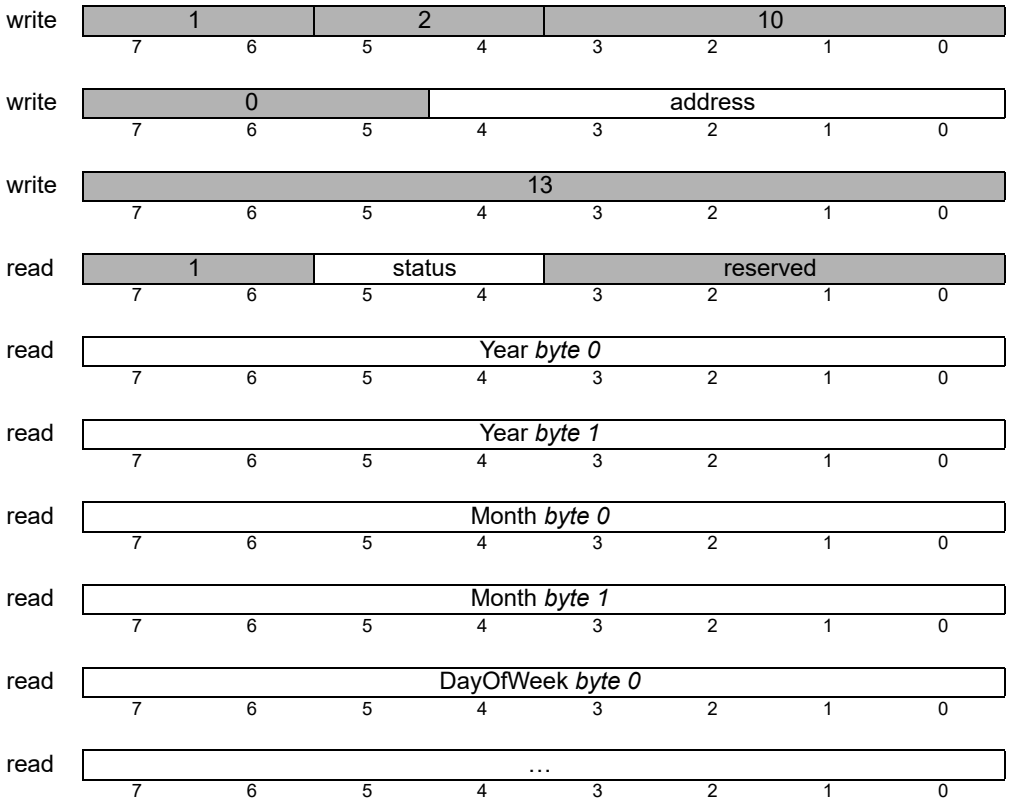
Arguments

None

Returned Data

Name	Type	Range
Year	unsigned 16 bit	0-0xFFFF
Month	unsigned 16 bit	1-12
DayOfWeek	unsigned 16 bit	0-6
Day	unsigned 16 bit	1-31
Hour	unsigned 16 bit	0-24
Minute	unsigned 16 bit	0-59
Second	unsigned 16 bit	0-59
Millisecond	unsigned 16 bit	0-999

Packet Structure



Description

The **Get Time Device** action retrieves the current real-time clock value in 24-hour format from the CME device addressed. Time zones are not supported.

C Syntax

```
PMDresult PMDDeviceGetSystemTime(PMDDeviceHandle *hDevice,
                                 SYSTEMTIME* time)
```

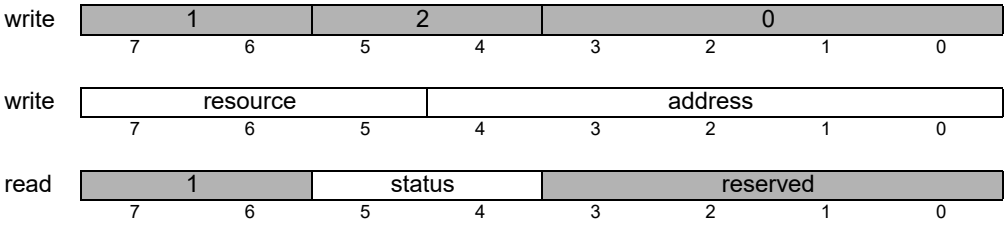
Coding

Action	Sub-action	Resource
0	-	any

Arguments None

Returned Data None

Packet Structure



Description

The **NOP** action does not result in any action on the part of the resource addressed, but may be used to verify that a resource with the given address exists. If the status field of the reply header is nonzero then an error of InvalidAddress indicates that no resource with the supplied address exists.

C Syntax

```
PMDDeviceNoOperation (PMDDeviceHandle *hDevice);
```

Coding

Action	Sub-action	Resource
3	24	0

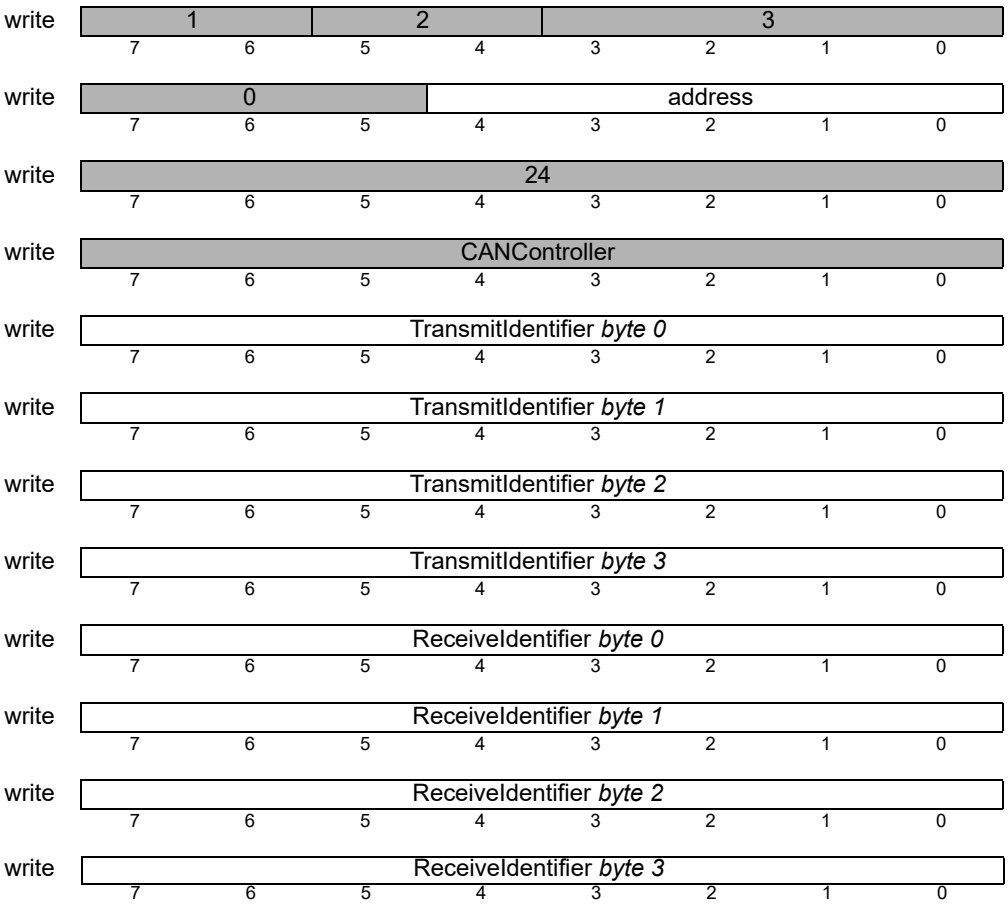
Arguments

Name	Type	Range	Encoding
CANController	unsigned 8 bit	0-1	
TransmitIdentifier	unsigned 32 bit	0-2047	
ReceiveIdentifier	unsigned 32 bit	0-2047	
Bitrate (bps)	unsigned 32 bit	0	1000k
		1	800k
		2	500k
		3	250k
		4	125k
		5	50k
		6	25k
		7	10k
		0x40	5M data & 1M nominal
		0x50	4M data & 1M nominal
		0x60	2M data & 1M nominal
		0x72	1M data & 500k nominal

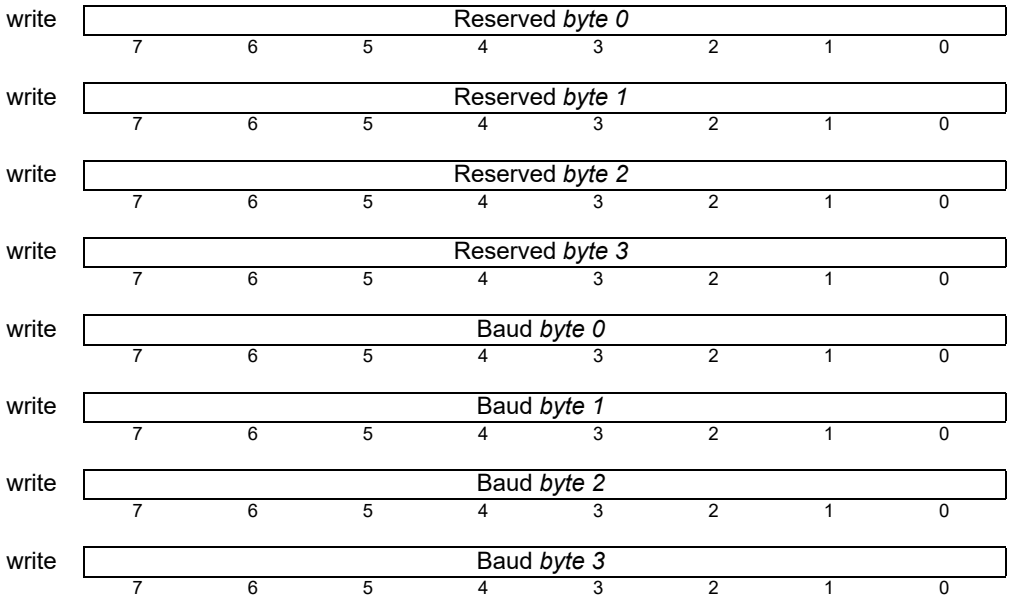
Returned Data

Name	Type	Range
PeriphAddress	unsigned 8 bit	1-31

Packet Structure



Packet Structure (cont.)



Description

The **Open CANFD Device** action is a request to a PRP device to return a PRP peripheral address associated with a CANFD port on the device. The CANFD port is the local physical CANFD port on the device itself: 0 for ExpCAN, and 1 for HostCAN (if applicable). *TransmitIdentifier* and *ReceiveIdentifier* are CAN identifiers used for sending and receiving messages. The point of view is the device, so *TransmitIdentifier* is used for sending messages from the PRP device to the peripheral CAN device, and *ReceiveIdentifier* should be used by the peripheral device to send messages to the PRP device. If either *TransmitIdentifier* or *ReceiveIdentifier* is zero than transmit or receive will be disabled. The Baud argument sets the bitrate of the specified CANcontroller. CANFD supports 2 bitrates during the transmission of a frame: a nominal bitrate and a data bitrate. The nominal bitrate is one of the standard CAN bitrates: 10,000 to 1,000,000 bps. The data bit rate has a range of 1,000,000 to 5,000,000 bps. The bitrate for the CAN port is set to the bitrate of the last call to **Open CANFD Device**.

Coding

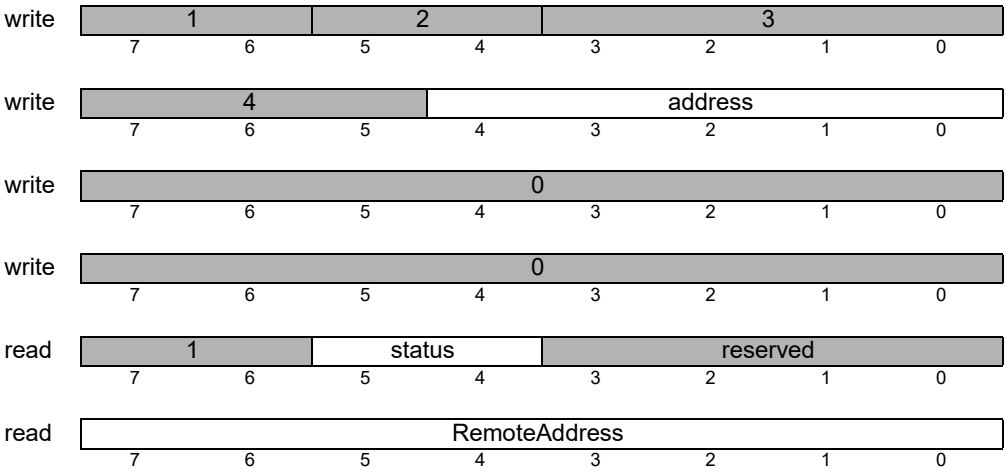
Action	Sub-action	Resource
3	1	4

Arguments None

Returned Data

Name	Type	Range
RemoteAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open Device Peripheral** action is used to allocate a PRP address for a ***Device*** resource that may be used to communicate with a PRP device accessible using an existing peripheral connection, for example a TCP or serial connection. The *RemoteAddress* returned may be used for any PRP action that may be addressed to a ***Device*** resource; such as other N-Series IONs.

C Syntax

```
PMDresult PMDPeriphOpenDevicePRP (PMDDeviceHandle *hDevice,
                                  PMDPeriphHandle *hPeriph);
```

Coding

Action	Sub-action	Resource
3	3	0

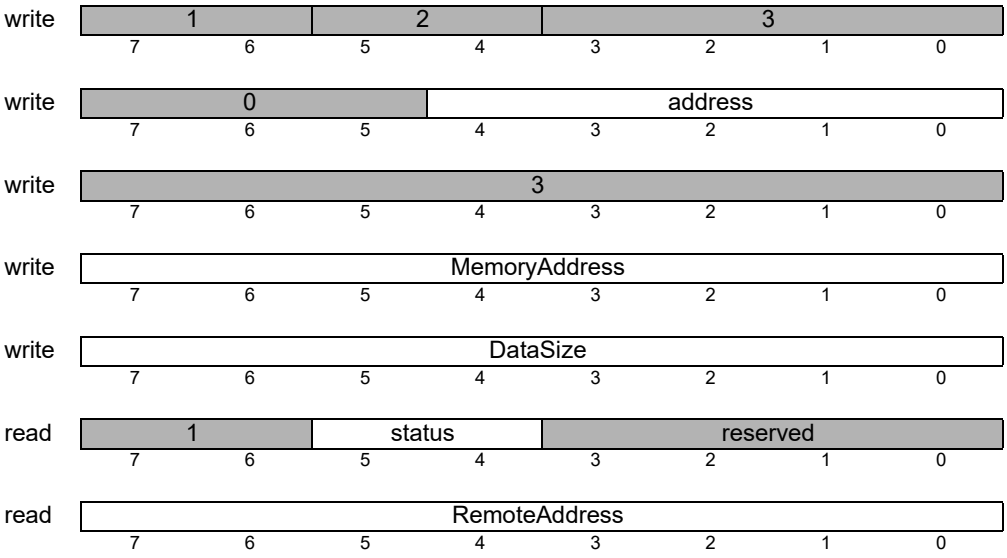
Arguments

Name	Type	Range
MemoryAddress	unsigned 8 bit	0-2
Datasize	unsigned 8 bit	1,2,4

Returned Data

Name	Type	Range
RemoteAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open Memory Device** action is used to request a connection to a ***Memory*** resource on a remote PRP device. The *MemoryAddress* argument indicates which ***Memory*** resource on the remote device is to be used and can be one of PMDMemoryAddress.

The returned *RemoteAddress* may be used as the address when accessing the resource, for example **Read** and **Write** actions to read and write values from a remote memory resource.

C Syntax

```
PMDresult PMDDeviceOpenMemory(PMDMemoryHandle *hMemory,
                              PMDDeviceHandle *hDevice,
                              PMDDataSize datasize,
                              PMDMemoryAddress  memoryaddress)
```

C# Syntax

```
PMDMemory memory = new PMDMemory(deviceRP, PMDDataSize.Size32Bit);
```

Coding

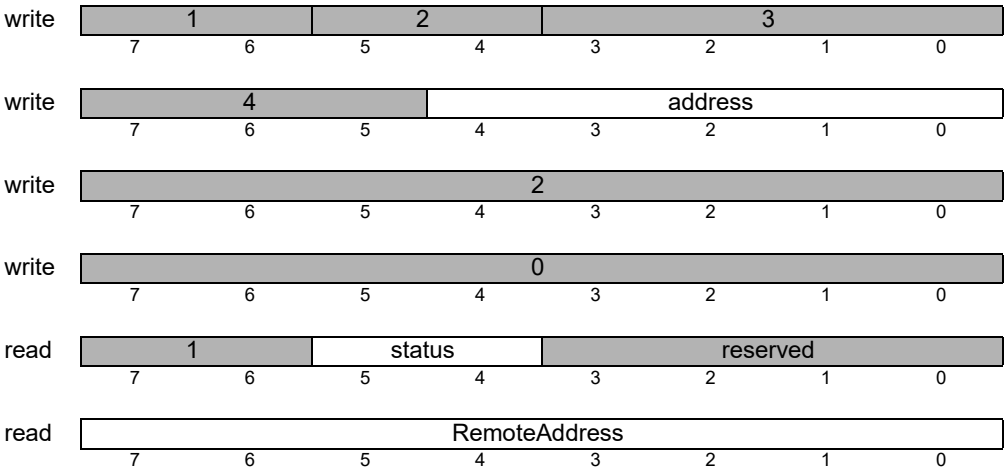
Action	Sub-action	Resource
3	0	4

Arguments None

Returned Data

Name	Type	Range
RemoteAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open MotionProcessor Peripheral** action is used to allocate a PRP address to a Magellan Motion Processor that is accessible using an existing PRP peripheral resource, using a serial port, SPI, CAN bus, or PC/104 ISA bus (PR83 only). The PRP *RemoteAddress* returned may be used to command the motion processor using the Command action. The PRP device to which this action is directed will perform the translation from the PRP protocol for Magellan motion processor commands to the native Magellan protocol.

For example, to use a CME device to control an ION module on a CAN bus, one would:

1. Open a CAN peripheral with the CAN identifiers used by the module for command send and receive, using OpenCAN directed to the CME Device.
3. Use Open MotionProcessor to get an address for the remote ION using the peripherals opened in step 1.
4. Send commands to the remote ION using the MotionProcessor address returned in step 2.

C Syntax

```
PMDresult PMDPeriphOpenDeviceMP(PMDDeviceHandle *hDevice,
                                PMDPeriphHandlle *hPeriph);
```

Coding

Action	Sub-action	Resource
3	25	4

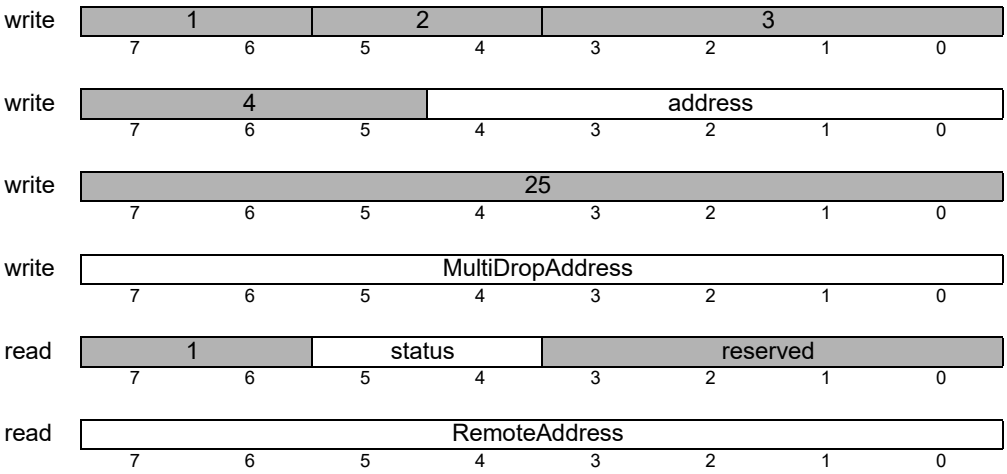
Arguments

Name	Type	Range
MultiDropAddress	unsigned 8 bit	0-31

Returned Data

Name	Type	Range
RemoteAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open MultiDrop Peripheral** action is used to obtain a peripheral that uses the PMD multi-drop serial protocol used for communicating with Magellan attached devices, such as non-CME ION modules, or with other PRP devices. The peripheral resource to which this action is directed must have been obtained using the Open Serial Device action; the "parent" peripheral must not be closed before the multi-drop peripheral returned by **Open MultiDrop**. The RemoteAddress returned by the **Open MultiDrop** action will typically be used as a target for **Open MotionProcessor** or **Open Device**.

For more information on the multi-drop protocol, see *Chapter 2, PMD Resource Access Protocol (PRP) Tutorial* and the *Magellan Motion Processor User Guide*.

C Syntax

```
PMDresult PMDPeriphOpenPeriphMultiDrop(PMDPeriphHandle *hPeriph,
                                       PMDPeriphHandle *hParent,
                                       PMDuint8 MultiDropAddress);
```

Coding

Action	Sub-action	Resource
3	18	0

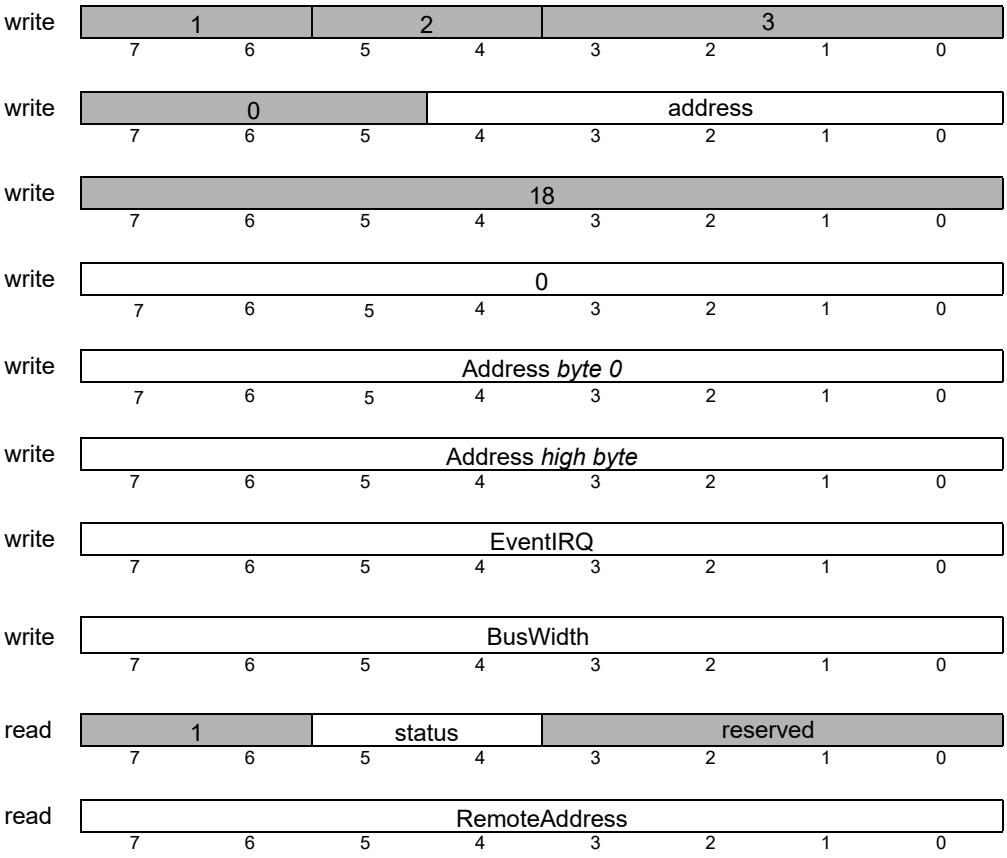
Arguments

Name	Type	Range
Address	unsigned 16 bit	0-0xFFFF
EventIRQ	unsigned 8 bit	0-0xFF
BusWidth	unsigned 8 bit	1,2,4

Returned Data

Name	Type	Range
PeriphAddress	unsigned 8 bit	0-0xFF

Packet Structure



Description

The **Open PIO Device** action is a request to open a connection to a parallel IO peripheral channel on a PRP device. Once such a peripheral is open the peripheral read or write actions may be used with it. *Address* is used to specify the channel to open; *BusWidth* to specify the size, in bytes, of individual data transfers *EventIRQ* is not used.

The return value *RemoteAddress* is a PRP address that may be used with resource type ***Peripheral*** for addressing the opened channel.

Consult the appropriate product user manual for details.

Open PIO Device (cont.)

C language interface

```
PMDresult PMDDeviceOpenPeriphPIO(PMDPeriphHandle*hPeriph
                                 PMDDeviceHandle*hDevice,
                                 WORD address,
                                 BYTE EventIRQ,
                                 PMDDataSize datasize);
```

Coding

Action	Sub-action	Resource
3	20	0

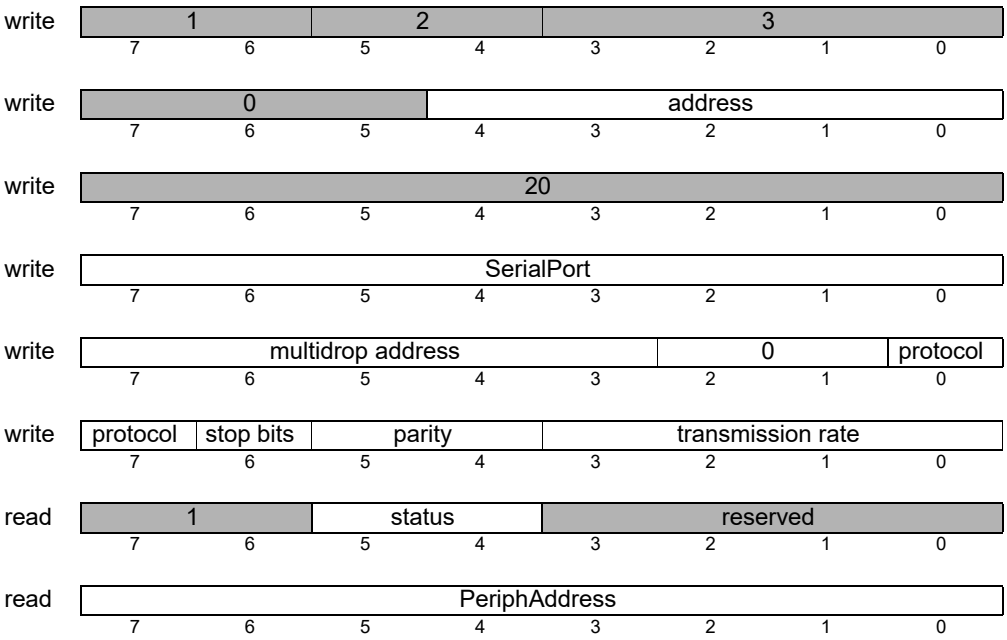
Arguments

Name	Type	Range
SerialPort	unsigned 8 bit	0-2
SerialMode	unsigned 16 bit	see below

Returned Data

Name	Type	Range
PeriphAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open Serial Device** action is a request to a PRP device to return a PRP peripheral address associated with a serial port on the device. *SerialPort* is the local physical serial port on the device itself: 0 for Serial1, and 1 for Serial2. *SerialMode* is a 16 bit word encoding serial parameters as shown in the table below. The return value, *PeriphAddress*, is a PRP address that may be used with the resource type Peripheral for addressing the newly opened serial peripheral until it is closed.

In order to open a peripheral that uses the PRP multi-drop serial protocol it is necessary to first open a Serial peripheral using the **Open Serial Device** action, and then to use the **Open MultiDrop Peripheral** action.

SerialMode Encoding

Bit Number	Name	Instance	Encoding
0-3	transmission rate	1200 baud	0
		2400 baud	1
		9600 baud	2
		19200 baud	3
		57600 baud	4
		115200 baud	5
		230400 baud	6
		460800 baud	7

Description (cont.)

SerialMode Encoding			
Bit Number	**Name**	**Instance**	**Encoding**
4-5	parity	none	0
		odd	1
		even	2
6	stop bits	1	0
		2	1
7-8	protocol	point-to-point	0
		multi-drop	3
9-10	reserved		0
10-15	multi-drop address	0	0-63

C Syntax

```
PMDresult PMDDeviceOpenPeriphSerial(PMDPeriphHandle *hPeriph,
                                    PMDDeviceHandle *hDevice,
                                    PMDSerialPort port,
                                    PMDSerialBaud baud,
                                    PMDSerialParity parity,
                                    PMDSerialStopBits stopbits);
```

Coding

Action	Sub-action	Resource
3	26	0

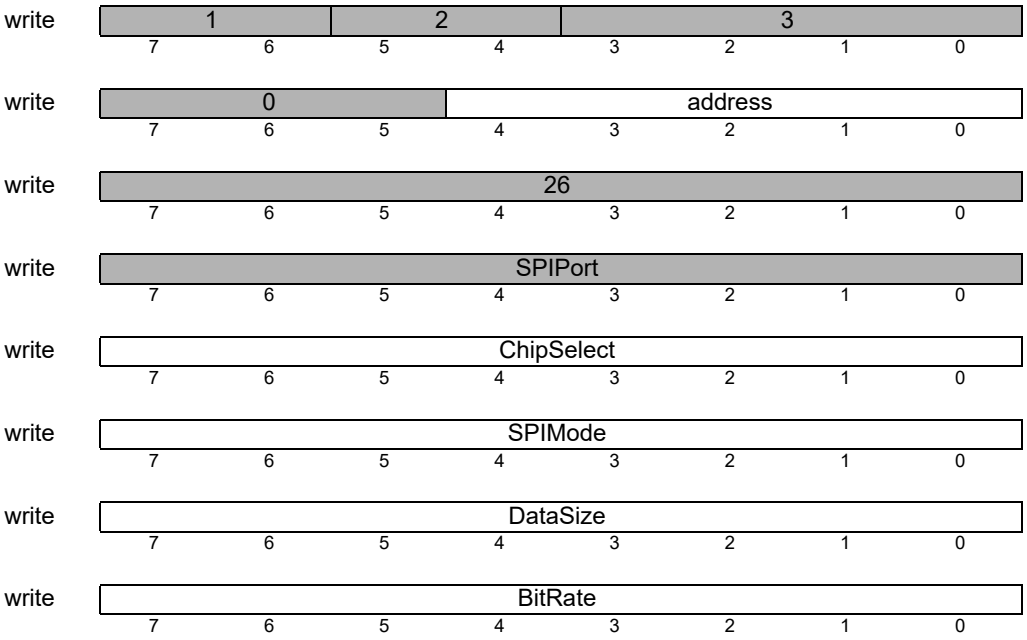
Arguments

Name	Type	Range
SPIPort	unsigned 8 bit	0-1
ChipSelect	unsigned 8 bit	0-4
SPIMode	unsigned 8 bit	0-3
DataSize	unsigned 8 bit	4-16
BitRate	unsigned 8 bit	1-7

Returned Data

PeriphAddress

Packet Structure



Description

The **Open SPI Device** action is a request to a PRP device to return a PRP peripheral address associated with an SPI port on the device. *SPIPort* is the local physical SPI port on the device itself: 0 for ExpSPI (SPI master), and 1 for HostSPI (SPI slave). *ChipSelect* is one of 4 possible chip select signals to use or 0 for no *ChipSelect*. *ChipSelect* is ignored if the HostSPI port is specified. *SPIMode* is the SPI mode of 0-3 as shown in the table below.

SPIMode 0: Rising Edge Without Delay. The SPI transmits data on the rising edge of the SPI clock signal and receives data on the falling edge of the SPI clock signal.

SPIMode 1: Rising Edge With Delay. The SPI transmits data one half-cycle ahead of the rising edge of the SPI clock signal and receives data on the rising edge of the SPI clock signal.

SPIMode 2: Falling Edge Without Delay. The SPI transmits data on the falling edge of the SPI clock and receives data on the rising edge of the SPI clock.

SPIMode 3: Falling Edge With Delay. The SPI transmits data one half-cycle ahead of the falling edge of the SPI clock signal and receives data on the falling edge of the SPI clock signal. *DataSize* is the number of bits in an SPI word. Valid values are 4-16. *Bitrate* is the SPI master clock frequency. Valid values are 1-7 corresponding to 20 MHz, 10 MHz, 5 MHz, 2.5 MHz, 1.25 MHz, 625 kHz, 312.5 kHz. Each *ChipSelect* can use a different *SPIMode*, *DataSize* and *BitRate*.

Description (cont)

The return value, PeriphAddress, is a PRP address that may be used with the resource type Peripheral for addressing the newly opened SPI peripheral until it is closed.

C Syntax

```
PMDresult PMDDeviceOpenPeriphSPI(PMDPeriphHandle* hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDSPIPort Port,
                                 PMDSPIChipSelect ChipSelect,
                                 PMDSPIMode SPIMode,
                                 PMDuint8 DataSize,
                                 PMDuint8 BitRate);
```

Coding

Action	Sub-action	Resource
3	22	0

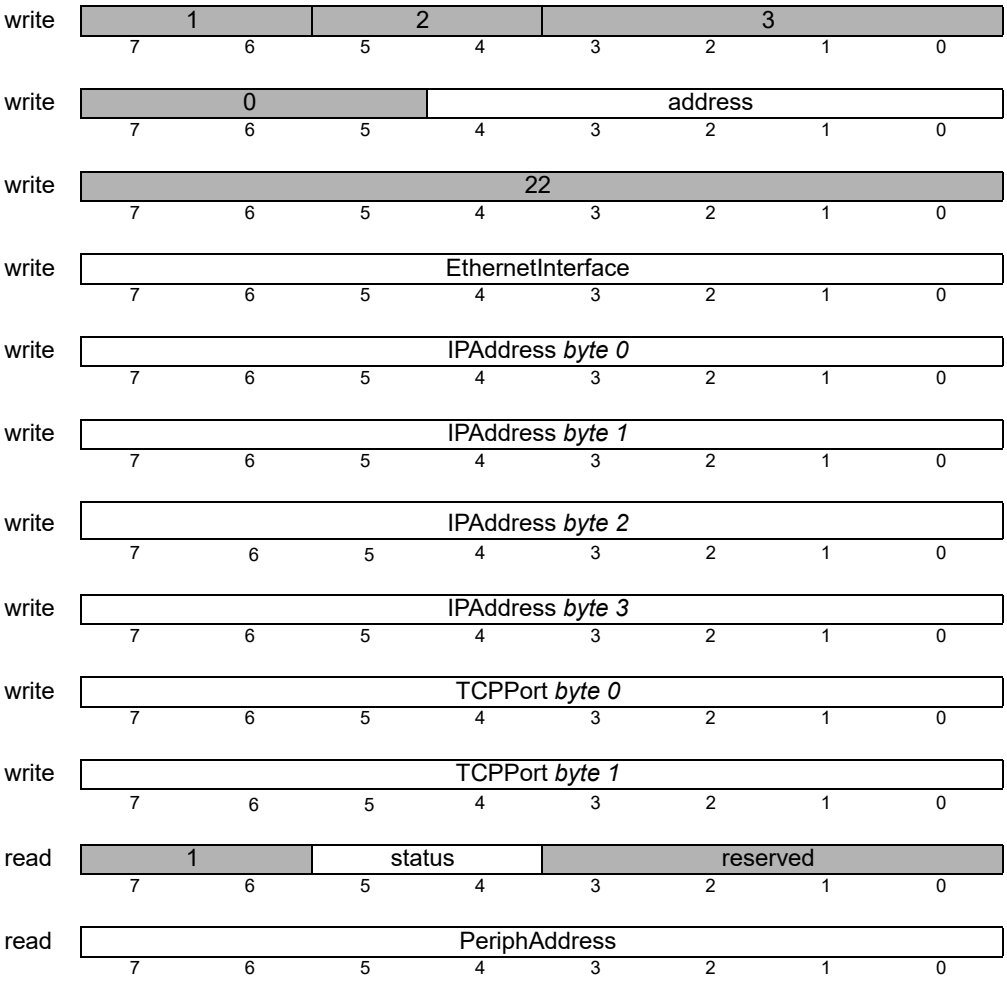
Arguments

Name	Type	Range
EthernetInterface	unsigned 8 bit	0
IPAddress	unsigned 32 bit	0-0xFFFFFFFF
TCPPort	unsigned 16 bit	0-0xFFFF

Returned Data

Name	Type	Range
PeriphAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open TCP** action is a request to a PRP device to return a PRP peripheral address associated with an Ethernet TCP connection. *EthernetInterface* is the local physical Ethernet interface; for all current PRP devices there is one Ethernet interface, so this argument should be zero.

IPAddress is the remote address to which a connection should be opened. If *IPAddress* is zero, then the port will be opened that will accept incoming connections, one incoming connection at a time may be handled by such a port. *TCPPort* is the TCP port to connect to or to listen on.

The return value, *PeriphAddress*, is a PRP address that may be used with the resource type ***Peripheral*** for addressing the newly opened Ethernet peripheral until it is closed.

Open TCP Device (cont.)

C language interface

```
PMDresult PMDDeviceOpenPeriphTCP(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDuint32 IPAddress,
                                 PMDuint16 TCPPort);
```

Coding

Action	Sub-action	Resource
3	23	0

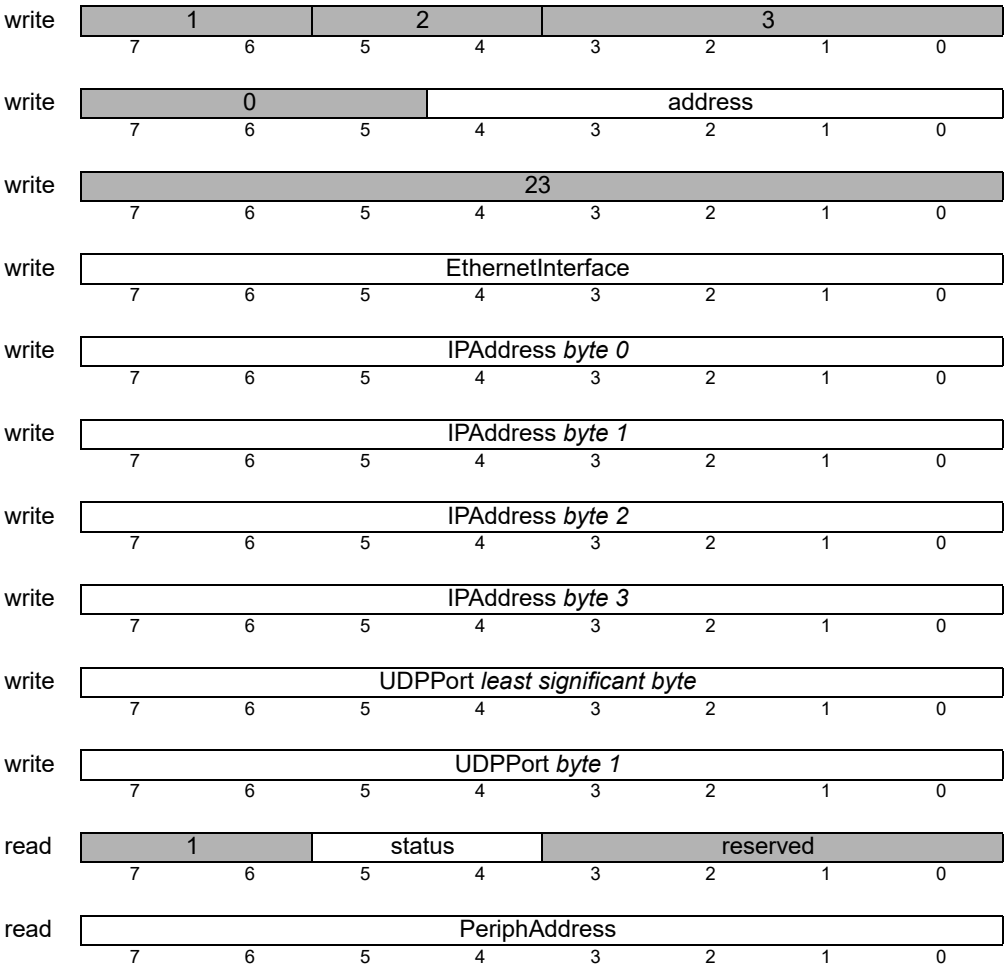
Arguments

Name	Type	Range
EthernetInterface	unsigned 8 bit	0
IPAddress	unsigned 32 bit	0-0xFFFFFFFF
UDPPort	unsigned 16 bit	0-0xFFFF

Returned Data

Name	Type	Range
PeriphAddress	unsigned 8 bit	1-31

Packet Structure



Description

The **Open UDP Device** action is a request to a PRP device to return a PRP peripheral address associated with an Ethernet UDP port and remote IP address. *EthernetInterface* is the local physical Ethernet interface; for all current PRP devices there is one Ethernet interface, so this argument should be zero.

IPAddress is the remote address to which UDP packets should be sent. If *IPAddress* is zero then the port will be opened that will accept incoming UDP packets. *UDPPort* is the UDP port to connect to or to listen on.

Description (cont.)

The return value, *PeriphAddress*, is a PRP address that may be used with the resource type ***Peripheral*** for addressing the newly opened Ethernet peripheral until it is closed.

C language interface

```
PMDresult PMDDeviceOpenPeriphUDP(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice,
                                 PMDuint32 IPAddress,
                                 PMDuint16 UDPPort);
```

Coding

Action	Sub-action	Resource
8	4	3

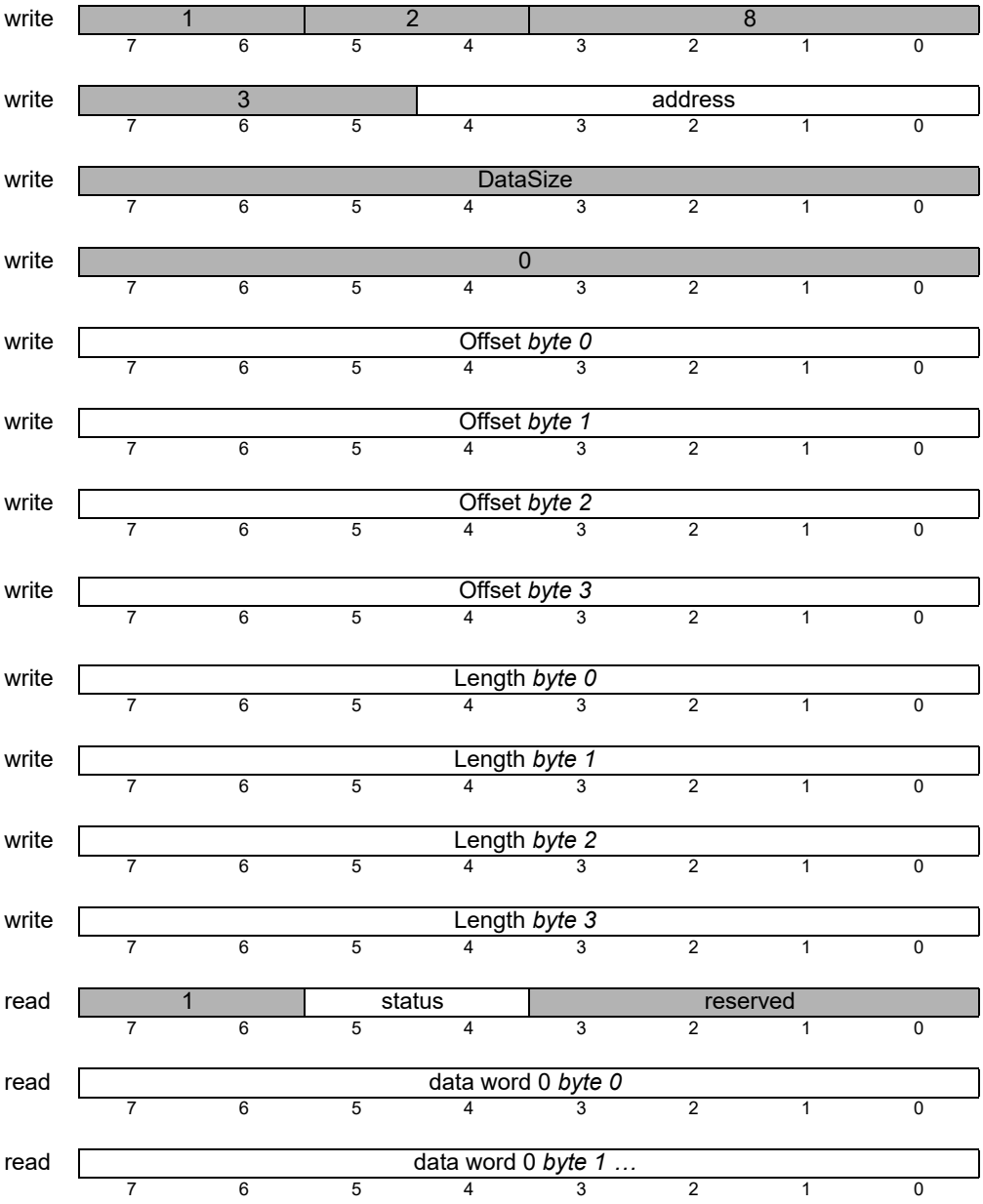
Arguments

Name	Type	Range	Units
DataSize	unsigned 8 bit	1,2,4	
Offset	unsigned 32 bit	0-0xFFFFFFFF	Datasize
Length	unsigned 32 bit	0-0xFFFF	Datasize

Returned Data

data words

Packet Structure



Read Memory (cont.)

Description

The **Read Memory** action is used to read a sequence of *DataSize* words from a memory resource. The *Offset* argument is an address in the memory. The *DataSize* argument is the size of the data to read: 1=byte, 2=word, or 4=double word. *Offset* should be divisible by *DataSize*. A non-aligned access will return PMD_ERR_ParameterAlignment. The *Length* argument is the number of *DataSize* words to read, exactly this number of *DataSize* words are returned as the message body of the response packet.

C Syntax

```
PMDresult PMDMemoryRead (PMDMemoryHandle *hMemory,
                         void *data,
                         PMDuint32 offset,
                         PMDuint32 length);
```

Coding

Action	Sub-action	Resource
8	2	4

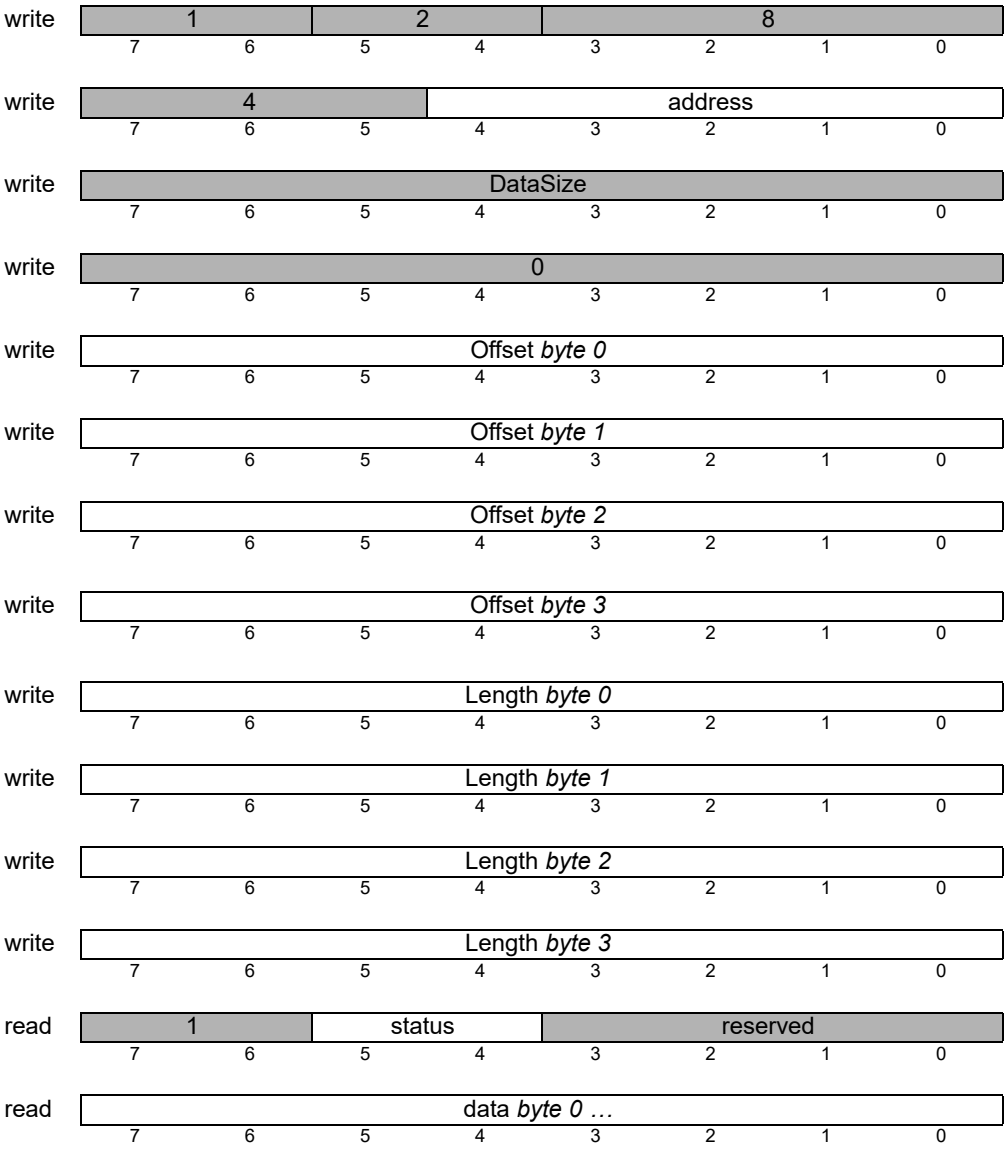
Arguments

Name	Type	Range	Units
DataSize	unsigned 8 bit	2,4	
Offset	unsigned 32 bit	0-0xFFFFFFFF	DataSize
Length	unsigned 32 bit	0-0xFFFF	DataSize

Returned Data

data bytes

Packet Structure



Description

The **Read Peripheral** action is used to read a sequence of *DataSize* words from a parallel bus peripheral such as a PC/104 bus or internal registers. The *DataSize* argument is the size of the data to read: a value of 2 represents a 16 bit word, or a value of 4 represents a 32 bit word. The *Offset* argument is an offset from the base address that was specified when the peripheral was opened; *Offset* must be even. The *Length* argument specifies the number of *DataSize* to read; *Length* must also be even. The data read is returned as the message body of the response packet.

Description (cont.)

This action is not applicable to other types of peripheral, and an InvalidResource error will be returned if another peripheral type is specified.

C Syntax

```
PMDresult PMDPeriphRead(PMDPeriphHandle *hPeriph,
                        void *data,
                        PMDuint32 offset,
                        PMDuint32 length);
```

Coding

Action	Sub-action	Resource
6	-	1

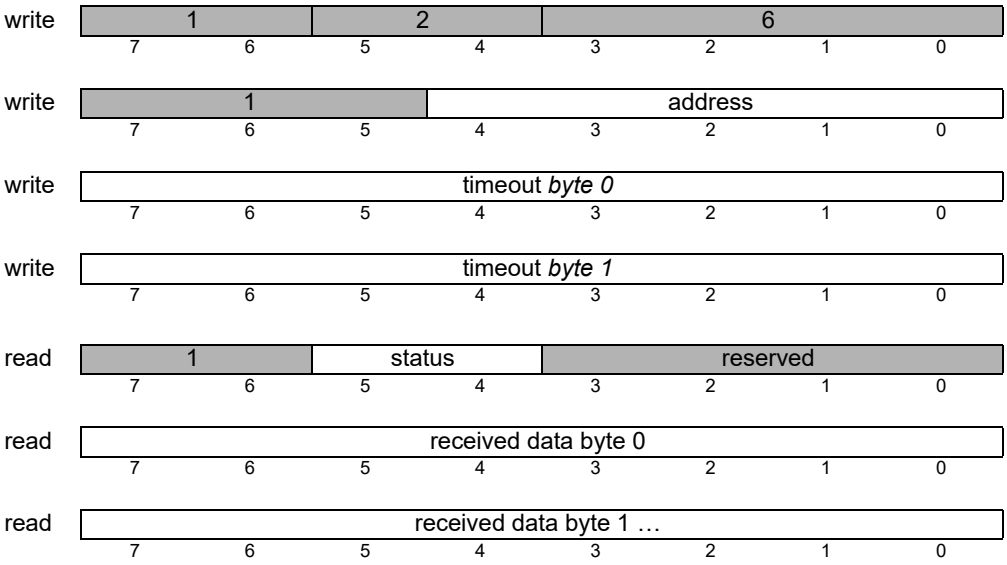
Arguments

Name	Type	Range	Units
timeout	unsigned 16 bit	0-0xFFFF	msec
nExpected	unsigned 16 bit	0-0xFFFF	bytes

Returned Data

data bytes

Packet Structure



Description

The **Receive CMotionEngine** action is used to receive user packet data sent by a user program running on a C-Motion Engine. See the description of **Send CMotionEngine** (p. 137) for a description of the user packet mechanism. C-Motion user programs send user packets by calling **PMDPeriphSend** using a peripheral opened with the **PMDDeviceOpenPeriphCME** procedure.

The ***timeout*** argument specifies the maximum number of milliseconds to wait for data before failing with a PRP timeout error. A ***timeout*** value of 65535 (0xFFFF) means no time limit. In case of a timeout no bytes will be returned.

The C-Motion Engine buffers only one outgoing user packet at a time.

The size of the message received is given implicitly by the size of the return packet. How the size of the return packet is determined depends on the transport mechanism in use.

C Syntax

```
PMDresult PMDDeviceOpenPeriphCME(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice);

PMDresult PMDPeriphReceive(PMDPeriphHandle *hPeriph,
                           void *buffer,
                           PMDuint32 *nReceived,
                           PMDuint32 nExpected,
                           PMDuint32 timeout);
```

Coding

Action	Sub-action	Resource
6	-	4

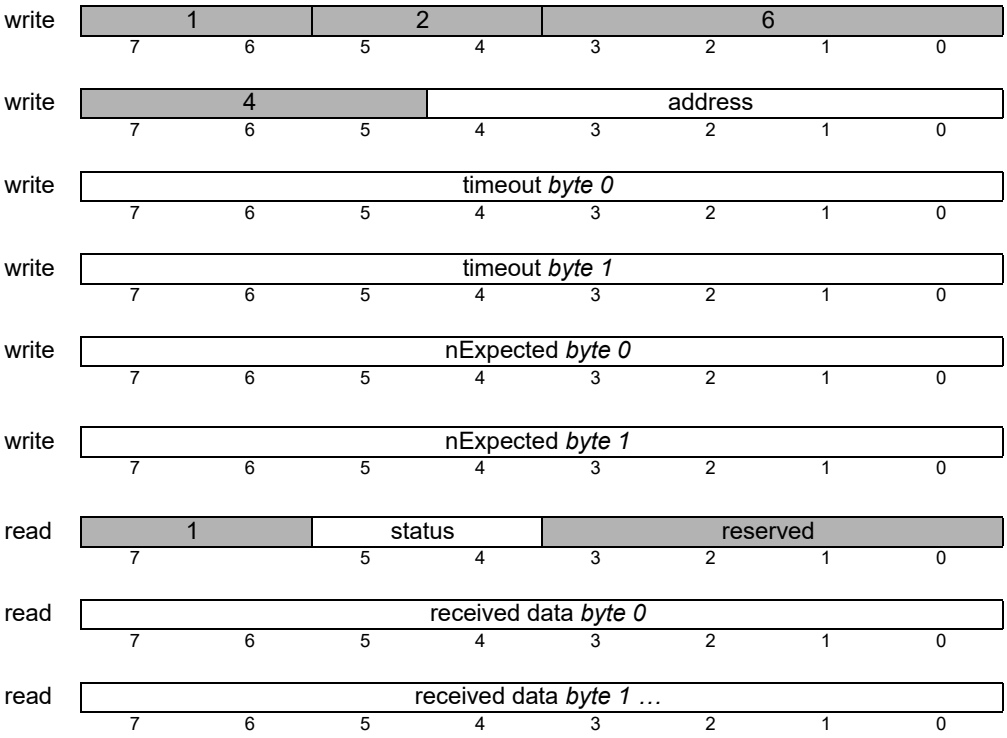
Arguments

Name	Type	Range	Units
timeout	unsigned 16 bit	0-0xFFFF	msec
nExpected	unsigned 16 bit	0-0xFFFF	bytes

Returned Data

data bytes

Packet Structure



Description

The **Receive Peripheral** action is used to receive data from some remote device using the communication channel specified by the ***Peripheral*** resource to which it is addressed.

The ***timeout*** argument specifies the maximum number of milliseconds to wait for data before failing with a PRP timeout error. In case of a time out any received bytes will be returned.

The ***nExpected*** argument specifies the maximum number of bytes to receive. For data that are naturally arranged in packets, for example TCP and UDP, only one packet will be received so the actual number of bytes returned may be less than ***nExpected***. For data that are not arranged in packets, for example data received on a serial port peripheral, exactly ***nExpected*** bytes must be received or a timeout results and any received bytes will be returned.

The number of bytes of data actually returned is encoded in the size of the packet, how that size is transmitted depends on the transport mechanism.

Description (cont.)

If the peripheral connection has been closed by some external action, for example a TCP connection that has been closed by a peer, then a status of PMD_ERR_NotConnected will be returned. All PMD_ERR_ values should be in the non-serifed font. Such a peripheral must be closed using the Close action. In the case of a TCP connection, after closing the unconnected peripheral a new peripheral with the same TCP port may be opened using the OpenTCP action.

C Syntax

```
PMDresult PMDPeriphReceive(PMDPeriphHandle *hPeriph,
                           void *buffer,
                           PMDuint32 *nReceived,
                           PMDuint32 nExpected,
                           PMDuint32 timeout);
```

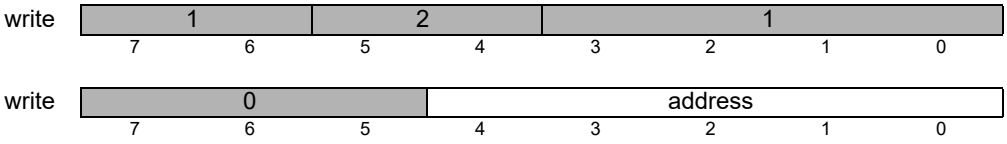
Coding

Action	Sub-action	Resource
1	-	0

Arguments None

Returned Data None

Packet Structure



Description

The **Reset Device** action may be used to reset a PRP device. No return packet is sent after this command except for nIONs. A minimum 500ms delay should be performed before sending the next command to allow for the device to reset. The return packet for the next command will be a PMD_ERR_RP_Reset error (0x2001), regardless of the command requested. A Reset error in reply to an action indicates that the command was not processed, and should be re-sent.

C Syntax

```
PMDresult PMDDeviceReset(PMDDeviceHandle *hDevice);
```

Coding

Action	Sub-action	Resource
5	-	1

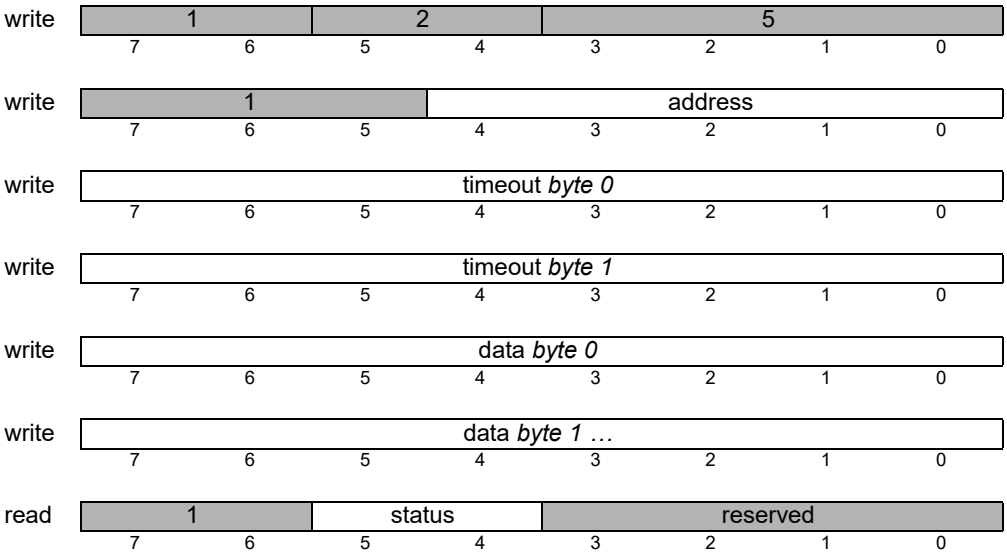
Arguments

Name	Type	Range	Units
timeout	unsigned 16 bit	0-0xFFFF	msec

Returned Data

None

Packet Structure



Description

The **Send CMotionEngine** action is used to send a user packet to a user program running on a C-Motion Engine, which may read them using the **PMDPeriphReceive** procedure applied to a peripheral opened with **PMDDeviceOpenPeriphCME**. The user packet mechanism allows arbitrary user data to be sent to or received from user programs without opening dedicated peripheral channels – the packets are encapsulated in PRP packets. User packets are sent as discrete units, and only one packet may be buffered before being read by a user program.

The *timeout* argument specifies how many milliseconds to wait for the user program to read the user packet.

The user packet mechanism is the simplest way to exchange data with running C-Motion Engine user programs, and has the advantage of working the same way regardless of the transport mechanism used to send packets, but it is limited in performance and flexibility. If user packets are not sufficient then peripheral channels specific to the user application should be opened and used.

The maximum size of a user packet is 250 bytes, as given by USER_PACKET in the file PMDPeriph.h. The actual size of the user packet sent is implicitly given by the size of the outgoing PRP packet. How the PRP packet size is determined depends on the transport mechanism in use.

C Syntax

```
PMDresult PMDDeviceOpenPeriphCME(PMDPeriphHandle *hPeriph,
                                 PMDDeviceHandle *hDevice);

PMDresult PMDPeriphSend(PMDPeriphHandle *hPeriph,
                        void *buffer,
                        PMDuint32 nCount,
                        PMDuint32 timeout);
```

Coding

Action	Sub-action	Resource
5	-	4

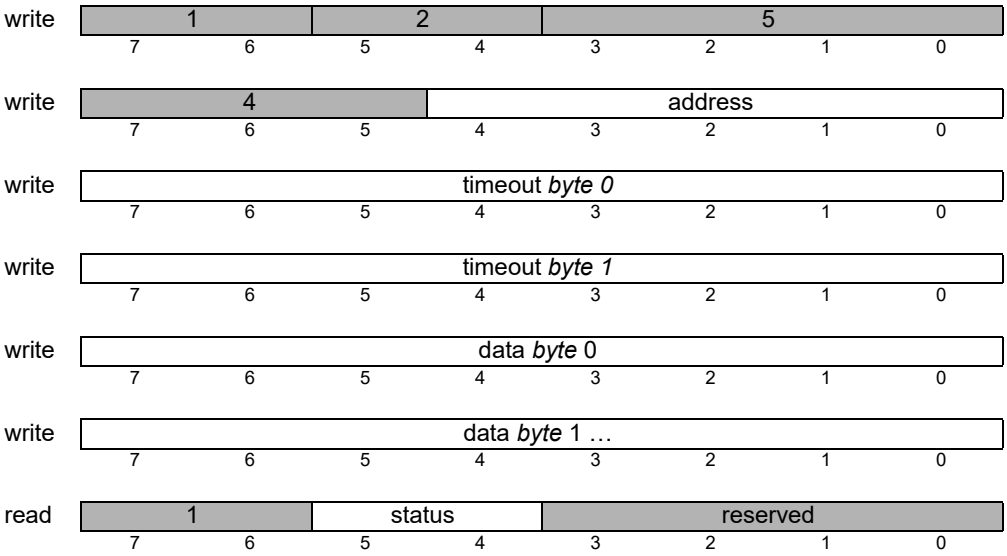
Arguments

Name	Type	Range	Units
timeout	unsigned 16 bit	0-0xFFFF	msec

Returned Data

None

Packet Structure



Description

The **Send Peripheral** action is used to transmit data to some remote device using the communication channel specified by the ***Peripheral*** resource to which it is addressed. The peripheral might be a TCP Ethernet connection, a serial port, pair of CAN bus identifiers, or any other peripheral type. The number of bytes to send is implicit in the size of the PRP packet, how this is determined depends on the transport mechanism in use.

If all of the data cannot be sent within ***timeout*** milliseconds then a PRP timeout error will be returned. In which case some of the data may have been sent, it is not possible to tell.

If the peripheral connection has been closed by some external action, for example a TCP connection that has been closed by a peer, then a status of PMD_ERR_NotConnected will be returned. Such a peripheral must be closed using the Close action. In the case of a TCP connection, after closing the unconnected peripheral a new peripheral with the same TCP port may be opened using the OpenTCP action.

C Syntax

```
PMDresult PMDPeriphSend(PMDPeriphHandle *hPeriph,
                        void *buffer,
                        PMDuint32 nCount,
                        PMDuint32 timeout);
```

Coding

Action	Sub-action	Resource
9	4	3

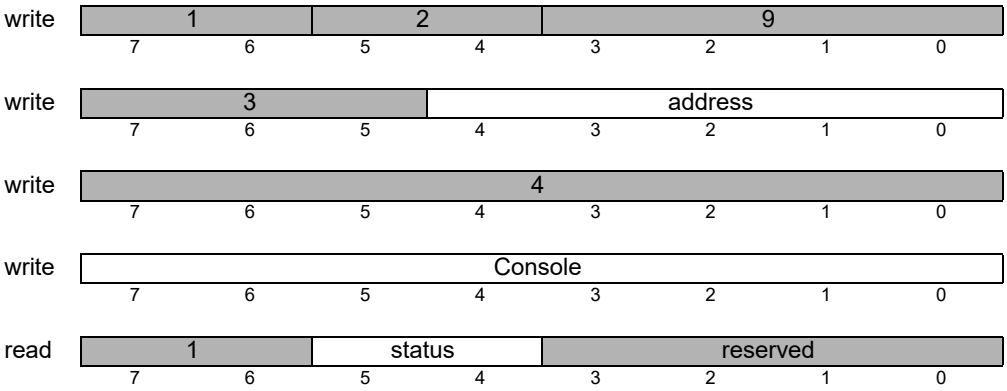
Arguments

Name	Type	meaning
Console	unsigned 8 bit	peripheral address

Returned Data

None

Packet Structure



Description

The Set **Console CMotionEngine** action is used to change the destination of console messages from a user program running in the C-Motion Engine to which the action is addressed. User programs can emit console messages using the C library procedure **PMDprintf**. Console messages are primarily intended for debugging and routine progress monitoring.

The *Console* argument is the address of a peripheral to be used for console output. If Console is zero, then all console output will be suppressed. If *Console* is nonzero it must be the address of a peripheral that was opened on the same device as the C-Motion engine being addressed – if it is an inappropriate peripheral address then an error will be returned.

C Syntax

```
PMDresult PMDCMESetConsole (PMDDeviceHandle *hDevice,
                            PMDPeriphHandle *hPeriph);
```

Coding

Action	Sub-action	Resource
9	2	0

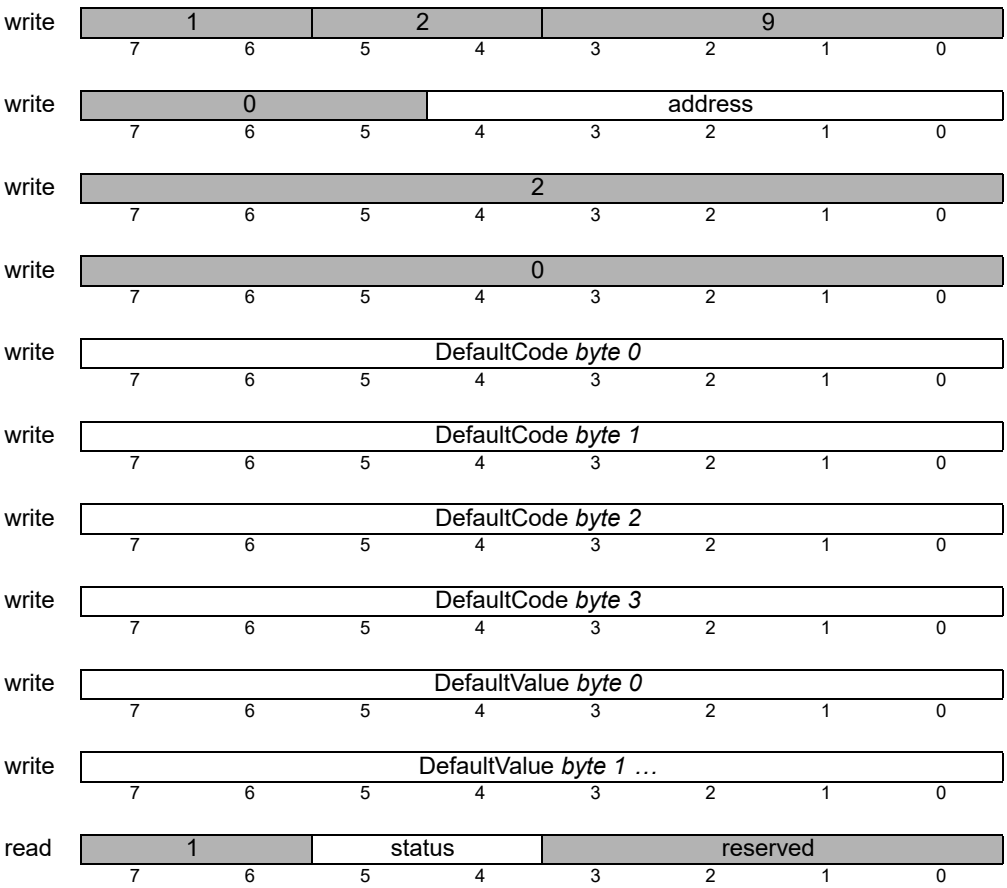
Arguments

Name	Type	meaning
DefaultCode	unsigned 32 bit	default identifier
DefaultValue	varies	

Returned Data

None

Packet Structure



Description

The **Set Default Device** action is used to change various non-volatile properties of a PRP device, for example the IP address, or whether to run a user program immediately after power up. The length of *DefaultValue* depends on the particular data type, and is encoded in the upper byte of *DefaultCode*. The length in bytes is the field value minus one; a length value of zero means one byte, one means two bytes. Most default values are either two or four bytes long, but some are longer.

Description (cont.)

The table below summarizes the set of default values and their codes:

N-Series ION CME Defaults			
Name	code	length (bytes)	factory default
DefaultIPAddress	0x0303	4	0xC0A80202 (192.168.2.2)
DefaultNetMask	0x0304	4	0xFFFFFF00 (255.255.255.0)
DefaultGateway	0x0305	4	0x00000000 (0.0.0.0)
DefaultTCPPort	0x0106	2	40100
DefaultSerial1Mode	0x010E	2	0x0004 (57600,n,8,1)
DefaultSerial2Mode	0x010F	2	0x0005 (115200,n,8,1)
DefaultRS485Duplex	0x0110	2	0 (Full duplex)
DefaultCANMode	0x0111	2	0x0000 (1000 kbps)
DefaultAutoStartMode	0x0114	2	0
DefaultConsoleIntfType	0x0118	2	0 (None)
DefaultConsoleIntfAddr	0x0119	2	0xC0A80201 (192.168.2.1)
DefaultConsoleIntfPort	0x011A	2	0
DefaultHostCANMode	0x0112	2	0xC000 (20 kbps)
DefaultDHCPTries	0x0120	2	2
DefaultTaskParam	0x011E	2	0
DefaultSerial3Mode	0x0121	2	0x0004 (57600,n,8,1)
DefaultSerial1ModeRS485	0x0124	2	0
DefaultDIOmux	0x0125	2	0x1555
DefaultDIOdir	0x0126	2	0
DefaultDIOout	0x0127	2	0
DefaultBiSSConfig	0x0129	2	0
DefaultSSIResolution	0x012A	2	0
DefaultBiSSFFrequency	0x012B	2	0
DefaultBiSSEnable	0x012C	2	0
DefaultBiSSSingleTurn	0x012D	2	0
DefaultBiSSMultiTurn	0x012E	2	0
DefaultBiSSRightBitShift	0x012F	2	0
All other values reserved.			

DefaultIPAddress is the IP address of the Ethernet controller. It is typically necessary to set this default using the serial interface to suit the network in which a PRP device is to be installed. The default value is chosen to be part of a reserved IP class, and is not routable on the Internet.

Note that IP addresses are typically written in "dotted quad" notation, where each byte is written in decimal, separated by a dot. In order to convert from dotted quad notation to hexadecimal write convert each dot-separated field to hexadecimal and concatenate.

DefaultNetMask is a bitmask defining which IP addresses are directly accessible in the local subnet, the default is for a class C network, and must typically be changed to suit the network in which the PRP device is installed.

DefaultGateway is the IP address of the router to be used for all non-local IP addresses. PRP devices does not support more general routing tables because it is expected that they will usually deal with hosts on the local network. *DefaultGateway* must be changed to enable routing to any non-local IP addresses, but that such routing may not be necessary for many applications.

Description (cont.)

DefaultTCPPort is the base TCP port used for accepting host commands. In most cases there is no reason to change the default value of 40100.

DefaultSerial1Mode and *DefaultSerial2Mode* are serial port modes with the same meaning as SerialMode in the **OpenSerial** action, and are applied to the two serial ports immediately after coming out of reset. Serial port modes may be changed later by using the **OpenSerial** action.

DefaultRS485Duplex controls whether duplex mode is used in case serial port Serial1 is configured as for RS-485. One means full-duplex, zero means half-duplex.

DefaultCANMode is an encoding of CAN bus parameters similar to that used by Magellan, as described in the *Magellan Motion Processor Programming Reference*, and are summarized below. The CAN mode cannot be changed except by using *DefaultCANMode*, it cannot be changed "on the fly."

DefaultCANMode fields

Bits	Name	Instance	Encoding
0-6	CAN NodeID	Node0	0
		Node1 …	1
		Node127	127
7-12	reserved		0
13-15	Transmission Rate	1,000,000 baud	0
		800,000 baud	1
		500,000 baud	2
		250,000 baud	3
		125,000 baud	4
		50,000 baud	5
		20,000 baud	6
		10,000 baud	7

All CAN devices on the same bus must use the same transmission rate in order to communicate properly. The *CAN NodeID* encodes a set of CAN identifiers to be used for accepting host commands and returning responses, and uses the same scheme as do Magellan Motion Processors. All PRP devices and all Magellan Motion Processors on the same CAN bus must have distinct NodeIDs. Messages with a CAN identifier of 0x600 + NodeID will be accepted as PRP host commands, and will be responded to using CAN identifier 0x580 + NodeID. Asynchronous event notification messages will be sent using CAN identifier 0x180 + NodeID.

DefaultAutoStartMode controls whether a user program in the C-Motion Engine will be run automatically after coming out of reset. A value of one means that any user program present will be automatically run, zero means that a user program will not be run until a CommandTaskStart action is received. Automatic starting of user programs will be inhibited if a user program has caused a previous reset, for example by causing an exception.

Description (cont.)

DefaultConsoleIntfType, *DefaultConsoleIntfAddr*, and *DefaultConsoleIntfPort* determine the communications channel that will be used for console (user program output) messages. The channel used may be changed at run time by using the **Set ValueConsole** action. The encoding of these default values is explained in the table below.

Console Output Defaults

DefaultConsoleIntfType value	Peripheral type	DefaultConsoleIntfAddr meaning	DefaultConsoleIntfPort meaning
0	none	ignored	ignored
1		reserved	
2	PCI	ignored	ignored
3		reserved	
4	serial	0 – Serial1, 1 – Serial2	port settings
5		reserved	
6		reserved	
7	UDP	IP address	UDP port
8	SPI		
9	PRP		
> 9		reserved	

DefaultDHCPTries is the number of attempts to obtain the IP configuration from the DHCP server.

DefaultTaskParam is the default 32 bit parameter to pass to the main user task upon startup.

DefaultSerial3Mode is the serial port mode to apply Serial3 the programming port. (0x0004 = 57600,n,8,1)

DefaultSerial1ModeRS485 is the serial port mode to apply when RS485 mode is enabled.

DefaultDIOmux is the default value to apply to the DIO signal mux PIO register 0x228.

DefaultDIOdir is the default value to apply to the DIO signal direction PIO register 0x222.

DefaultDIOout is the default value to apply to the DIO signal out PIO register 0x212.

DefaultBiSSConfig is the default value to apply to the BiSS config PIO register 0x100.

DefaultSSIResolution is the default value to apply to the BiSS resolution PIO register 0x102.

DefaultBiSSFFrequency is the default value to apply to the BiSS frequency PIO register 0x104.

DefaultBiSSEnable is the default value to apply to the BiSS enable PIO register 0x106.

DefaultBiSSSingleTurn is the default value to apply to the BiSS single-turn PIO register 0x108.

DefaultBiSSMultiTurn is the default value to apply to the BiSS multi-turnPIO register 0x10A.

DefaultBiSSRightBitShift is the default value to apply to the BiSS right bit shift PIO register 0x10C.

See the appropriate product user manual for a list of PIO registers.

C Syntax

```
PMDresult PMDSetDefault(PMDDeviceHandle *hDevice,
                        PMDDefault default,
                        void *value,
                        unsigned valueSize);
```

Coding

Action	Sub-action	Resource
9	15	0

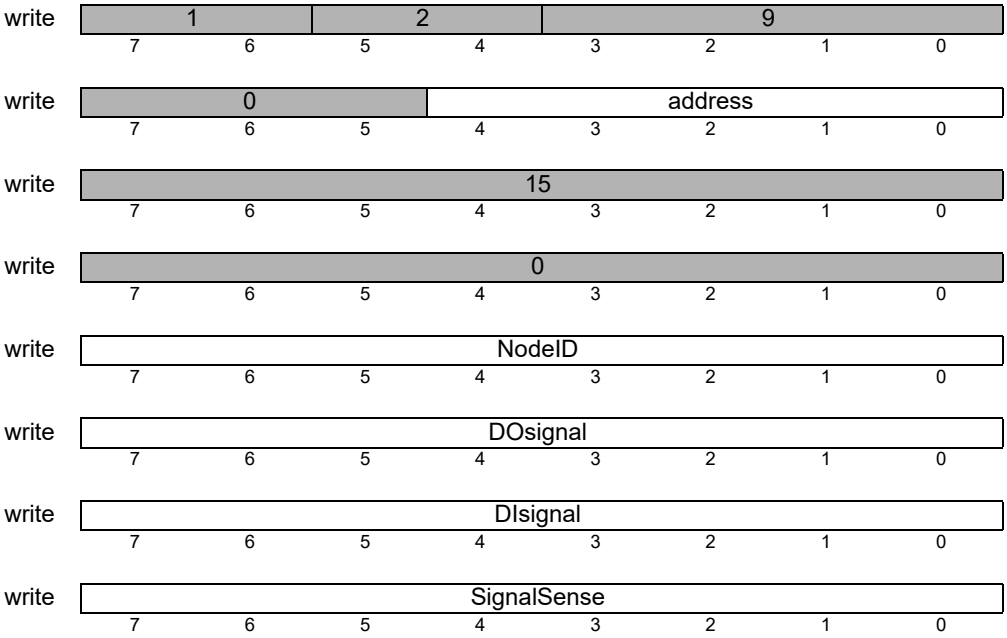
Arguments

Name	Type	Range
NodeID	unsigned 8 bit	0-255
DOsignal	unsigned 8 bit	0-8
DIsignal	unsigned 8 bit	0-8
SignalSense	unsigned 8 bit	0-1 (0=low, 1=high)

Returned Data

None

Packet Structure



Description

The **Set NodeID Device** action sets the *NodeID* of the interface on the CME device that the command is received on (Serial or CAN). This command is primarily used for daisy-chaining N-Series IONs to perform auto-addressing. If a digital input signal is specified in the command, the signal is sampled and if it is at the signal sense specified the node id is changed. If no digital input signal is specified (*DISignal* = 0) the node id is changed regardless. If a digital output signal is specified its pin muxing and direction are changed accordingly, and the output value is changed to the *SignalSense* value after a delay of 5ms to prevent the output signal from changing before other IONs process the command. If the device changed its node id to the node id specified it responds with the standard PRP response packet that no error occurred otherwise no response is sent.

The NodeID value is the desired NodeID to assign to the device. The *DOsignal* is the digital output signal that will be set to *SignalSense* if the sampled *DIsignal* is equal to *SignalSense*. Valid values are 0-8 (DIOs1-8). A value of 0 will not cause any DO to be changed. The *DIsignal* is the digital input signal to sample. Valid values are the same options as *DOsignal*.

C Syntax

```
PMDresult PMDDeviceSetNodeID(PMDDeviceHandle *hDevice,
                             PMDuint8 NodeId,
                             PMDuint8 DOSignal,
                             PMDuint8 DISignal,
                             PMDuint8 SignalSense);
```

Coding

Action	Sub-action	Resource
9	13	0

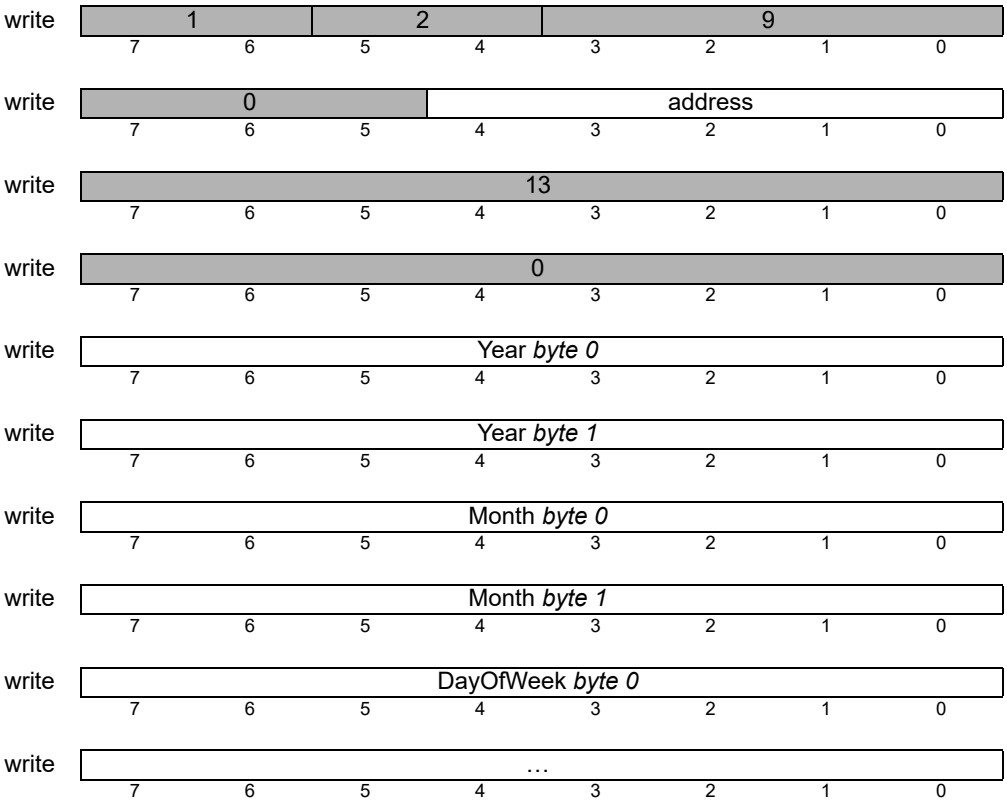
Arguments

Name	Type	Range
Year	unsigned 16 bit	0-0xFFFF
Month	unsigned 16 bit	1-12
DayOfWeek	unsigned 16 bit	0-6
Day	unsigned 16 bit	1-31
Hour	unsigned 16 bit	0-24
Minute	unsigned 16 bit	0-59
Second	unsigned 16 bit	0-59
Millisecond	unsigned 16 bit	0-999

Returned Data

None

Packet Structure



Description

The **Set Time Device** action sets the current real-time clock value of the CME device addressed.

C Syntax

```
PMDresult PMDDeviceSetSystemTime(PMDDeviceHandle *hDevice,
                                 const SYSTEMTIME* time)
```

Write Memory

Coding

Action	Sub-action	Resource
7	4	3

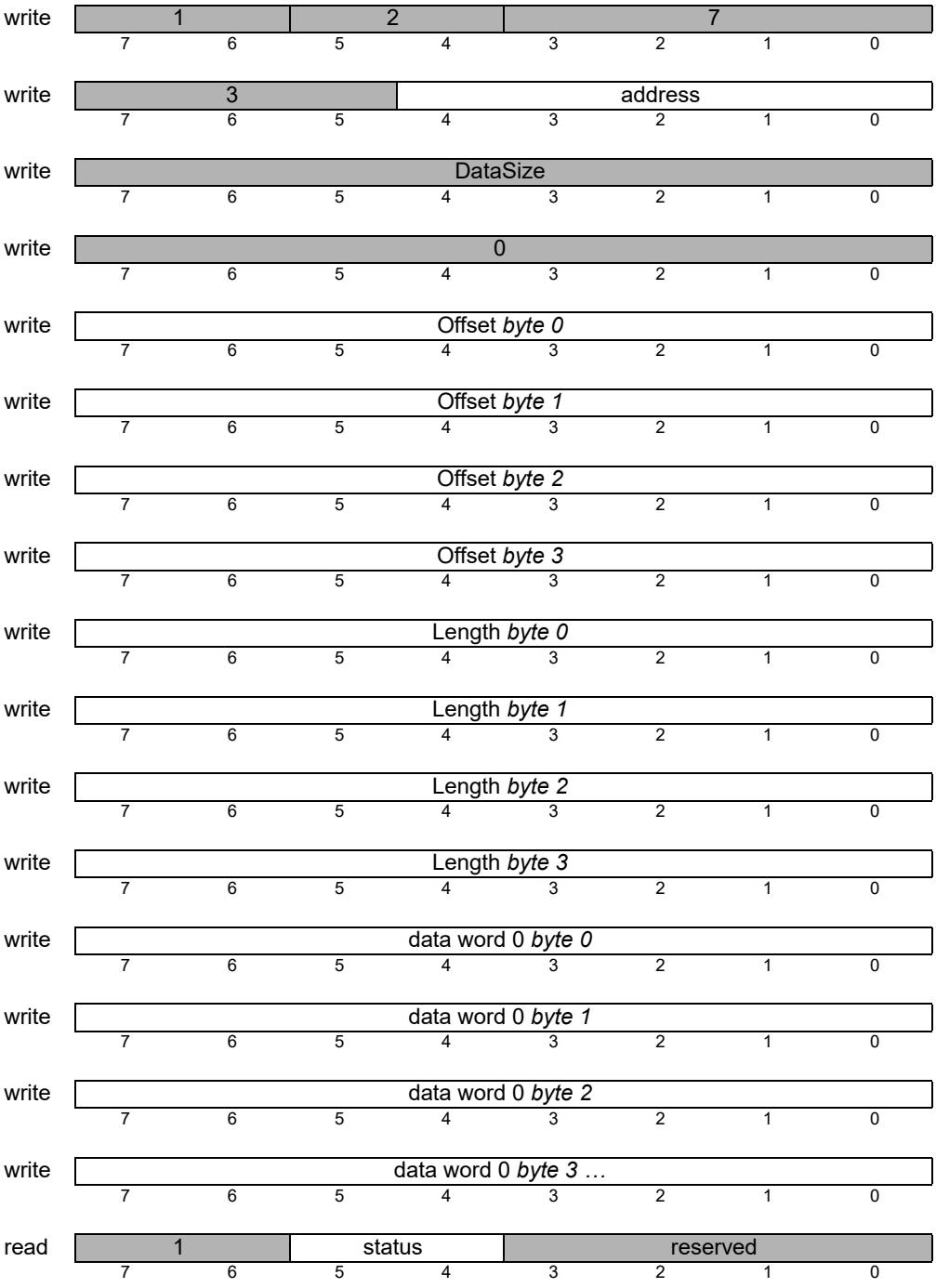
Arguments

Name	Type	Range	Units
DataSize	unsigned 8 bit	1,2,4	
Offset	unsigned 32 bit	0-0xFFFFFFFF	bytes
Length	unsigned 32 bit	0-0xFFFFFFFF	datasize

Returned Data

None

Packet Structure



Description

The **Write Memory** action is used to write a sequence of data words to a memory resource. The *Offset* argument is an index or address into the memory. *Offset* should be divisible by *DataSize*. A non-aligned access will return PMD_ERR_ParameterAlignment.

The *Length* argument is the number of *DataSize* words to write.

C Syntax

```
PMDresult PMDMemoryWrite(PMDMemoryHandle *hMemory,
                         void *data,
                         PMDuint32 offset,
                         PMDuint32 length);
```

Coding

Action	Sub-action	Resource
7	4	3

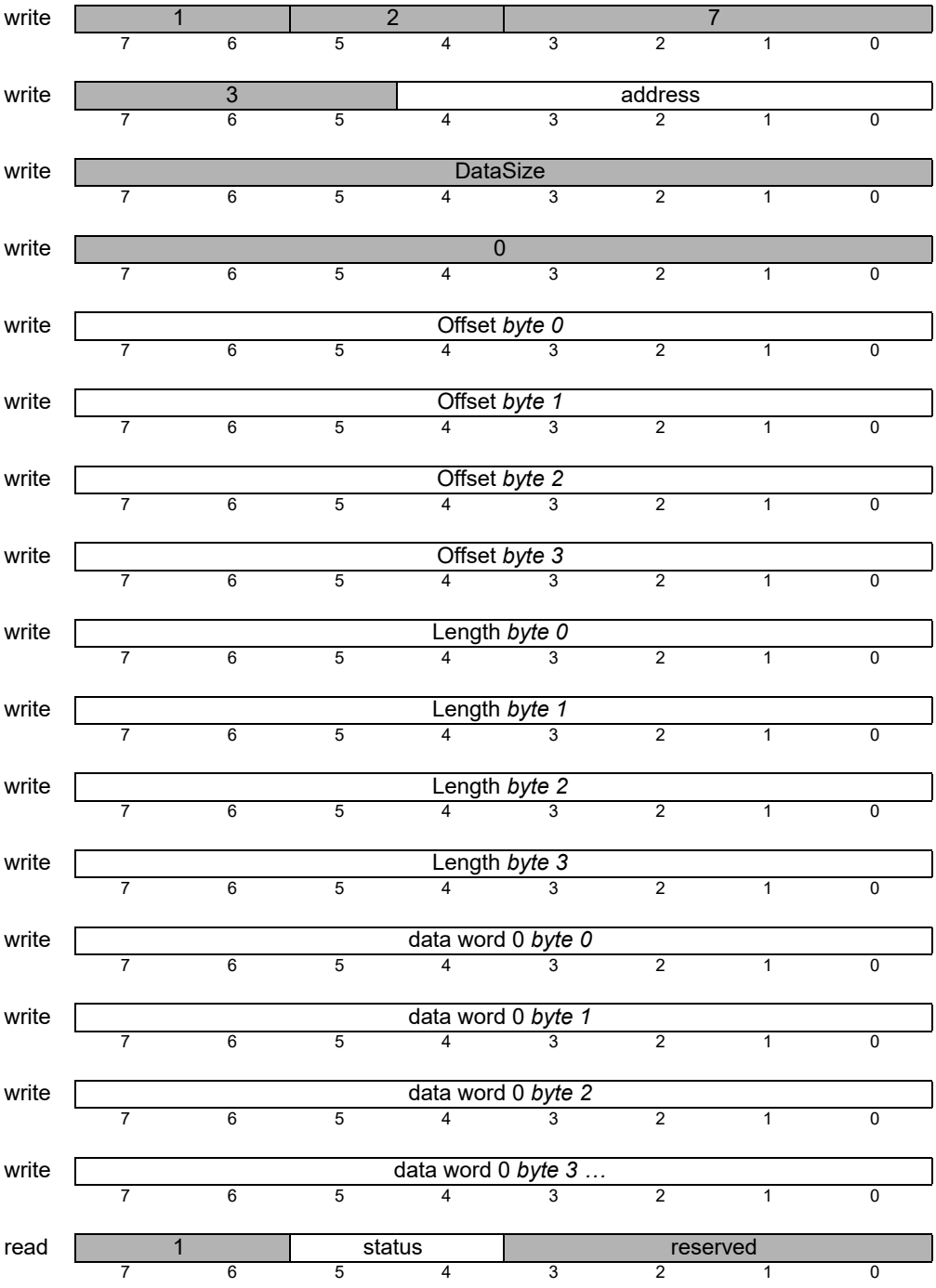
Arguments

Name	Type	Range	Units
DataSize	unsigned 8 bit	1,2,4	
Offset	unsigned 32 bit	0-0xFFFFFFFF	bytes
Length	unsigned 32 bit	0-0xFFFF	datasize

Returned Data

None

Packet Structure



Description

The **Write Peripheral** action is used to write a sequence of data words to a memory resource. The *Offset* argument is an index or address into the memory. *Offset* should be divisible by *DataSize*. A non-aligned access will return PMD_ERR_ParameterAlignment.

The *Length* argument is the number of *DataSize* words to write.

C Syntax

```
PMDresult PMDPeriphWrite(PMDMemoryHandle *hMemory,
                         void *data,
                         PMDuint32 offset,
                         PMDuint32 length);
```

Appendix A. PRP Transport

PRP may be transported using a serial, TCP/IP, CAN, or SPI communication channel. This section discusses these communication channel-specific aspects of PRP message transport and processing.

A.1 PRP Transport Over Serial

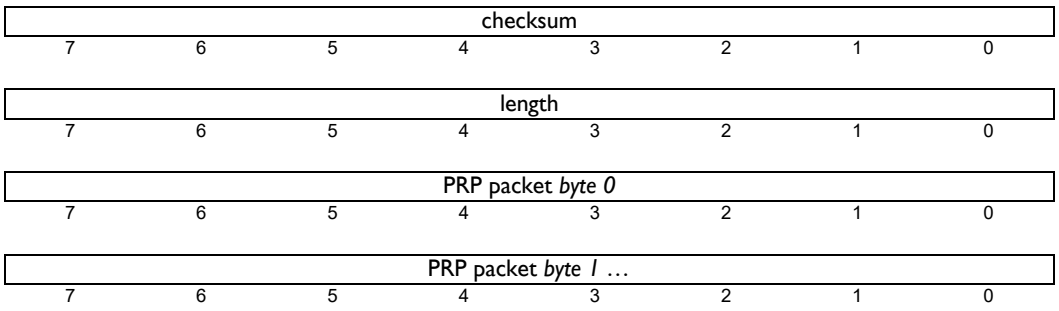
To transport PRP packets over serial a header is used to specify the length of the PRP packet and to detect most cases of packet corruption.

There are two cases of the serial protocol:

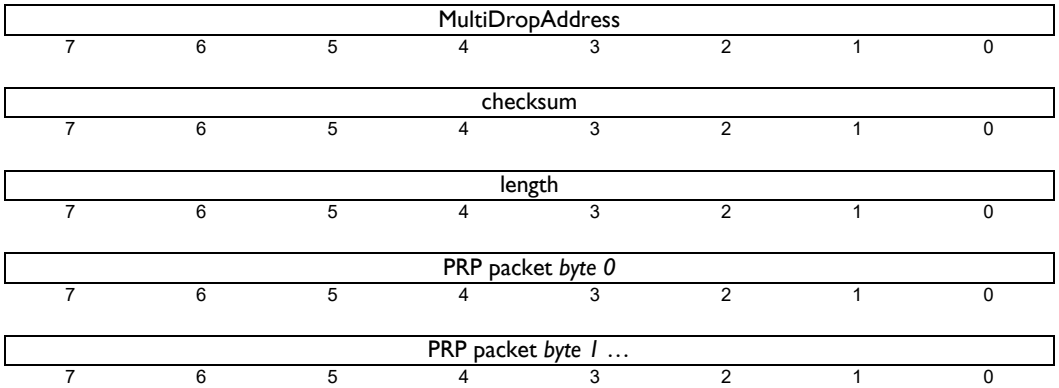
1. Point-to-point serial communication using either RS232 or RS485: only one PRP device and one host may be connected to the serial line.
2. Multi-drop serial communication using RS485: multiple PRP devices may share the same serial bus, but each must be configured to use a separate multi-drop address.

The figures below illustrate the packet formats for the two cases:

Point-to-Point Serial Packet



Multi-Drop Serial Packet



The MultiDropAddress field is used to address a particular serial device, and each device must be configured to use a different address.

The length field is the unsigned number of bytes in the PRP packet bytes. For example if there are 2 PRP packet bytes to be transported the length field value is 2.

The checksum field is a simple additive checksum modulo 256, over just the bytes in the PRP packet. For example if there are 2 PRP packet bytes to be transported then the checksum is calculated over these 2 bytes.

Both outgoing and response packets are formatted in the same way.

An error-free Serial/PRP communication sequence from the host controller to the PRP device consists of a full outgoing packet transmission with the correct checksum and specified number of bytes, and a full packet response with correct checksum and length received at the host controller. The return message must be received within a fixed amount of time determined by the host controller. Correctly setting this 'timeout window' may depend on factors such as baud rate, but 100 milliseconds is a typical safe value.

If the host controller receives a response packet with an incorrect checksum, or does not receive a complete packet (communications timeout), then the original message should be resent.

If a PRP device receives a packet with an incorrect checksum, then it will respond with a PRP error response packet with an error code of PMD_ERR_RP_Checksum. See Section 2.5.2, PRP Response Packet for a list of PRP response packet error codes.

If the PRP device does not receive the specified number of bytes within 100 milliseconds of beginning of packet reception, the incoming message is ignored and no message is sent to the host controller.

A.2 PRP Transport Over TCP/IP

PRP packets are realized as TCP/IP packets. Three padding bytes are added to the beginning of the response packet and can be ignored. For example if the PRP response packet is two bytes in length, the 1st, 2nd, and 3rd bytes of the TCP/IP response packet would hold zero, and the 4th and 5th bytes would hold the PRP response packet.

The length of each PRP packet is determined from the IP header.

In order to initiate a PRP connection, a host should establish a TCP connection to a PRP device using the port specified by the device default DefaultTCPPort. The factory default for this port is 40100, but it may be changed using **Set Device SetDefault**.

A.3 PRP Transport Over CAN

PRP over CAN uses the concept of a *node identifier*, a concept borrowed from CANOpen. The node identifier is a user-chosen integer between 1 and 127, inclusive, and is the least significant seven bits of any CAN identifier used for PRP communication. As long as their node identifiers are different, PRP devices should coexist (but not communicate) with CANOpen devices on the same CANbus.

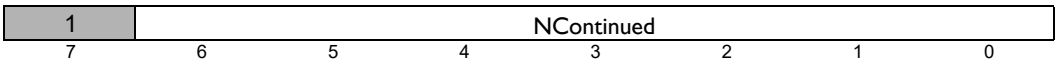
PRP uses three CAN identifiers for communication:

- 0x600 + NodeIdentifier is used for sending messages from the host to a PRP device. This identifier is used by default for SDO transmit by CANOpen devices.
- 0x580 + NodeIdentifier is used for sending responses from a PRP device to a host. This identifier is used by default for SDO receive by CANOpen devices.

CAN messages are limited to eight bytes of data, which means that some PRP packets may require several CAN messages for complete transport. In order to support this a segment/de-segment protocol is used. The protocol that is used by the PRP devices to accomplish this is very similar to the Service Data Object (SDO) protocol of the CANopen standard.

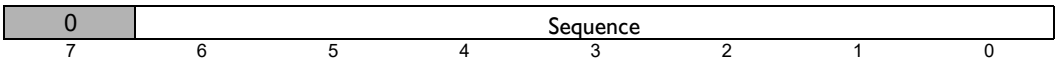
A header byte added as the first byte of each CAN message is used for segment identification. All of the remaining (up to 7) bytes are used for the PRP packet content. Each CAN message used for PRP is either an *initial* message, or a *continued* message. An initial message is the first message and is followed by zero or more continued messages, which complete the PRP packet content.

The header byte of the initial message has the form:



NContinued is the number of continued messages that will follow, and may be zero.

Each continued header byte has this form:



The first continued message has a Sequence value of one, and each subsequent message has a Sequence value one greater than that of the previous message. The final message has a Sequence value of NContinued.

If a message is received with an unexpected Sequence value, or an Initial message is received when expecting a Continued message, then the receiver will immediately send a PRP error packet with the error code PMD_ERR_RP_InvalidPacket. Each continued message must be sent within 100ms otherwise the PRP packet processing state machine will be reset.

The exact length of a PRP packet may not be determined after reading just the initial message with a nonzero NContinued value, because the length of the last message is not known. The length is at least 7 * NContinued + 1 and at most 7 * (NContinued + 1).

No PRP packet checksum is required because the integrity of each CAN message is protected by a CRC including the segment header bytes. Reception of the expected sequence numbers is very good evidence that a packet has been correctly received.

Example

To send the 17 byte PRP packet 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 the message-by-message CAN content is:

1st CAN message (all values in hex):

82, 01, 02, 03, 04, 05, 06, 07

2nd CAN message:

01, 08, 09, 0A, 0B, 0C, 0D, 0E

3rd CAN message:

02, 0F, 10, 11

A.4 PRP Transport over SPI

PRP transport over SPI utilizes standard SPI signals consisting of chip select, clock, MISO, and MOSI. In addition, a signal known as SPIStatus used for message sequence control is used. In the PRP system the host acts as the SPI master, and the PRP device acts as the SPI slave.

For reference, when operating as a PRP slave device (which is the default mode of operation) the Host SPI port signals for the N-Series ION Digital Drive are shown below:

Signal Name	Function	Input/Output
HostSPISelect	Chip Select	Input
HostSPIClock	Clock	Input
HostSPIXmt	MISO (Master In Slave Out)	Output
HostSPIRcv	MOSI (Master Out Slave In)	Input
HostSPIStatus	SPIStatus	Output

In the PRP system all SPI data is transmitted in bytes, most significant bit first, with 16 bit words being transmitted low byte first, then high byte. Full duplex communication with chip select, clock, MISO, and MOSI signals is assumed, meaning the slave is transmitting simultaneously as the host is transmitting. SPI mode 1 is used, meaning MISO and MOSI change on the rising edge of the clock and are latched on the falling edge.

A.4.1 Outgoing Message Format

The complete PRP message packet is sent by the host to the PRP device using a single SPI message. The contents of the complete PRP message consist of a two-byte header, the PRP payload (the PRP packet bytes), and a two byte checksum. If the PRP payload has an odd length in bytes, then a padding zero byte is sent after the payload and before the checksum.

The header contains a single byte length field which is the number of bytes in the PRP payload excluding any padding bytes. Following the length field is a byte with a value of zero.

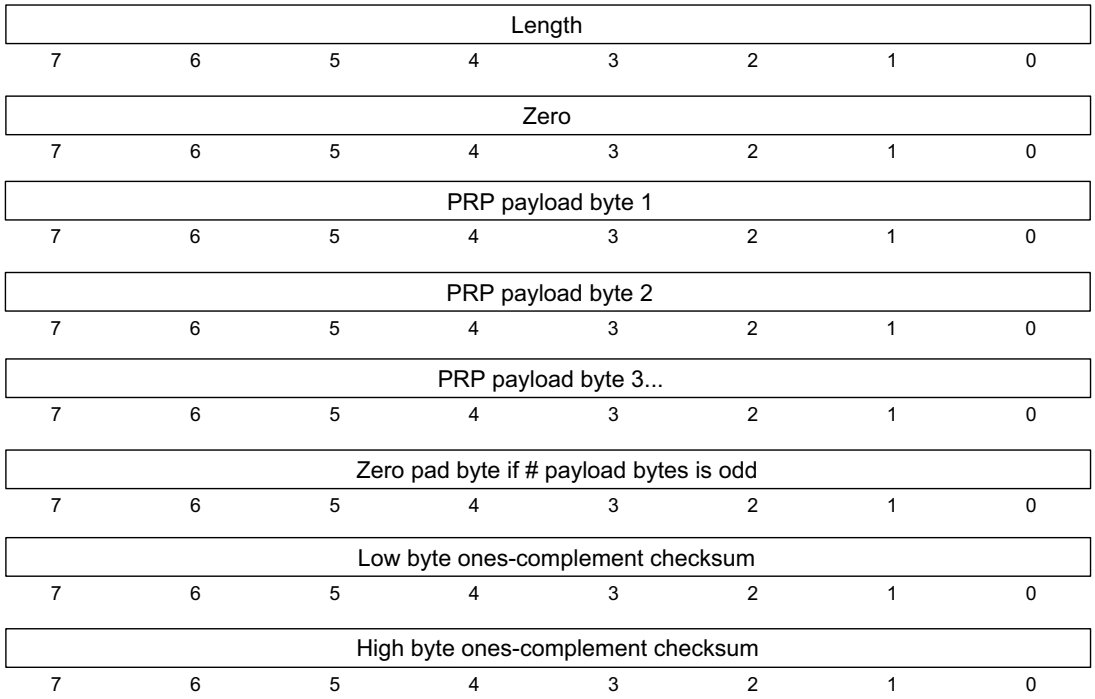


Figure A-1: Outgoing Packet Format for PRP over SPI

The checksum is the logical not of the 16 bit ones complement checksum of the complete PRP message including Header, PRP payload, pad byte if present, and the checksum. A ones complement checksum is computed by first adding together all message bytes as unsigned 16 bit words, assembling the result into a 32 bit value. If the high word of this 32 bit value is non-zero the high 16 bit word should be repeatedly added to the low 16 bit word as unsigned 16 bit values until the high word is zero. This will be accomplished in no more than two such "foldback" adds.

The computed ones complement checksum of a correctly received complete PRP message should be 0xFFFF. If the computed value is not 0xFFFF the PRP device will respond with a "checksum error" PRP packet. For a list of PRP error codes see Section 2.5.2, PRP Response Packet.

During outgoing message transmission the host should ignore any data received from the PRP device.

A.4.2 Response Message Format

A PRP response packet can be retrieved via a single SPI transaction or via multiple SPI transactions.

The overall format of the complete PRP response message is similar, but not identical, to the outgoing message. First a length byte is sent followed by two zero bytes (rather than one zero byte for the outgoing message header). Then the PRP payload is sent which is padded with a zero byte at the end if the number of bytes in the payload is odd. Finally a 16 bit checksum is sent.

Both the length and the checksum fields operate over the same fields as the outgoing message and are computed the same way, except that their values come from the response message content.

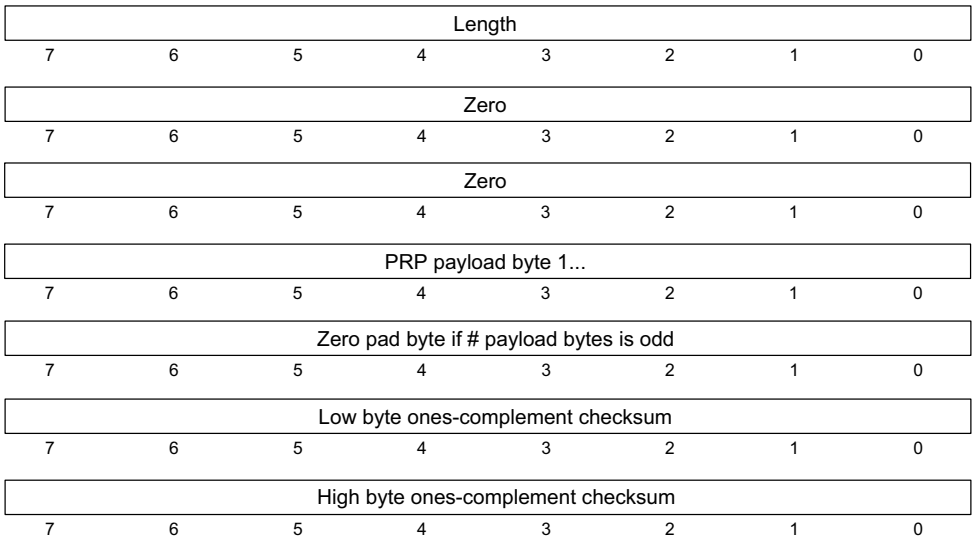


Figure A-2: Response Packet Format for PRP over SPI

A.4.3 SPI PRP Command Sequence

An SPI PRP command sequence consists of sending a command, waiting for *HostSPIStatus*, then reading the response. The chip select signal can either be de-asserted between sending and receiving or left asserted if it is the only device on the bus. The complete sequence of events for sending a command follows:

1. The host sends an outgoing complete PRP message.
2. While the slave processes this command, the host waits for *HostSPIStatus* to be asserted.
3. Once *HostSPIStatus* is asserted the host sends a 16 bit message containing a value of zero, and reads two bytes simultaneously transmitted by the PRP device to obtain the response header.
4. The host then reads the number of bytes of the PRP response indicated by the length field in the response header plus any pad byte. When retrieving the full response and trailing checksum, the host should send zeros and expect them to be ignored. The reading of the response header and the PRP payload can be two separate SPI transactions if desired, or the chip select signal can be left asserted throughout.
5. The host calculates and verifies the checksum. If the checksum is not valid then the response should not be accepted. The checksum includes all response packet bytes. A PRP response must be completely read

within 100ms after *HostSPIStatus* is asserted otherwise the PRP Device returns to the "waiting for outgoing PRP message" state and the response data is lost. *HostSPIStatus* will be deasserted when this occurs.

Example

An outgoing PRP message carried over SPI encodes the following:

MotionProcessor, Addr 0, Command, <SetPosition, #3, 0x12FEDC>

What is the byte-by-byte outgoing SPI data stream?

We first determine the content of the PRP payload, i.e., the PRP header and PRP body content. See Section 2.6.2, Automatically Assigned Addresses and Peripherals for encoding of a very similar PRP message.

```
0x62        // 1st byte of PRP header encoding a Command action
0x40        // 2nd byte of PRP header encoding a MotionProcessor resource, Addr 0
0x0210      // 6-byte PRP payload body encoding SetPosition #3, 0x12FEDC
0x0012
0xFEDC
```

The total length of the PRP payload is 8 bytes, and therefore no zero pad byte is added at the end of the payload. Had a pad byte been necessary it would be added at the very end of the payload.

Now we show the complete outgoing PRP message content. From the previous description, note that 16 bit values are encoded low byte first then second byte.

Complete outgoing PRP Message content:

```
0x08        // length field which is includes a PRP payload of 8 bytes
0x00        // zero
0x62        // 1st word of PRP payload
0x40
0x10        // 2nd word of PRP payload
0x02
0x12        // 3rd word of PRP payload
0x00
0xDC        // 4th word of PRP payload
0xFE
0x96        // computed folded checksum is 0x4169, inverted becomes 0xBE96
0xBE
```

To compute the needed checksum we add up all 16 bit words not including the checksum and maintain this sum in a 32 bit register. The above stream in 16 bit values is 0x0008, 0x4062, 0x0210, 0x0012, 0xFEDC. This gives a summed value of 0x14168. Next we add the 1 of the high word to the low word giving a result of 0x4169 with no carry into the high word indicating 'folding' is done. Finally we logical invert (not) this result giving 0xBE96, which is inserted as the calculated checksum in the outgoing message.

For the receiving SPI Device to check the checksum it adds up all received words including the checksum in the same way. This gives 0x1FFFE, which after folding the high word value into the low word gives 0xFFFF indicating a correct checksum.

Appendix B. Summary List of C-Motion API

B

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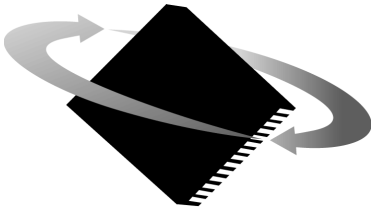

P M D

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