j1939 Documentation

Release

Feng

Apr 30, 2018

Contents

ANS is an open source ecosystem of inertial measurement unit

A web-based development platform efficiently to build up navigation system

Contents

The Application Protocol of Aceinna SAE J1939

REVISION HISTORY

Revision	Date	Author	Description
1.0	Jan 23, 2017	Feng	Initial version
1.1	Apr 20, 2017	Feng	Updated version upon feedback from customers
1.2	May 17, 2017	JF	Formatting
1.3	Sept 5, 2017	Feng / JF	Add configuration tables of MTLT user's guide and Change Name to Aceinna
1.3.1	Sept 6, 2017	JF	Updated Packet Rate Divider Table
1.3.2	Sept 22, 2017	JF	Update Data format description, New logo.
1.3.3	Sept 25, 2017	Feng / JF	Fix typo page 6
1.3.4	Mar 15, 2018	Feng	Change 5.5.1 and 5.5.2 match against firmware

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1. ## Introduction

1.1 Purpose

Aceinna J1939 Protocol (AJP) is a communication mechanism used for resolution of the identification of CAN nodes, configuration, and data exchange based upon SAE J1939 and the related standards.

It is a request and reply protocol and communicated within the boundaries of a single CAN network,never routed internetwork nodes. The property places AJP into the layer fourth in Open Systems Interconnection (OSI) model, but not developed into OSI framework. **1.2 Technical assistance**

For assistance or clarification on information in this document, submit a case to Aceinna Inc., www.Aceinna.com

2. ## Data Unit Definition

Unit reports data in standard engineering units as shown in following table.

Data Type	**Name**	**Scaling **	**Range**	**Offset* *	**Units**
Pitch / roll	Degree	1/32768	-250 to 252	-250	Deg
Angular rate	Rate of angular change	1/128	-250 to 250.992	-250	Deg/s
Accelerat ion	Linear accelerat ion	0.01	-320 to 322.55	-320	m/s^2

TABLE 1: Data Unit Definition

3. ## Function Overview

To execute a command the host controller sends a request packet as:

Priority	Base PGN	PDU format	PDU specific	Source Address	Host Data Field
6	59904	234	255	128-247	

The data field contains the priority, page and PGN of the function to be executed. The table below summarizes the functions supported and their base PGN.

Name	Ref	Base PGN	Description
Get Version	5.1.1	65242	Requests firmware version from SAE J1939 Node
Get ECU ID	5.1.2	64965	Requests the ECU ID
Algorithm Reset	5.1.3	65360	Resets the state estimation algorithm without reloading fields from EEPROM
Save Configuration	5.1.4	65361	Writes the current configuration into EEPROM
Test HW	5.2.1	65362	Checks the status of the hardware, software and sensors on the specific node
Test SW	5.2.2	65363	
Test Status	5.3	65364	Sets parameters on the specific node. Parameters include: packets to be broadcast; broadcast rate; orientation; accelerometer and rate sensor filter settings; user behavior switches
Packet Rate Divider	5.4.1	65365	Determines the Broadcast Rate
Data Packet Type	5.4.2	65366	Determines the type of packets broadcast
Digital Filter	5.4.3	65367	Set low pass filter for acceleration and rate sensors
Orientation	5.4.4	65368	Allows the orientation to be changed
User Behavior Switches	5.4.5	65369	
Acceleration Parameters	5.4.6	65373	Set acceleration parameters for Extended Kalman Filter
PS Setting Bank 0	5.5.1	65520	Allows user to change default PS for Bank 0 functions
PS Setting Bank 1	5.5.2	65521	Allows user to change default PS for Bank 1 functions

TABLE 2: Function Summary

4. **Packet type**

AJP claims two types of packets among J1939 nodes, as control and data message.

AJP supports two types of communication methods as SAE J1939 requests, global and specific.

Global packets may be performed as a sender to all, that all recipients must reply with a global address.

Specific packets may be used to exchange the operations between sender and recipient.

5. **Function Detail**

5.1 Command and Status Functions

5.1.1 Version Command:

Type: Global

Host Data Field: 0 Bytes

Host broadcasts a request packet following up SAEJ1939.

Units on the bus respond with PGN message: 0x18FEDA**SA**

Priority	Base PGN	PDU format	PDU specific	Source Address	Data Field
6	65242	254	218	128-247	5 bytes

Version Data Field Description

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
Major	Minor	Patch	Stage	Build

5.1.2 ECU ID Command:

Type: Global

Host Data Field: 0 bytes

Units on the bus respond with message: 0x18FDC5**SA***

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	64965	253	197	128-247	8 bytes

Data Field Definition follows up Table 1 of SAE J1939-81.

5.1.3 Algorithm Reset Command:

Type: Specific

Host Data Field: 3 Bytes

Response Data Field: 3 Bytes

PS is Host configurable. See section 5.5

Units on the bus respond with message: 00x18FF50**SA** (default).

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65360	255	80 (Default)	128-247	3 bytes

Data Field Definition

Byte	Description	Value
1	Request or response	0x00 = Request (Host) 0x01 = Response (Unit)
2	Address of unit being reset	Address of Unit (128- 247)
3	Success or failure	0x00 = Failure 0x01 = Success

5.1.4 Save Configuration Command:

Type: Specific.

Host Data Field: 3 Bytes.

Response Data Field: 3 Bytes.

PS is Host configurable. See section 5.5.

Units on the bus respond with message: 0x18FF51**SA** (default).

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65361	255	81	128-247	3 bytes

Data Field Definition.

Byte	Description	Value
1	Request or response	0x00 = Request (Host) 0x01 = Response (Unit)
2	Address of unit being reset	Address of Unit (128- 247)
3	Success or failure	0x00 = Failure 0x01 = Success

5.2 Test Functions:

5.2.1 Hardware bits:

Type: Broadcast

Host sends out a request command.

Response Data Field: 8 Bytes

Units on the bus respond with message: 0x18FF52**SA**

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65362	255	82	128-247	

HW Bits Data Field Definition

Bit	Description	Value
0	masterFail	0 = normal, 1 = fatal error has occurred
1	hardwareError	0 = normal, 1= internal hardware error
2	Not Defined	
3	softwareError	0 = normal, 1 = internal software error
4	inpPower	0 = normal, 1 = out of bounds
5	inpCurrent	0 = normal, 1 = out of bounds
6	inpVoltage	0 = normal, 1 = out of bounds
7	fiveVolt	0 = normal, 1 = out of bounds
8	threeVolt	0 = normal, 1 = out of bounds
9	twoVolt	0 = normal, 1 = out of bounds
10	twoFiveRef	0 = normal, 1 = out of bounds
11	sixVolt	0 = normal, 1 = out of bounds
12	grdRef	0 = normal, 1 = out of bounds
13	pcbTemp	0 = normal, 1 = out of bounds

The signals masterFail and hardwareError are controlled by y various systems checks in software that are classified into two categories: hardware and software. Instantaneous soft failures in each of these four categories will trigger these intermediate signals, but will not trigger the masterFail until the persistency conditions are met.

There are three intermediate signals that are used to determine when the masterStatus flag is asserted: hardwareStatus, sensorStatus, and softwareStatus. masterStatus is the logical OR of these intermediate signals. Each of these intermediate signals has a separate field with individual indication flags. Each of these indication flags can be enabled or disabled by the user. Any enabled indication flag will trigger the associated intermediate signal and masterStatus flag.

The hardwareError field contains flag that indicate various types of internal hardware errors.

5.2.2 Software bits:

Type: Specific

Host sends out a request command.

Response Data Field: 1 Byte

Units on the bus respond with message: 0x18FF53**SA**

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65363	255	83	128-247	

Software Bits Data Field Definition

Bit	Description	Value
0	softwareError	0 = normal, 1 = internal software error
1	algorithmError	0 = normal, 1= error
2	dataError	0 = normal, 1= error
3	initialization	0 = normal, 1 = error during algorithm initialization
4	overRange	0 = normal, 1 = fatal sensor over-range
5	missedNavigationStep	0 = normal, 1 = deadline missed for navigation
6	calibrationCRCError	0 = normal, 1 = incorrect CRC on calibration EEPROM data or data has been compromised by a WE command.

The softwareError field contains flags that indicate various types of software errors. Each type has an associated message with low level error signals. The softwareError flag in the BITstatus field is the bit-wise OR of algorithm and data error.

The software algorithmError contains flags that indicate various types of software errors and is the bit-wise OR of initialization, overRange and missedNavigationStep.

The software DataError contains flags that indicate low level software data errors, calibrationCRCError. **5.3 Status:**

Type: Specific

Host sends out a request command.

Response Data Field: 2 Bytes

Units on the bus respond with message: 0x18FF54**SA**

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65364	255	84	128-247	

Software Bits Data Field Definition

Bit	Description	Value
0	masterStatus	0 = nominal, 1 = hardware, sensor, com, or software alert
1	hardwareStatus	0 = nominal, 1 = programmable alert
2	softwareStatus	0 = nominal, 1 = programmable alert
3	sensorStatus	0 = nominal, 1 = programmable alert
4	unlocked1PPS	0 = not asserted, 1 = asserted
5	unlockedInternalGPS	0 = not asserted, 1 = asserted
6	noDGPS	0 = DGPS lock, 1 = no DGPS
7	unlockedEEPROM	0=locked, WE disabled, 1=unlocked, WE enabled
8	algorithmInit	0 = normal, 1 = the algorithm is in initialization mode
9	highGain	0 = low gain mode, 1 high gain mode
10	attitudeOnlyAlgorithm	0 = navigation state tracking, 1 = attitude only state tracking
11	turnSwitch	0 = off, 1 = yaw rate greater than turnSwitch threshold
12	Sensor overRange	0 = not asserted, 1 = asserted

The hardwareStatus field contains flags that indicate various internal hardware conditions and alerts that are not errors or problems and is the bit-wise OR of the logical AND of bit 4 to 7.

The softwareStatus field contains flags that indicate various software conditions and alerts that are not errors or problems and is the bit-wise OR of the logical AND of bit 8 to 11.

The sensorStatus field contains flags that indicate various internal sensor conditions and alerts that are not errors or problems and is bit 12. **5.4 Configure commands:**

5.4.1 Packet rate divider:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65365	255	85	128-247	2 bytes

1st byte: destination address

2nd byte is packet rate divider

Packet Rate Divider Field Value Definition

Byte Value	Packet Broadcast Rate
0	Quite Mode – No Broadcast
1	100 Hz (default)
2	50 Hz
4	25 Hz
5	20 Hz
10	10 Hz
20	5 Hz
25	4 Hz
50	2 Hz

The default PGN message on CAN bus is 0x18FF55**SA** and PS is configurable.

5.4.2 Data packet type:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65366	255	86	128-247	2 bytes

1st byte: destination address

2nd byte: Selects which packets to broadcast

bit 1 – slope sensor, bit 2 – angular rate, bit 3 – accelerometer.

The default PGN message on CAN bus is 0x18FF56**SA** and PS is configurable.

5.4.3 Digital filter:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65367	255	87	128-247	3 bytes

1st byte: destination address

2nd byte is to set low pass cutoff for rate sensors. Cutoff Frequency choices are 5, 10, 20, and 50Hz

3rd byte is to set low pass cutoff for accelerometers. Cutoff Frequency choices are 5, 10, 20, and 50Hz

The default PGN message on CAN bus is 0x18FF57**SA and** PS is configurable.

5.4.4 Orientation:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65368	255	88	128-247	3 bytes

1st byte: destination address

2nd and 3rd bytes determine forward, rightward, and downward facing sides

The default PGN message on CAN bus is 0x18FF58**SA** and PS is configurable.

Orientation Field Byte Value Definition

Orientation Field Value	*X Axis*	*Y Axis*	*Z Axis*
0x0000	+Ux	+Uy	+Uz
0x0009	-Ux	-Uy	+Uz
0x0023	-Uy	+Ux	+Uz
0x002A	+Uy	-Ux	+Uz
0x0041	-Ux	+Uy	-Uz
0x0048	+Ux	-Uy	-Uz
0x0062	+Uy	+Ux	-Uz
0x006B	-Uy	-Ux	-Uz
0x0085	-Uz	+Uy	+Ux
0x008C	+Uz	-Uy	+Ux
0x0092	+Uy	+Uz	+Ux
0x009B	-Uy	-Uz	+Ux
0x00C4	+Uz	+Uy	-Ux
0x00CD	-Uz	-Uy	-Ux
0x00D3	-Uy	+Uz	-Ux
0x00DA	+Uy	-Uz	-Ux
0x0111	-Ux	+Uz	+Uy
0x0118	+Ux	-Uz	+Uy
0x0124	+Uz	+Ux	+Uy
0x012D	-Uz	-Ux	+Uy
0x0150	+Ux	+Uz	-Uy
0x0159	-Ux	-Uz	-Uy
0x0165	-Uz	+Ux	-Uy
0x016C	+Uz	-Ux	-Uy

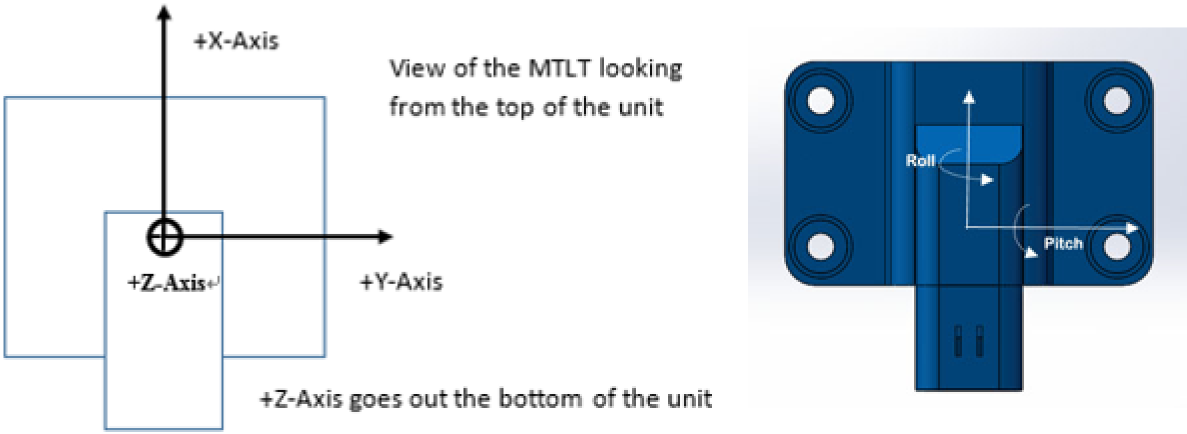


Figure: Default Orientation

5.4.5 User behavior switches:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65369	255	89	128-247	

1st byte: destination address

2nd and 3rd bytes are to set Restart on Over-range and Dynamic Motion.

The default PGN message on CAN bus is 0x18FF59**SA** and PS is configurable

Bit definition for User Behavior Switches

Bit	Description	Value
0	Free Integrate	0 = use feedback to stabilize the algorithm
1	Use Mags	1 = 6DOF inertial integration without stabilized feedback for 60 seconds
2	Use GPS	N/A
3	Stationary Yaw Lock	N/A
4	Restart on Over-range	N/A
5	Dynamic Motion	0 = Do not restart the system after a sensor over-range

5.4.6 Acceleration parameters (optional):

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65373	255	93	128-247	

1st byte: destination address

2nd to 7th bytes are 16-bit x, y and z acceleration parameters for the EKF coming from host side.

The default PGN message on CAN bus is 0x18FF5D**SA** and PS is configurable. **5.5 Assigning PS Numbers**

5.5.1 Bank0 of PS numbers:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65520	255	240	128-247	

8-byte payload indicates PS numbers instead of default values declared in this doc.

Byte 0: algorithm reset, byte 1: reserved, byte 2: hardware bits, byte 3: software bits, byte 4: status, byte 5–7: reserved.

PGN message on CAN bus is 0x18FFF0**SA**.

5.5.2 Bank1 of PS numbers:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	65521	255	241	128-247	

Byte 0: packet rate, byte 1: packet type, byte 2: digital filter, byte 3: orientation, byte 4-7: reserved.

PGN message on CAN bus is 0x18FFF1**SA**.

The pool of PS values should be from decimal 80 to 111. **5.6 Data Packet**

5.6.1 Slope sensor information 2:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	61481	240	41	128-247	

PGN message on CAN bus is 0xCF029**SA**

The format follows up the definition of slope sensor information 2 in J1939DA_201702.

The first 24-bit indicates pitch and the next 24-bit indicates roll, little-endian.

SLOT Id	Slot Name	Scaling	Range	Offset	Length
294	SAEad11	1/32768 deg/bit	-250 to 252 deg	-250 deg	3 bytes

5.6.2 Angular rate packet:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	61482	240	42	128-247	

PGN message on CAN bus is 0xCF02A**SA**

The format follows up the definition of angular rate information in J1939DA_201702.

Each 16 bits indicates the angular velocity (rate) of x, y, z, (little endian).

SLOT Id	Slot Name	Scaling	Range	Offset	Length
288	SAEva03	1/128 deg/s/bit	-250 to 252 deg/s	-250 deg/s	2 bytes

5.6.3 Acceleration sensor packet:

Priority	Base PGN	PDU format	PDU specific	Source address	Data Field
6	61485	240	45	128-247	

PGN message on CAN bus is 0x8F02D**SA**

The format follows the definition of acceleration sensor information in J1939DA_201702.

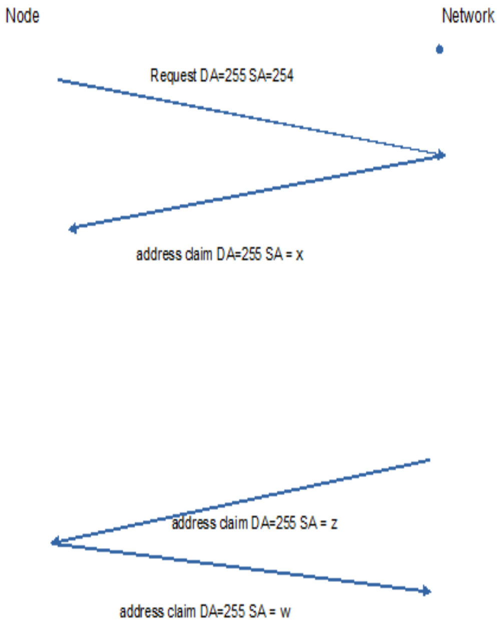
Each 16 bits indicates the acceleration of x, y, z, (little endian), with LSB = 0.01 m/s/s.

SLOT Id	Slot Name	Scaling	Range	Offset	Length
303	SAEad11	0.01 m/s:sup :2/bit	-320 to 322.55 m/s:sup :2	–320 m/s:sup :2	2 bytes

6. **Address claiming**

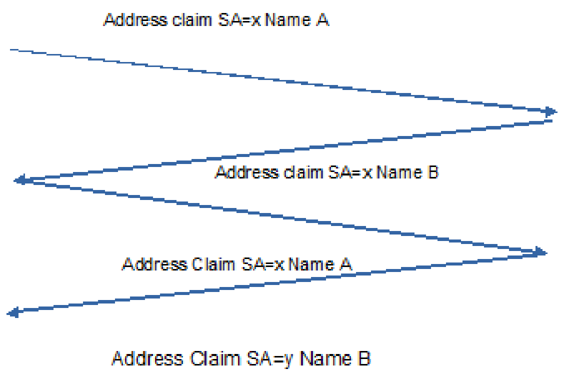
6.1 Non-existence of node address:

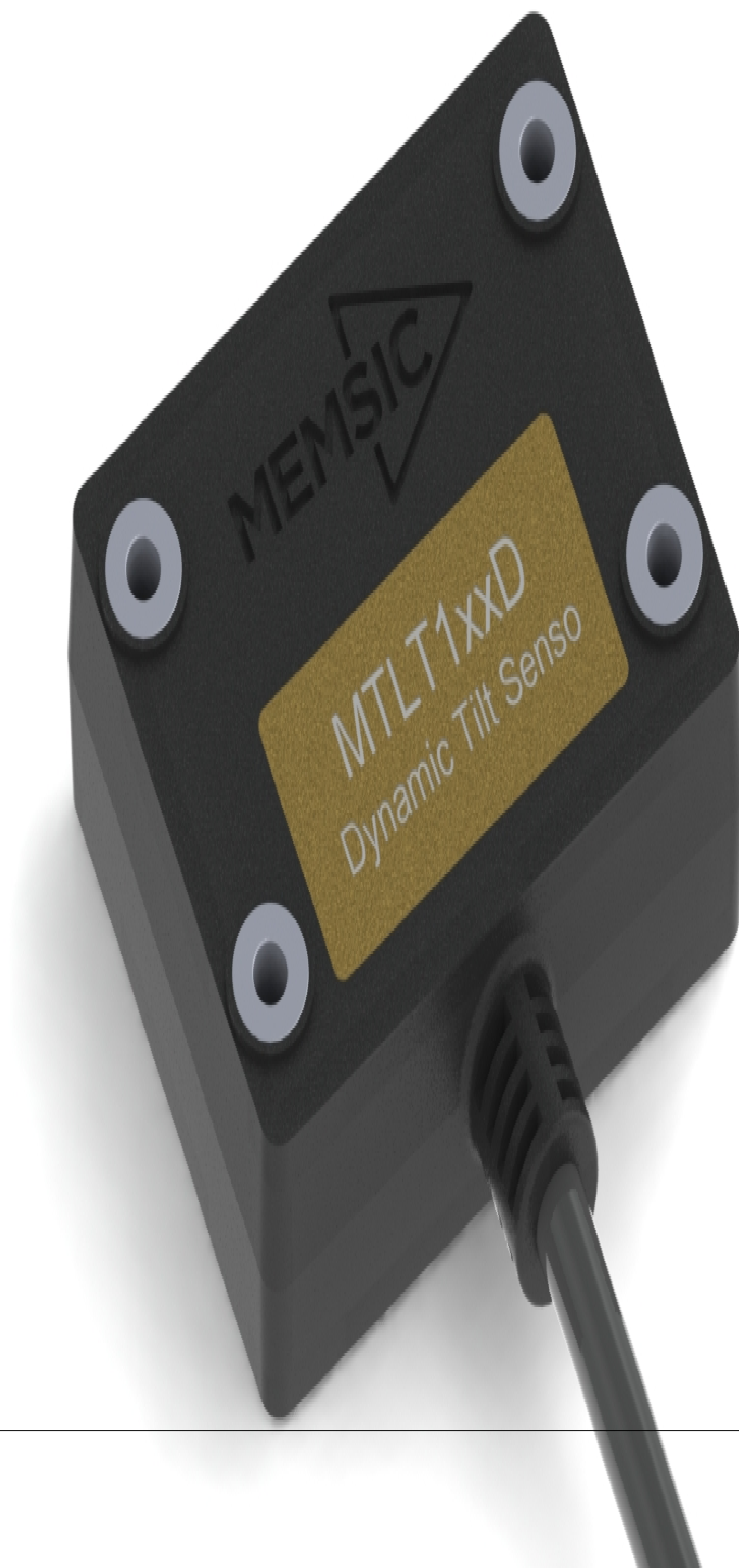
The node with null address sends out a global request and waits for the responses from all the nodes on CAN bus. Then, it sends out an address claim message with a chosen address.



6.2 Existence of node address:

The node with an existed address sends out an address claim message and waits for responses from all the nodes on CAN bus, then decides to keep the address or choose next available address.


Address claim SA=x Name A
Address claim SA=x Name B
Address Claim SA=x Name A
Address Claim SA=y Name B


MEMSIC
MTLT1xxD
Dynamic Tilt Senso

- **WARNING**

This product has been developed by Aceinna exclusively for commercial applications. It has not been tested for, and Aceinna makes no representation or warranty as to conformance with, any military specifications or that the product is appropriate for any military application or end-use. Additionally, any use of this product for nuclear, chemical, biological weapons, or weapons research, or for any use in missiles, rockets, and/or UAV's of 300km or greater range, or any other activity prohibited by the Export Administration Regulations, is expressly prohibited without the written consent of Aceinna and without obtaining appropriate US export license(s) when required by law. Diversion contrary to law is prohibited.

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** About this Manual**

The following annotations have been used to provide additional information.

NOTE

Note provides additional information about the topic.

EXAMPLE

Examples are given throughout the manual to help the reader understand the terminology.

IMPORTANT

This symbol defines items that have significant meaning to the user

⚠ **WARNING**

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to either the person or the equipment.

CHAPTER 1

Introduction

1.1 Manual Overview

This manual provides a comprehensive introduction to Aceinna's MTLT Series industrial tilt sensor products. For users wishing to get started quickly, please refer to the three page quick start guide included with each shipment. Table 1 table highlights the content in each section and suggests how to use this manual.

1. Manual Content

Manual Section	Who Should Read ?
Section 1: Manual Overview	All customers should read sections 1.1 and 1.2.
**Section 2: ** Connections	Customers who are connecting the MTLT Series products into a system with their own power supply and cable.
**Section 3: ** Installation and Operation of NAV-VIEW	Customers who are installing the MTLT Series products into a system and need details on using NAV-VIEW.
**Section 4: ** Theory of Operation	All customers should read Section 4. As the MTLT Series products are inter-related, use the chart at the beginning of Section 4 to ensure that you get an overview of all of the functions and features of your MTLT Series system.
**Section 5: ** Application Guide	Customers who want product configuration tips for operating the MTLT Series tilt sensors in a wide range of applications.
**Section 6-9: ** Programming, Communicating, Advanced Commands and BIT	Customers who wish to communicate with the MTLT Series system for sensor data, should review Section 6 and 7. Section 8 is for users who wish to configure the MTLT Series operating parameters (e.g., baud rate or power-up output rate) without NAV-VIEW.

1.2 Overview of the MTLT Series Inertial Systems

This manual provides a comprehensive introduction to the use of Aceinna's MTLT Industrial Tilt Sensor products listed in Table 2. This manual is intended to be used as a detailed technical reference and operating guide for the MTLT Series. Aceinna's MTLT Series products combine the latest in high-performance commercial MEMS (Microelectromechanical Systems) sensors and digital signal processing techniques to provide a small, cost-effective alternative to existing tilt sensors.

2. MTLT Series Feature Description

Series	Product	Features
MTLT1 Series	MTLT110S	Accelerometer based static tilt sensor. 3-DOF Accelerometer data plus static Roll and Pitch, plus a single pin tilt alarm. Plastic IP67 Housing with a 1.0 degree over-temperature accuracy on static tilt angles.
	MTLT105S	Accelerometer based static tilt sensor. 3-DOF Accelerometer data plus static Roll and Pitch, plus a single pin tilt alarm. Plastic IP67 Housing with a 0.5 degree over-temperature accuracy on static tilt angles.
	MTLT101S	Accelerometer based static tilt sensor. 3-DOF Accelerometer data plus static Roll and Pitch, plus a single pin tilt alarm. Plastic IP67 Housing with a 0.1 degree over-temperature accuracy on static tilt angles.
	MTLT105D	Gyro compensated dynamic tilt sensor. 3-DOF Accelerometer data, 3-DOF Gyro data, plus dynamic Roll and Pitch, plus a single pin tilt alarm. Plastic IP67 Housing with a 0.5 degree over-temperature accuracy on static tilt angles and 2.0 degree accuracy on dynamic tilt angles.
	MTLT101D	
		Gyro compensated dynamic tilt sensor. 3-DOF Accelerometer data, 3-DOF Gyro

The MTLT Series continues in Aceinna's long history of inertial sensors. We have 20 years of history building inertial and tilt sensor products. The MTLT Series comes in both a static (accelerometer only) configuration for stationary or low speed applications, and a dynamic (gyro compensated) configuration for mobile applications. Both static and dynamic configurations use the same high-performance microprocessor for on-board angle computations, and high-accuracy accelerometers.

The MTLT1 series sensors are housed in a sealed IP67 plastic enclosure ideal for outdoor or external applications. The MTLT1 uses a standard RS232 communication protocol for easy integration and a wide 9 – 32 volt input power range.

In addition to the accelerometers, the dynamic MTLT also includes a 3-axis gyro for dynamic compensation. Traditional accelerometer only tilt sensors are great in static or slow moving applications where the linear accelerations are insignificant compared to the Earth's gravity vector. However, when placed in a moving vehicle (land, water, or aerial), the linear accelerations of the vehicle motion can be interpreted as changes in tilt. With a gyro compensated tilt sensor, these linear accelerations can be filtered out by the on-board Kalman filter resulting in an accurate tilt measurement across all dynamic.

Each sensor in the MTLT family includes a tilt alarm. The tilt alarm is a single pin output that is raised high when the tilt exceeds a user defined threshold. The user defined threshold can be set using the RS232 port. The tilt alarm is ideal for low-cost applications that may not include a microprocessor for reading the tilt angles. After the threshold is set, the alarm pin can be attached directly to a control relay to lock out equipment when dangerous tilt levels are exceeded, or simply attached to an LED to give an operator an indication that he/she is driving on an unsafe incline.

The MTLT Series is supported by Aceinna's NAV-VIEW, a powerful PC-based operating tool that provides complete field configuration, diagnostics, charting of sensor performance, and data logging with playback.

CHAPTER 2

Connections

2.1 Connections

The MTLT1 Series has 6 flying leads on a 1 meter long cable

3. Connector Pin Assignments

Color	Signal
Red	Power Input
Black	Power Return
Green	RS232-RX
Yellow	Tilt Alarm
Orange	RS232-TX
Brown	RS232 Return

The maintain IP67 performance, the user must carefully seal the terminations of the flying leads.

2.2 Power Input and Power Input Ground

Power is applied to the MTLT1 Series sensor on red and black leads. The black wire is ground; the red wire should have 9 to 32 VDC.

- **WARNING**

Do not reverse the power leads or damage may occur.

2.3 Serial Data Interface

The serial interface is standard RS-232, 9600, 19200, 38400, or 57600 baud, 8 data bits, 1 start bit, 1 stop bit, no parity, and no flow control and will output at a user configurable output rate. The green and orange leads are designated as the main RS-232 interface pins. The serial data settings can be configured on a MTLT1 Series unit with NAV-VIEW. In order to set the serial data interface, select Unit Configuration, under the Menu Tab.

2.4 Alarm

The Alarm output is normally pulled low by a current sinking transistor. When the Alarm threshold is exceeded the transistor is turned off and the output will be pulled high by a 10K 1/16W resistor to the internal 3.3 Volt power supply.

CHAPTER 3

Installation and Operation of NAV-VIEW

NAV-VIEW allows users to control all aspects of the MTLT Series operation including data recording, definable alarm threshold and data transfer. In addition you will be able to control the orientation of the unit, sampling rate, packet type, and filter settings.

3.1 NAV-VIEW Computer Requirements

The following are minimum requirements for the installation of the NAV-VIEW Software:

- CPU: Pentium-class (1.5GHz minimum)
- RAM Memory: 500MB minimum, 1GB+ recommended
- Hard Drive Free Memory: 20MB
- Operating System: Windows 2000™, or XP™, Windows® 7
- Properly installed Microsoft .NET 2.0 or higher

3.1.1 Install NAV-VIEW

To install NAV-VIEW onto your computer:

1. Insert the CD “Inertial Systems Product Support” (Part No. 8160-0063) in the CD-ROM drive.
2. Locate the “NAV-VIEW” folder. Double click on the “setup.exe” file.
3. Follow the setup wizard instructions. You will install NAV-VIEW and .NET 2.0 framework.

3.2 Connections

The MTLT1 Series Inertial Systems products are shipped flying leads. To connect to NAV-VIEW the flying leads can be attached to a standard DB9 connector.

1. Connect the green lead (RS232-RX) to pin 3 of the DB9 connector
2. Connect the orange lead (RS232-TX) to pin 2 of the DB9 connector
3. Connect the brown lead (RS232-GND) to pin 5 of the DB9 connector
4. Connect the red lead (+) to power supply positive, 9-32VDC
5. Connect the black lead (-) to power supply negative
6. Connect the yellow lead (Alarm) to oscilloscope or DMM. GND is brown lead

Note: Allow at least 60 seconds after power up for the MTLT1 Series product to

initialize. The MTLT1 Series needs to be held motionless during this period.

WARNING

Do not reverse the power leads! Reversing the power leads to the MTLT Series can damage the unit; although there is reverse power protection, Aceinna is not responsible for resulting damage to the unit should the reverse voltage protection electronics fail.

3.3 Setting up NAV-VIEW

With the MTLT Series product powered up and connected to your PC serial port, open the NAV-VIEW software application.

1. NAV-VIEW should automatically detect the MTLT Series product and display the serial number and firmware version if it is connected.

2. If NAV-VIEW does not connect, check that you have the correct COM port selected. You will find this under the "Setup" menu. Select the appropriate COM port and allow the unit to automatically match the baud rate by leaving the "Auto: match baud rate" selection marked.

3. If the status indicator at the bottom is green and states, Unit Connected, you're ready to go. If the status indicator doesn't say connected and is red, check the connections between the MTLT Series product and the computer, check the power supply, and verify that the COM port is not occupied by another device.

4. Under the "View" menu you have several choices of data presentation. Graph display is the default setting and will provide a real time graph of all the MTLT Series data. The remaining choices will be discussed in the following pages.

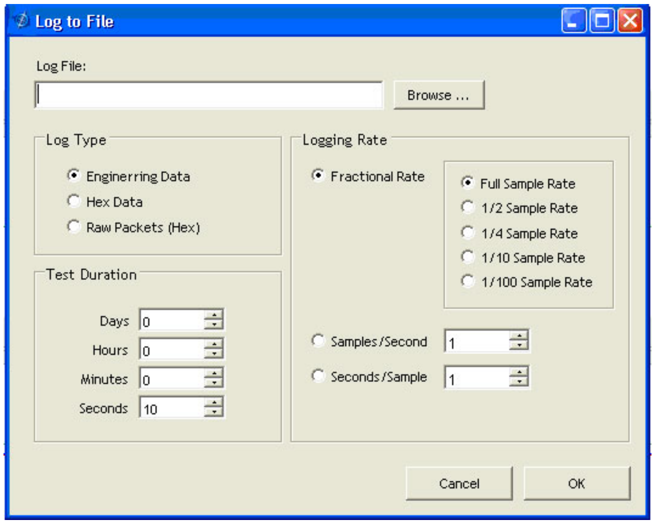
3.4 Data Recording

NAV-VIEW allows the user to log data to a text file (.txt) using the simple interface at the top of the screen. Customers can now tailor the type of data, rate of logging and can even establish predetermined recording lengths.

To begin logging data follow the steps below (See Figure 1):

1. Locate the icon at the top of the page or select "Log to File" from the "File" drop down menu.
2. The following menu will appear.

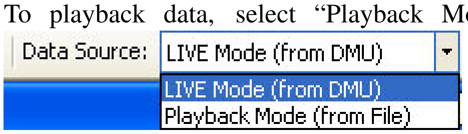
1. Log to File Dialog Screen

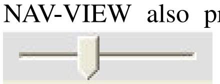


3. Select the "Browse" box to enter the file name and location that you wish to save your data to.
4. Select the type of data you wish to record. "Engineering Data" records the converted values provided from the system in engineering units, "Hex Data" provides the raw hex values separated into columns displaying the value, and the "Raw Packets" will simply record the raw hex strings as they are sent from the unit.
5. Users can also select a predetermined "Test Duration" from the menu. Using the arrows, simply select the duration of your data recording.
6. Logging Rate can also be adjusted using the features on the right side of the menu.
7. Once you have completed the customization of your data recording, you will be returned to the main screen where you can start the recording process using the button at the top of the page or select "Start Logging" from the "File" menu. Stopping the data recording can be accomplished using the button and the recording can also be paused using the button.

3.5 Data Playback

In addition to data recording, NAV-VIEW allows the user to replay saved data that has been stored in a log file.

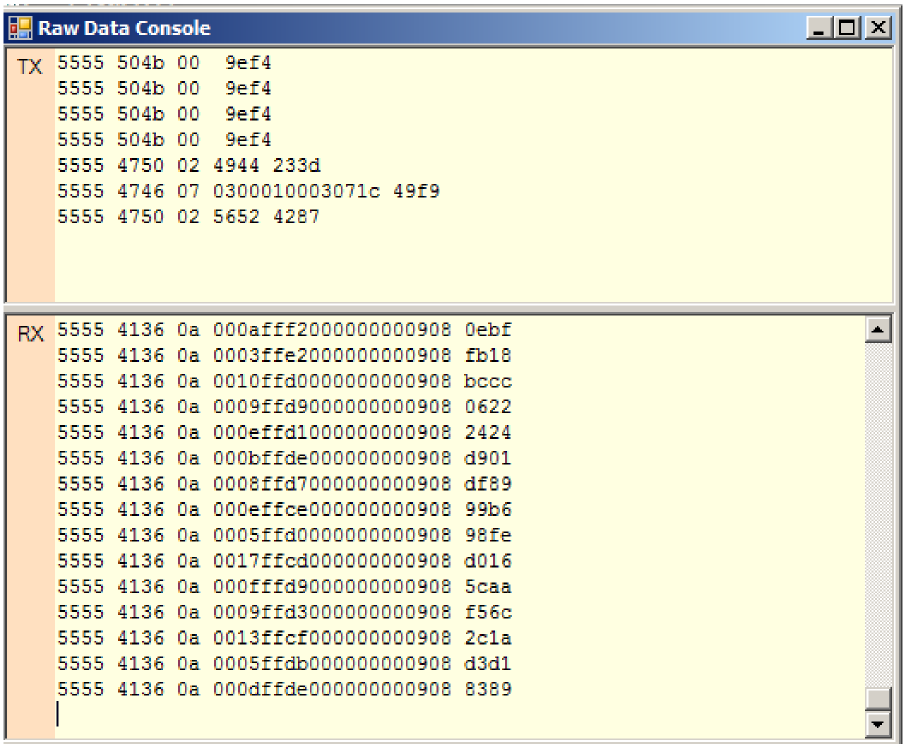
1. To playback data, select "Playback Mode" from the "Data Source" drop down menu at the top.


2. Selecting Playback mode will open a text prompt which will allow users to specify the location of the file they wish to play back. All three file formats are supported (Engineering, Hex, and Raw) for playback. In addition, each time recording is stopped/started a new section is created. These sections can be individually played back by using the drop down menu and associated VCR controls.
3. Once the file is selected, users can utilize the VCR style controls at the top of the page to start, stop, and pause the playback of the data.
4. NAV-VIEW also provides users with the ability to alter the start time for data playback. Using the  slide bar at the top of the page users can adjust the starting time.

3.6 Raw Data Console

NAV-VIEW offers some unique debugging tools that may assist programmers in the development process. One such tool is the Raw Data Console. From the "View" drop down menu, simply select the "Raw Data Console". This console provides users with a simple display of the packets that have been transmitted to the unit (Tx) and the messages received (Rx). An example is provided in Figure 2.

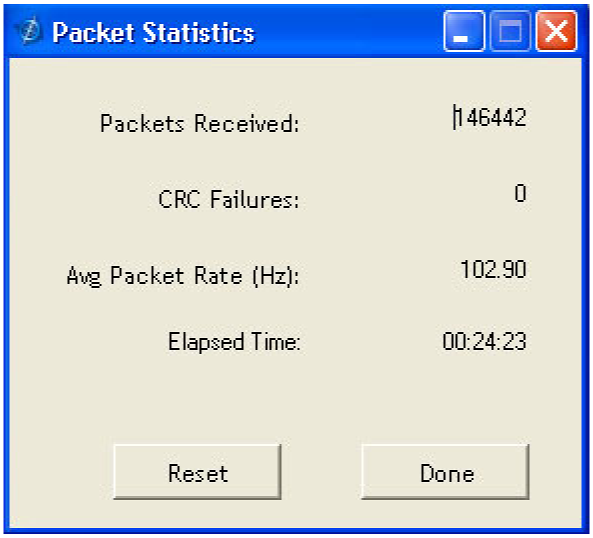
2. Raw Data Console



3.7 Packet Statistics View

Packet statistics can be obtained from the "View" menu by selecting the "Packet Statistics" option (See Figure 3). This view simply provides the user with a short list of vital statistics (including Packet Rate, CRC Failures, and overall Elapsed Time) that are calculated over a one second window. This tool should be used to gather information regarding the overall health of the user configuration. Incorrectly configured communication settings can result in a large number of CRC Failures and poor data transfer.

3. Packet Statistics



3.8 Unit Configuration

The Unit Configuration window (See Figure 4) gives the user the ability to view and alter the system settings. This window is accessed through the "Unit Configuration" menu item under the configuration menu. Under the "General" tab, users have the ability to verify the current configuration by selecting the "Get All Values" button. This button simply provides users with the currently set configuration of the unit and displays the values in the left column of boxes.

There are four tabs within the "Unit Configuration" menu; General, Advanced, BIT Configuration and tilt alarm. The General tab displays some of the most commonly used settings. The Advanced , BIT Configuration and tilt alarm menus provide users with more detailed setting information that they can tailor to meet their specific needs.

To alter a setting, simply select the check box on the left of the value that you wish to modify and then select the value using the drop down menu on the right side. Once you have selected the appropriate value, these settings can be set temporarily or permanently (a software reset or power cycle is required for the changes to take affect) by selecting from the choices at the bottom of the dialog box. Once the settings have been altered a "Success" box will appear at the bottom of the page.

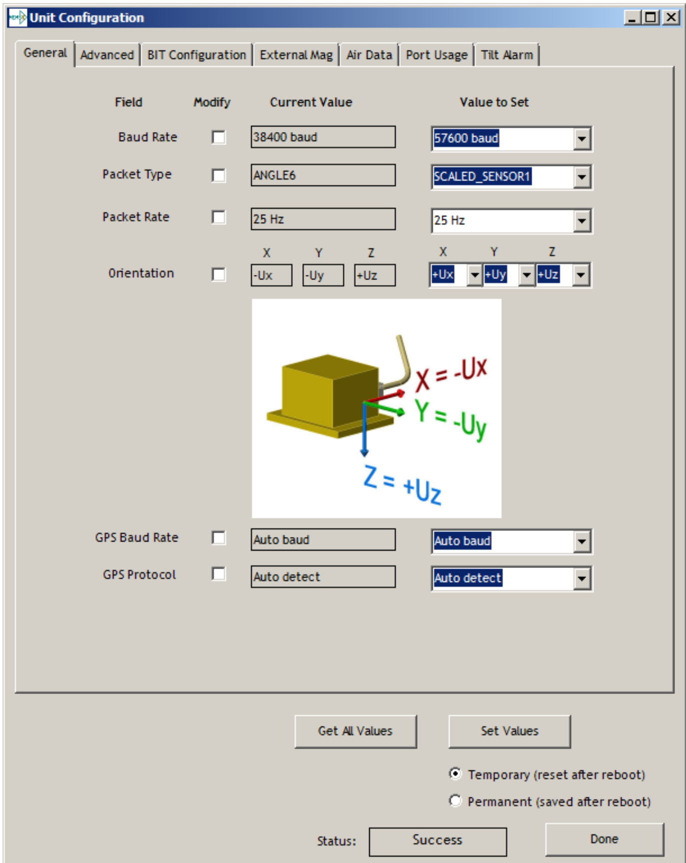
IMPORTANT

Caution must be taken to ensure that the settings selected are compatible with the system that is being configured. In most cases a "FAIL" message will appear if incompatible selections are made by the user, however it is the users responsibility to ensure proper configuration of the unit.

IMPORTANT

Unit orientation selections must conform to the right hand coordinate system as noted in Section 4.1 of this user manual. Selecting orientations that do not conform to this criteria are not allowed.

4. Unit Configuration



3.9 Advanced Configuration

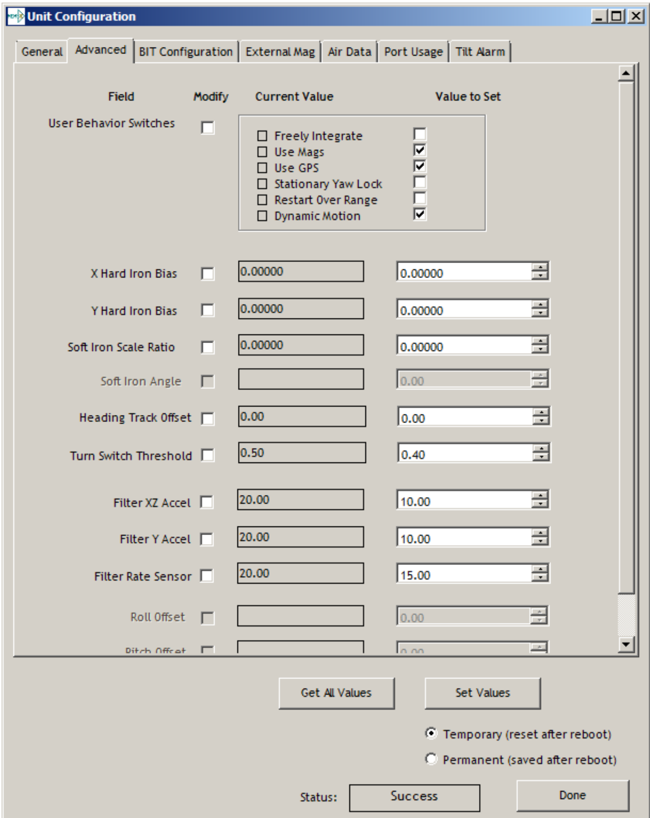
Users who wish to access some of the more advanced features of NAV-VIEW and the MTLT1 Series products can do so by selecting the “Advanced” tab at the top of the “Unit Configuration” window.

WARNING

Users are strongly encouraged to read and thoroughly understand the consequences of altering the settings in the “Advanced” tab before making changes to the unit configuration. These settings are discussed in detail in Chapter 4 below.

Behavior switches are identified at the top of the page with marked boxes. A blue box will appear if a switch has been enabled similar to Figure 5 below. The values can be set in the same manner as noted in the previous section. To set a value, users select the appropriate “Modify” checkbox on the left side of the menu and select or enable the appropriate value they wish to set. At the bottom of the page, users have the option of temporarily or permanently setting values. When all selections have been finalized, simply press the “Set Values” button to change the selected settings.

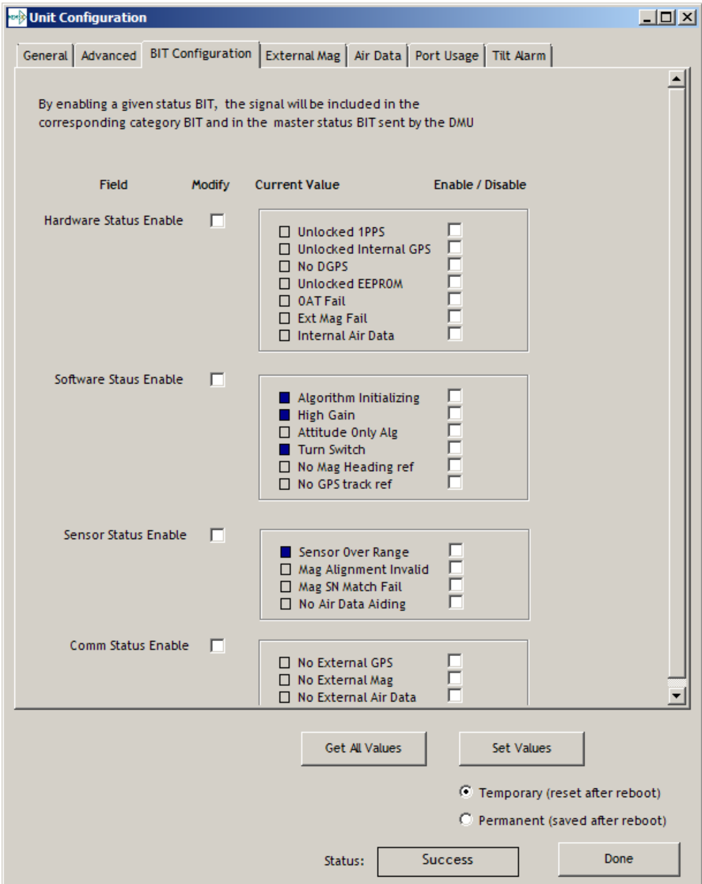
5. Advanced Settings



3.10 Bit Configuration

The third tab of the unit configuration window is "Bit Configuration" (See Figure 6). This tab allows the users to alter the logic of individual status flags that affect the masterStatus flag in the master BITstatus field (available in most output packets). By enabling individual status flags users can determine which flags are logically OR'ed to generate the masterStatus flag. This gives the user the flexibility to listen to certain indications that affect their specific application. The masterFail and all error flags are not configurable. These flags represent serious errors and should never be ignored.

6. BIT Configuration



3.11 Tilt alarm

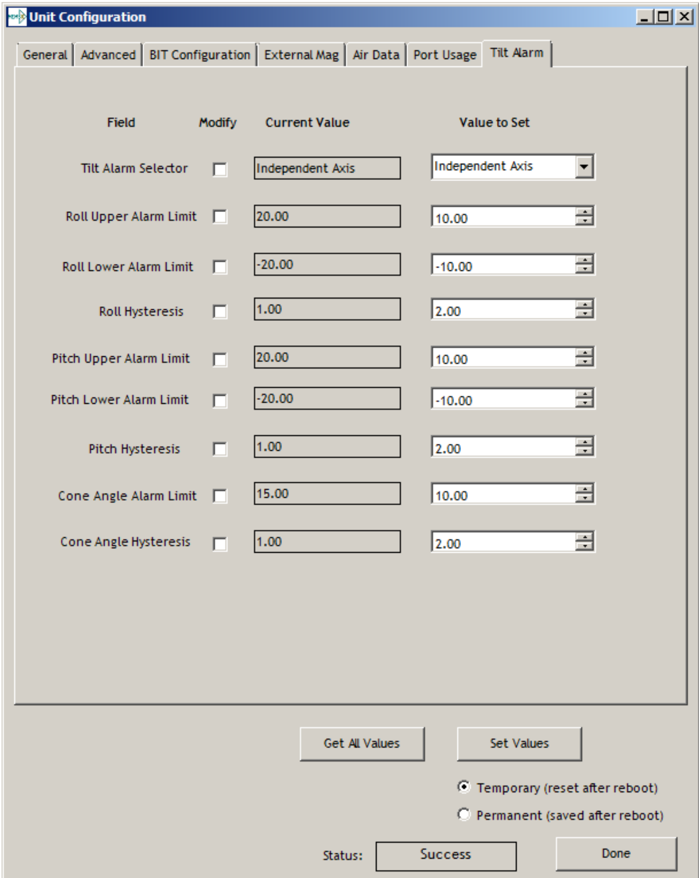
The final tab of the unit configuration window is “Tilt alarm” (See Figure 7). This tab allows the users to select alarm source and set alarm threshold angles with hysteresis.

Tilt alarm selector: independent roll/pitch or cone angle

Alarm limit: alarm upper and lower limits.

Hysteresis: alarm limit hysteresis

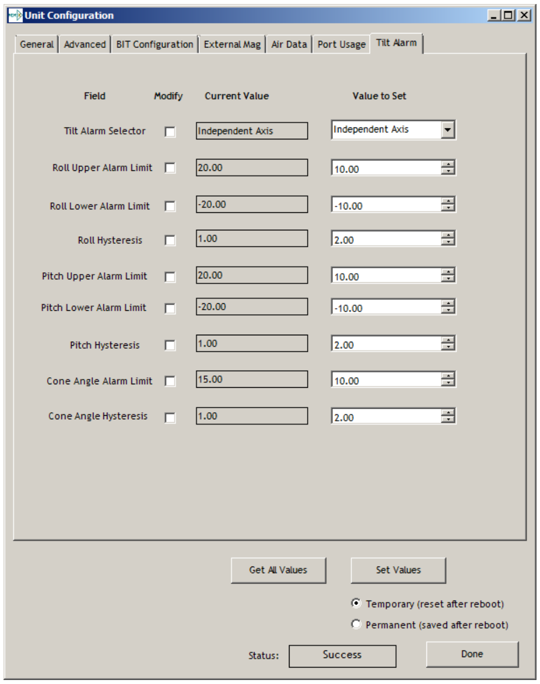
Figure 7. Tilt alarm



Read Unit Configuration

NAV-VIEW allows users to view the current settings and calibration data for a given MTLT Series unit by accessing the "Read Configuration" selection from the "Configuration" drop down menu (See Figure 8). From this dialog, users can print a copy of the unit's current configuration and calibration values with the click of a button. Simply select the "Read" button at the top of the dialog box and upon completion select the "Print" or "Print Preview" buttons to print a copy to your local network printer. This information can be helpful when storing hard copies of unit configuration, replicating the original data sheet and for troubleshooting if you need to contact Aceinna's Support Staff.

Figure 8. Read Configuration


Unit Configuration
General
Advanced
BIT Configuration
External Mag
Air Data
Port Usage
Tilt Alarm
Field
Modify
Current Value
Value to Set
Tilt Alarm Selector
Independent Axis
Independent Axis
Roll Upper Alarm Limit
20.00
10.00
Roll Lower Alarm Limit
-20.00
-10.00
Roll Hysteresis
1.00
2.00
Pitch Upper Alarm Limit
20.00
10.00
Pitch Lower Alarm Limit
-20.00
-10.00
Pitch Hysteresis
1.00
2.00
Cone Angle Alarm Limit
15.00
10.00
Cone Angle Hysteresis
1.00
2.00
Get All Values
Set Values
Temporary (reset after reboot)
Permanent (saved after reboot)
Status:
Success
Done

CHAPTER 4

Theory of Operation

This section of the manual covers detailed theory of operation for both the static and dynamic versions of the MTLT series family.

4. MTLT1 Series Overview

Product	Features	Learning More
MTLT1xxS	Accelerometer-based static tilt sensor	Read 4.1 and 4.2
MTLT1xxD	Gyro-compensated dynamic tilt sensor	Read 4.1, 4.2 and 4.3

Figure 9 shows the MTLT Series hardware block diagram. At the core of the MTLT Series is a high-performance MEMS 3-axis accelerometer. The dynamic MTLT tilt sensors also include a 3-axis MEMS gyroscope used for linear acceleration compensation. These sensors are based on rugged, field proven silicon bulk micromachining technology. Each sensor within the cluster is individually factory calibrated using Aceinna's automated manufacturing process. Sensor errors are compensated for temperature bias, scale factor, non-linearity and misalignment effects using a proprietary algorithm from data collected during manufacturing. Accelerometer, rate gyro, and magnetometer sensor bias shifts over temperature (-40 ^{0}C to +70 ^{0}C) are compensated and verified using calibrated thermal chambers and rate tables. The sensor data is fed into a high-speed microprocessor which calculates the roll and pitch data using our proprietary Kalman filters.

Figure 9. MTLT Series Hardware Block Diagram

Figure 10 shows the software block diagram. The accelerometer and gyro (dynamic only) sensor data is fed into a high speed 200Hz signal processing chain. Measurement data packets are available at fixed continuous output rates or on a polled basis.

Figure 10. MTLT Series Software Block Diagram

Figure 9 shows a simplified functional block diagrams for MTLT static and dynamic sensors. Dynamic sensors include a 3-axis gyro and take advantage of the Extended Kalman Filter. The common aiding sensor for the drift correction for the attitude (i.e., roll and pitch only) is a 3-axis accelerometer.

4.1 MTLT Series Default Coordinate System

The MTLT Series Inertial System default coordinate system is shown in Figure 11. As with many elements of the MTLT Series, the coordinate system is configurable with either NAV-VIEW or by sending the appropriate serial commands. These configurable elements are known as ***Advanced Settings***. This section of the manual describes the default coordinate system settings of the MTLT Series when it leaves the factory.

With the MTLT Series product connector facing you, and the label facing up, the axes are defined as follows:

Figure 11. MTLT1 Series Default Coordinate System

x-axis – from face with connector through the MTLT unit

y-axis – along the face with connector from left to right

z-axis – along the face with the connector from top to bottom

The axes form an orthogonal SAE right-handed coordinate system. Acceleration is positive when it is oriented towards the positive side of the coordinate axis. For example, with a MTLT Series product sitting on a level table, it will measure zero g along the x- and y-axes and -1 g along the z-axis. Normal Force acceleration is directed upward, and thus will be defined as negative for the MTLT Series z-axis.

The angular rate sensors are aligned with these same axes. The rate sensors measure angular rotation rate around a given axis. The rate measurements are labeled by the appropriate axis. The direction of a positive rotation is defined by the right-hand rule. With the thumb of your right hand pointing along the axis in a positive direction, your fingers curl around in the positive rotation direction. For example, if the MTLT Series product is sitting on a level surface and you rotate it clockwise on that surface, this will be a positive rotation around the z-axis. The x- and y-axis rate sensors would measure zero angular rates, and the z-axis sensor would measure a positive angular rate.

Pitch is defined positive for a positive rotation around the y-axis (pitch up). Roll is defined as positive for a positive rotation around the x-axis (roll right). Yaw is defined as positive for a positive rotation around the z-axis (turn right).

The angles are defined as standard Euler angles using a 3-2-1 system. To rotate from the body frame to an earth-level frame, roll first, then pitch, and then yaw.

4.1.1 Advanced Settings

The MTLT Series Inertial Systems have a number of advanced settings that can be changed. All units support baud rate, power-up output packet type, output rate, sensor low pass filtering, tilt-alarm configurations, and custom axes configuration. The units can be configured using NAV-VIEW, as described in Section 3, and also directly with serial commands as described in Sections 6-9.

IMPORTANT

The Delta-Theta, Delta-V packet is only recommended for use in continuous output mode at 5Hz or greater. Polled requests for this packet will produce values accumulated since the last poll request, and thus, are subject to overflow (data type wrap around).

4.2 4.2 Dynamic MTLT Theory of Operation

The MTLT1xxD supports dynamic roll and pitch measurements that are stabilized by the using the accelerometers as a long-term gravity reference and gyro for dynamic motion compensation. At a fixed 200Hz rate, the MTLT1xxD continuously maintains both the calibrated sensor (accelerometer and gyro) data as well as the roll and pitch data. As shown in the software block diagram Figure 10, after the Sensor Calibration block, the sensor data is passed into an Integration to Orientation block. The Integration to Orientation block integrates body frame sensed angular rate to orientation at a fixed 200 times per second within all of the MTLT1xxD Series products. For improved accuracy and to avoid singularities when dealing with the cosine rotation matrix, a quaternion formulation is used in the algorithm to provide attitude propagation.

As also shown in the software block diagram, the Integration to Orientation block receives drift corrections from the Extended Kalman Filter or Drift Correction Module. In general, rate sensors and accelerometers suffer from bias drift, misalignment errors, acceleration errors (g-sensitivity), nonlinearity (square terms), and scale factor errors. The largest error in the orientation propagation is associated with the rate sensor bias terms. The Extended Kalman Filter (EKF) module provides an on-the-fly calibration for drift errors, including the rate sensor bias, by providing corrections to the Integration to Orientation block and a characterization of the gyro bias state. In the MTLT1xxD, the internally computed gravity reference vector provides a reference measurement for the EKF when the MTLT1xxD is in quasi-static motion to correct roll and pitch angle drift and to estimate the X and Y gyro rate bias. Because the gravity vector has no horizontal component, the EKF has no ability to estimate either the yaw angle error or the Z gyro rate bias. The MTLT1xxD adaptively tunes the EKF feedback in order to best balance the bias estimation and attitude correction with distortion free performance during dynamics when the object is accelerating either linearly (speed changes) or centripetally (false gravity forces from turns). Because centripetal and other dynamic accelerations are often associated with yaw rate, the MTLT1xxD maintains a low-passed filtered yaw rate signal and compares it to the turnSwitch threshold field (user adjustable). When the user platform to which the MTLT1xxD is attached exceeds the turnSwitch threshold yaw rate, the MTLT1xxD lowers the feedback gains from the accelerometers to allow the attitude estimate to coast through the dynamic situation with primary reliance on angular rate sensors. This situation is indicated by the softwareStatusturnSwitch status flag. Using the turn switch maintains better attitude accuracy during short-term dynamic situations, but care must be taken to ensure that the duty cycle of the turn switch generally stays below 10% during the vehicle mission. A high turn switch duty cycle does not allow the system to apply enough rate sensor bias correction and could allow the attitude estimate to become unstable.

The MTLT1xxD algorithm has two major phases of operation. The first phase of operation is the initialization phase. During the initialization phase, the MTLT1xxD is expected to be stationary or quasi-static so the EKF weights the accelerometer gravity reference heavily in order to rapidly estimate the roll and pitch angles, and X, Y rate sensor bias. The initialization phase lasts approximately 60 seconds, and the initialization phase can be monitored in the softwareStatus BIT transmitted by default in each measurement packet. After the initialization phase, the MTLT1xxD operates with lower levels of feedback (also referred to as EKF gain) from the accelerometers to continuously estimate and correct for roll and pitch errors, as well as to estimate X and Y rate sensor bias.

If a user wants to reset the algorithm or re-enter the initialization phase, sending the algorithm reset command, 'AR', will force the algorithm into the reset phase.

The MTLT1xxD outputs digital measurement data over the RS-232 serial link at a selectable fixed rate (100, 50, 25, 20, 10, 5 or 2 Hz) or on as requested basis using the GP, 'Get Packet' command.

4.2.1 4.2.1 MTLT1xxD Advanced Settings

In addition to the configurable baud rate, packet rate, axis orientation, and sensor low-pass filter settings, the MTLT1xxD provides additional advanced settings which are selectable for tailoring the MTLT1xxD to a specific application requirements. These MTLT1xxD advanced settings are shown in Table 10 below:

5. MTLT1xxD Series Advanced Settings

Setting	Default	Comments
Baud Rate	38400	57600, 115200,23040 also available
Packet Type	A6	A7 also available
Packet Rate	25Hz	This setting sets the rate at which selected Packet Type, packets are output. If polled mode is desired, then select Quiet. If Quiet is selected, the MTLT1xxD will only send measurement packets in response to GP commands.
Orientation	See Fig. 12	To configure the axis orientation, select the desired measurement for each axes: NAV-VIEW will show the corresponding image of the MTLT1xxD, so it easy to visualize the mode of operation. See Section 8.4 Orientation Field settings for the twenty four possible orientation settings. The default setting points the connector AFT.
Filter Settings (5, 10, 20, 50 Hz)	20 Hz	The low pass filters are set to a default of 5Hz for the accelerometers, and 20 Hz for the angular rate sensors.
Freely Integrate	OFF	The Freely Integrate setting allows a user to turn the MTLT1xxD into a 'free gyro'. In free gyro mode, the roll, pitch and yaw are computed exclusively from angular rate with no kalman filter based corrections of roll, pitch, or yaw. When turned on, there is no coupling of

4.2.2 4.2.2 MTLT1xxD Built-In Test

The MTLT1xxD Built-In Test capability allows users of the MTLT1xxD to monitor health, diagnostic, and system status information of the unit in real-time. The Built-In Test information consists of a BIT word (2 bytes) transmitted in every measurement packet. In addition, there is a diagnostic packet 'T0' that can be requested via the Get Packet 'GP' command which contains a complete set of status for each hardware and software subsystem in the MTLT1xxD. See Sections 6 and 7 for details on the 'T0' packet.

The BIT word contained within each measurement packet is detailed below. The LSB (Least Significant Bit) is the Error byte, and the MSB (Most Significant Bit) is a Status byte with programmable alerts. Internal health and status are monitored and communicated in both hardware and software. The ultimate indication of a fatal problem is the masterFail flag.

The masterStatus flag is a configurable indication that can be modified by the user. This flag is asserted as a result of any asserted alert signals which have been enabled. See Advanced BIT (Section 9) for details on configuring the masterStatus flags. Table 11 shows the BIT definition and default settings for BIT programmable alerts in the MTLT1xxD.

6. MTLT1xxD Default BIT Status Definition

BITstatus Field	Bits	Meaning	Category
masterFail	0	0 = normal, 1 = fatal error has occurred	BIT
HardwareError	1	0 = normal, 1= internal hardware error	BIT
comError	2	0 = normal, 1 =| BIT communication | error |	
softwareError	3	0 = normal, 1 =| BIT internal | software error |	
Reserved	4:7	N/A	
masterStatus	8	0 = nominal, 1 = one or more status alerts	Status
hardwareStatus	9	Disabled	Status
comStatus	10	0 = nominal, 1 = No External GPS Comm	Status
softwareStatus	11	0 = nominal, 1 = Algorithm Initialization or High Gain	Status
sensorStatus	12	0 = nominal, 1 =	Status
Reserved	13:15	N/A	

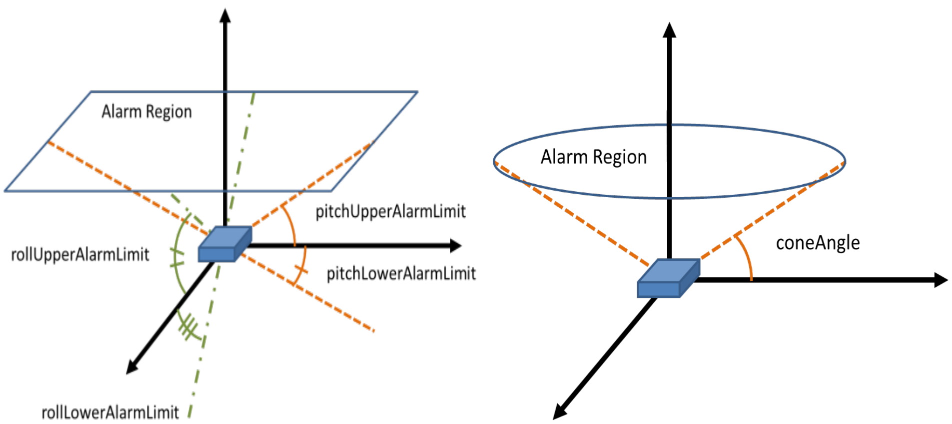
The MTLT1xxD also allows a user to configure the Status byte within the BIT message. To configure the word, select the BIT Configuration tab from the Unit Configuration menu. The dialog box allows selection of which status types to enable (hardware, software, sensor, and comm). Aceinna recommends for the vast majority of users, that the default Status byte for the MTLT1xxD is sufficient. For users, who wish to have additional visibility to when the MTLT1xxD EFK algorithm estimates that the MTLT1xxD is turning about its Z or Yaw axis, the softwareStatus bit can be configured to go high during a turn. In other words, the turnSwitch will turn on the softwareStatus bit. In the MTLT1xxD, the turnSwitch is by default set at 10.0 deg/sec about the z-axis.

4.3 Tilt Alarm (Independent vs. Cone Angle)

In many safety applications, accurately determining if the vehicle or equipment is tilted beyond a certain safety threshold is the most important requirement. The MTLT1 series tilt sensors is designed by be an all-in-one solution for both static and dynamic safety solutions.

The user can select tilt alarm mode for independent pitch and roll angles or cone angle through NAV-VIEW. Independent and cone angle are show in Figure 12.

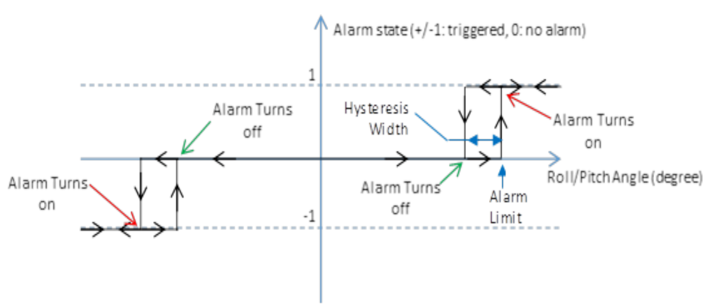
Figure 12. Independent & Cone Angle



Independent Cone Angle

Hysteresis: if the tilt exceeds user definable alarm threshold, alarm will change to high and it will hold the high level until the angle is less than the user definable clear threshold. The clear threshold is not user definable value, user can get the clear threshold by calculation. the formula is : Clear value = +/-(ABS(alarm limit) - hysteresis). Hysteresis is shown in figure 13.

Figure 13: Hysteresis



CHAPTER 5

Application Guide

5.1 Introduction

This section provides recommended advanced settings for tailoring the MTLT1 Series of tilt sensors to different types of application and platform requirements.

5.2 Equipment Leveling and lockout

MTLT can be used to level equipment or measure tilt while moving in heavy construction machinery, oil industry and so on.

The unit can be placed on the boom or chassis, for example, to measure tilt angle during moving or platform leveling. The measurement provides improved control while the alarm signal can be used for added protection and lockout.

In the oil industry, MTILT can be placed on a pumpjack to measure the walking beam angle change.

5.3 Aerial Work Platform Safety

To protect the safety of the operator, it is very important to control and correct the angle of the platform. MTLT can be used to measure and control the angle of the operator platform, chassis or boom. Multiple MTLT sensors can be used to measure the change of the angle between the chassis and boom. The alarm signal can be used for protection and lockout.

5.4 Land Vehicle

Payload imbalance can adversely affect handling and safety. More and more trucks use tilt sensors to optimize payload balance; increasing safety, improving fuel economy and minimizing wear of vehicle components.

CHAPTER 6

Programming Guide

The MTLT1 Series contains a number of different products which have different measurement capabilities. Depending on the model you purchased, various commands and output modes are supported. However, all models support a common packet structure that includes both command or input data packets (data sent to the MTLT1 Series) and measurement output or response packet formats (data sent from the MTLT1 Series). This section of the manual explains these packet formats as well as the supported commands. NAV-VIEW also features a number of tools that can help a user understand the packet types available and the information contained within the packets. This section of the manual assumes that the user is familiar with ANSI C programming language and data type conventions.

For an example of the code required to parse input data packets, please see refer to Appendix C.

For qualified commercial OEM users, a source code license of NAV-VIEW can be made available under certain conditions. Please contact your Aceinna representative for more information.

6.1 General Settings

The serial port settings are RS232 with 1 start bit, 8 data bits, no parity bit, 1 stop bit, and no flow control. Standard baud rates supported are: 9600, 19200, 38400, and 57600.

Common definitions include:

- A word is defined to be 2 bytes or 16 bits.
- All communications to and from the unit are packets that start with a single word alternating bit preamble 0x5555. This is the ASCII string "UU".
- All multiple byte values are transmitted Big Endian (Most Significant Byte First).
- All communication packets end with a single word CRC (2 bytes). CRC's are calculated on all packet bytes excluding the preamble and CRC itself. Input packets with incorrect CRC's will be ignored.
- Each complete communication packet must be transmitted to the MTLT1 Series tilt sensors within a 4 second period.

6.2 Number Formats

Number Format Conventions include:

- 0x as a prefix to hexadecimal values
- single quotes (‘’) to delimit ASCII characters
- no prefix or delimiters to specify decimal values.

Table 20 defines number formats:

7. Number Formats

Descriptor	Description	Size(bytes)	Comment	Range
U1	Unsigned Char	1		0 to 255
U2	Unsigned Short	2		0 to 65535
U4	Unsigned Int	4		0 to 2^32-1
I2	Signed Short	2	2’s Complement	-2^15 to 2^15-1
I2*	Signed Short	2	Shifted 2’s Complement	Shifted to specified range
I4	Signed Int	4	2’s Complement	-2^31 to 2^31-1
F4	Floating Point	4	IEEE754 Single Precision	-1*2^127 to 2^127
SN	String	N	ASCII	

6.3 Packet Format

All of the Input and Output packets, except the Ping command, conform to the following structure:

0x5555	*<2-byte packet type (U2)>*	*<payload byte-length (U1)>*	*<variable length payload>*	*<2-byte CRC (U2)>*

The Ping Command does not require a CRC, so a MTLT1 Series unit can be pinged from a terminal emulator. To Ping a MTLT1 Series unit, type the ASCII string 'UUPK'. If properly connected, the MTLT1 Series unit will respond with 'PK'. All other communications with the MTLT1 Series unit require the 2-byte CRC. {Note: A MTLT1 Series unit will also respond to a ping command using the full packet formation with payload 0 and correctly calculated CRC. Example: 0x5555504B009ef4 }.

6.3.1 Packet Header

The packet header is always the bit pattern 0x5555.

6.3.2 Packet Type

The packet type is always two bytes long in unsigned short integer format. Most input and output packet types can be interpreted as a pair of ASCII characters. As a semantic aid consider the following single character acronyms:

P = packet

F = fields

Refers to Fields which are settings or data contained in the unit

E = EEPROM

Refers to factory data stored in EEPROM

R = read

Reads default non-volatile fields

G = get

Gets current volatile fields or settings

W = write

Writes default non-volatile fields. These fields are stored in non-volatile memory and determine the unit's behavior on power up. Modifying default fields take effect on the next power up and thereafter.

S = set

Sets current volatile fields or settings. Modifying current fields will take effect immediately by modifying internal RAM and are lost on a power cycle.

6.3.3 Payload Length

The payload length is always a one byte unsigned character with a range of 0-255. The payload length byte is the length(in bytes) of the <*variable length payload*> portion of the packet ONLY, and does not include the CRC.

6.3.4 Payload

The payload is of variable length based on the packet type.

6.3.5 16-bit CRC-CCITT

Packets end with a 16-bit CRC-CCITT calculated on the entire packet excluding the 0x5555 header and the CRC field itself. A discussion of the 16-bit CRC-CCITT and sample code for implementing the computation of the CRC is included at the end of this document. This 16-bit CRC standard is maintained by the International Telecommunication Union (ITU). The highlights are:

Width = 16 bits

Polynomial 0x1021

Initial value = 0xFFFF

No XOR performed on the final value.

See Appendix C for sample code that implements the 16-bit CRC algorithm.

6.3.6 Messaging Overview

Table 21 summarizes the messages available by MTLT1 Series model. Packet types are assigned mostly using the ASCII mnemonics defined above and are indicated in the summary table below and in the detailed sections for each command. The payload byte-length is often related to other data elements in the packet as defined in the table below. The referenced variables are defined in the detailed sections following. Output messages are sent from the MTLT1 Series inertial system to the user system as a result of a poll request or a continuous packet output setting. Input messages are sent from the user system to the MTLT1 Series inertial system and will result in an associated Reply Message or NAK message. Note that reply messages typically have the same ***<2-byte packet type (U2)>*** as the input message that evoked it but with a different payload.

8. Message Table

ASCII Mnemonic	<2-byte packet type (U2)>	<payload byte-length (U1)>	Description	Type	Products Available
Link Test					
PK	0x504B	0	Ping Command and Response	Input/ Reply Message	ALL
CH	0x4348	N	Echo Command and Response	Input/ Reply Message	ALL
Interactive Commands					
GP	0x4750	2	Get Packet Request	Input Message	ALL
AR	0x4152	0	Algorithm Reset	Input/ Reply Message	ALL
NAK	0x1515	2	Error Response	Reply Message	ALL
Output Messages: Status & Other, (Polled Only)					
ID	0x4944	5+N	ID data	Output Message	ALL
VR	0x5652	5	Version Data	Output Message	ALL
T0	0x5430	28			ALL

CHAPTER 7

Communicating with the MTLT1 Series

7.1 Link Test.

7.1.1 Ping Command

Ping (‘PK’ = 0x504B)			
Preamble	Packet Type	Length	Termination
0x5555	0x504B	•	•

The ping command has no payload. Sending the ping command will cause the unit to send a ping response. To facilitate human input from a terminal, the length and CRC fields are not required. (Example: 0x5555504B009ef4 or 0x5555504B))

7.1.2 Ping Response

Ping (‘PK’ = 0x504B)			
Preamble	Packet Type	Length	Termination
0x5555	0x504B	0x00	<CRC (U2)>

The unit will send this packet in response to a ping command.

7.1.3 Echo Command

Echo (‘CH’ = 0x4348)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4348	N	<echo payload>	<CRC (U2)>

The echo command allows testing and verification of the communication link. The unit will respond with an echo response containing the *echo data*. The *echo data* is N bytes long.

7.1.4 Echo Response

Echo Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	echoData0	U1	•	•	first byte of echo data
1	echoData1	U1	•	•	Second byte of echo data
…	…	U1	•	•	Echo data
N-2	echoData. ..	U1	•	•	Second to last byte of echo data
N-1	echoData…	U1	•	•	Last byte of echo data

7.2 Interactive Commands

Interactive commands are used to interactively request data from the MTLT1 Series, and to calibrate or reset the MTLT1 Series.

7.2.1 Get Packet Request

Get Packet (‘GP’ = 0x4750)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4750	0x02	<GP payload>	<CRC (U2)>

This command allows the user to poll for both measurement packets and special purpose output packets including ‘T0’, ‘VR’, and ‘ID’.

GP Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	requested Pack-etTyp e	U2	•	•	The requested packet type

Refer to the sections below for Packet Definitions sent in response to the ‘GP’ command

7.2.2 Algorithm Reset Command

Algorithm Reset (‘AR’ = 0x4152)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4152	0x00	•	<CRC (U2)>

This command resets the state estimation algorithm without reloading fields from EEPROM. All current field values will remain in affect. The unit will respond with an algorithm reset response.

7.2.3 Algorithm Reset Response

Algorithm Reset (‘AR’ = 0x4152)			
Preamble	Packet Type	Length	Termination
0x5555	0x4152	0x00	<CRC (U2)>

The unit will send this packet in response to an algorithm reset command.

7.2.4 Error Response

Error Response (ASCII NAK, NAK = 0x1515)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x1515	0x02	<NAK payload>	<CRC (U2)>

The unit will send this packet in place of a normal response to a *faiiledInputPacketType* request if it could not be completed successfully.

NAK Payload Contents					
Byte Offset	Name	Format	Scaling	Units	Description
0	failedInp ut-PacketT ype	U2	•	•	the failed request

7.3 Output Packets (Polled)

The following packet formats are special informational packets which can be requested using the 'GP' command.

7.3.1 Identification Data Packet

Identification Data ('ID' = 0x4944)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4944	5+N	<ID payload>	<CRC (U2)>

This packet contains the unit *serialNumber* and *modelString*. The model string is terminated with 0x00. The model string contains the programmed versionString (8-bit Ascii values) followed by the firmware part number string delimited by a whitespace.

ID Payload Contents					
Byte Offset	Name	Format	Scaling	Units	Description
0	serialNumber	U4	•	•	Unit serial number
4	modelString	SN	•	•	Unit Version String
4+N	0x00	U1	•	•	Zero Delimiter

7.3.2 Version Data Packet

Version Data ('VR' = 0x5652)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x5652	5	<VR payload>	<CRC (U2)>

This packet contains firmware version information. *majorVersion* changes may introduce serious incompatibilities. *minorVersion* changes may add or modify functionality, but maintain backward compatibility with previous minor versions. *patch* level changes reflect bug fixes and internal modifications with little effect on the user. The build *stage* is one of the following: 0=release candidate, 1=development, 2=alpha, 3=beta. The *buildNumber* is incremented with each engineering firmware build. The *buildNumber* and *stage* for released firmware are both zero. The final beta candidate is v.w.x.3.y, which is then changed to v.w.x.0.1 to create the first release candidate. The last release candidate is v.w.x.0.z, which is then changed to v.w.x.0.0 for release.

VR Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	major verion	U1	•	•	Major firmware version
1	minor version	U1	•	•	Minor firmware version
2	patch	U1	•	•	Patch level
3	stage	•	•	•	Development Stage (0=release candidate, 1=develop 2=alpha, 3=beta)
4	build number	U1	•	•	Build number

7.3.3 Test 0 (Detailed BIT and Status) Packet

Test (‘T0’ = 0x5430)				
Preamble	Packet Type	Length	Payload	Termination
03.3x5555	0x5430	0x1C	<T0 payload>	<CRC (U2)>

This packet contains detailed BIT and status information. The full BIT Status details are described in Section 9 of this manual.

T0 Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	BITstatus	U2	•	•	Master BIT and Status Field
2	hardware BIT	U2	•	•	Hardware BIT Field
4	hardware PowerBIT	U2	•	•	Hardware Power BIT Field
6	hardware Environmental |BIT	U2	•	•	Hardware Environmental | BIT Field
8	comBIT	U2	•	•	**communication** BIT Field
10	comSerial ABIT	U2	•	•	Communication | Serial A | BIT Field
12	comSerial BBIT	U2	•	•	Communication | Serial B | BIT Field
14	software BIT	U2	•	•	Software BIT Field
16	software Algorithm BIT	U2	•	•	Software Algorithm BIT Field
18	software DataBIT	U2	•	•	Software Data BIT Field
20	hardware Status	U2	•	•	Hardware Status Field
22	comStatus	U2	•	•	

7.4 Output Packets (Polled or Continuous)

7.4.1 Angle Data Packet 6 (Default Data)

Angle Data ('A6' = 0x4132)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4136	0x0A	<A6 payload>	<CRC (U2)>

This packet contains angle data. Data involving angular measurements include the factor pi in the scaling and can be interpreted in either radians or degrees.

Angles: scaled to a range of [-pi,+pi) or [-180 deg to +180 deg).

A6 Payload					
Byte Offset	Name	Format	Scaling	Units	Descriptio n
0	rollAngle	I2	2*pi/2^16 [360°/2^1 6]	Radians [°]	Roll angle
2	pitchAngle	I2	2*pi/2^16 [360°/2^1 6]	Radians [°]	Pitch angle
4	timeITOW	U4	1	ms	DMU ITOW (sync to GPS) Not Implemented
8	BITstatus	U2	•	•	Master BIT and Status

7.4.2 Angle Data Packet 7

Angle Data ('A7' = 0x4137)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4137	0x10	<A7 payload>	<CRC (U2)>

This packet contains angle data and selected sensor data scaled in most cases to a signed 2^16 2's complement number. Data involving angular measurements include the factor pi in the scaling and can be interpreted in either radians or degrees.

Angles: scaled to a range of [-pi,+pi) or [-180 deg to +180 deg).

Accelerometers: scaled to a range of [-10,+10) g

A7 Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	rollAngle	I2	2*pi/2^16 [360°/2^1 6]	Radians [°]	Roll angle
2	pitchAngl e	I2	2*pi/2^16 [360°/2^1 6]	Radians [°]	Pitch angle
4	xAccel	I2	20/2^16	g	X accelerom eter
6	yAccel	I2	20/2^16	g	Y accelerom eter
8	zAccel	I2	20/2^16	g	Z accelerom eter
10	timeITOW	U4	1	ms	DMU ITOW (sync to GPS) Not Implemented
14	BITstatus	U2	•	•	Master BIT and Status

CHAPTER 8

Advanced Commands

The advanced commands allow users to programmatically change the MTLT1 Series settings. This section of the manual documents all of the settings and options contained under the Unit Configuration tab within NAV-VIEW. Using these advanced commands, a user's system can change or modify the settings without the need for NAV-VIEW.

8.1 Configuration Fields

Configuration fields determine various behaviors of the unit that can be modified by the user. These include settings like baud rate, packet output rate and type, algorithm type, etc. These fields are stored in EEPROM and loaded on power up. These fields can be read from the EEPROM using the 'RF' command. These fields can be written to the EEPROM affecting the default power up behavior using the 'WF' command. The current value of these fields (which may be different from the value stored in the EEPROM) can also be accessed using the 'GF' command. All of these fields can also be modified immediately for the duration of the current power cycle using the 'SF' command. The unit will always power up in the configuration stored in the EEPROM. Configuration fields can only be set or written with valid data from Table 22 below.

9. Configuration Fields

configuration fields	**field ID**	**Valid Values** Values**	**description**
Packet rate divider	0x0001	0,1,2,4,5,10,20 25, 50	quiet, 100Hz, 50Hz, 25Hz, 20Hz, 10Hz, 5Hz, 4Hz,2Hz
Unit BAUD rate	0x0002	,2,3,5,6	38400, 57600 115200, 230400
Continuous packet type	0x0003	Any output packet type	Not all output packets available for all products. See detailed product descriptions.
Unused	0x0004		
Gyro Filter Setting	0x0005	7142-65535 [5Hz] 3571-7141 [10Hz] 1530-3570 [20Hz] 0-1529 [50 Hz]	Sets low pass cutoff for rate sensors. Cutoff Frequency choices are 5, 10, 20, and 50Hz
Accelerometer Filter Setting	0x0006	7142-65535 [5Hz] 3571-7141 [10Hz] 1530-3570 [20Hz] 0-1529 [50 Hz]	Sets low pass cutoff for accelerometers. Cutoff Frequency choices are 5, 10, 20, and 50Hz
Orientation	0x0007	See below	Determine forward, rightward, and downward facing sides
User Behavior Switches	0x0008	Any	Free Integrate (60 seconds), Use Mags, Use GPS, Stationary Yaw Lock, …
Roll upper alarm angle	0x0029	[-25,25](deg)	Roll upper alarm limit
Roll lower	0x002A	[-25,25](deg)	Roll lower

Note: BAUD rate SF has immediate effect. Some output data may be lost. Response will be received at new BAUD rate.

8.2 Continuous Packet Type Field

This is the packet type that is being continually output. The supported packet depends on the model number. Please refer to Section 6.4 for a complete list of the available packet types.

8.3 Digital Filter Settings

These two fields set the digital low pass filter cutoff frequencies (See Table 23). Each sensor listed is defined in the default factory orientation. Users must consider any additional rotation to their intended orientation.

10. Digital Filter Settings

Filter Setting	Sensor
FilterGyro	Ux,Uy,Uz Rate
FilterAccel	Ux,Uy,Uz Accel

8.4 Orientation Field

This field defines the rotation from the factory to user axis sets. This rotation is relative to the default factory orientation (connector aft, baseplate down). The default factory axis setting for the MTLT1 orientation field is (-Ux, -Uy, +Uz) as shown in Figure 15 below. With this default orientation, +X is defined as opposite where the connector is pointing, +Z is down through the base, and +Y is created by making the final orthogonal axis right-hand-rule. The user axis set is (X, Y, Z) as defined by this default orientation field loaded at the factory, but this can be changed as per Table 24.

Figure 15. MTLT1 Orientation Field (0x0009)

11. MTLT1 Orientation Definitions

Description	Bits	Meaning
X Axis Sign	0	0 = positive, 1 = negative
X Axis	1:2	0 = Ux, 1 = Uy, 2 = Uz, 3 = N/A
Y Axis Sign	3	0 = positive, 1 = negative
Y Axis	4:5	0 = Uy, 1 = Uz, 2 = Ux, 3 = N/A
Z Axis Sign	6	0 = positive, 1 = negative
Z Axis	7:8	0 = Uz, 1 = Ux, 2 = Uy, 3 = N/A
Reserved	9:15	N/A

There are 24 possible orientation configurations (See Table 25). Setting/Writing the field to anything else generates a NAK and has no effect.

12. MTLT1 Orientation Fields

Orientation Field Value	X Axis	Y Axis	Z Axi*
0x0000	+Ux	+Uy	+Uz
0x0009	-Ux	-Uy	+Uz
0x0023	-Uy	+Ux	+Uz
0x002A	+Uy	-Ux	+Uz
0x0041	-Ux	+Uy	-Uz
0x0048	+Ux	-Uy	-Uz
0x0062	+Uy	+Ux	-Uz
0x006B	-Uy	-Ux	-Uz
0x0085	-Uz	+Uy	+Ux
0x008C	+Uz	-Uy	+Ux
0x0092	+Uy	+Uz	+Ux
0x009B	-Uy	-Uz	+Ux
0x00C4	+Uz	+Uy	-Ux
0x00CD	-Uz	-Uy	-Ux
0x00D3	-Uy	+Uz	-Ux
0x00DA	+Uy	-Uz	-Ux
0x0111	-Ux	+Uz	+Uy
0x0118	+Ux	-Uz	+Uy
0x0124	+Uz	+Ux	+Uy
0x012D	-Uz	-Ux	+Uy
0x0150	+Ux	+Uz	-Uy
0x0159	-Ux	-Uz	-Uy
0x0165	-Uz	+Ux	-Uy
0x016C	+Uz	-Ux	-Uy

8.5 User Behavior Switches

This field allows on the fly user interaction with behavioral aspects of the algorithm (See Figure 26).

13. MTLT1 Behavior Switches

Description	Bits	Meaning
Free Integrate	0	0 = use feedback to stabilize the algorithm, 1 = 6DOF inertial integration without stabilized feedback for 60 seconds
Use Mags	1	N/A
Use GPS	2	N/A
Stationary Yaw Lock	3	N/A
Restart on Over-range	4	0 = Do not restart the system after a sensor over-range, 1 = restart the system after a sensor over-range
Dynamic Motion	5	0=vehicle is static, force high gain corrections, 1= vehicle is dynamic, use nominal corrections
Reserved	6:15	N/A

8.6 Tilt alarm

The fields from 0x0029 to 0x0031 allow the users to select alarm source and set alarm threshold angles with hysteresis.

8.7 Commands to Program Configuration

8.7.1 Write Fields Command

Write Fields ('WF' = 0x5746)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x5746	1+numFields *4	<WF payload>	<CRC (U2)>

This command allows the user to write default power-up configuration fields to the EEPROM. Writing the default configuration will not take affect until the unit is power cycled. *NumFields* is the number of words to be written. The *field0, field1, etc.* are the field

IDs that will be written with the *field0Data, field1Data, etc.*, respectively. The unit will not write to calibration or algorithm fields. If at least one field is successfully written, the unit will respond with a write fields response containing the field IDs of the successfully written fields. If any field is unable to be written, the unit will respond with an error response. Note that both a write fields and an error response may be received as a result of a write fields command. Attempts to write a field with an invalid value is one way to generate an error response. A table of field IDs and valid field values is available in Section 8.1.

WF Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	numFields	U1	•	•	The number of fields to write
1	field0	U2	•	•	The first field ID to write
3	field0Data	U2	•	•	The first field ID's data to write
5	field1	U2	•	•	The second field ID to write
7	field1Data	U2	•	•	The second field ID's data
…	…	U2	•	•	…
numFields *4 -3	field…	U2	•	•	The last field ID to write
numFields *4 -1	field…Data	U2	•	•	The last field ID's data to write

Write Fields Response

Write Fields ('WF' = 0x5746)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x5746	1+numFields *2	<WF payload>	<CRC (U2)>

The unit will send this packet in response to a write fields command if the command has completed without errors.

WF Payload					
Byte Offset	Name	Format	Scaling	Units	Descripti on
0	numFields	U1	•	•	The number of fields written
1	field0	U2	•	•	The first field ID written
3	field1	U2	•	•	The second field ID written
…	…	U2	•	•	More field IDs written
numFields *2 – 1	Field…	U2	•	•	The last field ID written

8.7.2 Set Fields Command

Set Fields ('SF' = 0x5346)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x5346	1+numFields *4	<SF payload>	<CRC (U2)>

This command allows the user to set the unit's current configuration (SF) fields immediately which will then be lost on power down. *NumFields* is the number of words to be set. The *field0, field1, etc.* are the field IDs that will be written with the *field0Data, field1Data, etc.*, respectively. This command can be used to set configuration fields. The unit will not set calibration or algorithm fields. If at least one field is successfully set, the unit will respond with a set fields response containing the field IDs of the successfully set fields. If any field is unable to be set, the unit will respond with an error response. Note that both a set fields and an error response may be received as a result of one set fields command. Attempts to set a field with an invalid value is one way to generate an error response. A table of field IDs and valid field values is available in Section 8.1.

SF Payload					
Byte Offset	*Name*	*Format*	*Scaling*	*Units*	*Descript ion*
0	numFields	U1	•	•	The number of fields to set
1	field0	U2	•	•	The first field ID to set
3	field0Dat a	U2	•	•	The first field ID's data to set
5	field1	U2	•	•	The second field ID to set
7	field1Dat a	U2	•	•	The second field ID's data to set
…	…	U2	•	•	…
numFields *4 -3	field…	U2	•	•	The last field ID to set
numFields *4 -1	**field…Dat** a	U2	•	•	The last field ID's data to set

Set Fields Response

Set Fields ('SF' = 0x5346)				
Preamble	*Packet Type*	*Length*	*Payload*	*Terminatio n*
0x5555	0x5346	1+numFields *2	<SF payload>	<CRC (U2)>

The unit will send this packet in response to a set fields command if the command has completed without errors.

SF Payload					
Byte Offset	*Name*	*Format*	*Scaling*	*Units*	*Descript ion*
0	numFields	U1	•	•	The number of fields set
1	field0	U2	•	•	The first field ID set
3	field1	U2	•	•	The second field ID set
…	…	U2	•	•	More field IDs set
numFields *2 - 1	Field…	U2	•	•	The last field ID set

8.8 Read Fields Command

Read Fields ('RF' = 0x5246)				
Preamble	*Packet Type*	*Length*	*Payload*	*Termination*
0x5555	0x5246	1+numFields *2	<RF payload>	<CRC (U2)>

This command allows the user to read the default power-up configuration fields from the EEPROM. *NumFields* is the number of fields to read. The *field0, field1, etc.* are the field IDs to read. RF may be used to read configuration and calibration fields from the EEPROM. If at least one field is successfully read, the unit will respond with a read fields response containing the field IDs and data from the successfully read fields. If any field is unable to be read, the unit will respond with an error response. Note that both a read fields and an error response may be received as a result of a read fields command.

RF Payload					
Byte Offset	*Name*	*Format*	*Scaling*	*Units*	*Description*
0	numFields	U1	•	•	The number of fields to read
1	field0	U2	•	•	The first field ID to read
3	field1	U2	•	•	The second field ID to read
...	...	U2	•	•	More field IDs to read
numFields *2 - 1	Field...	U2	•	•	The last field ID to read

8.9 Read Fields Response

Read Fields ('RF' = 0x5246)				
Preamble	*Packet Type*	*Length*	*Payload*	*Terminatio n*
0x5555	0x5246	1+numFields *4	<RF payload>	<CRC (U2)>

The unit will send this packet in response to a read fields request if the command has completed without errors.

RF Payload					
Byte Offset	*Name*	*Format*	*Scaling*	*Units*	*Descripti ion*
0	numFields	U1	•	•	The number of fields read
1	field0	U2	•	•	The first field ID read
3	field0Dat a	U2	•	•	The first field ID's data read
5	field1	U2	•	•	The second field ID read
7	field1Dat a	U2	•	•	The second field ID's data read
. . .	. . .	U2	•	•	. . .
numFields *4 -3	field. . .	U2	•	•	The last field ID read
numFields *4 -1	field. . . Dat a	U2	•	•	The last field ID's data read

8.10 Get Fields Command

Get Fields ('GF' = 0x4746)				
Preamble	*Packet Type*	*Length*	*Payload*	*Termination*
0x5555	0x4746	1+numFields *2	<GF Data>	<CRC (U2)>

This command allows the user to get the unit's current configuration fields. *NumFields* is the number of fields to get. The *field0, field1, etc.* are the field IDs to get. GF may be used to get configuration, calibration, and algorithm fields from RAM. Multiple algorithm fields will not necessarily be from the same algorithm iteration. If at least one field is successfully collected, the unit will respond with a get fields response with data containing the field IDs of the successfully received fields. If any field is unable to be received, the unit will respond with an error response. Note that both a get fields and an error response may be received as the result of a get fields command.

GF Payload					
Byte Offset	Name	Format	Scaling	Units	Description
0	numFields	U1	•	•	The number of fields to get
1	field0	U2	•	•	The first field ID to get
3	field1	U2	•	•	The second field ID to get
…	…	U2	•	•	More field IDs to get
numFields *2 – 1	Field…	U2	•	•	The last field ID to get

8.11 Get Fields Response

Get Fields (‘GF’ = 0x4746)				
Preamble	Packet Type	Length	Payload	Termination
0x5555	0x4746	1+numFields*4	<GF Data>	<CRC (U2)>

The unit will send this packet in response to a get fields request if the command has completed without errors.

GF Payload					
Byte Offset	Name	Format	Scaling	Units	Descriptio n
0	numFields	U1	•	•	The number of fields retrieved
1	field0	U2	•	•	The first field ID retrieved
3	field0Dat a	U2	•	•	The first field ID’s data retrieved
5	field1	U2	•	•	The second field ID retrieved
7	field1Dat a	U2	•	•	The second field ID’s data
…	…	U2	•	•	…
numFields *4 -3	field…	U2	•	•	The last field ID retrieved
numFields *4 -1	field…Dat a	U2	•	•	The last field ID’s data retrieved

CHAPTER 9

Advanced BIT

9.1 Built In Test (BIT) and Status Fields

Internal health and status are monitored and communicated in both hardware and software. The ultimate indication of a fatal problem is a hardware BIT signal on the user connector which is mirrored in the software BIT field as the masterFail flag. This flag is thrown as a result of a number of instantly fatal conditions (known as a "hard" failure) or a persistent serious problem (known as a "soft" failure). Soft errors are those which must be triggered multiple times within a specified time window to be considered fatal. Soft errors are managed using a digital high-pass error counter with a trigger threshold.

The masterStatus flag is a configurable indication as determined by the user. This flag is asserted as a result of any asserted alert signals which the user has enabled.

The hierarchy of BIT and Status *fields* and signals is depicted here:

- *BITstatus Field*
  - masterFail
    - hardwareError
      - *hardwareBIT Field*
      - powerError
      - *hardwarePowerBIT Field*
      - inpPower
      - inpCurrent
      - inpVoltage
      - fiveVolt
      - threeVolt
      - twoVolt
      - twoFiveRef

- sixVolt
- grdRef
- environmentalError
- *hardwareEnvironmentalBIT Field*
- pcbTemp

* comError
  - *comBIT Field*
  - serialAError
  - *comSerialABIT Field*
  - transmitBufferOverflow
  - receiveBufferOverflow
  - framingError
  - breakDetect
  - parityError
  - serialBError
  - *comSerialBBIT Field*
  - transmitBufferOverflow
  - receiveBufferOverflow
  - framingError
  - breakDetect
  - parityError
* softwareError
  - *softwareBIT Field *
  - algorithmError
  - *softwareAlgorithmBIT Field*
  - initialization
  - overRange
  - missedIntegrationStep
  - dataError
  - *softwareDataBIT Field*
  - calibrationCRCError
  - magAlignOutOfBounds

– masterStatus
  * hardwareStatus
    - *hardwareStatus Field*
    - unlocked1PPS (N/A)

      - unlockedInternalGPS (N/A)
      - noDGPS (N/A)
      - unlockedEEPROM
    - comStatus
      - *comStatus Field*
      - noExternalGPS (Default)
    - softwareStatus
      - *softwareStatus Field*
      - algorithmInitialization (enabled by default)
      - highGain (enabled by default)
      - attitudeOnlyAlgorithm
      - turnSwitch
    - sensorStatus
      - *sensorStatus Field*
      - overRange (enabled by default)

9.2 Master BIT and Status (BITstatus) Field

The BITstatus field is the global indication of health and status of the MTLT1 Series product (See Table 29). The LSB contains BIT information and the MSB contains status information.

There are four intermediate signals that are used to determine when masterFail and the hardware BIT signal are asserted. These signals are controlled by various systems checks in software that are classified into three categories: hardware, communication, and software. Instantaneous soft failures in each of these four categories will trigger these intermediate signals, but will not trigger the masterFail until the persistency conditions are met.

There are four intermediate signals that are used to determine when the masterStatus flag is asserted: hardwareStatus, sensorStatus, comStatus, and softwareStatus. masterStatus is the logical OR of these intermediate signals. Each of these intermediate signals has a separate field with individual indication flags. Each of these indication flags can be enabled or disabled by the user. Any enabled indication flag will trigger the associated intermediate signal and masterStatus flag.

14. MTLT1 BIT Status Field

BITstatus Field	Bits	Meaning	Category
masterFail	0	0 = normal, 1 = fatal error has occurred	BIT
HardwareError	1	0 = normal, 1= internal hardware error	BIT
comError	2	0 = normal, 1 = communication error	BIT
softwareError	3	0 = normal, 1 = internal software error	BIT
Reserved	4:7	N/A	
masterStatus	8	0 = nominal, 1 = hardware, sensor, com, or software alert	Status
hardwareStatus	9	0 = nominal, 1 = programmable alert	Status
comStatus	10	0 = nominal, 1 = programmable alert	Status
softwareStatus	11	0 = nominal, 1 = programmable alert	Status
sensorStatus	12	0 = nominal, 1 = programmable alert	Status
Reserved	13:15	N/A	

9.3 hardwareBIT Field

The hardwareBIT field contains flags that indicate various types of internal hardware errors (See Table 30). Each of these types has an associated message with low level error signals. The hardwareError flag in the BITstatus field is the bit-wise OR of this hardwareBIT field.

15. MTLT1 Hardware BIT Field

hardwareBIT Field	Bits	Meaning	Category
powerError	0	0 = normal, 1 = error	Soft
environmentalError	1	0 = normal, 1 = error	Soft
reserved	2:15	N/A	

9.4 hardwarePowerBIT Field

The hardwarePowerBIT field contains flags that indicate low level power system errors (See Table 31). The powerError flag in the hardwareBIT field is the bit-wise OR of this hardwarePowerBIT field.

16. MTLT1 Hardware Power BIT Field

hardwarePowe rBIT Field	Bits	Meaning	Category
inpPower	0	0 = normal, 1 = | Soft out of bounds |	
inpCurrent	1	0 = normal, 1 = | Soft out of bounds |	
inpVoltage	2	0 = normal, 1 = | Soft out of bounds |	
fiveVolt	3	0 = normal, 1 = | Soft out of bounds |	
threeVolt	4	0 = normal, 1 = | Soft out of bounds |	
twoVolt	5	0 = normal, 1 = | Soft out of bounds |	
twoFiveRef	6	0 = normal, 1 = | Soft out of bounds |	
sixVolt	7	0 = normal, 1 = | Soft out of bounds |	
grdRef	8	0 = normal, 1 = | Soft out of bounds |	
Reserved	9:15	N/A	

9.5 hardwareEnvironmentalBIT Field

The hardwareEnvironmentalBIT field contains flags that indicate low level hardware environmental errors (See Table 32). The environmentalError flag in the hardwareBIT field is the bit-wise OR of this hardwareEnvironmentalBIT field.

17. MTLT1 Hardware Environment BIT Field

hardwareEnvi ron- mentalBIT Field	Bits	Meaning	Category
pcbTemp	0	0 = normal, 1 = out of bounds	Soft
Reserved	9:15	N/A	

9.6 comBIT Field

The comBIT field contains flags that indicate communication errors with external devices (See Table 33). Each external device has an associated message with low level error signals. The comError flag in the BITstatus field is the bit-wise OR of this comBIT field.

18. MTLT1 COM BIT Field

comBIT Field	Bits	Meaning	Category
serialAError	0	0 = normal, 1 = error	Soft
serialBError	1	N/A	
Reserved	2:15	N/A	

9.7 comSerialABIT Field

The comSerialABIT field (See Table 34) contains flags that indicate low level errors with external serial port A (the user serial port). The serialAError flag in the comBIT field is the bit-wise OR of this comSerialABIT field.

19. MTLT1 Serial Port A BIT Field

comSerialABI T Field	Bits	Meaning	Category
transmitBufferO verflow	0	0 = normal, 1 = overflow	Soft
receiveBufferOv erflow	1	0 = normal, 1 = overflow	Soft
framingError	2	0 = normal, 1 = error	Soft
breakDetect	3	0 = normal, 1 = error	Soft
parityError	4	0 = normal, 1 = error	Soft
Reserved	5:15	N/A	

9.8 softwareBIT Field

The softwareBIT field contains flags that indicate various types of software errors (See Table 36). Each type has an associated message with low level error signals. The softwareError flag in the BITstatus field is the bit-wise OR of this softwareBIT field.

20. MTLT1 Softrware BIT Field

softwareBIT Field	Bits	Meaning	Category
algorithmError	0	0 = normal, 1 = error	Soft
dataError	1	0 = normal, 1 = error	Soft
Reserved	2:15	N/A	

9.9 softwareAlgorithmBIT Field

The softwareAlgorithmBIT field contains flags that indicate low level software algorithm errors (See Table 37). The algorithmError flag in the softwareBIT field is the bit-wise OR of this softwareAlgorithmBIT field.

21. MTLT1 Software Algorithm BIT Field

SoftwareAlgo rithmBIT Field	Bits	Meaning	Category
initialization	0	0 = normal, 1 = error during algorithm initialization	Hard
overRange	1	0 = normal, 1 = fatal sensor over-range	Hard
missedNavigatio nStep	2	0 = normal, 1 = fatal hard deadline missed for navigation	Hard
Reserved	3:15	N/A	

9.10 softwareDataBIT Field

The softwareDataBIT field contains flags that indicate low level software data errors (See Table 38). The dataError flag in the softwareBIT field is the bit-wise OR of this softwareDataBIT field.

22. MTLT1 Software Data BIT Field

SoftwareData BIT Field*	Bits	Meaning	Category
calibrationCRCE rror	0	0 = normal, 1 = incorrect CRC on calibration EEPROM data or data has been compromised by a WE command.	Hard
magAlignOutOfBo unds	N/A	Parameter not implemented in this software version	N/A
Reserved	2:15	N/A	

9.11 hardwareStatus Field

The hardwareStatus field contains flags that indicate various internal hardware conditions and alerts that are not errors or problems (See Table 39). The hardwareStatus flag in the BITstatus field is the bit-wise OR of the logical AND of the hardwareStatus field and the hardwareStatusEnable field. The hardwareStatusEnable field is a bit mask that allows the user to select items of interest that will logically flow up to the masterStatus flag.

23. MTLT1 Hardware Status BIT Field

hardwareStatus Field*	Bits	Meaning
unlocked1PPS	0	0 = not asserted, 1 = asserted
unlockedInternalGPS	1	0 = not asserted, 1 = asserted
noDGPS	2	0 = DGPS lock, 1 = no DGPS
unlockedEEPROM	3	0=locked, WE disabled, 1=unlocked, WE enabled
Reserved	4:15	N/A

9.12 comStatus Field

The comStatus field contains flags that indicate various external communication conditions and alerts that are not errors or problems (See Table 40). The comStatus flag in the BITstatus field is the bit-wise OR of the logical AND of the comStatus field and the comStatusEnable field. The comStatusEnable field is a bit mask that allows the user to select items of interest that will logically flow up to the masterStatus flag.

24. MTLT COM Status BIT Field

comStatus Field	Bits	Meaning
noExternalGPS	0	N/A
Reserved	1:15	N/A

9.13 softwareStatus Field

The softwareStatus field contains flags that indicate various software conditions and alerts that are not errors or problems (See Table 41). The softwareStatus flag in the BITstatus field is the bit-wise OR of the logical AND of the softwareStatus field and the softwareStatusEnable field. The softwareStatusEnable field is a bit mask that allows the user to select items of interest that will logically flow up to the masterStatus flag.

25. MTLT1 Software Status Field

softwareStatus Field*	Bit*	Meaning
algorithmInit	0	0 = normal, 1 = the algorithm is in initialization mode
highGain	1	0 = low gain mode, 1 high gain mode
attitudeOnlyAlgorithm	2	0 = navigation state tracking, 1 = attitude only state tracking
turnSwitch	3	0 = off, 1 = yaw rate greater than turnSwitch threshold
Reserved	4:15	N/A

9.14 sensorStatus Field

The sensorStatus field contains flags that indicate various internal sensor conditions and alerts that are not errors or problems (See Table 42). The sensorStatus flag in the BITstatus field is the bit-wise OR of the logical AND of the sensorStatus field and the sensorStatusEnable field. The sensorStatusEnable field is a bit mask that allows the user to select items of interest that will logically flow up to the masterStatus flag.

26. MTLT1 Sensor Status Field

sensorStatus Field	Bits	Meaning
overRange	0	0 = not asserted, 1 = asserted
Reserved	1:15	N/A

9.15 Configuring the Master Status

The masterStatus byte and its associated programmable alerts are configured using the Read Field and Write Field command as described in Section 8, Advanced Commands. Table 43 shows the definition of the bit mask for configuring the status signals.

27. MTLT1 Master Status Byte Configuration Fields

configuration field	field ID	Valid Values	**Description* *
hardwareStatusEnable	0x0010	Any	Bit mask of enabled hardware status signals
comStatusEnable	0x0011	Any	Bit mask of enabled communication status signals
softwareStatusEnable	0x0012	Any	Bit mask of enabled software status signals
sensorStatusEnable	0x0013	Any	Bit mask of enabled sensor status signals

9.15.1 hardwareStatusEnable Field

This field is a bit mask of the hardwareStatus field (see BIT and status definitions). This field allows the user to determine which low level hardwareStatus field signals will flag the hardwareStatus and masterStatus flags in the BITstatus field. Any asserted bits in this field imply that the corresponding hardwareStatus field signal, if asserted, will cause the hardwareStatus and masterStatus flags to be asserted in the BITstatus field.

9.15.2 comStatusEnable Field

This field is a bit mask of the comStatus field (see BIT and status definitions). This field allows the user to determine which low level comStatus field signals will flag the comStatus and masterStatus flags in the BITstatus field. Any asserted bits in this field imply that the corresponding comStatus field signal, if asserted, will cause the comStatus and masterStatus flags to be asserted in the BITstatus field.

9.15.3 softwareStatusEnable Field

This field is a bit mask of the softwareStatus field (see BIT and status definitions). This field allows the user to determine which low level softwareStatus field signals will flag the softwareStatus and masterStatus flags in the BITstatus field. Any asserted bits in this field imply that the corresponding softwareStatus field signal, if asserted, will cause the softwareStatus and masterStatus flags to be asserted in the BITstatus field.

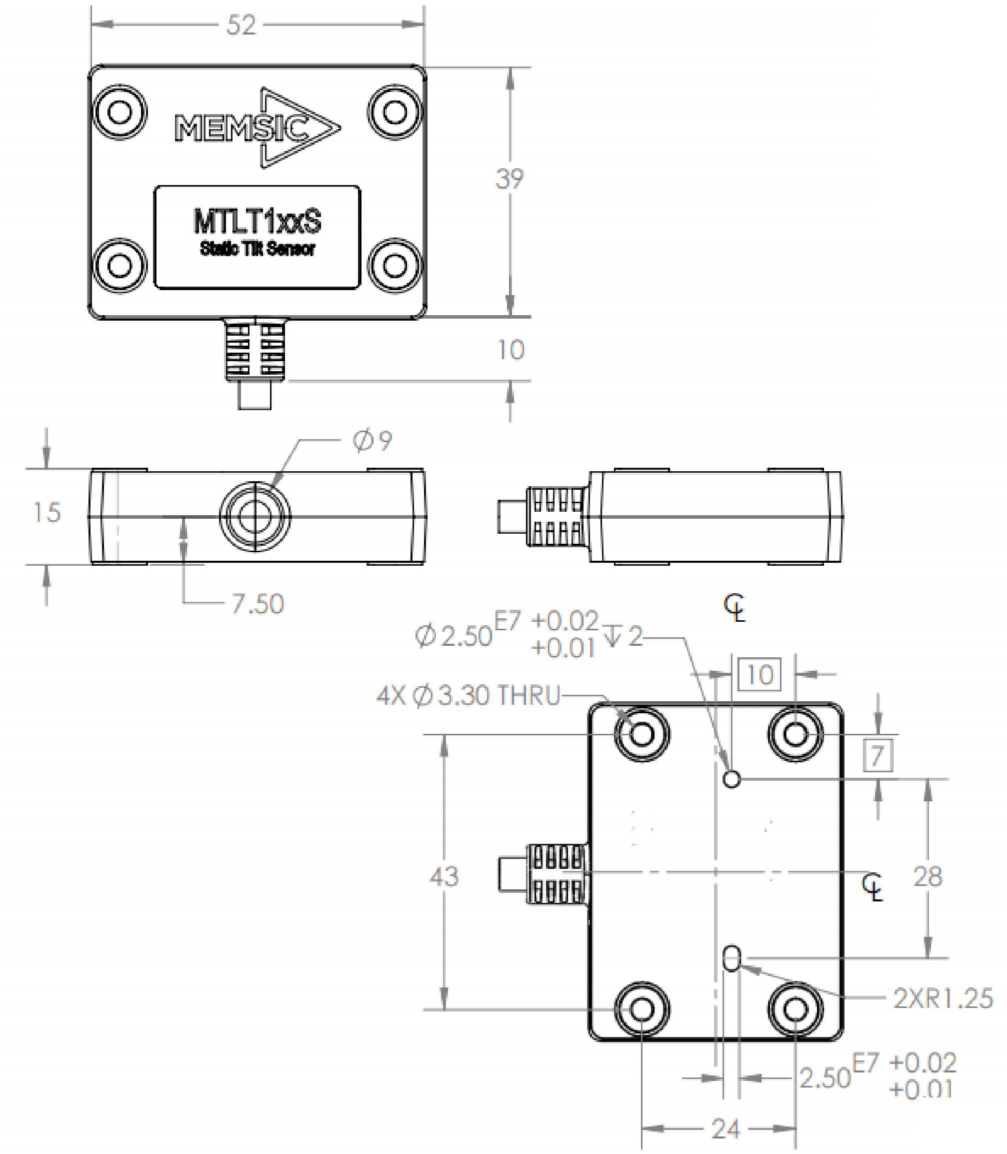
9.15.4 sensorStatusEnable Field

This field is a bit mask of the sensorStatus field (see BIT and status definitions). This field allows the user to determine which low level sensorStatus field signals will flag the sensorStatus and masterStatus flags in the BITstatus field. Any asserted bits in this field imply that the corresponding sensorStatus field signal, if asserted, will cause the sensorStatus and masterStatus flags to be asserted in the BITstatus field.

CHAPTER 10

Appendix A. Mechanical Specifications

7. MTLT1 Series Outline Drawing


52
39
10
MEMSIC
MTLT1xxS
Static Tilt Sensor
Ø9
15
7.50
Ø2.50 E7 +0.02 +0.01 ⊽ 2
4X Ø3.30 THRU
10
7
43
28
2XR1.25
2.50 E7 +0.02 +0.01
24

CHAPTER 11

Appendix C. Sample Packet-Parser Code

11.1 Overview

This appendix includes sample code written in ANSI C for parsing packets from data sent by the MTLT1 Series Tilt Systems. This code can be used by a user application reading data directly from the MTLT1 Series product, or perhaps from a log file.

The sample code contains the actual parser, but also several support functions for CRC calculation and circular queue access.:

- **process_memsic_packet** – for parsing out packets from a queue. Returns these fields in structure ACEINNA_PACKET (see below). Checks for CRC errors
- **calcCRC** – for calculating CRC on packets.
- **Initialize** - initialize the queue
- **AddQueue** - add item in front of queue
- **DeleteQueue** - return an item from the queue
- **peekWord** - for retrieving 2-bytes from the queue, without popping
- **peekByte** – for retrieving a byte from the queue without popping
- **Pop** - discard item(s) from queue
- **Size** – returns number of items in queue
- **Empty** – return 1 if queue is empty, 0 if not
- **Full** - return 1 if full, 0 if not full

The parser will parse the queue looking for packets. Once a packet is found and the CRC checks out, the packet's fields are placed in the ACEINNA_PACKET structure. The parser will then return to the caller. When no packets are found the parser will simply return to the caller with return value 0.

The ACEINNA_PACKET stucture is defined as follows:

typedef struct memsic_packet

```
{
unsigned short packet_type;
char length;
unsigned short crc;
char data[256];
} ACEINNA_PACKET;
```

Typically, the parser would be called within a loop in a separate process, or in some time triggered environment, reading the queue looking for packets. A separate process might add data to this queue when it arrives. It is up to the user to ensure circular-queue integrity by using some sort of mutual exclusion mechanism within the queue access functions.

11.2 Code listing

```
#include <stdio.h>
/* buffer size */
#define MAXQUEUE 500
/*
* circular queue
*/
typedef struct queue_tag
{
int count;
int front;
int rear;
char entry[MAXQUEUE];
} QUEUE_TYPE;
/*
* ACEINNA packet
*/
typedef struct memsic_packet
{
unsigned short packet_type;
char length;
unsigned short crc;
char data[256];
} ACEINNA_PACKET;
QUEUE_TYPE circ_buf;
```

```
/******************************************************************************
* FUNCTION: process_memsic_packet looks for packets in a queue
* ARGUMENTS: queue_ptr: is pointer to queue to process
* result: will contain the parsed info when return value is 1
* RETURNS: 0 when failed.
* 1 when successful
*******************************************************************************/
int process_memsic_packet(QUEUE_TYPE *queue_ptr, ACEINNA_PACKET *result)
{
unsigned short myCRC = 0, packetCRC = 0, packet_type = 0, numToPop=0, counter=0;
char packet[100], tempchar, dataLength;
if(Empty(queue_ptr))
{
return 0; /* empty buffer */
}
/* find header */
for(numToPop=0; numToPop+1<Size(queue_ptr) ;numToPop+=1)
{
if(0x5555==peekWord(queue_ptr, numToPop)) break;
}
Pop(queue_ptr, numToPop);
if(Size(queue_ptr) <= 0)
{
/* header was not found */
return 0;
}
/* make sure we can read through minimum length packet */
if(Size(queue_ptr)<7)
{
return 0;
}
/* get data length (5th byte of packet) */
dataLength = peekByte(queue_ptr, 4);
/* make sure we can read through entire packet */
if(Size(queue_ptr) < 7+dataLength)
{
```

```
return 0;
}
/* check CRC */
myCRC = calcCRC(queue_ptr, 2,dataLength+3);
packetCRC = peekWord(queue_ptr, dataLength+5);
if(myCRC != packetCRC)
{
/* bad CRC on packet – remove the bad packet from the queue and return */
Pop(queue_ptr, dataLength+7);
return 0;
}
/* fill out result of parsing in structure */
result->packet_type = peekWord(queue_ptr, 2);
result->length = peekByte(queue_ptr, 4);
result->crc = packetCRC;
for(counter=0; counter < result->length; counter++)
{
result->data[counter] = peekByte(queue_ptr, 5+counter);
}
Pop(queue_ptr, dataLength+7);
return 1;
}
/*****************************************************************************
* FUNCTION: calcCRC calculates a 2-byte CRC on serial data using
* CRC-CCITT 16-bit standard maintained by the ITU
* (International Telecommunications Union).
* ARGUMENTS: queue_ptr is pointer to queue holding area to be CRCed
* startIndex is offset into buffer where to begin CRC calculation
* num is offset into buffer where to stop CRC calculation
* RETURNS: 2-byte CRC
*****************************************************************************/
unsigned short calcCRC(QUEUE_TYPE *queue_ptr, unsigned int startIndex, unsigned int num) {
unsigned int i=0, j=0;
unsigned short crc=0x1D0F; //non-augmented inital value equivalent to augmented initial value 0xFFFF
for (i=0; i<num; i+=1) {
crc ^= peekByte(queue_ptr, startIndex+i) << 8;
```

```
for(j=0;j<8;j+=1) {
if(crc & 0x8000) crc = (crc << 1) ^ 0x1021;
else crc = crc << 1;
}
}
return crc;
}
/*****************************************************************************
* FUNCTION: Initialize - initialize the queue
* ARGUMENTS: queue_ptr is pointer to the queue
*****************************************************************************/
void Initialize(QUEUE_TYPE *queue_ptr)
{
queue_ptr->count = 0;
queue_ptr->front = 0;
queue_ptr->rear = -1;
}
/*****************************************************************************
* FUNCTION: AddQueue - add item in front of queue
* ARGUMENTS: item holds item to be added to queue
* queue_ptr is pointer to the queue
* RETURNS: returns 0 if queue is full. 1 if successful
*****************************************************************************/
int AddQueue(char item, QUEUE_TYPE *queue_ptr)
{
int retval = 0;
if(queue_ptr->count >= MAXQUEUE)
{
retval = 0; /* queue is full */
}
else
{
queue_ptr->count++;
queue_ptr->rear = (queue_ptr->rear + 1) % MAXQUEUE;
queue_ptr->entry[queue_ptr->rear] = item;
retval = 1;
```

```
}
return retval;
}
/****************************************************************************
* FUNCTION: DeleteQeue - return an item from the queue
* ARGUMENTS: item will hold item popped from queue
* queue_ptr is pointer to the queue
* RETURNS: returns 0 if queue is empty. 1 if successful
****************************************************************************/
int DeleteQueue(char *item, QUEUE_TYPE *queue_ptr)
{
int retval = 0;
if(queue_ptr->count <= 0)
{
retval = 0; /* queue is empty */
}
else
{
queue_ptr -> count–;
*item = queue_ptr->entry[queue_ptr->front];
queue_ptr->front = (queue_ptr->front+1) % MAXQUEUE;
retval=1;
}
return retval;
}
/****************************************************************************
* FUNCTION: peekByte returns 1 byte from buffer without popping
* ARGUMENTS: queue_ptr is pointer to the queue to return byte from
* index is offset into buffer to which byte to return
* RETURNS: 1 byte
* REMARKS: does not do boundary checking. please do this first
****************************************************************************/
char peekByte(QUEUE_TYPE *queue_ptr, unsigned int index) {
char byte;
int firstIndex;
firstIndex = (queue_ptr->front + index) % MAXQUEUE;
```

```
byte = queue_ptr->entry[firstIndex];
return byte;
}
/*******************************************************************************
* FUNCTION: peekWord returns 2-byte word from buffer without popping
* ARGUMENTS: queue_ptr is pointer to the queue to return word from
* index is offset into buffer to which word to return
* RETURNS: 2-byte word
* REMARKS: does not do boundary checking. please do this first
*******************************************************************************/
unsigned short peekWord(QUEUE_TYPE *queue_ptr, unsigned int index) {
unsigned short word, firstIndex, secondIndex;
firstIndex = (queue_ptr->front + index) % MAXQUEUE;
secondIndex = (queue_ptr->front + index + 1) % MAXQUEUE;
word = (queue_ptr->entry[firstIndex] << 8) & 0xFF00;
word |= (0x00FF & queue_ptr->entry[secondIndex]);
return word;
}
/*******************************************************************************
* FUNCTION: Pop - discard item(s) from queue
* ARGUMENTS: queue_ptr is pointer to the queue
* numToPop is number of items to discard
* RETURNS: return the number of items discarded
*******************************************************************************/
int Pop(QUEUE_TYPE *queue_ptr, int numToPop)
{
int i=0;
char tempchar;
for(i=0; i<numToPop; i++)
{
if(!DeleteQueue(&tempchar, queue_ptr))
{
break;
}
}
return i;
```

```
}
/*****************************************************************************
* FUNCTION: Size
* ARGUMENTS: queue_ptr is pointer to the queue
* RETURNS: return the number of items in the queue
********************************************************************************/
int Size(QUEUE_TYPE *queue_ptr)
{
return queue_ptr->count;
}
/*****************************************************************************
* FUNCTION: Empty
* ARGUMENTS: queue_ptr is pointer to the queue
* RETURNS: return 1 if empty, 0 if not
********************************************************************************/
int Empty(QUEUE_TYPE *queue_ptr)
{
return queue_ptr->count <= 0;
}
/*****************************************************************************
* FUNCTION: Full
* ARGUMENTS: queue_ptr is pointer to the queue
* RETURNS: return 1 if full, 0 if not full
********************************************************************************/
int Full(QUEUE_TYPE *queue_ptr)
{
return queue_ptr->count >= MAXQUEUE;
}
```

CHAPTER 12

Appendix D. Sample Packet Decoding

8. Example payload from Angle Data Packet 2 (A2)
9. Example payload from Scaled Data Packet 1 (S1)

CHAPTER 13

Warranty and Support Information

13.1 Customer Service

As a Aceinna customer you have access to product support services, which include:

- Single-point return service
- Web-based support service
- Same day troubleshooting assistance
- Worldwide Aceinna representation
- Onsite and factory training available
- Preventative maintenance and repair programs
- Installation assistance available

13.2 Contact Directory

United States: Phone: 1-408-964-9700 (8 AM to 5 PM PST)

Fax: 1-408-854-7702 (24 hours)

Email: techsupportca@memsic.com

Non-U.S.: Refer to website www.memsic.com

13.3 Return Procedure

13.3.1 Authorization

Before returning any equipment, please contact Aceinna to obtain a Returned Material Authorization number (RMA).

Be ready to provide the following information when requesting a RMA:

- Name
- Address
- Telephone, Fax, Email
- Equipment Model Number
- Equipment Serial Number
- Installation Date
- Failure Date
- Fault Description
- Will it connect to NAV-VIEW?

13.3.2 Identification and Protection

If the equipment is to be shipped to Aceinna for service or repair, please attach a tag TO THE EQUIPMENT, as well as the shipping container(s), identifying the owner. Also indicate the service or repair required, the problems encountered and other information considered valuable to the service facility such as the list of information provided to request the RMA number.

Place the equipment in the original shipping container(s), making sure there is adequate packing around all sides of the equipment. If the original shipping containers were discarded, use heavy boxes with adequate padding and protection.

13.3.3 Sealing the Container

Seal the shipping container(s) with heavy tape or metal bands strong enough to handle the weight of the equipment and the container.

13.3.4 Marking

Please write the words, "***FRAGILE, DELICATE INSTRUMENT***" in several places on the outside of the shipping container(s). In all correspondence, please refer to the equipment by the model number, the serial number, and the RMA number.

13.3.5 Return Shipping Address

Use the following address for all returned products:

> Aceinna, Inc.
>
> 3180 De La Cruz Blvd, #130
>
> Santa Clara, CA 95054
>
> Attn: RMA Number (XXXXXX)

13.4 Warranty

The Aceinna product warranty is one year from date of shipment.