Serving the Vending / Foodservice management industry

Multi-Drop Bus / Internal Communication Protocol

MDB / ICP

Supported by the Technical Members of:

NAMA	**N**ational **A**utomatic **M**erchandising **A**ssociation
EVA	**E**uropean **V**ending **A**ssociation
EVMMA	**E**uropean **V**ending **M**achine **M**anufacturers **A**ssociation

Version 3.0

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Multi-Drop Bus / Internal Communication Protocol

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Revisions

Version 3.0

Version 3.0 of this specification is the third release of the international **Multi-Drop Bus / Internal Communication Protocol** (**MDB / ICP**). This specification is the continued effort put forth by technical members of NAMA and the EVA. The basis for this specification is the Version 2.0 international **Multi-Drop Bus / Internal Communication Protocol** (**MDB / ICP**) released on October 4, 2002.

Of special note are the four major changes that were made to the specification:

- Added a second Cashless Device peripheral address in Section 7
- Replaced the Audit Unit with the Communications Gateway in Section 8
- Added the Coin Hopper or Tube – Dispenser in Section 10 (new)
- Assigned 2 addresses to be used for experimental peripherals

The following lists the primary revisions to the Version 3.0 of the **MDB / ICP.**

Section 1 – General Information

Section 1.3

- Changed the Level and Options chart for the Communications Gateway and the Coin Hopper or Tube – Dispenser

Section 2 – Communication Format

Section 2.2

- Added headers for the Response Codes
- Clarified non response processing for Master-to-Peripheral and Peripheral-to-Master communication.

Section 2.3

- Updated the Peripheral Address table for the Communications Gateway, Coin Hopper, Cashless Payment 1, and Experimental addresses
- Defined the use of the experimental addresses

Section 2.5

- Added new RESET examples F & G.

Section 5 – Coin Acceptor / Changer

Section 5.2

- Renamed the STATUS command to SETUP command
- Added a new Possible Credited Coin Removal status code (0Dh)

Section 6 – Bill Validator

Section 6.2

- Renamed the STATUS command to SETUP command
- Added a new Possible Credited Bill Removal status code (0Ch)

Section 7 – Cashless Device(s) (New Cashless Device #2)

Changed name from Cashless Payment to Cashless Device

Section 7.1

- Added information regarding the dual addresses for two Cashless Device peripherals (10h and 60h)

Section 7.3

- Updated Command & Response table for dual addresses

Section 7.4

- Updated Command/Response Formats for dual addresses

Section 8 – Communications Gateway (New Peripheral)

Sections 8.1 through 8.6

- Replaced former Audit Unit sections with new Communications Gateway Sections

Section 9 –Universal Satellite Device (USDC)

Section 9.3

- Updated POLL table with proper number of bytes (FTL portion)
- Changed “numeric row and column” to “Item Number”

Section 10 – Coin Hopper or Tube – Dispenser (New Peripheral)

Sections 10.1 through 10.5

- Added complete new sections

Version 2.0

Version 2.0 of this specification is the second release of the international **Multi-Drop Bus / Internal Communication Protocol** (**MDB / ICP**). This specification is the culmination of effort put forth by technical members of NAMA, the EVMMA, and the EVA. The basis for this specification is the Version 1.0 international **Multi-Drop Bus / Internal Communication Protocol** (**MDB / ICP**) released on October 14, 1998.

The following lists the primary revisions to the Version 2.0 of the **MDB / ICP**

Introduction

Foreword

- Clarified that the Standard is a communication interface

Section 1 - General Information

Section 1.1

- Added 3rd paragraph noting interface specification vs. system specification

Section 1.3

- Added entire Levels and Options section

Section 2 - Communication Format

Section 2.1

- Changed Mode Bit Master-to-Peripheral text

Section 2.2

- Removed “command” from Master-to-Peripheral 4th paragraph
- Changed RET description

Section 2.3

- Defined address 0000xxxB (00H) for VMC
- Provided address information to show hexadecimal format

Section 2.4

- Changed format to 2.4.X sub-sections and added 2.4.4 on Levels

Section 2.5

- Changed RET description

Section 2.6

- Added complete File Transport Layer Section

Section 3 - Bus Timing

Section 3.1

- Added 2nd sentence to t_{setup}

Section 4 - Hardware Specification

Section 4.3

- Modified complete section and added AMP as alternate source to Molex

Section 4.4

- Added pin numbers to schematic

Section 5 - Coin Acceptor / Changer

Section 5.1

- Provided additional address information

Section 5.3

- Added recommended RESET command sequence
- Modified STATUS response to indicate Country / Currency Codes
- Modified County / Currency Code to include ISO 4217 (Appendix A1)
- Added Note 2 to DISPENSE (ODH) command
- Added FTL POLLed responses
- Added FTL "b3" option bit
- Added FTL expansion commands
- Cosmetic changes to all EXPANSION commands
- Split ALTERNATIVE PAYOUT (0FH-02H) and PAYOUT STATUS (0FH-03H) command into two separate commands (cosmetic change only)
- Added text to ALTERNATIVE PAYOUT (0FH-02H) Y1 description
- Added Note 3 to ALTERNATIVE PAYOUT STATUS (0FH-03H)

Section 5.5

- Added "**See Note 2 …**" text
- Added "If both peripherals supported" to Note

Section 6 - Bill Validator

Section 6.1

- Provided additional address information

Section 6.3

- Added recommended RESET command sequence
- Modified STATUS response to indicate Country / Currency Codes
- Modified County / Currency Code to include ISO 4217 (Appendix A1)
- Added Level 2 information
- Added Level 2 option bytes w/ new EXPANSION COMMANDs:
  - 37H 01H Level 2 Option Bit Enable
  - 37H 02H Level 2 Identification
- Added FTL POLLed responses
- Added FTL "b0" option bit
- Added FTL expansion commands
- Modified last sentence in SECURITY command to link to Z9-Z10 STATUS response

- Cosmetic changes to all EXPANSION commands

Section 6.5

- Added “If both peripherals supported” to Note

Section 7 - Cashless Payment

Section 7.2 & 7.2.7

- Added Level 03 Negative Vend Request

Section 7.2.2

- Changed 1st sentence to link Setup to 7.4.1 information

Section 7.2.4

- Added Negative Vend and Revalue

Section 7.2.7

- Added Level 03 Negative Vend Request

Section 7.3

- Added bold text regarding defining currency at the beginning of a session
- Broke uninterruptable table into VMC Command and Reader Response
- Added Level 03 NEGATIVE VEND REQUEST to VMC Command table
- Added Level 03 DATA ENTRY REQUEST to Reader Response table
- Highlighted command out of sequence hard resets from VMC
- Moved Vend Failure Sequence to 7.4.8

Section 7.3 – Table 1

- Changed name to COMMANDS & RESPONSES
- Changed Comment column to VMC / Reader Level Support
- Linked all commands and responses to Levels
- Added DATA ENTRY REQUEST POLLed responses
- Added FTL POLLed responses
- Added FTL commands
- Added NEGATIVE VEND REQUEST responses
- Defined 14H-1AH and 20H-FEH as “For Future Use”

Section 7.4.1

- Cosmetically modified RESET command sequence
- Added 32 bit SETUP MAX/MIN PRICE
- Changed text following **Reader response**

Section 7.4.2

- Clarified Level 01 information (reader has no revalue capability)
- Added Level 03 information
- Modified SETUP response to indicate Country / Currency Codes
- Modified County / Currency Code to include ISO 4217 (Appendix A1)
- Added bold Note in Z3-Z4 County / Currency Code
- Added definition for Miscellaneous Options “b4 – b7”

Section 7.4.3

- Added Level 03 SETUP if Expanded Currency Mode

Section 7.4.4

- Added Level 03 BEGIN SESSION response if Expanded Currency Mode
- Added Level 03 VEND APPROVED response if Expanded Currency Mode
- Added Level 03 PERIPHERAL ID response if Expanded Currency Mode
- Clarified COMMAND OUT OF SEQUENCE definition
- Added Level 03 REVALUE LIMIT AMOUNT response if Expanded Currency Mode
- Added Level 03 DATA ENTRY REQUEST response if Data Entry Mode
- Added Level 03 DATA ENTRY CANCEL response if Data Entry Mode
- Added Level 03 FTL REQ TO RCV response if FTL Mode
- Added Level 03 FTL RETRY / DENY response if FTL Mode
- Added Level 03 FTL SEND BLOCK response if FTL Mode
- Added Level 03 FTL OK TO SEND response if FTL Mode
- Added Level 03 FTL REQ TO SEND response if FTL Mode

Section 7.4.5

- Added Level 03 VEND command if Expanded Currency Mode
- Added Level 03 VEND APPROVED response if Expanded Currency Mode

Section 7.4.8

- Added Vend Failure (from 7.3)

Section 7.4.10

- Added Level 03 VEND command if Expanded Currency Mode

Section 7.4.11 (new)

- Added complete Level 03 NEGATIVE VEND Request section

Section 7.4.15 (new)

- Added complete Level 03 DATA ENTRY Request section

Section 7.4.16

- Added Level 03 REVALUE Request command if Expanded Currency Mode

Section 7.4.17

- Added Level 03 REVALUE Limit Request command if Expanded Currency Mode

Section 7.4.18

- Added Level 03 EXPANSION REQUEST ID response if Expanded Currency Mode

Section 7.4.22

- Added Level 03 EXPANSION ENABLE OPTIONS command

Section 7.4.23

- Added Level 03 FTL REQ TO RCV command & responses if FTL Mode

Section 7.4.24

- Added Level 03 FTL RETRY / DENY command if FTL Mode

Section 7.4.25

- Added Level 03 FTL SEND BLOCK command & response if FTL Mode

Section 7.4.26

- Added Level 03 FTL OK TO SEND command if FTL Mode

Section 7.4.27
- Added Level 03 FTL REQ TO SEND command & responses if FTL Mode

Section 7.7
- Added Example Vend Session #10 (Single Negative Vend)

Section 8 - Audit Device

Section 8.1
- Provided additional address information

Section 8.3
- Added FTL POLLed responses
- Added FTL "b3" option bit
- Added FTL expansion commands

Section 9 - Universal Satellite Device

Section 9.1
- Provided additional address information

Section 9.3
- Added FTL POLLed responses
- Added FTL "b2" option bit
- Added FTL expansion commands

Document Revision History
- Deleted

Appendix 1 - Currency Codes
- Added entire section (based on **ISO 4217**)

Appendix 2 - Battery Operated Card Reader
- Added entire section

Version 1.0

Version 1.0 of this specification is the first release of the international **Multi-Drop Bus / Internal Communication Protocol** (**MDB / ICP**). This specification is the culmination of effort put forth by technical members of NAMA, the EVMMA, and the EVA. The basis for this specification is the **International Multi-Drop Bus Interface Standard** published by NAMA and the **Internal Communication Protocol** published by the EVMMA. The NAMA document was originally introduced on October 19, 1993 and later revised on August 19, 1994, June 20, 1997, and October 15, 1997. The EVMMA document was adopted in 1994 and later revised in 1995.

The following lists the primary revisions to the original two documents which were "combined" to create Version 1.0 of the **MDB / ICP**. In actuality, the NAMA **MDB** was the basis of the **MDB / ICP** with the exception of Section 7 which came from the EVMMA **ICP**. Besides typographical corrections and actual feature changes (below), the entire document was edited to provide a more uniform appearance.

The following lists the primary revisions to the Version 1.0 of the **MDB / ICP.**

Hardware Specification - Section 4.3

- Added drawings of the MDB male and female connectors.

Coin Acceptor / Changer - Section 5.3

- Added Expansion commands:
  - 0F-05 Send Current Diagnostic Status
  - 0F-06 Send Controlled Manual Fill Report
  - 0F-07 Send Controlled Manual Payout Report

Coin Acceptor / Changer - Section 5.5

- Added coin acceptance and coin payout power requirements for coin changers using motorized payout mechanisms.
- Added note about simultaneously supplying bill validator transport power.

Bill Validator - Section 6.5

- Added note about simultaneously supplying coin mechanism coin acceptance power.

Cashless Payment - Section 7.2.6

- Added Level 02 Revalue capability.

Cashless Payment - Section 7.3

- Added Level 02 REVALUE REQUEST.
- Removed NAK (NCK) response from uninterruptable state and unexecutable command descriptions.
- Eliminated the BUSY response to vend failure sequences.
- Modified Table 1 per above.

Cashless Payment - Section 7.4.1

- Further defined the initializing sequence following a RESET command.

Cashless Payment - Section 7.4.2

- Further defined the Z7 Application Maximum Response Time.
- Added Z8 – b3 for supporting the VEND/CASH SALE subcommand.

Cashless Payment - Section 7.4.4

- Begin Session (03h) - Added Level 02 Reader Z4-Z10 data.
- Malfunction/Error (0Ah) - Added error code 1100 (refund error).
- Command Out of Sequence (0Bh) - Added Z2 data.
- Eliminated Busy (0Ch) response.
- Added Level 02 Reader Revalue Approved (0Dh) response.
- Added Level 02 Reader Revalue Denied (0Eh) response.
- Added Level 02 Reader Revalue Limit Amount (0Fh) response.
- Added Level 02 Reader User File Data (10h) response.
- Added Level 02 Reader Time/Date Request (11h) response.

Cashless Payment - Section 7.4.10

- Added Level 01 Reader CASH SALE (13h/05h) VMC command.

Cashless Payment - Section 7.4.14

- Added Level 02 Reader Revalue - Request (15h/00h) VMC command.

Cashless Payment - Section 7.4.15

- Added Level 02 Reader Revalue – Limit Request (15h/01h) VMC command.

Cashless Payment - Section 7.4.17

- Obsoleted EXPANSION – Read User File (17h/01h) VMC command.

Cashless Payment - Section 7.4.18

- Obsoleted EXPANSION – Write User File (17h/02h) VMC command.

Cashless Payment - Section 7.4.19

- Added Level 02 Reader Write Time/Date File (17h/03h) VMC command.

Cashless Payment - Section 7.5

- Further defined the non-response time with the “Application Maximum Response Time” Z7.

Cashless Payment - Section 7.6 (original ICP Spec)

- Moved this section (ICP Payment Media Return Button) to Section 7.3.2.

Cashless Payment - Section 7.6 (MDB/ICP Spec)

- Previously was the ICP 7.7 with no modifications.

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Introduction

Foreword

This voluntary Standard contains basic requirements for a vending machine communication interface within the limitations given below and in the General Information section of this Standard. These requirements are based on sound engineering principles, research, field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, and others having specialized experience. These requirements are subject to revision as further experience and investigation may show it necessary or desired.

NAMA, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of NAMA represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the NAMA Standard is processed. NAMA shall not be responsible to anyone for use or reliance upon Standard by anyone. NAMA shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, reliance upon this Standard.

Standard Review

A complete review of this standard shall be conducted at least every five years to keep requirements consistent with technology. These reviews shall be conducted by representatives from industry and user groups on the NAMA Vending Technology Standards Committee at that time.

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Section 1

General Information

1.1 Introduction

This document defines a serial bus interface for electronically controlled vending machines. The interface is a 9600 baud Master-Slave arrangement where all peripherals are Slaves to a Master controller.

The intent of this document is to standardize vending machines that employ electronic control (traditionally known as vending mechanism controller - VMC) so that all vending and peripheral equipment communicates identically.

It should be noted that this document is a vending machine interface / protocol specification and **not** a vending machine system specification. Each machine manufacturer should provide a specification on the overall operation of the machine.

1.2 Operational and Application Notes

The serial bus, or Multi-Drop Bus (MDB) is configured for Master-Slave operation. There is one Master with capability of communicating with up to thirty-two peripherals. The Master is defined as the Vending Machine Controller (VMC).

Each peripheral is assigned a unique address and command set. The master will “poll” the Bus for peripheral activity. That is, each peripheral is asked for activity, and responds with either an acknowledge, negative acknowledgment, or specific data dependent on its current activity. If a peripheral does not respond within a predefined time, (t-non-response as defined in the peripheral sections) it is assumed that it is not present on the Bus.

Bus interference, or “crashes” are prevented because each peripheral only responds upon being polled. Since there is only one master, and all communication is initiated by the Master, Bus “crashes” are easily precluded.

All peripherals will recognize a disable command, or commands, sent by the Master. This allows for disabling of individual peripherals for various reasons, for example, power management techniques.

Error checking and correction is accomplished by using checksums (CHK) and a retransmit command.

1.3 Levels and Options

Since the introduction of the earliest Multi-Drop Bus specification, functional levels and operational options have been established for most of the peripherals on the MDB/ICP interface. These have provided the capability for new features to be implemented as new requirements and features were needed for the international vending industry.

1.3.1 Levels

Levels of peripheral functionality were established when a major change occurred in the peripheral that added extended commands and responses. Due to potential conflicts between a VMC level and a peripheral level, neither the VMC nor the peripheral should issue a command or reply with a response that is not supported by the other device.

The VMC must initially determine (via the appropriate STATUS or SETUP command) the level of a peripheral before determining which commands it can issue to that device. **A VMC must only send commands that are supported by the peripheral.** For example, a Level 3 command may only be issued to a Level 3 or higher peripheral and must not be issued to a Level 1 or 2 peripheral.

The Cashless Payment and the Universal Satellite Device can also learn the respective level of the VMC for that device. This information is sent via the SETUP command. **It is the responsibility of the peripheral to only send responses that are supported by the VMC.** For example, a Level 3 response may only be sent to a Level 3 or higher VMC and must not be sent to a Level 1 or 2 VMC. Effectively, the VMC and peripheral should support the highest common level.

For total compatibility, VMCs and peripherals should support all lower levels. **For new designs after July 2000, it is strongly recommended that VMCs and peripherals must support all lower levels.** Commercial or regional issues may cause machine or peripheral manufacturers to implement only specific levels; however, this is a decision (and risk) made by the machine or peripheral manufacturer.

1.3.2 Options

Options were established in the peripherals to provide various additional operational features that may be required for specific vending applications. As the name implies, these features are “above and beyond” the standard core of required functionality.

At power on and after a Bus Reset or a RESET command, all options are disabled. During the initialization command sequences, the VMC determines the optional features supported by the peripherals. The VMC will then enable the features it is going to use. Until the feature is enabled, it is the responsibility of the

peripheral to ignore feature specific commands and not respond with feature specific responses.

1.3.3 Currently Established Levels and Options

The following table provides a brief description of each of the currently established levels and options of the various MDB/ICP peripherals. Please refer to the specific sections for each device for more detailed information.

Peripherals	Levels	Options	Description
Coin Changer	1	n/a	Never released
	2	none	Supports standard commands
	3	below	Supports Expansion ID command and optionally supports commands for features below
		b0	Alternative Payout Method
		b1	Extended Diagnostics
		b2	Controlled Manual Fill and Payout
		b3	File Transport Layer (FTL)
Bill Validator	1	none	Supports standard commands and Expansion ID command without options
	2	below	Supports expansion ID command with options and optionally supports commands for features below
		b0	File Transport Layer (FTL)
Cashless Device #1 & #2	1	below	Supports standard commands and Expansion ID command. Readers do not have revaluation capability
		b0*	Reader is capable of restoring funds to card
		b1*	Reader is multivend capable
		b2*	Reader has a display available
		b3*	Reader supports VEND-CASH SALE command
			*bits in the SETUP-Config command

	2	above	Supports Revalue, Time/Date, Read User File (obsolete), and Write User File (obsolete) commands

Peripherals	Levels	Options	Description
Cashless Device #1 & #2 (continued)	3	above & below	Supports expansion ID command with options and optionally supports commands for features below (bits in the Level 3 Expansion ID command)
		b0**	File Transport Layer (FTL)
		b1**	16 or 32 Bit Monetary Format
		b2**	Multi Currency / Multi Lingual
		b3**	Negative Vend
		b4**	Data Entry
			**bits in the Level 3 Expansion ID command
Communications Gateway	1	none	Obsolete (former Audit Unit)
	2	none	Obsolete (former Audit Unit)
	3	below	Supports Expansion ID command and optionally supports commands for features below
		b0	File Transport Layer (FTL)
		b1	Verbose Mode
Universal Satellite Device (USD)	1	below	Supports all basic commands and optionally supports commands for features below
		b0	USD is capable of storing and controlling pricing
		b1	USD is capable of selecting items to vend
		b2	File Transport Layer (FTL)
Coin Hopper or Tube - Dispenser	1	below	Supports Expansion ID command and optionally supports commands for features below
		b0	File Transport Layer (FTL)

Section 2

Communication Format

2.1 Byte Format

Baud Rate: 9600 NRZ

Serial Bit Format: 1 Start Bit
8 Data Bits
1 Mode Bit
1 Stop Bit

11 Bits Total

LSB										MSB
Start	0	1	2	3	4	5	6	7	Mode	Stop

Mode Bit: Master-to-Peripheral

The mode bit differentiates between ADDRESS bytes and DATA bytes. ADDRESS bytes must be read by all peripherals, DATA bytes are only read by the peripheral that has been addressed.

The mode bit is set (logic one) to indicate an ADDRESS byte, and not set (logic zero) to indicate a DATA byte.

Mode Bit: Peripheral-to-Master

The mode bit must be set on the last byte sent when data is sent from a Slave to the Master.

2.2 Block Format

Master-to-Peripheral

A Communication Block for Master-to-Slave transmissions is defined as an Address byte, optional data bytes, and a CHK byte. A block is limited to a maximum of thirty-six (36) bytes.

The upper five bits (MSB) of the Address Byte will be used for addressing. That is, bits 7,6,5,4,3 of the previous byte description will be used for addressing.

The lower three bits (i.e. 2,1,0) of the Address Byte will contain peripheral specific commands. This will allow up to eight instructions to be embedded in the first byte of a block.

The VMC Master will respond to data from a peripheral with an Acknowledgment (ACK), Negative Acknowledgment (NAK), or Retransmit (RET). These are defined later in the document. The 5 mS time-out (t-response) described in the Bus Timing section of this document is the equivalent of a NAK.

If the addressed Slave does not respond within the 5 mS time-out (silence), the Master may repeat the same command, or send a different command, until it receives an answer or until the end of the Non-Response time, as defined in the peripheral sections. See Example in 2.5D. The RESET command should not be used as a recovery method to a 5 mS time-out (t-response) until after exceeding the Non-response time. The VMC may send commands to any other peripheral during this time.

Peripheral-to-Master

A Communication Block for Slave-to-Master transmissions consists of either a data block and a CHK byte, a acknowledgment (ACK), or a negative acknowledgment (NAK).

The 5 mS time-out (t-response) described in the Bus Timing section of this document is the equivalent of a NAK command. In addition, it is recommended that the peripheral use this time-out as the NAK when a reception error of the ADDRESS byte occurs. This will prevent several peripherals from trying to simultaneously respond with a NAK.

A data block consists of one or more data bytes followed by a CHK byte. The CHK byte is defined later in this document.

The data block and CHK byte are limited to a maximum size of 36 bytes.

A CHK byte is not required when a peripheral responds with NAK or ACK byte. ACK and NAK are defined later in this document.

The peripheral must set the mode bit on the last byte sent to signify end of transmission. This will be either the CHK byte of a block, a NAK byte, or an ACK byte. The mode bit must not be set except for the conditions above.

A peripheral response of ACK or NAK signifies the end of the exchange.

When a peripheral responds with a data block, the VMC must respond with an ACK, NAK or RET. If the Master cannot respond within the 5 mS time-out (t-response) the peripheral must repeat the data block, or append it, at the next possible occasion (i.e. to a later POLL). The same behavior is to apply when the Master responds with NAK.

CHK Byte

A CHK byte must be sent at the end of each block of data. The CHK byte is a checksum calculated by adding the ADDRESS byte and all DATA bytes. The CHK byte is not included in the summation. The carry bit for CHK additions is ignored since the CHK byte is limited to eight bits.

The following example shows a CHK byte calculation for a possible response to a STATUS command sent to a USA changer slave. See section 5 for details of byte meanings.

02H	Changer feature level
00H	Country code for USA
01H	Country code for USA
05H	Coin scaling factor
02H	Decimal place
00H	Coin type routing
07H	Coin type routing
01H	Coin type 0 has value of 1 scaling factor
02H	Coin type 1 has value of 2 scaling factor
05H	Coin type 2 has value of 5 scaling factor
14H	Coin type 3 has value of 20 scaling factor
FFH	Coin type 4 is a token
12CH	Therefore the CHK byte would be equal to 2CH

A checksum will be performed on all full blocks of communication. A checksum will not be performed on ACK, NAK, or RET bytes.

Response Codes

The following codes are reserved for the ACK, NAK and RET bytes:

ACK	00H	(acknowledgment/checksum correct)
RET	AAH	(Retransmit the previously sent data. **Only the VMC can transmit this byte**)
NAK	FFH	(Negative acknowledge)
		The VMC and peripheral must also recognize the 5 mS time-out (t-response) as a NAK.

NOTE: To improve system reliability it is recommended that when receiving ACK, NAK, or RET the receiving device counts the number of bits set in the byte. This method will require at least two bit errors in the byte before the byte can be mis-interpreted.

Bus Reset

The VMC may reset all peripherals by pulling the transmit line “active” for a minimum of 100 mS. This informs all peripherals to abort any activity and return to its power-on reset state. Details of this state for each peripheral are provided in later sections of this document. It is recommended that the VMC re-initialize each peripheral after this type of reset.

2.3 Peripheral Addresses

The addresses below are defined. Note again that the bits shown are the upper five bits (7,6,5,4,3) of the Address Byte and will be used for all addressing including the File Transport Layer described in Section 2.6. The lower three bits (2,1,0) are used for the command.

Address		Definition
00000xxxB	(00H)	Reserved for VMC
00001xxxB	(08H)	Changer
00010xxxB	(10H)	Cashless Device #1
00011xxxB	(18H)	Communications Gateway
00100xxxB	(20H)	Display
00101xxxB	(28H)	Energy Management System
00110xxxB	(30H)	Bill Validator
00111xxxB	(38H)	Reserved for Future Standard Peripheral
01000xxxB	(40H)	Universal Satellite Device #1
01001xxxB	(48H)	Universal Satellite Device #2
01010xxxB	(50H)	Universal Satellite Device #3
01011xxxB	(58H)	Coin Hopper or Tube - Dispenser
01100xxxB	(60H)	Cashless Device #2
01101xxxB	(68H)	Reserved for Future Standard Peripherals
.	.	.
.	.	.
.	.	.
11011xxxB	(D8H)	Reserved for Future Standard Peripherals
11100xxxB	(E0H)	Experimental Peripheral #1
11101xxxB	(E8H)	Experimental Peripheral #2
11110xxxB	(F0H)	Vending Machine Specific Peripheral #1
11111xxxB	(F8H)	Vending Machine Specific Peripheral #2

Experimental Peripheral Addresses

Experimental Peripheral addresses 11100xxxB (E0H) and 11101xxxB (E8H) are reserved for use by manufacturers when designing and field testing potential new MDB/ICP devices. These addresses are **temporary** and once the new device is approved by NAMA and the EVA, the device will be assigned a different permanent peripheral address. Use of the Experimental Peripheral addresses shall be limited to "in house" testing and "closed site" field trials. Manufacturers must understand that any devices in the field with Experimental Peripheral addresses must be recalled or updated to the permanent address if the device is approved by NAMA and the EVA. If not approved by NAMA and the EVA, the devices must be recalled or have their addresses changed to the Vending Machine Specific peripheral addresses described below.

Vending Machine Specific Peripheral Addresses

Vending Machine Specific peripheral addresses (addresses 11110xxxB (F0H) and 11111xxxB (F8H)) are reserved for Non-Standard or proprietary applications. These devices are allowed a unique set of commands.

All other peripherals are defined as Standard devices. These peripherals must follow the specifications to ensure compatibility between manufacturers.

2.4 Software Operational Rules

2.4.1 Power Budget

The VMC must regulate the power budget. That is, peripherals must be enabled and disabled dependent on power availability. The power bus is defined later in this document.

2.4.2 Bytes

During multi-byte messages the most significant byte is sent first.

> Any bytes within a command or response that are not specifically defined should be left in a 0 state. For Level 03 or lower coin mechanisms, Level 01 bill validators, and Level 01 card readers, this is not a requirement but a suggestion.

2.4.3 Polling

The following are recommendations for the methods of VMC to peripheral software operation.

> Each peripheral should be polled every 25-200 milliseconds. This can be done by the POLL command or any other appropriate command.
>
> If a peripheral has not responded to a poll for its maximum Non-Response time, the VMC should continue to poll the peripheral at least every ten seconds with a RESET command. (See Example G in Section 2.5).

2.4.4 Levels

Due to potential conflicts between a VMC level and a peripheral level, neither the VMC nor the peripheral should issue a command or reply with a response that is not supported by the other device.

The VMC must initially determine (via the appropriate STATUS or SETUP command) the level of a peripheral before determining which commands it can issue to that device. **A VMC must only send commands that are supported by the peripheral.** For example, a Level 3 command may only be issued to a Level 3 or higher peripheral and must not be issued to a Level 1 or 2 peripheral.

The Cashless Payment and the Universal Satellite Device can also learn the respective level of the VMC for that device. This information is sent via the SETUP command. **It**

is the responsibility of the peripheral to only send responses that are supported by the VMC. For example, a Level 3 response may only be sent to a Level 3 or higher VMC and must not be sent to a Level 1 or 2 VMC. Effectively, the VMC and peripheral should support the highest common level.

For total compatibility, VMCs and peripherals should support all lower levels. **For new designs after July 2000, it is strongly recommended that VMCs and peripherals must support all lower levels.** Commercial or regional issues may cause machine or peripheral manufacturers to implement only specific levels; however, this is a decision (and risk) made by the machine or peripheral manufacturer.

2.5 Typical Session Examples

A. The diagram below represents a typical transmission when a peripheral is idle.

VMC:

ADD* CHK

Peripheral:

ACK*

B. The diagram below represents a typical transmission when a peripheral has data to return.

VMC:

ADD* CHK ACK

Peripheral:

DAT DAT CHK*

C. The diagram below represents a typical transmission when the VMC has data to send.

VMC:

ADD* DAT DAT CHK

Peripheral:

ACK*

*Indicates mode bit set

D. The diagram below represents a typical transmission when the VMC determines a CHK is not correct. The VMC will respond one of two ways:

Send a NAK to the peripheral to indicate that the information was not received correctly then perform other tasks. Note: When the Master answers with NAK (or silence which is treated equally) the slave has to repeat the response, in order to ensure the execution of the response (i.e. coin reception etc.).

OR

The VMC may send a retransmit (RET) command alerting the peripheral to retransmit the previously sent data.

VMC:

ADD* DAT CHK RET ACK

Peripheral:

DAT DAT CHK* DAT DAT CHK*

*Indicates mode bit set.

E. This diagram represents a situation where the peripheral does not respond within the 5 mS time-out (t-response).

VMC:

ADD* CHK ADD* CHK

Peripheral:

[silence…] ACK*

F. This diagram represents a situation where the peripheral does not respond to a command and after its maximum Non-Response time, is reset by the controller.

Controller		Peripheral	Comment
Command X	→		
	←	Response	Normal response
Command Y	→		
	←	[silence…]	No response
Command Y	→		
	←	[silence…]	No response
Command Y	→		
	←	[silence…]	No response
			Peripheral does not response within its allocated Non-Response Time.
RESET	→		Software Reset
	←	[silence…]	Peripheral in initialization routine
RESET	→		
	←	ACK	Peripheral operational again
POLL	→		
	←	JUST RESET	Peripheral indicates finished RESET processing
ACK	→		
			Peripheral initialization sequence is performed as recommended in each peripheral section.

G. This diagram represents a situation where the peripheral is disconnected or goes offline. The controller should send a RESET command every 10 seconds to determine if, and when, the peripheral becomes active again.

Controller		Peripheral	Comment
Command X	→		
	←	Response	Normal response
Command Y	→		
	←	[silence…]	No response
Command Y	→		
	←	[silence…]	No response
Command Y	→		
	←	[silence…]	No response
			Peripheral does not response within its allocated Non-Response Time.
RESET	→		Software Reset
	←	[silence…]	Peripheral offline
RESET	→		Software Reset
	←	[silence…]	Peripheral offline
			Wait 10 seconds
RESET	→		
	←	[silence…]	Peripheral offline
			Wait 10 seconds
RESET	→		
		[silence…]	Peripheral offline
			Wait 10 seconds
RESET	→		
		[silence…]	Peripheral offline

2.6 File Transport Layer

The **F**ile **T**ransport **L**ayer (**FTL**) provides a method to send and/or receive high level information between peripherals or between a peripheral and the VMC. It is **not** intended to be used for standard vending credit and control functions. An example would be loading new validation parameters into a coin changer or bill validator.

Since the MDB/ICP interface is "driven" by the VMC, it has to be a network manager for all FTL data transfers. It acts as a temporary mailbox and data switch for FTL blocks; however, the information that is sent via FTL does not have to be interpreted by the VMC. The VMC simply uses the destination and source address information provided in the MDB/ICP command and response structure to forward the data to the proper recipient.

2.6.1 FTL Process Overview

If a peripheral needs to transfer data to another peripheral (or the VMC):
- The VMC must poll the peripheral,
- The peripheral must answer with a "REQUEST TO SEND",
- The VMC must get approval to forward data (if necessary),
- The VMC requests the first data block,
- The VMC ACKs the first block and forwards to destination,
- The process repeats until all blocks are sent.

If the VMC needs to transfer data to a peripheral:
- The VMC must send a "REQUEST TO SEND",
- The peripheral approves or denies the transfer request,
- If approved, the VMC sends the first data block,
- The peripheral ACKs the first data block,
- The process repeats until all blocks are sent.

If a peripheral (A) needs to request a transfer of data from another peripheral (B):
- The VMC must poll the peripheral A,
- Peripheral A must send a "REQUEST TO RECEIVE",
- The VMC forwards the request to peripheral B,
- Peripheral B decides to honor the request or not,
- If approved, peripheral B sends the first data block,
- The VMC forwards the data block to peripheral A,
- The process repeats until all blocks are sent.

2.6.2 FTL Detailed VMC Operation

The VMC must act as a network manager, it is responsible for checking peripheral status and managing network resources as described below, it must:

- Be aware of which peripherals are active and support the FTL. If a file transfer is requested involving a peripheral that does not support it, the VMC should deny the transfer using RETRY/DENY defined later.
- Poll peripherals to become aware that a data transfer is requested.
- Read data blocks from selected peripherals.
- If VMC receives a NAK, it should attempt to finish current command/response up to 5 times. After that, it should abort file transfer as defined by the protocol.
- Send data blocks to destination device, if not the VMC itself.
- Repeat these steps for all data blocks, as needed.

2.6.3 FTL General Operation

- The FTL "session" would transfer a "file" using several "blocks". The "Dest" and "Src" are switched by the VMC directing each block to its destination.
- All responses can be sent immediately after receipt of command or the command can be ACK'ed and the response sent in a delayed fashion (meeting all appropriate time-outs). However, FTL responses must NOT be combined with responses to any other commands, at any time.
- File transfers less than 256 blocks are terminated by sending an empty data file (SEND BLOCK with no data). File transfers of exactly 256 blocks are terminated by block #FE followed by block #FF.
- It is recommended that files larger than one block:
  1) Include a CRC in their data. The transport layer is <u>not</u> responsible for checking for correct CRCs.
  2) Include a time out mechanism to prevent system dead locks. The transport layer is **<u>not</u>** responsible for checking for dead locked file transfers.
- To prevent a system dead lock, the VMC must poll other peripherals during all data transfers and service them accordingly.
- Since the VMC is not knowledgeable about the contents of the file transfer it should not disable any peripherals due to a transfer request. This will be the responsibility of the peripherals themselves. They may internally disable and report so to the VMC if possible, or they may just stop responding to the VMC until ready. The latter may cause the VMC to try to reset the peripheral.

2.6.4 FTL Command and Response Sets For All Components

The table below defines the VMC commands and peripheral responses that occur during an FTL data transfer. Note that the peripheral responses can either be immediate to the VMC's command or delayed and provided to a subsequent POLL. Definitions are provided on the following page.

Command / Response	VMC Cmd[1]	Resp	Source Data (bytes)	Destination Response
REQ TO SEND	α7/FE	1F	Dest (1) Src (1) File ID (1) Length (1) Control (1)	OK TO SEND or RETRY/DENY
OK TO SEND	α7/FD	1E	Dest (1) Src (1)	SEND BLOCK (repeated until whole file is transferred)
SEND BLOCK	α7/FC	1D	Dest (1) Block # (1) Data (1 to 31)	ACK
RETRY/DENY	α7/FB	1C	Dest (1) Src (1) Retry delay (1)	ACK
REQ TO RCV	α7/FA	1B	Dest (1) Src (1) File ID (1) Max Length (1) Control (1)	SEND BLOCK (repeated until whole file is transferred) or RETRY/DENY

Note 1: The α7 represents the address of the destination device (defined in Section 2.3) logically OR'd with a hexadecimal 0x07.

Dest **1 byte**

The destination address of the peripheral where the data block (**not the whole file**) is being sent to. All addresses refer to the standard MDB defined peripheral addresses as defined in Section 2.3. Note that 00000xxx (00H) will be used for the VMC. Examples are a changer (08H), audit system (18H), bill validator (30H), and universal satellite device #2 (48H).

Src **1 byte**

The source address of the peripheral where the data block (**not the whole file**) is being sent from. All addresses refer to the standard MDB defined peripheral addresses as defined in Section 2.3. Note that 00000xxx (00H) will be used for the VMC. Examples are the same as in the **Dest** above.

File ID **1 byte**

The type of information desired. NAMA will maintain a list of standard file ID's and a definition of what each file type means. Note that if a device responds with a "Retry delay" of FFH it should be interpreted that this device does not support the requested function.

Currently defined file IDs include:

00H: Manufacture ID information. This file must start with the manufactures three character manufactures code, anything after that would be up to the manufacture to define.

01H: DTS defined file. This file must follow the format defined in the EVA-DTS standard. This would include the DXS record as well as all data up to and including the DXE record.

0FH to 0FFH: This range of files may be used for Manufacturer Specific information. The content and format of these files are left up to the manufacturer to define.

Additional ID proposals must be evaluated by the NAMA MDB/ICP technical standard committee.

(Max) Length **1 byte**

The total number of blocks that will (can) be included in the entire file. This byte should be used as a counter to determine the amount of data blocks to be transferred.

Control **1 byte**

This byte contains information that can be used by the VMC and peripherals to determine how the data transfer is conducted. Included controls are:

b0: Reset after transfer. The receiving peripheral should reset itself after the file transfer is complete.
b1: End of File. The last block of the current FTL session contains the end of this file. If clear (=0), then another FTL session will follow with additional blocks. If set (=1), then this is the last (or only) FTL session to be sent.
b2 - b7: Not used, must be set to 0

Block # **1 byte**

The sequential number of this block, within the total file, that is being requested/sent. All data blocks must be identified by a block number, counting up from 0 (first block) to 255.

Data Block **1 to 31 byte(s)**

The actual data portion of the block. All data must fit into a 31 byte, or less, string. The standard MDB CHK byte will signify the end of block. (Peripherals will have to use inter-byte time out when receiving blocks from the VMC.) Knowledge of the contents of this data is only required by the source and destination devices.

Retry Delay **1 byte**

A time delay that the sender should wait before trying to re-send the entire data file again. If a device is not capable of receiving a file in its current state, this byte should represent the number of seconds before it will be ready to receive the data. If the device simply refuses to accept the file it must answer with a “Retry Never” signified by a 00H retry delay. If the device is not present, block synchronization is lost, or other failure mode arises a “Retry Never” should be used to abort/deny the current file transfer.

File Transport Layer Examples

Below are examples of data transfers between the VMC and a peripheral or between two different peripherals via the VMC.

SUCCESSFUL TRANSFER – VMC TO PERIPHERAL A			
Peripheral A	**VMC**	**Peripheral B**	**Comments**
	← REQ TO SEND (α7/FE)		Request to send "n" blocks
OK TO SEND (1E)	→		
	← ACK		
	← SEND BLOCK (α7/FC)		Repeated "n" times
ACK	→		

DENIED TRANSFER – VMC TO PERIPHERAL A			
Peripheral A	**VMC**	**Peripheral B**	**Comments**
	← REQ TO SEND (α7/FE)		
RETRY/00 (1C)	→		Denied
	← ACK		

SUCCESSFUL REQUEST – VMC TO PERIPHERAL A			
Peripheral A	**VMC**	**Peripheral B**	**Comments**
	← POLL (varies)		
REQ TO RCV (1B)	→		Request receive "n" blocks
	← ACK		
	← SEND BLOCK (α7/FC)		Repeated "n" times
ACK	→		

DENIED REQUEST – VMC TO PERIPHERAL A			
Peripheral A	**VMC**	**Peripheral B**	**Comments**
	← POLL (varies)		
REQ TO RCV (1B)	→		Request receive "n" blocks
	← ACK		
	← RETRY/00 (α7/FB)		Denied
ACK	→		

VMC ABORTED TRANSFER – VMC TO PERIPHERAL A				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	REQ TO SEND (α7/FE)		Request to send "n" blocks
OK TO SEND (1E)	→			
	←	ACK		
	←	SEND BLOCK (α7/FC)		Repeated "n" times
ACK	→			
	←	RETRY/00 (α7/FB)		Aborted!
ACK	→			

PERIPHERAL ABORT TRANSFER – VMC TO PERIPHERAL A				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	REQ TO SEND (α7/FE)		Request to send "n" blocks
OK TO SEND (1E)	→			
	←	ACK		
	←	SEND BLOCK (α7/FC)		
RETRY/00 (1C)	→			Aborted!
	←	ACK		

SUCCESSFUL TRANSFER – PERIPHERAL A TO VMC				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		
REQ TO SEND (1F)	→			Request to send "n" blocks
	←	ACK		
	←	OK TO SEND (α7/FD)		
SEND BLOCK (1D)	→			Repeated "n" times
	←	ACK		

DENIED TRANSFER – PERIPHERAL A TO VMC				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		Request to send "n" blocks
REQ TO SEND (1F)	→			
	←	ACK		
	←	RETRY/00 (α7/FB)		Denied
ACK	→			

SUCCESSFUL TRANSFER – PERIPHERAL A TO PERIPHERAL B				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		
REQ TO SEND (1F)	→			Request to send "n" blocks
	←	ACK		
		REQ TO SEND (1F) (α7/FE)	→	
			← OK TO SEND (1E)	
		ACK	→	
	←	OK TO SEND (α7/FD)		
SEND BLOCK (1D)	→			Repeated "n" times
	←	ACK		
		SEND BLOCK (α7/FC)	→	
			← ACK	

DENIED TRANSFER – PERIPHERAL A TO PERIPHERAL B				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		
REQ TO SEND (1F)	→			Request to send "n" blocks
	←	ACK		
		REQ TO SEND (1F) (α7/FE)	→	
			← RETRY/00 (1C)	Denied
		ACK	→	
	←	RETRY/00 (α7/FB)		

ACK ➔

SUCCESSFUL REQUEST - PERIPHERAL A TO PERIPHERAL B				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		
REQ TO RCV (1B)	→			Request receive "n" blocks
	←	ACK		
		REQ TO RCV (α7/FA)	→	
			← SEND BLOCK (1D)	Repeated "n" times
		ACK	→	
	←	SEND BLOCK (α7/FC)		
ACK	→			

DENIED REQUEST – PERIPHERAL A TO PERIPHERAL B				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		
REQ TO RCV (1B)	→			Request receive "n" blocks
	←	ACK		
		REQ TO RCV (α7/FA)	→	
			← RETRY/00 (1C)	Denied
		ACK	→	
	←	RETRY/00 (α7/FB)		
ACK	→			

PERIPHERAL A TRANSFER TO PERIPHERAL B – ABORTED BY A					
Peripheral A		**VMC**		**Peripheral B**	**Comments**
	←	POLL (varies)			
REQ TO SEND (1F)	→				Request to send "n" blocks
	←	ACK			
		REQ TO SEND (α7/FE)	→		
			←	OK TO SEND (1E)	
		ACK	→		
	←	OK TO SEND (α7/FD)			
SEND BLOCK (1D)	→				
	←	ACK			
		SEND BLOCK (α7/FC)	→		
			←	ACK	
		.			Repeated "n" times
		.			
		.			
	←	POLL (varies)			
RETRY/00 (1C)	→				Aborted!
	←	ACK			
		RETRY/00 (α7/FB)	→		
			←	ACK	

PERIPHERAL A TRANSFER TO PERIPHERAL B – ABORTED BY B				
Peripheral A		**VMC**	**Peripheral B**	**Comments**
	←	POLL (varies)		
REQ TO SEND (1F)	→			Request to send "n" blocks
	←	ACK		
		REQ TO SEND (α7/FE) →		
			← OK TO SEND (1E)	
		ACK →		
	←	OK TO SEND (α7/FD)		
SEND BLOCK (1D)	→			
	←	ACK		
		SEND BLOCK (α7/FC) →		
			← ACK	
		.		
		.		Repeated "n" times
		.		
	←	POLL (varies)REQ BLOCK (α7/FD)		
SEND BLOCK (1D)	→			
	←	ACK		
		SEND BLOCK (α7/FC) →		
			← RETRY/00 (1C)	Aborted!
		ACK →		
	←	RETRY/00 (α7/FB)		
ACK	→			

Section 3

Bus Timing

3.1 Timing Definitions

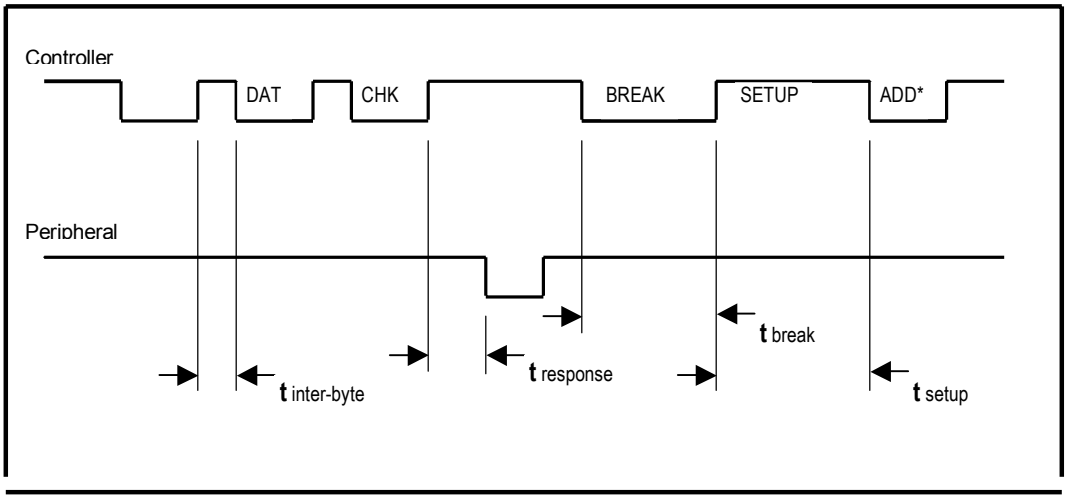
Baud rate	=	The rate of bit transfer per second.
t inter-byte (max.)	=	The maximum time allowed between bytes in a block transmission.
t response (max.)	=	The maximum time any device, master or peripheral, will take to respond to a valid communication.
t break (VMC)	=	The minimum time of the Bus Reset signal sent by the VMC to reset all peripherals.
t setup	=	The minimum set-up time before the VMC attempts to communicate after a reset signal. Peripheral devices may choose to not respond for up to the non-response time defined in each peripheral section.

3.2 Timing Specifications

Baud Rate	=	9600 +1%/-2% NRZ
t inter-byte (max.)	=	1.0 mS
t response (max.)	=	5.0 mS
t break (min.)	=	100 mS
t setup (min.)	=	200 mS

NOTE: All peripherals have the option of not responding to the VMC. Non-response timing is defined in the peripheral specification.

3.3 Timing Diagram



NOTE: * indicates that the mode bit is set

Section 4

Hardware Specification

4.1 Bus Power Supply Definition

The information below defines the minimum VMC voltage output. The actual current ratings per peripheral will be defined in their respective sections.

Power supply filtering is optional, therefore if a peripheral requires more power, or tighter regulation, they may elect to supply their own power, or filtering, from available sources elsewhere in the machine.

VMC Voltage Output:

Minimum	=	20 VDC rms.(rectified and optionally filtered)
Nominal	=	34 VDC unreg.(rectified and filtered) 24 VDC rms.(rectified only)
Maximum	=	42.5* VDC(ripple voltage upper limit) * High line input may allow 45 VDC peak (max.).

4.2 Bus Transmitter / Receiver Specification

The following section describes the 5V, optically isolated, current loop system between the Master and the Slave.

VMC Master:

Transmit:

Minimum source current (active):	100 mA @ 4V
Maximum leakage current (inactive):	100 uA

NOTES: 1) The transmit line must be able to withstand a short while in the active mode.

2) 15 mA should be added for each peripheral over six.

Receive:

Minimum input current (active):	15 mA @ 1V
Maximum input current (inactive):	1 mA

Peripheral Slave:

Receive:

Maximum input current (active):	15 mA @ 4V
Maximum input current (inactive):	100 uA

Transmit:

Minimum sink current (active):	15 mA @ 1V
Maximum leakage current (inactive):	30 uA

4.3 Connector Specification

Connector assemblies supplied by the NAMA approved suppliers, noted in Section 4.3.6, are intermateable and meet or exceed the minimum requirements identified in Sections 4.3.1, 4.3.2, 4.3.3, 4.3.4, and 4.3.5 when tested in the mated condition. NAMA must approve any supplier changes to the fit, form, or function. Discrete components, i.e. contacts, are not required to be inter-changeable between supplier products.

4.3.1. **Material**

4.3.1.1. Terminal: Phosphor Bronze
4.3.1.2. Plating: Tin or Tin/Lead
4.3.1.3. Housing: UL 94V-2 nylon

4.3.2. **Ratings**

Section	Item	Requirement
4.3.2.1.	Rated Voltage (Max)	600 Volts AC
4.3.2.2.	Maximum Rated Current (Six Circuit)	7 Amps
4.3.2.3.	Ambient Temperature Range (including terminal T-rise)	-40°C to +105°C

4.3.3. **Electrical Performance**

Section	Item	Test Condition	Requirement
4.3.3.1.	Contact Resistance	Mate Connectors, measure by dry circuit, 20 mV max., 10 mA. Wire resistance shall be removed from the measured value.	10 mΩ Max.
4.3.3.2.	Insulation Resistance	Mate Connectors, apply 500V DC between adjacent terminal or ground.	1000 MΩ Min.
4.3.3.3.	Dielectric Strength	Mate Connectors, apply 1500V AC for 1 minute between adjacent terminal or ground.	No Breakdown.

4.3.4. **Mechanical Performance**

Section	Item	Test Condition			Requirement
4.3.4.1.	Insertion and Withdrawal Force	Insert and withdraw connectors at a speed rate of 25 +/- 3mm / minute.			Noted Below
	6 Pos Insertion Max.		6 Pos Withdrawal Min.		
	Initial	30th cycle	Initial		30th cycle
	41.2 N	38.2 N	2.9 N		2.4 N
4.3.4.2.	Crimping Pull Out Force	Mount the crimped terminal, apply axial force on the wire at a rate of 25 +/- 3mm minute.			16 AWG: 88 N Min. 18 AWG: 88 N Min. 20 AWG: 59 N Min. 22 AWG: 39 N Min. 24 AWG: 29 N Min. 26 AWG: 20 N Min. 28 AWG: 10 N Min.
4.3.4.3.	Terminal Insertion Force	Insert the crimped terminal into the housing.			15 N Max.
4.3.4.4.	Terminal/Housing Retention Force	Apply axial pull out force at the speed rate of 25 +/- 3mm / minute.			22 N Min.
4.3.4.5.	Locking / Unlocking Force	Measure force to lock & unlock connector housings (without contacts) at a rate of 25 +/- 3mm / minute.			Lock: 30 N Max. Unlock: 50 N Min.

4.3.5. **Environmental Performance**

Section	Item	Test Condition	Requirement	
4.3.5.1.	Repeated Insertion / Withdrawal	When mated up to 30 cycles repeatedly by rate of 10 cycles per minute.	Contact Resistance	20 mΩ Max.
4.3.5.2.	Temperature Rise	Carrying rated current load.	30°C Rise Max.	
4.3.5.3.	Vibration	Amplitude: 1.5mm P-P Sweep Time: 10-55-10 Hz in 1 minute. Duration: 2 hours in each X,Y,Z axis.	Appearance	No Damage
			Contact Resistance	20 mΩ Max.
			Discontinuity	1 μ sec. Max.
4.3.5.4.	Shock	50 G; 3 strokes in each X,Y,Z axis.	Appearance	No Damage
			Contact Resistance	20 mΩ Max.
			Discontinuity	1 μ sec Max.
4.3.5.5.	Heat Resistance	105 +/- 2°C, 96 hours	Appearance	No Damage
			Contact Resistance	20 mΩ Max.
4.3.5.6.	Cold Resistance	-40 +/- 3°C, 96 hours	Appearance	No Damage
			Contact Resistance	20 mΩ Max.
4.3.5.7.	Humidity	Temperature: 60 +/- 2°C Relative Humidity: 90% - 95% Duration: 96 hours	Appearance	No Damage
			Contact Resistance	20 mΩ Max.
			Dielectric Strength	No Breakdown
			Insulation Resistance	1000 MΩ Min.
4.3.5.8.	Temperature Cycling	5 Cycles: a) - 55°C ; 30 Minutes b) 105°C ; 30 Minutes	Appearance	No Damage
			Contact Resistance	20 mΩ Max.
4.3.5.9.	Salt Spray	48 +/- 4 hours exposure to salt spray from 5 +/- 1% solution at 35 +/- 2°C.	Appearance	No Damage
			Contact Res.	20 mΩ Max.
4.3.5.10.	SO_2 Gas	24 hour exposure to 50 +/- 5 ppm SO_2 gas at 40 +/- 2°C.	Appearance	No Damage
			Contact Res.	Max.

4.3.6 **Approved Suppliers and Part Numbers**

4.3.6.1. Suppliers

Molex : Mini-Fit, Jr.™ Product
AMP: AMP-DUAC™ Product

4.3.6.2. Peripherals

Connector: Six (6) Circuit Receptacle Housing

Molex 39-01-2060
AMP P/N 106527-6

Terminals: Female Contacts (sockets), Tin

Molex 39-00-0065
AMP P/N 106528-2 or 106529-2

Strain Relief: The strain relief shall not exceed a Maximum Form Factor of 0.85 inch wide x 0.75 inch high x 1.90 inch long, excluding integrated hinges and wire ties.

Molex 15-04-0296
AMP P/N 1375618-1

4.3.6.3. Bus Harness

Connector: Six (6) Circuit Plug Housing

Molex 39-01-2061
AMP P/N 794550-6 or 794542-6

Terminals: Male Contacts (pins), Tin

Molex 39-00-0067
AMP P/N 794578-1 or 794576-1

4.3.6.4. VMC Connector (Direct PCB Mount)

Vertical Header: Male Contacts (pins), Tin

Molex 39-28-1063
AMP P/N 794664-6

Right Angle Header: Male Contacts (pins), Tin

Molex 39-30-1060
AMP P/N 794448-1

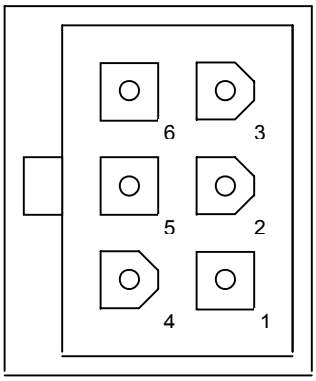
4.3.6.5. Approved Parts – Alternate Form Factors

Select applications may require connector configurations with alternate form factors. Alternate form factor connectors may be used provided they are:

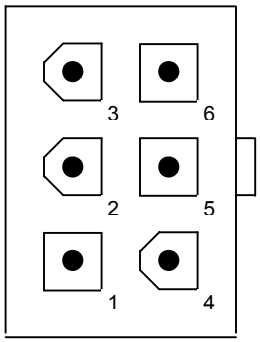
- provided by the Approved Suppliers listed
- part of the Approved Supplier Product Family portfolio
- intermateable with the approved connector part numbers listed
- meet the performance objectives set forth in this specification

Connector Pin-out:

Line 1 - 34 VDC
Line 2 - DC Power Return
Line 3 - N/C
Line 4 - Master Receive
Line 5 - Master Transmit
Line 6 - Communications Common



Peripheral Connector
Face View
Receptacle
(Sockets)



VMC / Bus Connector
Face View
Header
(Pins)

4.4 Example Schematic