

# **Software Specification**

## **Test Instrument Module System (TIMS)**

### **Data Link**

### **Communications Protocol**

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## **1 INTRODUCTION**

The protocol described herein is intended for use between one or more host applications controllers (PC) and one or more microcontroller devices. The protocol presented here is comprised of two layers; the data link layer and the packet layer.

## **2 SCOPE**

This specification presents the necessary information to design, develop, use and maintain interoperable software and firmware communication protocol between host(s) and device(s).

This specification does not address any requirements necessary to interface the data transport layer to the physical layer or physical layer device drivers, nor does this specification address the information content required to be passed between the packet layer and an applications program.

## **3 CONTACT INFORMATION**

### **3.1 SALES AND SUPPORT**

WireWorks West, Inc.  
965 Mission Street, Suite 600  
San Francisco, CA 94103

415-348-1400 Office  
415-348-1414 Fax  
415-348-1408 Technical Support  
800-755-1400 Toll Free Sales

[www.wireworkswest.com](http://www.wireworkswest.com)

#### 4 REFERENCE DOCUMENTS

<i>Description</i>	<i>Doc. No</i>	<i>Company/Author</i>	<i>Rev/Date</i>

## 5 SPECIFICATION

### 5.1 PROTOCOL DESIGN CONSIDERATIONS

The primary consideration in the development of this protocol is the intended use within microcontroller application devices. Usually a microcontroller device has limited memory and computing power, therefore a certain set of considerations or design rules is adopted to provide reliable and reasonable performance within the constraints of available resources. Generally a host applications controller, such as a PC, does not have the same limitations as a microcontroller; however the host must adhere to the protocol.

Some of the design considerations and rules include:

- Data link layer data will be 8-bit bytes, regardless of being transmitted in byte parallel or bit serial format.
- Data link frames will be transmitted in an asynchronous manner between the data link layer and either the physical layer or the physical layer software driver.
- Device control and status is performed through message packets.
- The message packet processing must provide for a minimum of 64 bytes of operating data, plus control and status overhead.
- The message packet must support both global and specific device addressing by a sender.
- The message packet must support a return address from the sender for a directed response from a specifically addressed receiver.
- An operating rule; a control message to a specific address must be acknowledged with a reply.
- An operating option; a receiving device may, while processing a received message, silently discard any further received bytes till a response message has been transmitted.
- An operating rule; a device shall not transmit to a host without request from the host. The host may enable a device to transmit subsequently without further request. Such activity will require network consideration or arbitration.
- An operating rule; a device may transmit to another device without a request from the host. Such activity will require network consideration or arbitration.

Note: Arbitration, as mentioned above, is an application specific issue, and is beyond the scope of this specification.

## 5.2 PHYSICAL LAYER

The primary purpose of the physical layer is to provide an electronic data stream interface for packet communications. Basic technologies such as RS-232, RS-488, USB, Parallel IO, etc., may be employed as long as there are no technology specific requirements imposed on the packet protocol.

## 5.3 PACKET STRUCTURE

The design of the packet structure is intended to be independent from knowledge of the actual Level-2 Data Link Layer Protocol used to deliver the packet.

### Packet Structure

<b>Element</b>	<b>Description</b>	<b>Type</b>
<b>TO</b>	The address of the device the packet is being sent to.	U8
<b>FROM</b>	The address of the device the packet is being sent from.	U8
<b>CONTROL</b>	Command code to the recipient	U16
<b>STATUS</b>	Response code to the originator.	U16
<b>REF</b>	Packet reference number.	U8
<b>LENGTH</b>	Number of bytes of data in the Data element minus 1	U8
<b>DATA</b>	Byte array containing additional command relative information	[U8]
<b>LRC</b>	Longitudinal Redundancy Check	U8

*NOTES      LRC valid for monitor firmware versions vD0 and newer*

### 5.3.1 Packet “TO” Address Element

The packet “TO” address element identifies the device the packet is being sent to.

- ☐ An address value of 0x00 is reserved as a global broadcast address.
- ☐ An address value of 0xFF is reserved for use in fatal error response packets where the originators from address cannot be relied on.
- ☐ A device receiving a message with a “TO” address of 0x00 shall not issue a response. A device reset function shall always be executed, otherwise, the recipient device should only execute the control function if that function does not request data or is otherwise inappropriate to perform without confirmation to the requesting device (a module specific application issue to be determined by the module designer).
- ☐ A device shall silently discard a packet with a “TO” address of 0xFF. However the host controller should monitor for messages sent with a “TO” address of 0xFF in order to determine if a significant number of communications problems exist.
- ☐ A device shall silently discard a packet where the “TO” address does not match the device’s own address.
- ☐ All devices interconnected within a common physical link must have a unique non-zero address.

### 5.3.2 Packet “FROM” Address Element

The packet “FROM” address element identifies the device the packet is being sent from.

- ☐ The transmitting device should place its device address into the “FROM” element of the packet.
- ☐ A recipient shall silently discard a packet with a “FROM” address of 0x00.
- ☐ A recipient shall silently discard a packet with a “FROM” address that matches the device’s address.
- ☐ A recipient shall silently discard a packet with a “FROM” address of 0xFF.

### 5.3.3 Packet “CONTROL” Element

The packet “CONTROL” element identifies a particular function to perform.

- ☐ The responding device shall echo back the control code.

### 5.3.4 Packet “STATUS” Element

The packet “STATUS” element identifies general status as it relates to the receipt of a control code.

- ☐ A status code value of 0x0000 is reserved as No-Fault status.
- ☐ The status element of an originated command packet shall be ignored.

### 5.3.5 Packet “REF” Element

The packet “REF” element is an optional message packet identifier.

- ☐ The device originating a command packet may place a value into the “Ref” element of the packet.
- ☐ The receiving device shall echo back the “Ref” value in any response packet.
- ☐ Slave devices generating response packets automatically to a single

### 5.3.6 Packet “LENGTH” Element

The packet “LENGTH” element identifies the number of contiguous bytes within the data element beginning with the first data byte that is valid for a given function.

- ☐ The data length value is equal to the number of data bytes in the “Data” element minus 1.

### 5.3.7 Packet “DATA” Element

The packet “DATA” element contains information that may be required to perform a specific function.

- ☐ A minimum of one data byte shall always be transmitted in the “Data” element.

### 5.3.8 Packet “LRC” Element

The packet “LRC” element contains longitudinal redundancy check byte. The LRC byte is calculated as follows:

- ☐ The LRC is calculated using all of the bytes of the packet excluding the LRC.
- ☐ The LRC is calculated the same for both transmit and receive packets.
- ☐ The LRC accumulator is loaded with 0xAA as an initial seed value.
- ☐ The TX/RX byte is added to the LRC accumulator, then the accumulator bits are rotated left by one bit ( $B_0 \leftarrow B_7 \leftarrow B_6 \leftarrow B_5 \leftarrow B_4 \leftarrow B_3 \leftarrow B_2 \leftarrow B_1 \leftarrow B_0$ ) (eg, 0x55 becomes 0xAA).
- ☐ Following the last Data byte being transmitted, the value of the LRC accumulator is transmitted.
- ☐ The received LRC is compared to the accumulated LRC value, if equal then LRC is OK.

## 5.4 DATA TRANSMISSION CONVENTIONS

The data transmission format for Layer-1, Physical Layer, shall be determined or defined by the specific mechanism utilized for a particular application.

The data transmission format for multi-byte data formats shall be as follows:

- ☐ Numeric values shall be transmitted with the most significant byte first followed by successively lesser significant bytes.
- ☐ String values shall be transmitted as an unsigned byte array with the array index element of zero being transmitted first followed by incrementally the next index element of the array.

## 5.5 ADDITIONAL PACKET/APPLICATION LAYER RULES

- ☐ A communication exchange consists of the originator/sender transmitting a command packet followed by the recipient sending back a response packet. In the event that the originator transmits a command packet to the broadcast address (0X00), that is - addressed to all recipients, the recipient(s) shall not send a response packet.
- ☐ To preclude the possibility of inadvertent broadcast messages in certain network configurations, a recipient should ignore (silently discard) any packet received that contains 0x00 as the originators “From” device address.
- ☐ A recipient should ignore (silently discard) any packet received that contains 0xFF as the originators “From” device address.
- ☐ A recipient should ignore (silently discard) any packet received that contains a “From” address that matches the recipient’s own device address.



## 6 ERROR RESPONSES

### Error Response Packet

Element	Type	Value	Description
TO	U8	> 0x00 < 0xFF	The "From" address of the command packet
FROM	U8	0xnn	Where "nn" is the device address
CONTROL	U16	(tbd)	The "Control" value of the command packet
STATUS	U16	> 0x0000	Status Code
REF	U8	(tbd)	The "Ref" value of the command packet
LENGTH	U8	(tbd)	
DATA	[u8]	(tbd)	See detail below
			Additional error data per specific device function
LRC	u8	Calculated	

### Fatal Error Response Packet

Element	Type	Value	Description
TO	U8	0xFF	
FROM	U8	0xnn	Where "nn" is the device address
CONTROL	U16	0x0000	
STATUS	U16	> 0x0000	Status Code
REF	U8	0x00	
LENGTH	U8	0x00	
DATA	[u8]	None	
			Additional error data per specific device function
LRC	u8	Calculated	

## 7 CONTROL AND STATUS CODES

Control and status codes are maintained within a WireWorks West data base, and are described in other application specific documentation.