JUPITER TMS
TRANSIENT MONITORING SYSTEM

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Jupiter TMS User Manual
Rev. 19.2, February 2019
Firmware Version: 19.2.18

Revision History

Status	Revision	Description	Author	Release Date
Released	18.1	Jupiter TMS User Manual.	SLS	October, 2018
Released	19.1	Added Windows/Linux share drive mapping configuration. Updated remote server documentation to include new customer dashboard login, user preferences, and waveform display login. Added option and documentation for external cellular modem interface.	SLS	January, 2019
Released	19.2	Updated local configuration interface definitions, local data access functionality, and local waveform viewing functionality. Added local system test documentation.	SLS	February, 2019

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Warranty Information:

NOTE: THE WARRANTY BELOW REPLACES ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. SLS SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT OR OTHERWISE. THE CUSTOMER IS RESPONSIBLE FOR THE TRANSPORTATION AND INSURANCE CHARGES FOR THE RETURN OF PRODUCTS TO THE SERVICE FACILITY. SLS WILL RETURN ALL PRODUCTS UNDER WARRANTY WITH TRANSPORT PREPAID.

The Jupiter TMS unit is warranted for normal use and operation, within specifications, for a period of one year from shipment. SLS will either repair or, at our discretion, replace any product returned to us within this period. However, in order to do this we must first examine the product and find that it is defective due to workmanship or materials and not due to misuse, neglect, accident, or abnormal conditions or operation. SLS shall not be responsible for any defect, damage, or failure caused by any of the following: a) attempted repairs or installations by personnel other than SLS representatives, or b) improper connection to incompatible equipment, or c) for any damage or malfunction caused by the use of non-SLS supplies. Furthermore, SLS shall not be obligated to service a product that has been modified or integrated where the modification or integration increases the task duration or difficulty of servicing the TMS. Spare and replacement parts, and repairs, all have a 90-day warranty. The Jupiter TMS firmware has been thoroughly tested and is presumed to be functional. Nevertheless, it is supplied without warranty of any kind covering detailed performance. Products not manufactured by SLS are covered solely by the warranty of the original equipment manufacturer.

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1 Jupiter TMS Part Number Index

Table 2: Jupiter TMS part number index, Version 2019, Revision A.

Jupiter TMS Part Number	Jupiter TMS Description
TMS-IF-19A	Indoor unit, fiber-optic communication, flat-surface mounting hardware (rubber feet).
TMS-IFW-19A	Indoor unit, fiber-optic communication, wall-mounting hardware (mounting tabs).
TMS-IFR-19A	Indoor unit, fiber-optic communication, 19-in rack-mounting hardware.
TMS-IE-19A	Indoor unit, Ethernet communication, flat-surface mounting hardware (rubber feet).
TMS-IEW-19A	Indoor unit, Ethernet communication, wall-mounting hardware (mounting tabs).
TMS-IER-19A	Indoor unit, Ethernet communication, 19-in rack-mounting hardware.
TMS-IC-19A	Indoor unit, cellular communication, flat-surface mounting hardware (rubber feet).
TMS-ICW-19A	Indoor unit, cellular communication, wall-mounting hardware (mounting tabs).
TMS-ICR-19A	Indoor unit, cellular communication, 19-in rack-mounting hardware.

2 Jupiter TMS Accessories

Table 3: Jupiter TMS accessories index.

Jupiter TMS Accessory	Part Number	Notes
3-Axis B-dot Antenna	SR-BDT-1L-300	See Appendix E for datasheet
Flat-Plate D-dot Antenna	SR-DDT-101-GP-03	See Appendix F for datasheet
Handheld Pulse Generator	SLS-PG-01	
Indoor GPS Kit	SLS-GPS-I	Ships with 3 m integrated coaxial cable and SMA/BNC coaxial adapter for mating to chassis.
Outdoor GPS Kit	SLS-GPS-O	Ships with outdoor-rated GPS antenna, Polyphasor GPS coaxial SPD, 25-ft and 50-ft low-loss coaxial cables, and appropriate coaxial adapters. Longer coaxial cables available upon request.
Universal Rack Rail Kit	SLS-URK-01	Rail kit for Jupiter TMS, 19-in rack mounting
Jupiter TMS AC/DC Power Supply	SLS-PS-01	24VDC power supply for Jupiter TMS
10-ft BNC Coaxial Cable	SLS-CA-10-BNC	
25-ft BNC Coaxial Cable	SLS-CA-25-BNC	
50-ft BNC Coaxial Cable	SLS-CA-50-BNC	
75-ft BNC Coaxial Cable	SLS-CA-75-BNC	
100-ft BNC Coaxial Cable	SLS-CA-100-BNC	
N-M to BNC-F Adapter	SLS-AD-NMBNCF	Utilize with B-dot and D-dot sensor outputs
50 Ω Cap Resistor	SLS-AD-50CRBNC	
Powertek Rogowski Current Monitors	-	Contact SLS for recommendations on specific Rogowski current monitors to fit your requirements.
Pearson Electronics Current Transformers	-	Contact SLS for recommendations on specific Pearson Electronics current transformers to fit your requirements.
Rogowski Current Monitor Conduit Interface Enclosure	SLS-EN-RG-01	Conduit interface enclosure to support four Rogowski current monitors (power and data) for power monitoring in critical facilities.

3 Jupiter TMS Unpacking

The Jupiter TMS packaging includes the following items:

1. Jupiter TMS
2. 24VDC power supply

Additional accessories (see Table 3) are shipped separately.

Jupiter TMS is shipped in a rigid shipping box with formed foam padding to protect the unit during the shipping process. When unpacking the Jupiter TMS unit, care should be taken when cutting the packing tape that secures the shipping box. If the protective foam is pierced by a cutting instrument, the Jupiter TMS chassis and external components may be subject to damage.

SLS recommends that Jupiter TMS users retain the original Jupiter TMS packaging for both safely transporting the unit, and for shipment to SLS if any future maintenance, re-calibration, etc. is required.

4 Jupiter TMS Specifications

Table 4: Jupiter TMS general specifications.

General	
Power Input	24 VDC
Power Consumption	25 W (nominal)
Battery Backup Capacity	2 hours (nominal)
External Communication	Fiber LAN, Ethernet, or Cellular modem
Local Communication	Ethernet
Timing	GPS (BNC input, 50 Ω)
Auxiliary Power Outputs	4 (12 V, 500 mA shared)
Environmental	
Temperature	0°C - 50°C
Relative Humidity	0% - 90% (non-condensing)
Altitude	up to 40,000-ft (controlled environment)
Enclosure	
Construction	Aluminum
Coating	Blue anodized
Mounting	Flat-surface, wall-mount, 19-in rack-mount
Weight	24-lbs
Length	18.65-in
Width	17-in (flat-surface, wall-mount), 19-in (rack-mount)
Height	5.5-in (flat-surface), 5.35-in (wall-mount), 5.25-in (rack-mount)
Data Acquisition	
Analog Channels	4
Connectivity	BNC, 50 Ω
Analog Inputs	Differential or Single-Ended
Sampling Rate	80 MS/s (up to 125 MS/s)
Bandwidth	41 MHz
Bit Depth	14-bit
Channel Memory	4 GB (total)
Permanent Storage	128 GB
Input Impedance	50 Ω, 1 MΩ
Input Coupling	DC, AC, GND
Range	±200 mV, ±2 V, ±20 V, ±200 V
Trigger	Edge (+/-), Window (enter/exit)
Logic Trigger	OR, AND

5 Jupiter TMS Safety Instructions

Jupiter TMS operators should observe the instructions provided in this section to ensure personal safety and the proper operation of the instrument.

Important: SLS does not assume any responsibility for the overall safety of integrated systems that may incorporate Jupiter TMS. Jupiter TMS may be utilized to provide transient monitoring for facility power applications and other applications where dangerous voltages and currents may be present. Users should understand the potential dangers of interfacing sensors to these systems, and should always consult a licensed electrician for installation. SLS does not assume any responsibility for personal injury and/or damage to infrastructure/equipment that may occur as a result of improper or unsafe system installation.

Chassis Grounding

The Jupiter TMS chassis must be bonded to the electrical ground using the $\frac{1}{4}$-in-20 ground stud located on the rear panel of the instrument (Figure 1).

Figure 1: Jupiter TMS chassis ground stud on rear panel.

Cooling Vents

Jupiter TMS is equipped with cooling vents on both the front and rear panels of the instrument (Figure 2). The vents allows forced air circulation through the instrument via the panel-mounted fan on the rear panel. Avoid placing objects within 6-in of the cooling vents to ensure proper air-flow.

Figure 2: Jupiter TMS chassis cooling vents.

Removal of Covers or Components

Do not remove Jupiter TMS covers, bulkhead-mount components, or internally-mounted components and wiring harnesses. For all Jupiter TMS system maintenance requirements, please contact SLS.

Faulty Operation Condition

If the Jupiter TMS unit fails to operate correctly, cease usage of the instrument and contact SLS for assistance. Operating the Jupiter TMS unit in a failure condition may result in further damage to the instrument.

Cleaning

Depending on the environment where Jupiter TMS is installed, dust may accumulate on the surfaces of the chassis. A vacuum may be used to remove dust from the chassis and the fan vents.

6 Jupiter TMS Operating Environment

Jupiter TMS is designed to be operated only in the indoor environment. Operating the unit outdoors will result in permanent damage to the unit.

Temperature

Jupiter TMS is designed to operate in an indoor environment with temperature range between 0°C and 50°C.

Relative Humidity

Jupiter TMS is designed to operate in an indoor environment with relative humidity varying between 0% and 90% (non-condensing).

Altitude

Jupiter TMS is rated to operate in a controlled environment (e.g., aboard aircraft) at altitudes up to 40,000-ft.

7 Jupiter TMS Dimensions & Mounting

Jupiter TMS supports three different mounting installation options. The customer should specify which mounting option(s) are desirable when ordering the system (reference Table 2).

1. Flat-surface installation
2. Wall-mount installation
3. Rack-mount installation

The outer dimensions of the Jupiter TMS chassis, including only the flat-surface mounting hardware, are the following:

Length: 18-65-in **Width:** 17-in **Height:** 5.5-in

With the wall-mounting installation kit, the outer dimensions of the Jupiter TMS chassis are the following:

Length: 18-65-in **Width:** 19-in **Height:** 5.35-in

With the rack-mounting installation kit, the outer dimensions of the Jupiter TMS chassis are the following:

Length: 18-65-in **Width:** 19-in **Height:** 5.25-in

The Jupiter TMS unit has a nominal weight of 24.5 lbs. Note the instrument weight will vary slightly depending on desired mounting hardware. The additional weight of the AC/DC power supply is 2.5 lbs.

Flat-Surface Installation

For benchtop installations or other installations on flat-surfaces where securing the Jupiter TMS unit is not required, the instrument is provided with rubber feet on the four bottom corners of the chassis (Figure 3). The rubber feet wiill prevent the Jupiter TMS chassis from sliding on the flat-surface under normal usage conditions. SLS recommends that the flat-surface mounting installation should only be utilized when risk of dropping or moving the unsecured instrument is determined to be sufficiently low.

Figure 3: Jupiter TMS flat-surface installation with rubber feet.

Wall-Mount Installation

The standard Jupiter TMS mounting installation includes the wall-mounting kit. Four removable mounting tabs are bolted to the bottom four corners of the chassis. Each tab includes a mounting hole to accommodate a $\frac{1}{4}$-in fastener. The mounting tabs may be utilized to mount the Jupiter TMS chassis to a solid surface (horizontal or vertical) in any configuration with the exception of upside-down (Figure 4). The restriction against upside-down mounting is due to the integrated sealed lead-acid battery that is part of automated battery-backup system. The battery manufacturer recommends against installing the battery in the upside-down orientation. When mounting the instrument, ensure that appropriate fasteners are utilized to support the instrument's weight.

Figure 4: Jupiter TMS wall-mount installation.

Rack-Mount Installation

Jupiter TMS is also offered with an optional rack-mounting kit that enables the unit to be securely mounted in a standard 19-in rack. With the rack mounting option, the front plate of the Jupiter TMS chassis is extended to mount directly into a 19-in rack through a series of holes designed to accommodate #10 fasteners. Prior to installing the Jupiter TMS unit in the rack, the included universal rail support kit (Gruber Model #34-102100) should be installed. Dimensions for the universal rail kit can be found at `https://www.cablesandkits.com/racks-cabinets/rackmount-rails/34-102100/pro-2721/`. The universal rail kit can accommodate racks with lengths ranging from 20.25-in to 33.25-in. To install the Jupiter TMS unit in the rack after the universal rail kit is installed, carefully slide the instrument onto the support rails until the front plate of the Jupiter TMS chassis contacts the rack. Then, secure the front panel of Jupiter TMS to the rack using #10 fasteners.

Important: Do not install the Jupiter TMS unit in a rack without the universal rail support kit. The front panel of the Jupiter TMS chassis is not designed to support the full weight of the instrument.

For high-vibration environments or where additional security is required, contact SLS for additional rack-mounting options.

Securing the Power Supply

For any of the three Jupiter TMS mounting configurations, ensure that the AC/DC power supply brick is properly secured. While the power supply connection to the rear panel of Jupiter TMS is a locking connection (via two slot head screws), do not hang the AC/DC power supply brick (2.5 lbs) from the power connection without proper support.

8 Jupiter TMS Connections

This section provides details on connectivity to the Jupiter TMS unit encompassing power, communication, monitoring, and test/measurement leads. Note that all connections described in this section may not be present depending on the options specified when the Jupiter TMS unit was purchased.

8.1 Power Supply & Fuse Holder

Jupiter TMS is shipped with a 220 W AC/DC power supply (Figure 5). The power supply part number is FSP220-AAAN2. Additional power supplies are available (see Table 3).

Figure 5: Jupiter TMS AC/DC power supply.

The power supply input is connected to facility power (100-240 V, 50-60 Hz) via a separate power cable (standard grounded 3-prong NEMA 5-15p to IEC 60320 C13). Note the included power cable is compatible with typical AC power outlets found in the United States, Canada, Mexico, and Japan. The power cable may be substituted with a similar grounded cable that includes the appropriate plug for the region of installation. The output of the included power supply is 24 VDC. The power supply plug (Phoenix Contact #1786857) connects to the rear panel of the Jupiter TMS Chassis through a keyed, panel-mount receptacle (Figure 6). Two small slot-head screws lock the power connector to the Jupiter TMS chassis. When the internal battery is fully charged, the maximum power consumption of Jupiter TMS is 25 W (at 24 VDC). Typical power consumption is 20 W (at 24 VDC). The Jupiter TMS chassis includes an integrated battery-backup system that will enable the system to operate for 2 hours (typical) in the absence of facility power.

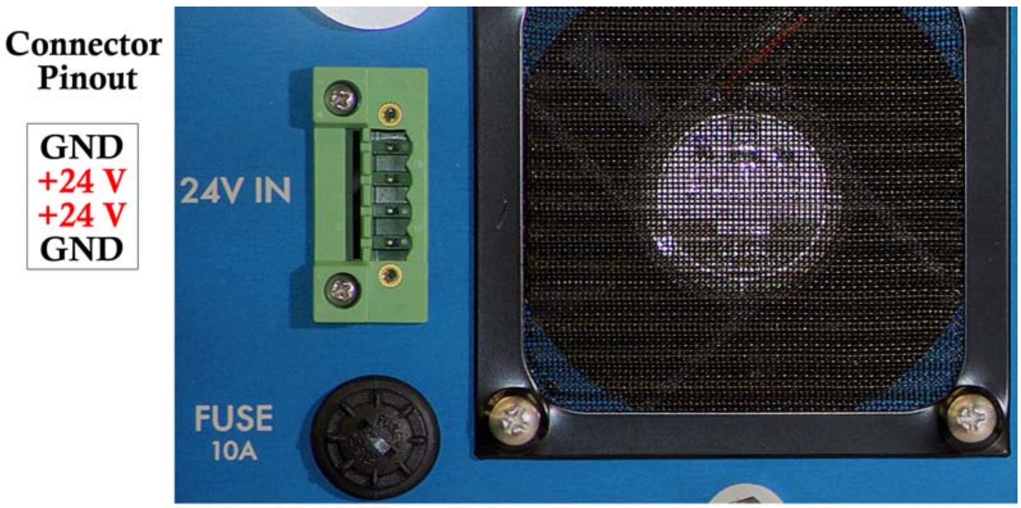


Figure 6: Jupiter TMS input power receptacle. The connector pin-out is shown at left.

The power input to Jupiter TMS is protected via an inline 5 A fuse. The fuse is accessible through the bulkhead-mount fuse holder shown in Figure 6. The fuse holder can be opened by inserting a medium-sized flat-head screwdriver into the exterior slot and turning counter-clockwise.

8.2 Cellular Antennas

Jupiter TMS is available with an integrated (in some markets) or external cellular modem (Sierra Wireless model RV50) for communication and data transmission. The datasheet for the cellular modem is available at `https://www.sierrawireless.com/products-and-solutions/routers-gateways/rv50/`. Multiple versions of the RV50 cellular modem are available to support LTE and WCDMA networks worldwide. Jupiter TMS model numbers that support cellular communication are provided in Table 2. The cellular modem requires two antennas for optimal link bandwidth. When the integrated cellular modem option is specified, Jupiter TMS is provided with two 50 Ω SMA female bulkhead connectors above the fan grating on the rear panel of the instrument (Figure 7). Cellular antennas (provided when the cellular option is specified) can be attached directly to the SMA female bulkhead connectors, or can be installed elsewhere and connected to the bulkhead connections via appropriate 50 Ω low-loss coaxial cables. For external cellular modems, the cellular modem is connected to the Jupiter TMS chassis via either the Ethernet or fiber-optic WAN port on the rear of the chassis (see Section 8.6). Note that when the cellular option is not specified, the mounting holes for the SMA bulkhead feed-through connectors are filled with appropriate fasteners.

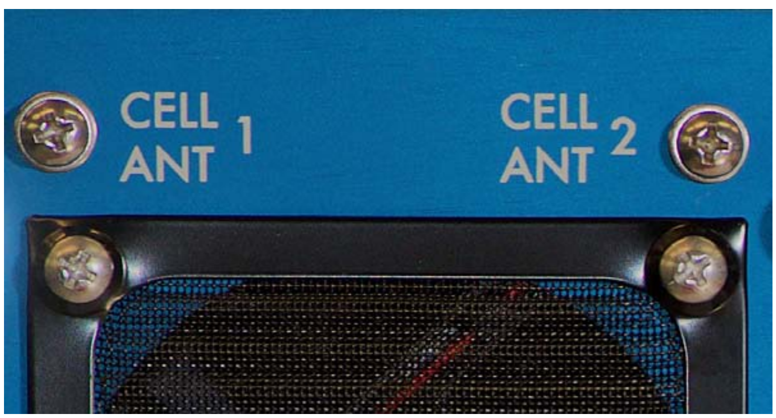


Figure 7: Jupiter TMS cellular antenna connections for an integrated cellular modem. Note that the mounting holes for the SMA female bulkhead feed-through connectors are filled with appropriate fasteners for this Jupiter TMS unit, which did not incorporate a cellular modem.

8.3 Auxiliary Power Outputs

Jupiter TMS is equipped with four 12 V auxiliary power connections located on the rear panel of the instrument (Figure 8). The combined power output capability of the four auxiliary power outputs is 6 W or 500 mA. Each output is fused internally at 350 mA via a resettable fuse.

Figure 8: Jupiter TMS auxiliary power ports on rear panel.

The output ports are connector part number Hirose #MXR-8RA-3S(71). The corresponding mating connector is part number Hirose #MKR-8PA-3PB(71). The pin-out of the panel-mount power connector is shown in Figure 9. Pin #2 provides 12 V, Pin #1 is ground, and Pin #3 is not connected.

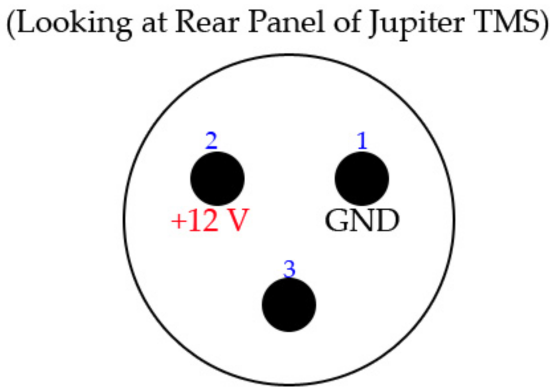


Figure 9: Jupiter TMS auxiliary power connector pin-out diagram.

The Jupiter TMS auxiliary power output ports can be used to power external signal conditioning electronics and active sensors. For critical facility power monitoring applications (see the *Critical Facility Application Note* in Appendix A), the Jupiter TMS auxiliary power outputs are used to provide power to four Rogowski current monitors that sense transient currents on three-phase facility power mains in addition to the ground current of the mains surge protective device (SPD). SLS offers a variety of Rogowski current monitors and the corresponding conduit interfacing enclosures for integration with Jupiter TMS. These accessories are provided in Table 3.

8.4 GPS Antenna Input

Jupiter TMS includes an integrated GPS timing receiver module that provides the data acquisition system with a precision time-base synchronized to Universal Coordinated Time (UTC). The GPS antenna connection is located on the rear panel of the instrument (Figure 10). SLS offers two GPS timing kits as accessories to the Jupiter TMS unit (see Table 3). For indoor usage (where GPS coverage is adequate inside the facility), the SLS-GPS-I kit provides a magnetic puck antenna with an integrated 3 m coaxial cable and a coaxial adapter to mate to the BNC female GPS timing input on the Jupiter TMS rear panel. For outdoor usage (where GPS coverage dictates that the antenna is placed outside the facility), the SLS-GPS-O kit provides an outdoor-rated surface-mount GPS antenna, a Polyphasor GPS coaxial surge protector, 25-ft and 50-ft low-loss coaxial cables, and the appropriate coaxial adapters. Longer coaxial cable lengths are available upon request.

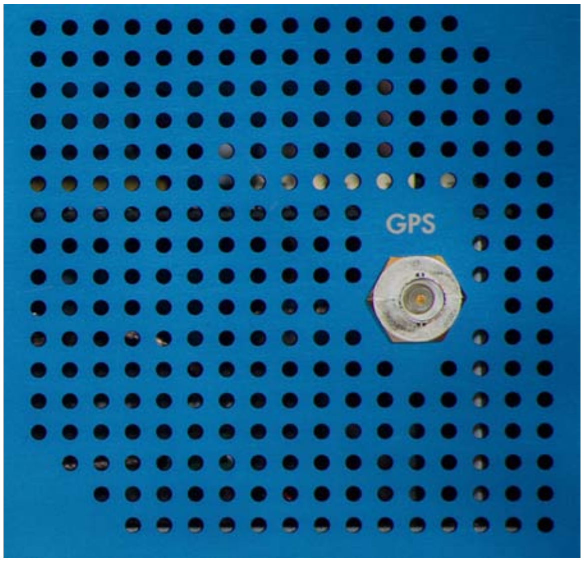


Figure 10: Jupiter TMS GPS antenna connection on rear panel.

8.5 Coaxial Data Acquisition Channel Inputs

Jupiter TMS has four differential input data acquisition channels. The channel inputs are labeled 1-4 on the front panel of the instrument (Figure 11). Each differential input channel consists of two BNC female bulkhead connectors that are individually labeled "+" for the positive input and "-" for the negative input. The Jupiter TMS differential input channels are software-configurable to be either 50 Ω or 1 MΩ inputs (see Section 9.7). Additionally, each input channel is software-configurable to four input voltage ranges (±200 mV, ±2 V, ±20 V, ±200 V). The maximum voltage ranges for each input input impedance and range are provided in Table 5. If signals outside the safe range of the Jupiter TMS data acquisition inputs are expected, external signal conditioning and/or inline signal attenuation will be required.

Jupiter TMS is a 50 Ω characteristic impedance system. To avoid impedance mismatches, coaxial cables connected to Jupiter TMS channel inputs should be 50 Ω characteristic impedance cables. Jupiter TMS may be used to digitize the outputs of both differential or single-ended output sensors. For

Table 5: Jupiter TMS coaxial input maximum voltage ratings as functions of channel input impedance (50 Ω or 1 MΩ) and channel input voltage range (±200 mV, ±2 V, ±20 V, ±200 V)

		Analog Channel Maximum Input Voltage Ranges			
		±200 mV	±2 V	±20 V	±200 V
Input	50 Ω	12 V RMS	12 V RMS	12 V RMS	12 V RMS
Impedance	1 MΩ	±200 V PK	±200 V PK	±200 V PK	±200 V PK

differential output sensors (such as typical magnetic field loop antennas), sensor output leads connect to both the positive and negative inputs of the input channel. For single-ended sensor outputs (such as many common current transformers, electric field sensors, etc.), the sensor output will typically be connected to the positive channel input while the negative channel input is left open. Note if a single-ended output sensor is connected to Jupiter TMS and the channel input impedance is set to 1 MΩ, it is good practice to cap the open channel input with a 50 Ω cap resistor (available from SLS as a Jupiter TMS accessory, see Table 3).

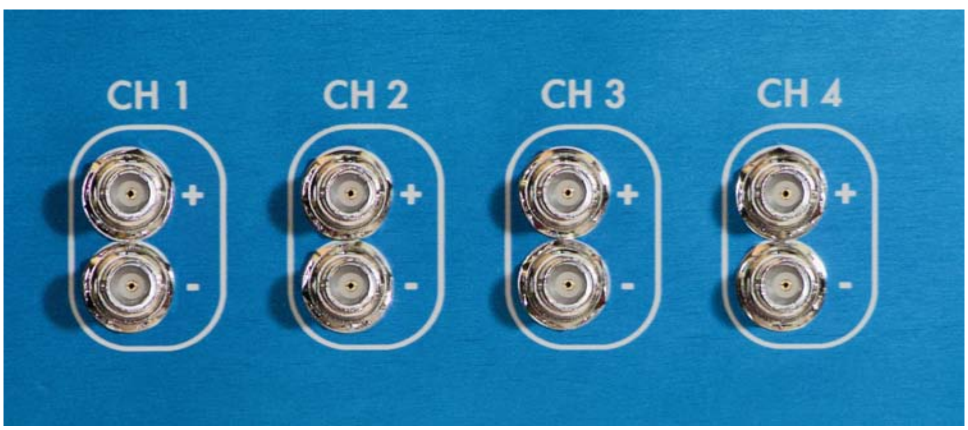


Figure 11: Jupiter TMS coaxial data acquisition input channels on the front panel.

8.6 Communications Ports

Jupiter TMS is equipped with four communications ports on the rear panel of the instrument (Figure 12). For units with the fiber-optic communication option, the "WAN" port is populated with a duplex LC termination single-mode fiber-optic coupler. For units with the cellular communication option, the "WAN" port is filled with a blank panel.

USB 1 (Reserved for SLS Use Only)

The USB 1 port provides a local serial console connection to the Jupiter TMS unit. This secured port is dedicated for SLS engineering usage for instrument diagnostics and troubleshooting.

USB 2

The USB 2 port provides an open USB connection that can be used to connect an external hard-disk or other storage media to the Jupiter TMS unit. Note this connection is not utilized in the standard Jupiter TMS configuration. If external storage is required, discuss your external storage requirements with SLS.

LAN

The LAN port provides local Ethernet connectivity to Jupiter TMS. The LAN port is used to perform local configuration of the Jupiter TMS network and data acquisition settings (see Section 9).

WAN

For Jupiter TMS units with the fiber-optic communication option, the WAN port provides "outside world" network connectivity to the instrument. The WAN port interface is a duplex 9/125 µm single-mode fiber-optic coupler that accepts LC-style fiber terminations.

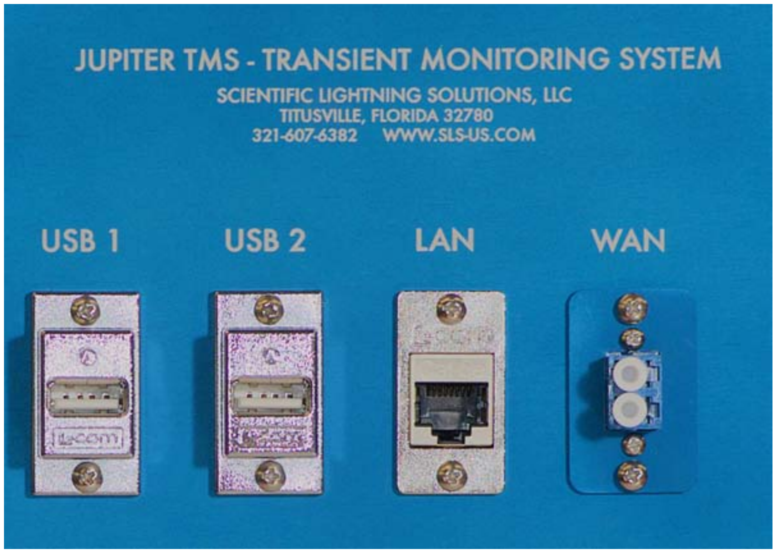


Figure 12: Jupiter TMS communications ports on the rear panel. This image shows the WAN port populated with the duplex fiber-optic coupler option for LC-style fiber terminations.

9 Jupiter TMS Setup & Configuration

This section details the Jupiter TMS startup procedure, network configuration, data acquisition settings configuration, data acquisition control, and the functionality of the LED front panel indicators related to system operation.

Jupiter TMS is designed to interface with a remote web server for automatic uploading of all acquired data, system status information, and alerts. The remote server also provides an online waveform display tool in addition to automated reporting capabilities. The remote web server is pre-configured for the customer prior to shipment of the Jupiter TMS unit. A customer may utilize a single remote server for multiple Jupiter TMS units. SLS provides the Jupiter TMS remote server for new customers for 6 months free of charge. Details on the remote server interface are provided in Section 11.

For installations where internet access or IT Security restrictions prevent the usage of a cloud-based remote server, Jupiter TMS interfaces with local Linux or Windows share drives for data transfer and off-unit file storage. Standalone applications are available for installation on a local workstation that mirror the browser-based applications that operate on the remote server.

Important: Jupiter TMS can be shipped to the customer with pre-configured network and data acquisition settings based on the customer's individual requirements. If the customer elects to have Jupiter TMS unit pre-configured, the external computer configuration (Section 9.2), network configuration (Section 9.4), and data acquisition configuration (Section 9.7) procedures outlined below may be initially disregarded. These procedures may be referenced at a later time if changes to the system configuration are required.

9.1 GPS Antenna Connection

Jupiter TMS obtains precision timing information from the GPS constellation through an external antenna interface. Recall the GPS antenna connection is located on the rear panel of the instrument (Figure 10).

> **Important:** In order for the internal timing engine within Jupiter TMS to lock to the GPS constellation and provide the unit with precision timing, the GPS antenna input must be connected to Jupiter TMS prior to powering on the unit.

9.2 External Computer Configuration

For Jupiter TMS systems that have not been pre-configured by SLS, operators will need to utilize an external computer (laptop or local workstation) to interface with Jupiter TMS during the configuration process. After the configuration process has been completed, the external computer is no longer required. Local communication to Jupiter TMS is handled through the LAN Ethernet interface on the rear panel of the instrument (see Section 8.6). On the external computer, configure a static IP address on the Ethernet port with the following settings:

IP Address: 192.168.1.10

Network Mask: 255.255.255.0

Connect a Cat 5/5e/6 Ethernet cable between the Ethernet port on the external workstation and the LAN port on the rear panel of Jupiter TMS (see Section 8.6).

9.3 System Power-Up

Ensure that the power plug from the AC/DC adapter (see Section 8.1) is attached to the Jupiter TMS power receptacle on the rear panel of the instrument. Jupiter TMS may be powered-on by pressing the push-button power switch on the front panel of the instrument (Figure 13). When the power switch is pressed, the operator will hear an audible mechanical click inside the unit associated with relay contact closure. Shortly thereafter, the LED light ring on the front panel power switch will illuminate in blue. When power is supplied to the data acquisition electronics internally, the “Power” indicator LED on the left side of the instrument front panel will illuminate green.

Figure 13: Jupiter TMS power switch on the front panel (left) and data acquisition electronics power LED indicator (right).

The boot procedure requires a typical time of about 1 minute. Near the end of the boot process, the “Status” and “Comm” LED indicators on the instrument front panel will briefly illuminate in orange (Figure 14). The operator will hear several audible clicks inside the unit associated with signal relays being exercised. During the boot process, the Jupiter TMS unit automatically collects a segment of data using the current data acquisition settings. During this test data collection, each coaxial input of Jupiter TMS is grounded (see Section 9.7). The DC voltage offset of each channel is measured and saved to internal storage. When the boot process has completed, the “Status” LED on the instrument front panel will illuminate in solid green to indicate the system is armed and ready to acquire data (Figure 14). If Jupiter TMS has been pre-configured by SLS, the network and data acquisition configurations are loaded on system power-up. The user may proceed to verifying communication status to the Linux remote server or Linux/Windows share drives (Section 9.5). Otherwise, the user may connect to Jupiter TMS through the LAN port by opening a web-browser on the external computer connected to Jupiter TMS and navigating to `192.168.1.70/`. The Jupiter TMS control center will be displayed when the address is accessed (Figure 15). The user may then proceed to the Network Configuration procedure (Section 9.4).

Important: If Jupiter TMS has not be pre-configured by SLS, the system will load a default data acquisition configuration on initial power-up. With the default data acquisition settings, the system triggers on all four triggers are disabled, and thus, the system will not trigger on any applied external signals connected to the coaxial input channels. If the Jupiter TMS network configuration settings have not been configured by SLS, the system will load a blank network configuration on initial power-up. The default network configuration does not include specified network parameters that allow the unit to connect to a remote server or share drive.

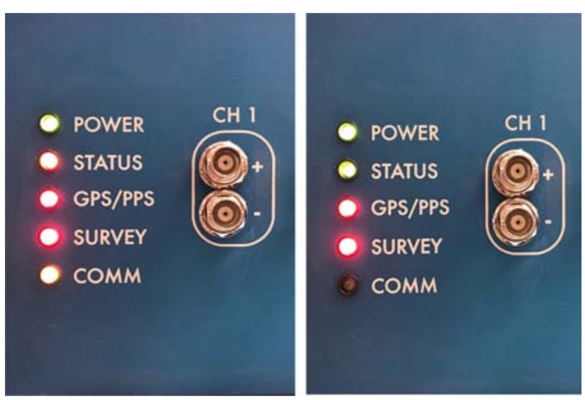


Figure 14: Jupiter TMS power front panel LED indicators during the boot process. At left, "Status" and "Comm" LEDs are briefly illuminated in orange near the end of the boot process. When the system is fully booted, armed, and ready to acquire data, the "Status" LED is illuminated in green (right).

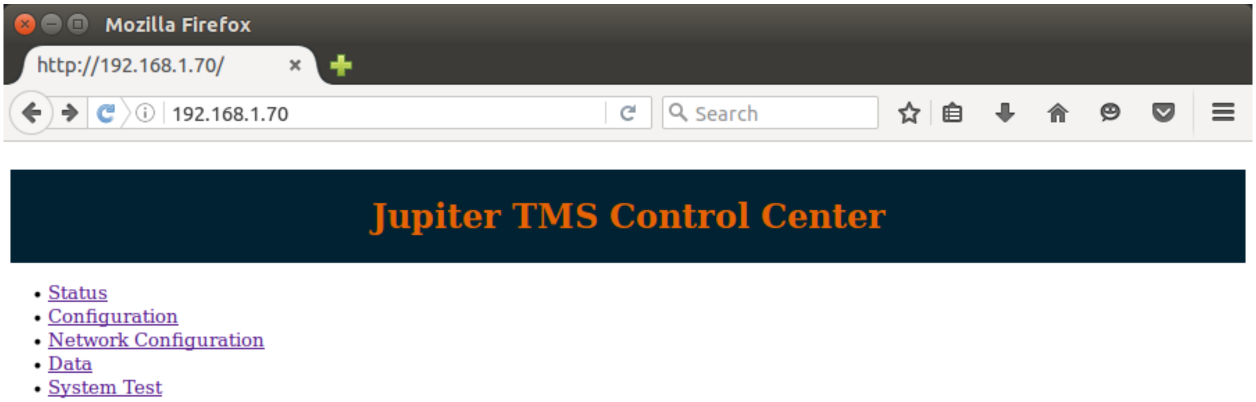


Figure 15: Jupiter TMS Control Center, accessed via navigating to `192.168.1.70/` from a web-browser window on a computer connected to the Jupiter TMS LAN port.

9.4 Network Configuration

Jupiter TMS network configuration settings are established via the local browser-based application. The network configuration page is accessed directly by navigating to `192.168.1.70/networkconfig/`, or by clicking the "Network Configuration" link from the Control Center (see Figure 15). Note that the network configuration settings may be provided to SLS in advance of Jupiter TMS shipment to the customer to allow for pre-configuration. Jupiter TMS supports three network configuration options for data transfer and off-unit file storage. The three network configuration options are described below.

1. **Linux Cloud Server:** The Linux cloud-based server is ideally suited for Jupiter TMS installations where outside-world network connectivity is available and IT Security restrictions allow connections (data transfer, file download, system configuration , etc.) via a remote server. The Linux cloud server connection provides the greatest flexibility and the most extensive collection of supporting utilities that can be accessed from any web-connected device.

2. **Linux NFS Share Drive:** For Jupiter TMS installations where outside-world internet access is not available, or IT Security restrictions dictate that Jupiter TMS data and system configuration are not accessible accept on a secure local network, Jupiter TMS can be configured to transfer all data to a mounted Linux NFS share drive on the secure local network. The NFS share drive can be hosted on either a local Linux server or on a local network workstation running either Linux or Mac OSX.

3. **Windows CIFS Share Drive:** For Jupiter TMS installations where outside-world internet access is not available, or IT Security restrictions dictate that Jupiter TMS data and system configuration are not accessible accept on a secure local network, Jupiter TMS can be configured to transfer all data to a mounted Windows CIFS share drive on the secure local network. The CIFS share drive can be hosted on either a local Windows server or on a local network workstation running Windows.

A screenshot of the Jupiter TMS network configuration page is shown in Figure 16. The Jupiter TMS network configuration option (Linux Cloud Server, Linux NFS Share Drive, or Windows CIFS Share Drive) is selected under the File Storage Media drop-down menu. The available user input fields on the form below change based on the user selection in the File Storage Media drop-down list.

If the “Linux Cloud Server” option is selected from the drop-down list, the following user-input fields are available:

Server IP Address

Enter the static IP address of the remote web server. The input field is expecting an IP address in the format “X.X.X.X” and will not allow submissions that do not meet the required format. The Server IP address field is a required entry. Note that the server IP address will be pre-populated by SLS. The field may be used to change the server IP address if required.

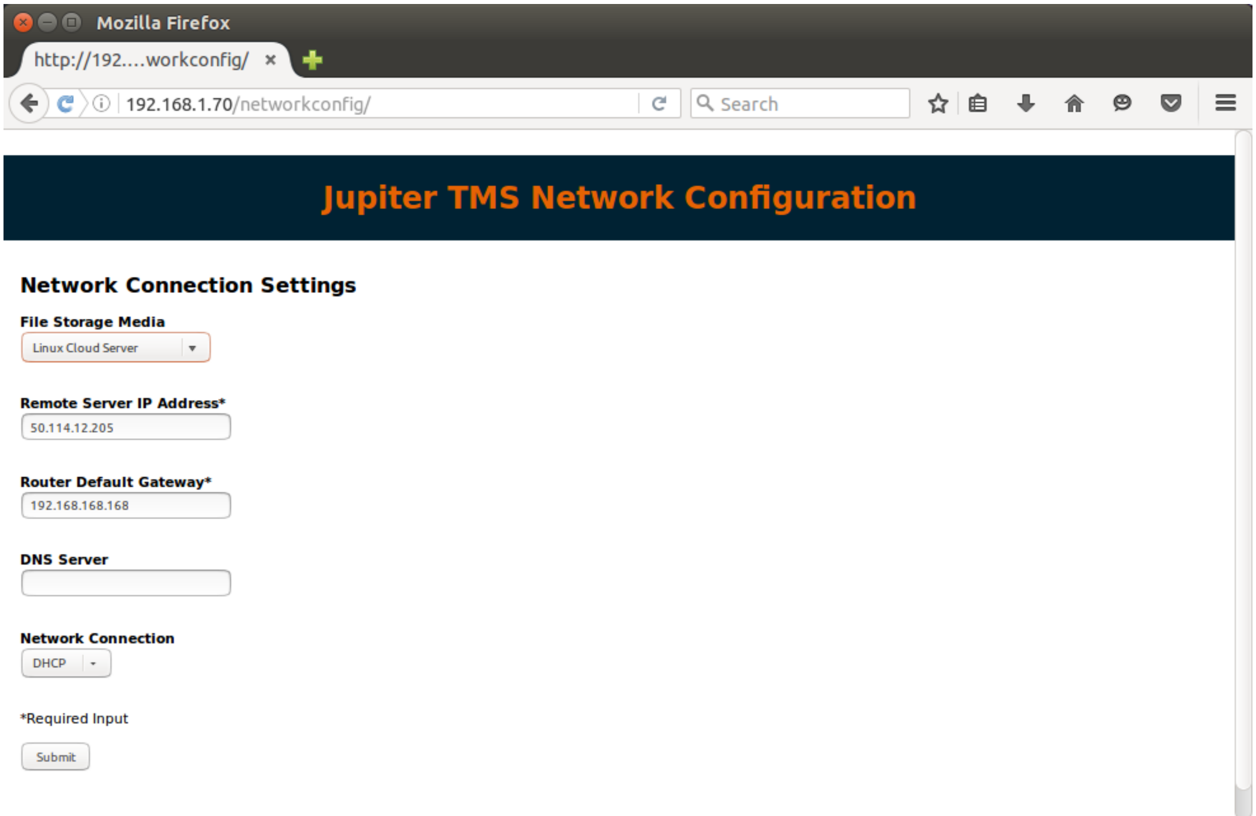


Figure 16: Jupiter TMS network configuration page. The page is accessed through the local Ethernet port on the rear panel of the Jupiter TMS chassis. In this case, the Linux Cloud Server connection option and the DHCP network connection are selected.

Default Gateway

Enter the default gateway of the router or access point that is providing the Internet connectivity to the Jupiter TMS system. The input field is expecting an default gateway address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The default gateway information can be obtained from the IT department of the organization. The default gateway field is a required entry.

DNS Server

The DNS server field is not a required entry for DHCP connections. If a specific DNS server is required, the address may be entered. The input field is expecting a DNS server address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. Specific DNS information can be obtained from the IT department of the organization.

Network Connection

The "Network Connection" drop-down menu allows the user to choose between a DHCP connection and a static IP address configuration. In Figure 16, the DHCP option is selected. If the Static IP option is selected, two additional fields are populated on the network configuration form (Figure 17).

Static IP Address

If the Static IP network configuration is selected, the Static IP address field is activated on the form. The input field is expecting an IP address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The Static IP Address field is a required entry if the network connection is selected to be Static IP. The static IP address will be allocated by the IT department of the organization.

Network Mask

If the Static IP network configuration is selected, the Network Mask field is activated on the form. The input field is expecting an network mask in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The Network Mask field is a required entry if the network connection is selected to be Static IP. The appropriate network mask can be obtained from the IT department of the organization.

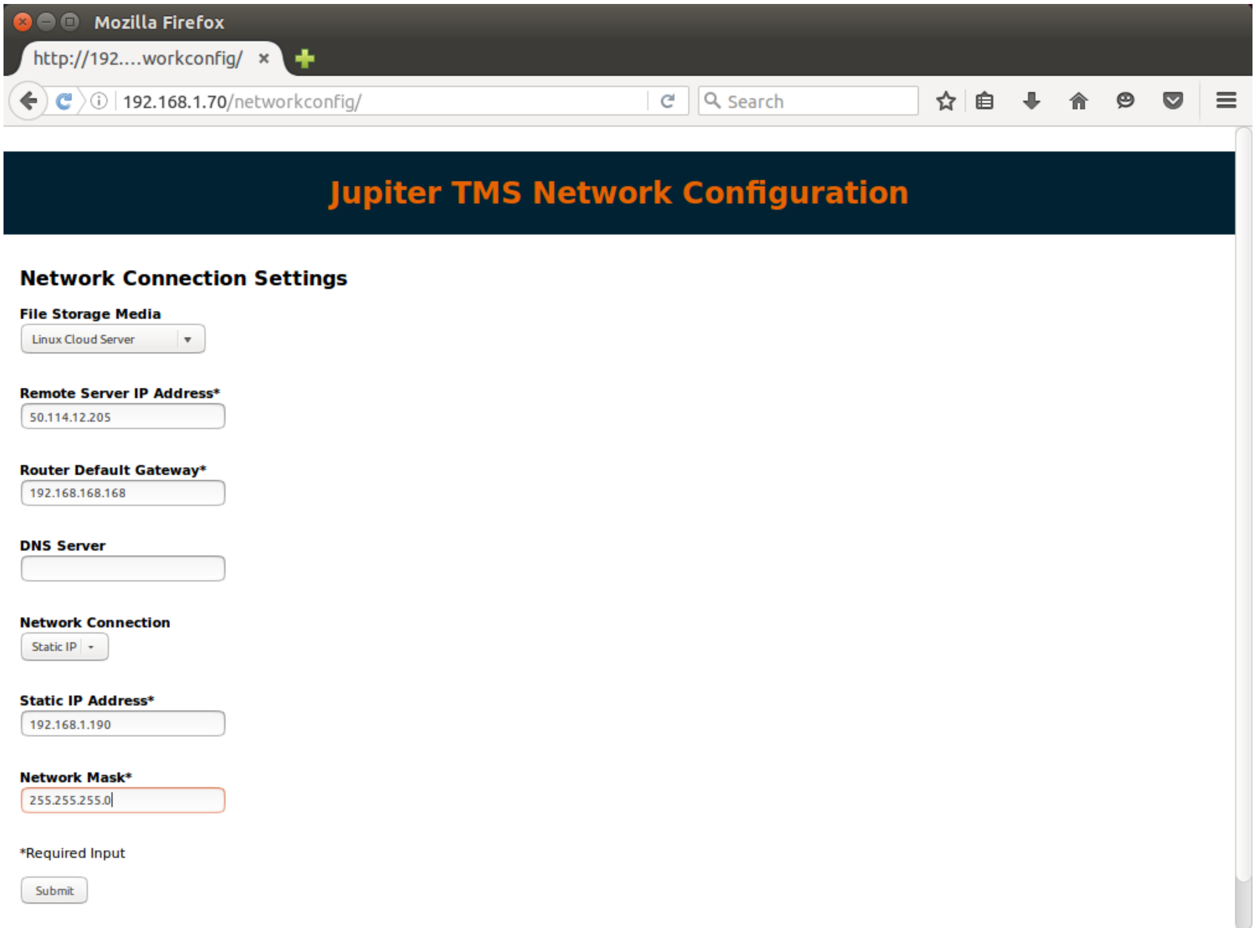


Figure 17: Jupiter TMS network configuration page, accessed via navigating to `192.168.1.70/networkconfig` from a web-browser window on a computer connected to the Jupiter TMS LAN port. In this case, the Linux Cloud Server connection option and the Static IP network configuration are selected.

If the "Linux NFS Share Drive" option is selected from the drop-down list (Figure 18), the following user-input fields are available:

Share Drive Host IP Address

Enter the static IP address of the server or workstation that hosts the NFS share drive. The input field is expecting an IP address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The Share Drive Host IP address field is a required entry.

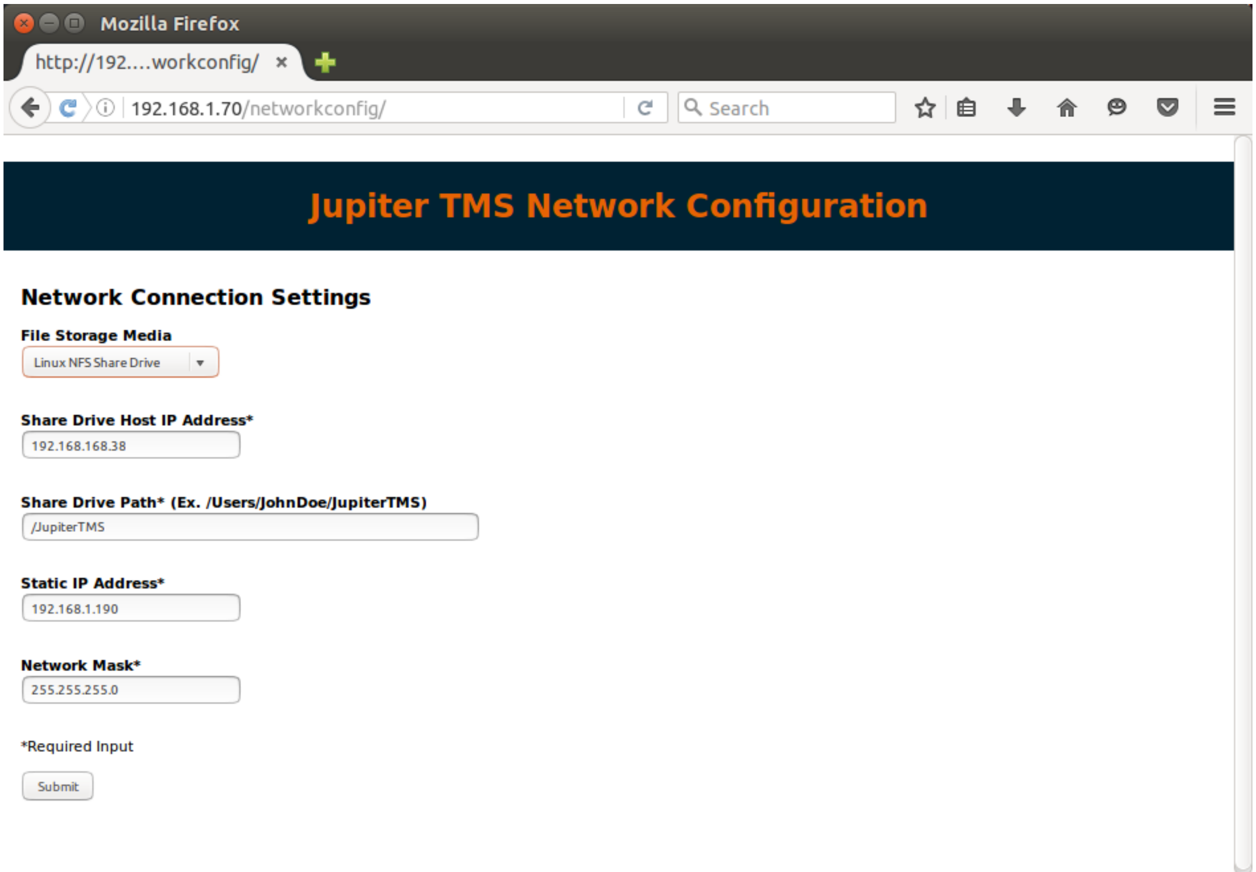


Figure 18: Jupiter TMS network configuration page, accessed via navigating to `192.168.1.70/networkconfig` from a web-browser window on a computer connected to the Jupiter TMS LAN port. In this case, the Linux NFS Share Drive option is selected.

Share Drive Path

Enter the full absolute path of the share drive on the server or workstation. Note the leading "/" is required.

Static IP Address

Enter the static IP address of the Jupiter TMS unit. The input field is expecting an IP address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The static IP address will be allocated by the IT department of the organization and should be on the same subnet as the Linux server or workstation that hosts the NFS share drive.

Network Mask

Enter the network mask of the Jupiter TMS unit. The input field is expecting an network mask in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The appropriate network mask can be obtained from the IT department of the organization.

If the "Windows CIFS Share Drive" option is selected from the drop-down list (Figure 19), the following user-input fields are available:

Share Drive Host IP Address

Enter the static IP address of the server or workstation that hosts the NFS share drive. The input field is expecting an IP address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The Share Drive Host IP address field is a required entry.

Share Drive Path

Enter the absolute path of the share drive on the server or workstation, excluding the domain name of the Windows server or workstation. For example, if the full path of the Windows share drive is "//WindowsUser/JupiterTMS", then the appropriate path to enter is "/JupiterTMS". Note the leading "/" is required.

Windows User Name

Enter the Windows user name of the Windows server or workstation.

Windows Password

Enter the Windows password of the Windows server or workstation.

Static IP Address

Enter the static IP address of the Jupiter TMS unit. The input field is expecting an IP address in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The static IP address will be allocated by the IT department of the organization and should be on the same subnet as the Windows server or workstation that hosts the CIFS share drive.

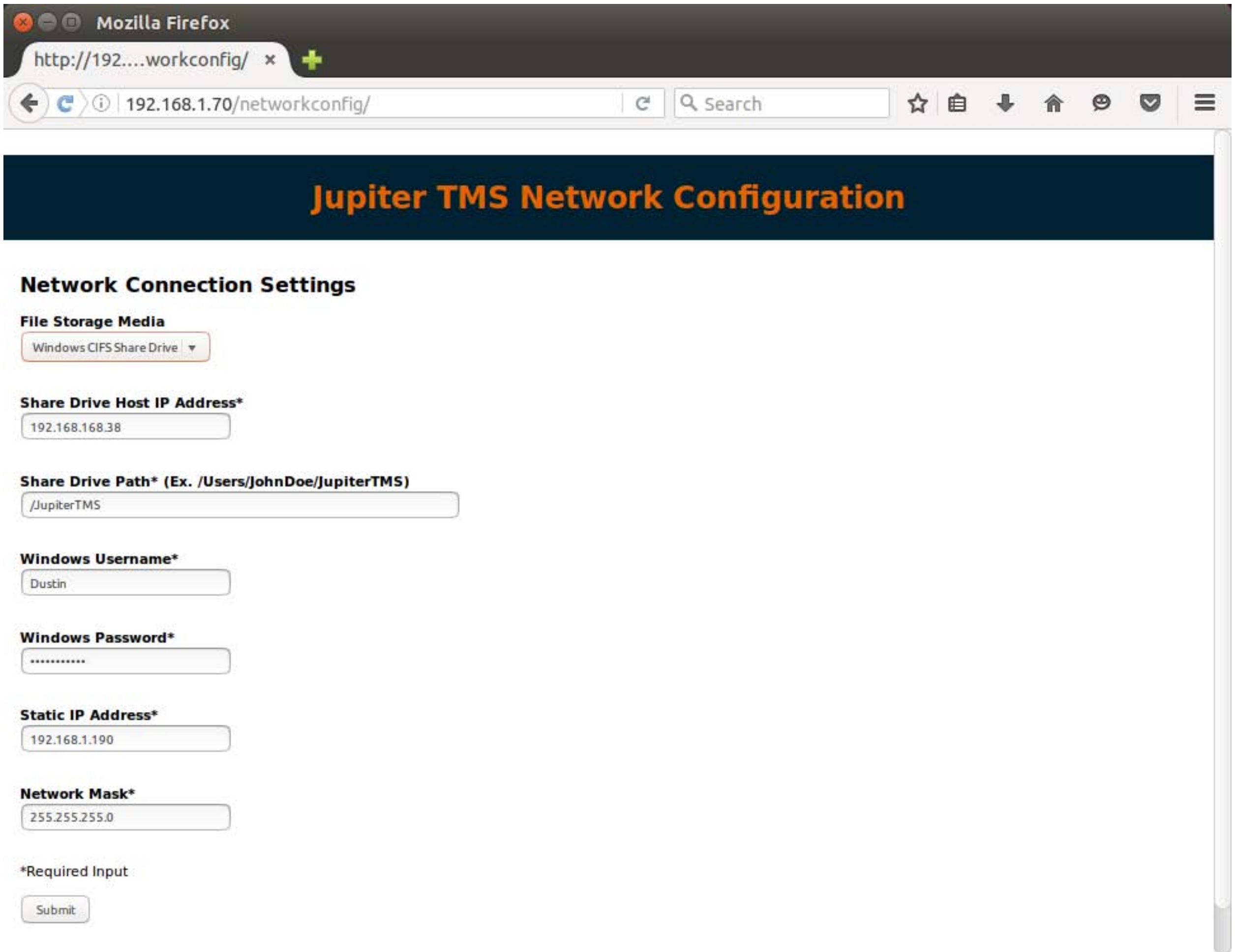


Figure 19: Jupiter TMS network configuration page, accessed via navigating to `192.168.1.70/networkconfig` from a web-browser window on a computer connected to the Jupiter TMS LAN port. In this case, the Windows CIFS Share Drive option is selected.

Network Mask

Enter the network mask of the Jupiter TMS unit. The input field is expecting an network mask in the format "X.X.X.X" and will not allow submissions that do not meet the required format. The appropriate network mask can be obtained from the IT department of the organization.

When the network configuration has been completed, the user should click the "Submit" button at the bottom of the form (Figure 16). To instantiate the network configuration changes, the Jupiter TMS unit must be power cycled. To power cycle the unit, the user should press the Power button on the front panel of the Jupiter TMS chassis (Figure 13), wait several seconds, and then power on the unit by again pressing the Power button. When the unit is powered on, the network changes that were selected will be instantiated.

9.5 Communication Status

After the network configuration has been established, the Jupiter TMS unit will automatically attempt to connect to the either the remote web server (IP address specified on the Network Configuration form, Figure 16) or the Linux/Windows share drive within one minute of the conclusion of the boot process. When the network connection has been successfully established, the "Comm" indicator LED on the chassis front panel will illuminate green (Figure 20). The Jupiter TMS unit transmits a "heartbeat" signal to the remote server or Linux/Windows share drive once a minute after the initial connection has been established to alert the remote server or Linux/Windows share drive (and the users) that the system is connected. If the heartbeat signal is successfully transmitted, the "Comm" LED will remain illuminated green. If the communication is lost between the Jupiter TMS unit and the remote server or Linux/Windows share drive, the "Comm" LED will illuminate red until network communication is restored.

For remote web server users, an indication of the connection status between Jupiter TMS and the remote server is immediately available through the graphical customer dashboard on the remote server (see Section 11). The remote server communication indicator mimics the function of the front panel "Comm" LED. For Linux/Windows share drive users, system network communication status is not available through a graphical user interface by default. Local system dashboard options are available for Linux/Windows share drive users upon request if the host server/workstation connected to the

Jupiter TMS unit supports the installation of peripheral software.

Figure 20: Jupiter TMS power front panel "Comm" LED is illuminated solid green when a successful connection has been established with the remote server or Linux/Windows share drive.

9.6 GPS Status

The internal timing engine inside Jupiter TMS will immediately begin the process of locking to the GPS constellation when power is applied to the unit. There are two LED indicators on the Jupiter TMS front panel that provide information on the GPS status. The "GPS/PPS" LED flashes in red with the 1 pulse-per-second (PPS) pulse, indicating the unit is receiving GPS signals from the constellation. If no GPS antenna is connected, or the unit is not receiving a GPS signal (due to local interference or other causes), the "GPS/PPS" LED will illuminate continuously red. The "Survey" LED indicator on the Jupiter TMS front panel provides information on the survey-status of the GPS lock to the constellation. When a Jupiter TMS system is installed and powered on, the initial "survey-in" period for the GPS lock can take up to 24 hours. During this time period, the timing engine is continuously improving its timing accuracy. When the survey-in period is complete (the timing engine determines that its location is established below a specified distance tolerance), the "Survey" LED indicator will illuminate green continuously. When the survey-in period is complete, the typical RMS timing accuracy of Jupiter TMS to UTC is better than 20 ns. If the Jupiter TMS unit is powered off, but kept in the same location, the subsequent survey-in period will be much shorter. Conversely, if the Jupiter TMS unit is powered off and transported to a different location, the survey-in duration will be the similar to the initial setup.

For pre-configured Jupiter TMS units, the system setup procedure is complete after the user has verified that the GPS is receiving PPS pulses from the constellation. The unit is now configured for unattended data acquisition. For Jupiter TMS units that have not been pre-configured by SLS, proceed to Section 9.7 and follow the procedure to configure the Jupiter TMS data acquisition system.

9.7 Data Acquisition & Channel Configuration

The Jupiter TMS data acquisition settings are configured through the local browser-based configuration page. The data acquisition configuration page is accessed by navigating directly to `192.168.1.70/config/`, or by clicking the "Configuration" link from the Control Center (see Figure 15). A screenshot of the Jupiter TMS channel configuration page is shown in Figure 21.

On initial system power-up, a default configuration is loaded and the system is automatically armed for acquiring data. This default configuration is persistent until an alternate configuration is loaded or entered by the user through the data acquisition configuration interface. The channel configuration interface allows the user to modify the Jupiter TMS analog input channel settings, trigger settings, and capture settings through an intuitive series of input fields, drop-down menus, and check-boxes. The general Jupiter TMS data acquisition settings are described below, followed by the channel-specific configuration settings.

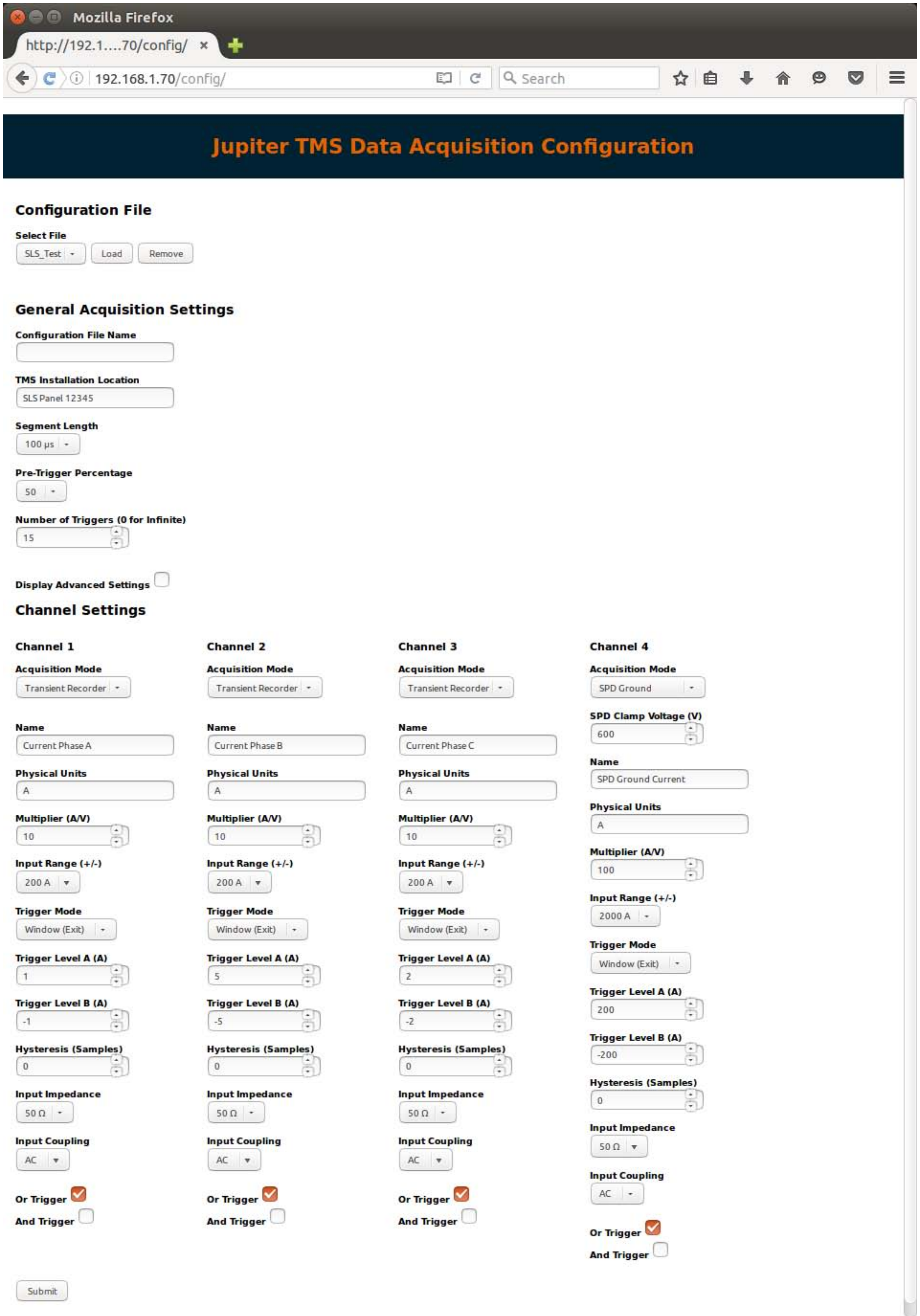


Figure 21: Jupiter TMS data acquisition configuration interface page.

Configuration File: Select File

The "Select File" drop-down menu allows the user to load settings from a previously-defined configuration file that has been saved to permanent storage. When the "Load" button is pressed, the configuration settings within the selected file are populated into the appropriate form fields on the page. Alternately, the user may delete a previously-defined configuration file from permanent storage by clicking the "Remove" button after selecting a file within the drop-down menu. Note the configuration file removal is permanent.

General Setting: Configuration File Name

When an existing configuration file is loaded or a new configuration is specified, the user must enter an alphanumeric (limit 20 character) configuration file name before submitting the configuration. If a duplicate file name is specified to a listed file in the configuration file drop-down menu, that file will be overwritten with the new configuration settings. Otherwise, a new configuration file will be created with the user-defined file name.

General Setting: TMS Installation Location

The "TMS Installation Location" field is a text input field that allows the user to specify a description of the installation location of the unit. For example, this field may be populated with an electrical panel designation if Jupiter TMS is installed to monitor transient on a facility mains power feed. The text input field has a maximum width of 20 alphanumeric characters. The user input text is written to an entry in the data acquisition file header (the data acquisition file header is defined in Appendix B of this document).

General Setting: Segment Length

The Jupiter TMS analog-to-digital converter (ADC) samples at a rate of 80 MS/s (12.5 ns/sample) with 14-bits of vertical resolution. Each sample point is saved in a two-byte word. The "Segment Length" drop-down menu allows the user to specify the length of each acquired data segment. Available options are listed in Table 6. Table 6 also includes the corresponding number of sample points that will be recorded based on the segment length specified, in addition to the approximate data acquisition file size associated with each segment length. Jupiter TMS is equipped with 4 GB of internal RAM, which enables each channel to capture about 6.25 s (500 million sample points) of continuous data before the internal RAM buffer is filled. The RAM is configured in a circular buffer, where samples recorded by the ADC are continuously written. When a valid trigger is received, the data stored in RAM are immediately read out to permanent storage. Note that the transfer speed from RAM to permanent storage is significantly less than the speed at which data samples are written to the RAM circular buffer. If the internal RAM buffer is filled due to an excessively high trigger rate, the system will continue to operate, but will be unable to store additional data until sufficient data have been automatically moved from RAM to permanent storage. For general transient monitoring applications, where high-bandwidth, short-duration signals are expected, segment lengths of the order of hundreds of microseconds to 10 milliseconds are recommended. In this more typical configuration, RAM buffer overruns should not occur unless trigger thresholds are erroneously set within the system noise, or unexpected transient signals occur on the monitored channels at excessively high rates.

General Setting: Pre-Trigger Percentage

The “Pre-Trigger Percentage” drop-down menu specifies where the trigger point should occur in the segment length specified, that is, how many pre-trigger and post-trigger samples occur relative to the trigger point. Pre-trigger percentages are available for selection in 10% increments from 0% to 100%. Table 7 tabulates the number of pre-trigger and post-trigger samples that are acquired for each possible segment length. For example, an 80000 sample point segment length with 50% specified in the trigger percentage input field would result in the trigger point occurring at sample number 40000. Similarly, a 20% pre-trigger percentage would result in the trigger point occurring at sample number 16000. Captured data segments will always contain the full post-trigger point number of samples, but may have a truncated number of pre-trigger samples if the pre-trigger window overlaps the post-trigger window of a previous trigger.

Jupiter TMS is a zero-deadtime transient recorder; that is, no samples of data are missed between subsequent triggers. For example, consider two triggers that occur spaced in time by exactly 0.75 ms. The time sequence is illustrated in Figure 22. In this case, The full pre-trigger and post-trigger windows are captured for the first trigger pulse, resulting in a record length of 80000 sample points. The subsequent trigger occurs exactly 0.25 ms after the end of the first data segment. In this case, the pre-trigger window of the subsequent data segment is truncated (including 0.25 ms of data instead of 0.5 ms of data) while the full post-trigger window is captured.

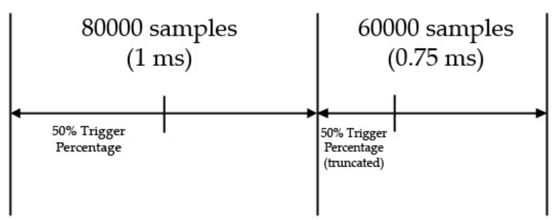


Figure 22: Illustration of LSP Jupiter TMS zero dead-time recording for consecutive triggers.

General Setting: Number of Triggers

The number of triggers input field specifies how many data segments Jupiter TMS should capture before the acquisition is disarmed. For infinite triggers, the user should enter a “0” in the number of triggers input field. For most applications of Jupiter TMS, where the unit is installed to provide continuous, unattended monitoring for critical facilities and assets, the user will configure the unit to record an infinite number of triggers. This will allow the unit to trigger each time a qualified transient is detected (without ever disarming). A user may specify a finite number of triggers during the initial setup of the system (for example, while performing an analysis of the local noise environment in order to properly set the trigger thresholds for each channel). Specifying a finite number of triggers may also be useful if the instrument is being utilized in an attended laboratory setting where the excitation is controlled. In this case, Jupiter TMS functions as a bench-top high-speed data recorder.

Table 6: Jupiter TMS available data segment lengths and corresponding sample points and data acquisition file sizes. The approximate number of files that can be simultaneously stored in acquisition RAM and in permanent SD card storage are also provided as a function of segment length.

Segment Length	Sample Points Per Channel	Total Sample Points (4 Channels)	Approximate File Size (4 Channels)	Approximate 4GB RAM File Capacity	Approximate 32GB SD Card File Capacity
10 µs	800	3.2K	6.4 KB	640K	5M
50 µs	4K	16K	32 KB	128K	1M
100 µs	8K	32K	64 KB	64K	500K
500 µs	40K	160K	320 KB	12.8K	100K
1 ms	80K	320K	640 KB	6.4K	50K
5 ms	400K	1.6M	3.2 MB	1.28K	10K
10 ms	800K	3.2M	6.4 MB	640	5K
50 ms	4M	16M	32 MB	128	1K
100 ms	8M	32M	64 MB	64	500
500 ms	40M	120M	320 MB	12	100

Table 7: Pre-trigger and post-trigger samples (pre, post) as a function of segment length and pre-trigger percentage.

	Pre-Trigger Percentage										
Segment Length	0	10	20	30	40	50	60	70	80	90	100
10 µs	0, 800	80, 720	160, 640	240, 560	320, 480	400, 400	480, 320	560, 240	640, 160	720, 80	800, 0
50 µs	0, 4K	400, 3.6K	800, 3.2K	1.2K, 2.8K	1.6K, 2.4K	2K, 2K	2.4K, 1.6K	2.8K, 1.2K	3.2K, 800	3.6K, 400	4K, 0
100 µs	0, 8K	800, 7.2K	1.6K, 6.4K	2.4K, 5.6K	3.2K, 4.8K	4K, 4K	4.8K, 3.2K	5.6K, 2.4K	6.4K, 1.6K	7.2K, 800	8K, 0
500 µs	0, 40K	4K, 36K	8K, 32K	12K, 28K	16K, 24K	20K, 20K	24K, 16K	28K, 12K	32K, 8K	36K, 4K	40K, 0
1 ms	0, 80K	8K, 72K	16K, 64K	24K, 56K	32K, 48K	40K, 40K	48K, 32K	56K, 24K	64K, 16K	72K, 800	80K, 0
5 ms	0, 400K	40K, 360K	80K, 320K	120K, 280K	160K, 240K	200K, 200K	240K, 160K	280K, 120K	320K, 80K	360K, 40K	400K, 0
10 ms	0, 800K	80K, 720K	160K, 640K	240K, 560K	320K, 480K	400K, 400K	480K, 320K	560K, 240K	640K, 160K	720K, 8K	800K, 0
50 ms	0, 4M	400K, 3.6M	800K, 3.2M	1.2M, 2.8M	1.6M, 2.4M	2M, 2M	2.4M, 1.6M	2.8M, 1.2M	3.2M, 800K	3.6M, 400K	4M, 0
100 ms	0, 8M	800K, 7.2M	1.6M, 6.4M	2.4M, 5.6M	3.2M, 4.8M	4M, 4M	4.8M, 3.2M	5.6M, 2.4M	6.4M, 1.6M	7.2M, 800K	8M, 0
500 ms	0, 40M	4M, 36M	8M, 32M	12M, 28M	16M, 24M	20M, 20M	24M, 16M	28M, 12M	32M, 8M	36M, 4M	40M, 0

Channel Setting: Acquisition Mode

The "Acquisition Mode" drop-down menu allows the user to choose between two acquisition modes (Transient Recorder mode and SPD Ground mode). Note that the acquisition mode setting does not effect the recording of the data, but rather instructs the system to populate additional fields in the data file header that are used by the automated server-side waveform display application (see Section 11.5) and reporting tools to perform analysis and calculations on the recorded data.

1. ***Transient Recorder Mode:*** Transient Recorder Mode is the standard acquisition mode of Jupiter TMS. This mode should be used for all measurements accept where the ground current of a Surge Protective Device (SPD) is being directly monitored.

2. ***SPD Ground Mode:*** SPD Ground Mode should be selected from the drop-down menu when the particular channel is being used to measure the ground current of a SPD (for example, the SPD on a critical facility incoming power mains). When the SPD Ground Mode is selected, an additional numerical input box is shown beneath the Acquisition Mode drop-down menu (see Figure 23). The user should enter the SPD Clamp Voltage in this numerical input box. The SPD clamp voltage is typically printed on the SPD casing, or is available in the product literature. When the acquired waveforms are transmitted to the remote server, an automated processing routine utilizes the measured SPD ground current and the user-defined SPD clamp voltage to calculate the energy dissipation of the SPD due to the measured transient. This value is reported to the user in the automatically generated report, and is available through the waveform display interface.

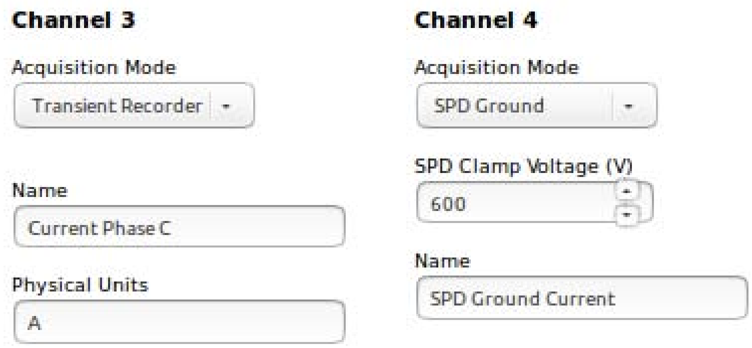


Figure 23: Jupiter TMS channel configuration interface page with SPD Ground Mode selected on Channel 4. Note the additional "SPD Clamp Voltage" numerical input field that was exposed when the SPD Ground Mode selection was activated.

Channel Setting: Channel Name

For each of the four input channels, the user can specify an alphanumeric channel name. The channel name is written into the data file header for each channel. The channel name field will accept up to 20 alphanumeric characters.

Channel Setting: Physical Units

The "Physical Units" field allows the user to enter the physical units of the measurement being recorded. For example, this field be populated with "Amperes" (or simply "A") for a current measurement, or "kV/m/µs" for an electric field derivative measurement. The physical units text input, which can accept up to 20 characters, is written to the data file header for each channel. Note that when the physical units field is changed, the labels of subsequent input fields ("Multiplier", "Input Range", "Trigger Level A", and "Trigger Level B") are all automatically expressed in terms of physical units.

Channel Setting: Multiplier

The "Multiplier" numerical input field allows the user to enter the multiplier (also known as the transfer function) of the sensor connected to the given channel. The multiplier is expressed in "units/V", where "units" correspond to the physical units entry above. The multiplier is the conversion factor for the physical quantity sensed by the connected sensor that corresponds to a 1 V output. For example, in

Figure 21, Channel 1 is set to measure the output of an electric field derivative sensor (D-dot), which has physical units of “kV/m/µs” and multiplier of 105.5 kV/m/µs/V.

Channel Setting: Input Range

The user can select from four input ranges for each of the four analog input channels in the “Input Range” drop-down menu. The nominal input dynamic range of Jupiter TMS is ±2 V. Internally, the signal path can be selected to route through a gain of ten stage, an attenuation of ten stage, or an attenuation of 100 stage. These settings correspond to the following nominal input ranges:

1. ± 2 V (pass-through)
2. ± 200 mV (input signal x 10)
3. ± 20 V (input signal ÷ 10)
4. ± 200 V (input signal ÷ 100)

When the “Physical Units” and “Multiplier” fields are specified, the input ranges shown in the drop down menu are automatically multiplied by the numerical input of the “Multiplier” field and labeled with the appropriate physical units. For example, in Figure 21, Channel 1 is set to measure the output of D-dot sensor, which has physical units of “kV/m/µs” and multiplier of 105.5 kV/m/µs/V. The input range of “± 211 kV/m/µs” was selected, which corresponds to the pass-through setting (no gain or attenuation applied to the recorded signal).

Important: Jupiter TMS has four differential input channels. The value selected in the "Input Range" field assumes the sensor connected to Jupiter TMS will be a differential output sensor. In some cases (e.g., many current probes), the sensor may have a single-ended output. For these sensors, the sensor output should typically be connected to the positive ("+") channel input (Figure 11). When a single-ended sensor output is connected to Jupiter TMS, only one leg of the differential input is being driven by an input signal. As a result, the maximum input range is reduced by a factor of two from nominally $\pm 2\,\text{V}$ to $\pm 1\,\text{V}$ (or equivalently, only the bottom 13-bits of the 14-bit digitizer dynamic range are being utilized).

Channel Setting: Trigger Mode

For each of the four input channels, the user can specify one of four trigger modes. The trigger modes are described below and are illustrated graphically in Figure 24. For each trigger mode, the yellow star in Figure 24 indicates where in time the trigger would occur.

1. ***Positive***- A trigger is issued if the rising edge of the input signal crosses the Level A trigger threshold (Level B is ignored if Positive trigger mode is specified).

2. ***Negative***- A trigger is issued if the falling edge of the input signal crosses the Level A trigger threshold (Level B is ignored if Negative trigger mode is specified).

3. ***Window (Enter)***- A trigger is issued if the signal enters the window between specified Trigger Level A and Trigger Level B.

4. ***Window (Exit)***- A trigger is issued if the signal exits the window between specified Trigger Level A and Trigger Level B.

For the window trigger modes illustrated in Figure 24, the Trigger Level A and Trigger Level B are shown as being above and below the zero level, respectively. Note this is simply an example and is not required. Trigger Level A and Trigger Level B can be located anywhere within the valid input range specified above. Users should set Trigger Level A to a larger value than Trigger Level B, however, if the user accidentally enters a larger value for Trigger Level B, the levels will be swapped internally (that is, Trigger Level A will always be larger than Trigger Level B).

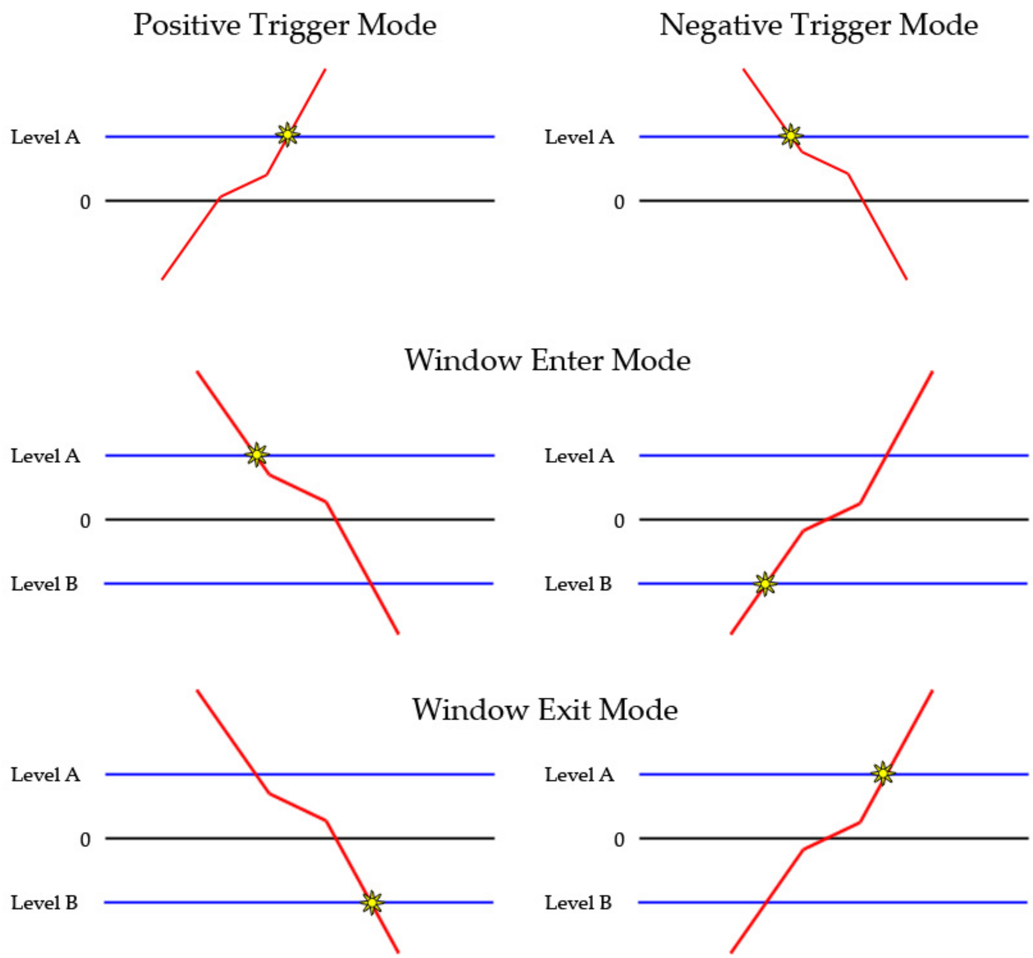


Figure 24: Illustration of Jupiter TMS trigger modes (positive, negative, window (enter), window (exit)). The yellow start indicates the time where the trigger would occur.

Channel Setting: Trigger Level A

For each of the four input channels, the user can specify two numeric triggers levels (A and B). The trigger levels are expressed in physical units, as per the physical units text input field (see above). The possible trigger levels are bounded by the value of the "Input Range" drop-down selection. If a user enters a trigger level that exceeds the specified range, a warning message will be issued and the value will not be accepted. The out-of-range warning message assumes the connected sensor is a differential output sensor. If a single-ended sensor is connected, recall that the input range of the channel is reduced by a factor of two. In this case, the user must ensure that the specified trigger threshold is below the reduced channel input range. An illustration of the differential and single-ended cases for a Jupiter TMS input channel is provided in Figure 25. For the single-ended case, if Trigger Level A is specified above 1 V, the system will not be able to trigger. Note that Trigger Level A is required for all four trigger modes.

The user-specified Trigger Level A for each input channel is automatically compensated for the measured DC offset of the particular channel (see Section 9.3). The DC offset compensation is illustrated in Figure 26.

Channel Setting: Trigger Level B

For each of the four input channels, the user can specify two numeric triggers levels (A and B). The trigger levels are expressed in physical units, as per the physical units text input field (see above). The possible trigger levels are bounded by the value of the "Input Range" drop-down selection. If a user enters a trigger level that exceeds the specified range, a warning message will be issued and the value will not be accepted. The out-of-range warning message assumes the connected sensor is a differential output sensor. If a single-ended sensor is connected, recall that the input range of the channel is effectively reduced by a factor of two. In this case, the user must ensure that the specified trigger threshold is below the reduced channel input range (see Figure 25).

The user-specified Trigger Level B for each input channel is automatically compensated for the measured DC offset of the particular channel (see Section 9.3). The DC offset compensation is illustrated in Figure 26.

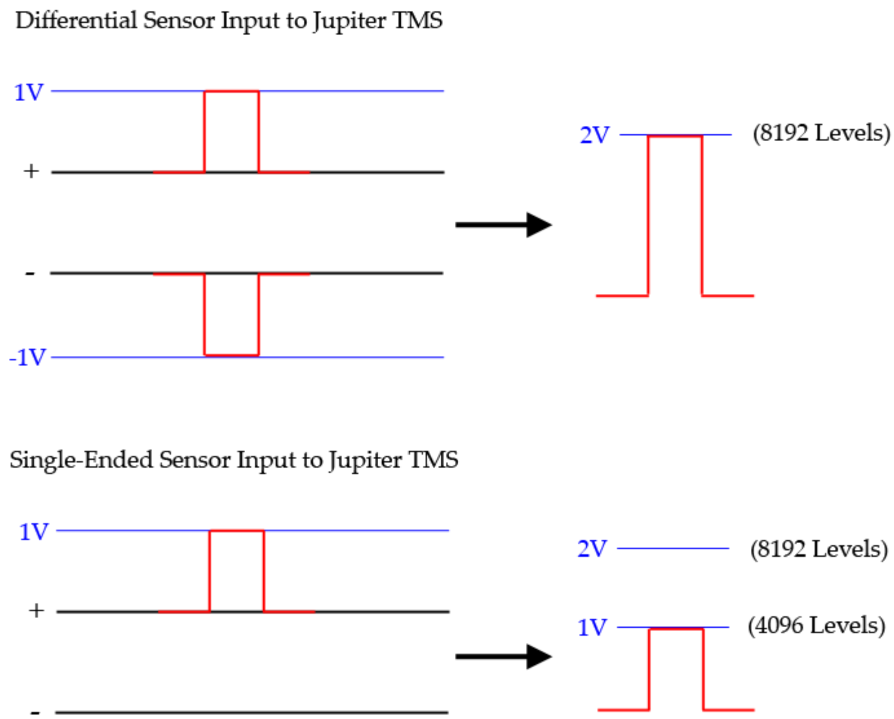


Figure 25: Illustration of Jupiter TMS differential versus single-ended input signals. For the single-ended input, the specified Trigger Level A must be below 1 V in order for the system to trigger.

Important: Trigger Level B is only utilized for the window-enter and window-exit trigger modes to define the lower level trigger threshold. Trigger Level B is not utilized for either the "Positive" or "Negative" trigger modes. Any values entered for Trigger Level B when the "Positive" or "Negative" trigger modes are specified will be ignored.

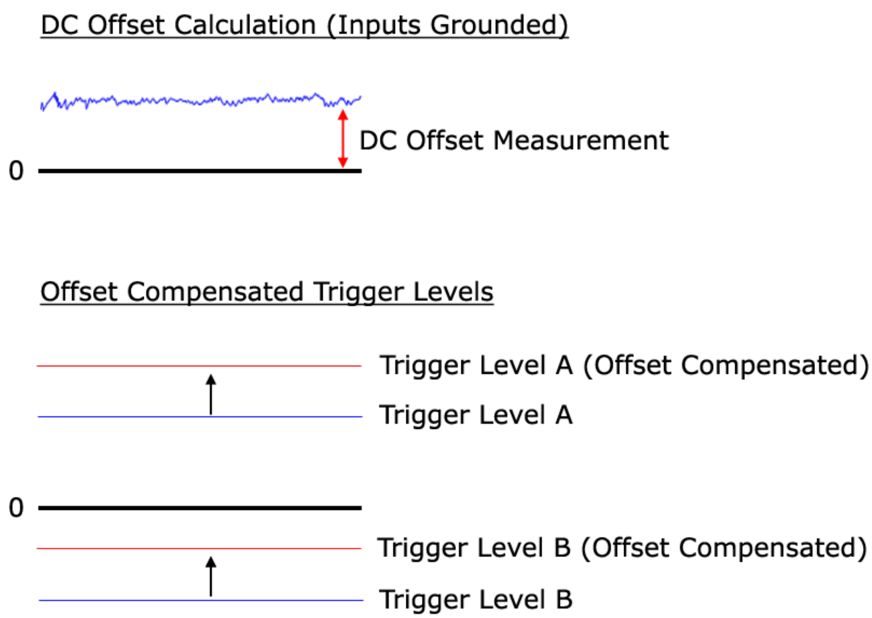


Figure 26: Illustration of Jupiter TMS automatic DC offset compensation for user-defined Trigger Level A and Trigger Level B.

Channel Setting: Hysteresis Samples

For each of the four input channels, the user can specify a positive integer number of hysteresis samples. The number of hysteresis samples dictates how long the signal must remain above or below the specified trigger condition before the system issues a valid trigger. The hysteresis input field is specified in units of sample points (recall that each sample point corresponds to a time window of 12.5 ns). The hysteresis functionality is illustrated in Figure 27 for an example with the "Positive" trigger mode selected. When no hysteresis samples are entered (hysteresis = 0), Jupiter TMS is triggered to save a record the instant when a qualified trigger is encountered. When "N" hysteresis samples are entered, the trigger is "armed" when the signal exceeds the specified trigger threshold, but Jupiter TMS is not actually triggered to save a record unless the signal remains above/below the trigger threshold for "N" samples. The hysteresis function can also be used to eliminate triggers from impulsive local noise. In this case, the noise signal may only exceed the threshold for a few sample points, whereas the signal of interest will exceed the threshold for a much larger time duration.

Triggers due to the impulsive local noise can be filtered by setting the hysteresis sample input to a value slightly larger than the time duration the local noise signal typically exceeds the specified trigger threshold.

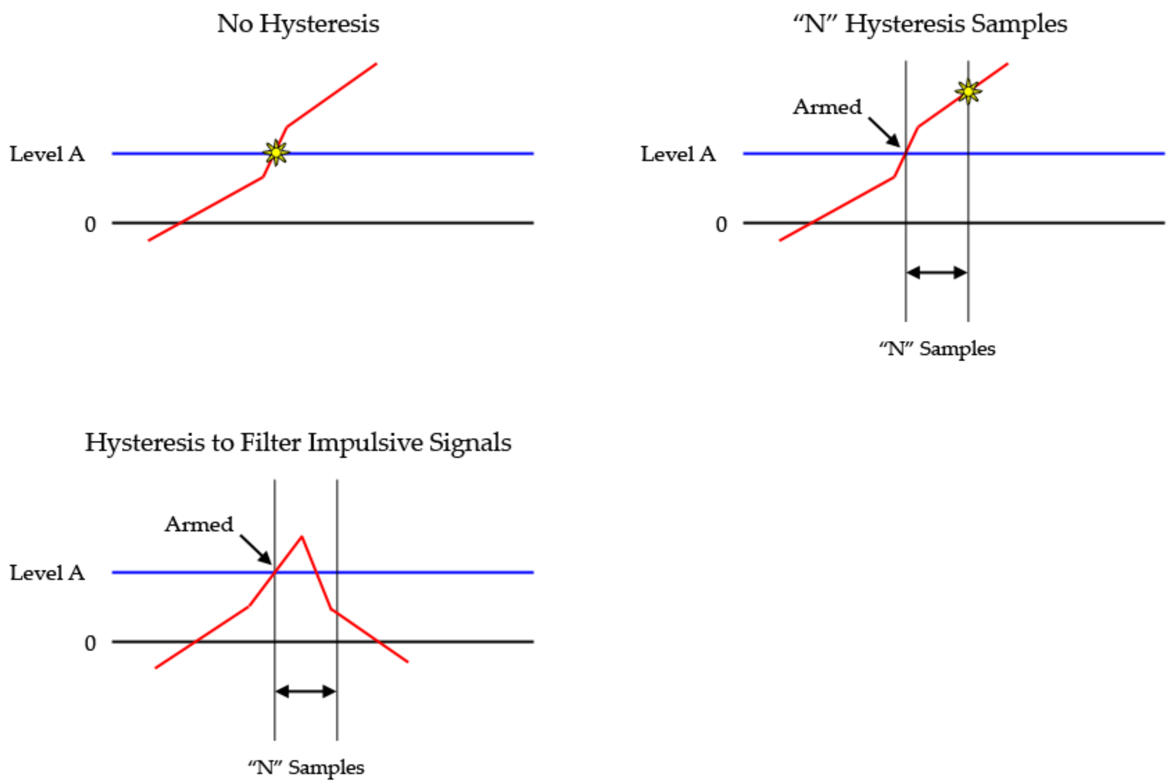


Figure 27: Illustration of Jupiter TMS hysteresis functionality. For this example, the "Positive" trigger mode is illustrated. The trigger position is indicated by the yellow star.

Channel Setting: Input Impedance

The user can select the input impedance for each of the four Jupiter TMS input channels. The available options are **50 Ω** and **1 MΩ**.

For general transient monitoring applications where high-bandwidth signals are being transmitted from the sensor to Jupiter TMS over 50 Ω coaxial cables, it is good practice to terminate the Jupiter TMS channel input in 50 Ω to avoid impedance mismatches that can lead to reflections for signals with high-frequency content. The 1 MΩ setting may be utilized if the length of the cable run between the sensor and the Jupiter TMS channel input is very short (typical convention is $L < \frac{\lambda}{10}$, where λ is the wavelength corresponding to the maximum signal frequency content expected), the expected signal content is very low ($\frac{\lambda}{10} >> L$), or when the sensor (or signal conditioner) is not capable of driving a $50\,\Omega$ load.

> **Important:** The Jupiter TMS front-end electronics may be damaged if excessive signal levels are applied to the coaxial inputs (see Table 5) when a $50\,\Omega$ input impedance is specified, particularly if those signals are applied over a long time duration. When the largest input range is selected (corresponding to a $\pm 200\,\mathrm{V}$ differential input), a warning is issued to the user if the $50\,\Omega$ input impedance setting is selected. With this configuration, if a signal at or near the full dynamic range is applied over a long time duration, the front-end electronics are subject to damage from excessive power dissipation. When the largest input range is selected, the $50\,\Omega$ input impedance setting should **only** be utilized if there is no possibility of long duration, high-amplitude signals being applied to the Jupiter TMS input channel (see Section 8.5).

Channel Setting: Input Coupling

The user can select the input coupling for each of the four Jupiter TMS input channels. The available coupling options are **DC Coupling**, **AC Coupling**, and **GND**.

For many high-bandwidth transient monitoring applications, the AC Coupling setting is often utilized because the connected sensors do not have DC frequency response. This is typically valid for electromagnetic field change sensors, many current probes, etc. Note the Jupiter TMS AC Coupling electronics have a low frequency cut-off of about 16 Hz. For cases where the sensor does have DC frequency response (e.g., a current viewing resistor), the DC Coupling setting is more appropriate. The GND setting may be used when the user wishes to ground each leg of the differential channel input.

Logical "OR" and "AND" Triggers

The logic "OR" and logic "AND" triggers for each Jupiter TMS input channel may be used independently or in combination to create basic or complex logical triggering schemes.

By default, the "OR" trigger is enabled for each of the four channels. With this setting, when a valid trigger is received on any of the four channels (dictated by the trigger mode and levels established during the system configuration above), Jupiter TMS will be triggered to save a record. If no selections are made on either the "OR" or "AND" triggers, the trigger scheme defaults to an equivalent "OR" trigger on all four channels. If only "AND" triggers are set on multiple channels, Jupiter TMS will be triggered to save a record only when a valid trigger is received simultaneously on the channels where the "AND" trigger is enabled. The "AND" trigger does not incorporate any temporal hysteresis. Six examples of how the logical "OR" and "AND" triggers can be used to create different trigger schemes are illustrated in Figure 28. Note the first three examples are the default case, the no-selection case, and the "AND" trigger case previously documented. The later examples show a trigger set on only a single channel, a combination of "OR" and "AND" triggers set on all four channels, and finally, a scenario where both the "OR" and "AND" triggers are set for a single channel. For each example case, the logical evaluation of the trigger scheme is annotated.

Figure 28: Illustration of Jupiter TMS logic trigger examples for basic and complex trigger schemes.

Submit Button

When the user has completed the Jupiter TMS configuration, the changes are submitted by clicking the “Submit” button at the bottom of the page. The acquisition must then be re-armed for the new configuration changes to be executed (see Section 9.8).

> **Important:** Additional Jupiter TMS digitizer configuration settings are available by clicking on the “Display Advanced Settings” checkbox located above the “Channel Settings” heading (Figure 21). These settings are used for testing the Jupiter TMS system during initial system deployment, troubleshooting, and for unique data acquisition requirements. These settings should not be modified under normal operation conditions at the risk of jeopardizing the integrity of system operation and acquired data. If specific data acquisition requirements exists that are not available under the standard system configuration options, please contact SLS for assistance.

9.8 Arming & Disarming Data Acquisition

The Jupiter TMS Status page provides the ability to arm and disarm the data acquisition and also provides the user with feedback on the current state of the system. The Jupiter TMS status page is accessed by navigating to `192.168.1.70/status/`, or by clicking the “Status” link from the Control Center (see Figure 15). A screenshot of the Jupiter TMS status page is shown in Figure 29. The individual Jupiter TMS Status page controls are described below.

Figure 29: Screenshot of the Jupiter TMS Status page.

System Arm Button

The "Arm" button on the Jupiter TMS Status page arms the data acquisition system after a new configuration file has been loaded (after the user has clicked the "Submit" button on the configuration form, see Section 9.7), or after the system has been manually disarmed. When the data acquisition system is armed, valid triggers on the input channels will result in the system saving records. Note that Jupiter TMS automatically arms the data acquisition system on power-up using the last known configuration. This configuration is persistent until a change is enacted by the user. The DC offset measurement routine (see Section 9.3) is executed any time the "System Arm" button is pressed. The channel inputs are grounded, a sample of data is collected, and the DC offset of each channel is measured. The new DC offset values are saved to permanent storage and are used to compensate the user-defined trigger thresholds (see Figure 26).

System Disarm Button

The "System Disarm" button on the Jupiter TMS Status page disarms the data acquisition system. When the data acquisition system is disarmed, no records will be saved due to incoming signals on the input channels. After a disarm function is performed, Jupiter TMS must be re-armed by pressing the "System Arm" button in order for data to be recorded. When Jupiter TMS is re-armed following a disarm operation, the same configuration file is loaded unless the user modified the configuration. Note that the data acquisition does not have to be disarmed in order to perform an update to the system configuration. However, the new configuration will not be loaded until the system is disarmed and then re-armed.

Manual Trigger Button

The "Manual Trigger" button will issue a manual software trigger to the Jupiter TMS data acquisition system. The system must be armed for the manual trigger to operate. Once the manual trigger is acquired, the system will automatically disarm. Note the system will disarm after a manual trigger is issued regardless of the specified number of triggers (finite or infinite). The manual trigger functionality is very useful for capturing a snapshot of the local noise during the system setup process. The data captured during the manual trigger can be used to fine-tune the trigger thresholds for each connected sensor.

System status information is located on the Jupiter TMS status page below the control buttons to provide current status on the system operation. The first line provides the current firmware version of the Jupiter TMS firmware. The second line provides a status string with various system status information. The status information will refresh when the page is refreshed. The fields of the status string are defined below:

1. **"Records Captured":** indicates the total number of files that have been saved to permanent storage since the system was last armed.

2. **"GPS Locked":** indicates the current status of the GPS lock (1 = locked, 0 = unlocked)

3. **"Time":** indicates the current time to second accuracy

4. **"GPS Status":** indicates the quality of the GPS lock (15 = 3D lock)

5. **"Armed":** indicates whether data acquisition is armed (1 = armed, 0 = disarmed)

6. **"Records Unsaved":** indicates the number of records waiting to be saved to permanent storage from RAM

10 Jupiter TMS Operation

Jupiter TMS is designed to provide continuous transient monitoring while requiring no human interaction. After the instrument is installed/mounted (Section 7) and configured (Section 9), the unit requires no additional maintenance until a configuration change is required (due to new sensors, settings, or a change in physical location). The following sections provide information on the operation of Jupiter TMS after the installation and configuration is complete.

10.1 Data Acquisition Status

When the Jupiter TMS data acquisition is armed (either by powering on the unit or arming the unit manually, see Section 9.8), the "Status" LED on the front panel of the unit will illuminate in solid green. The "Status" LED provides the user with a quick indication that the unit is acquiring data. Whenever a valid trigger is received and the unit saves a record to permanent storage, the "Status" LED on the front panel will flash rapidly three times. If the "Status" LED is illuminated in solid red, the unit is disarmed and not acquiring data. If the user has selected a finite number of triggers during the system configuration, the "Status" LED will illuminate red after the triggers have been captured and the instrument automatically disarms. If the user has specified an infinite number of triggers during the system configuration (a more typical use case for an unattended installation of Jupiter TMS), the status LED should always remain illuminated green unless an unrecoverable error has forced the system to disarm.

10.2 Data Transfer

When Jupiter TMS is triggered to record data, the data acquisition file (.TR file extension) is automatically saved to permanent storage. The binary data acquisition file contains the header information (see Appendix C for a fully parsed .TR file header) as well as the recorded data for all four channels. After the file is fully completed saving to permanent storage, it is automatically uploaded to the specified remote server address or transferred to the specified share drive. File upload time varies proportionally with record length and also varies proportionally to the available bandwidth of the network connection provided to Jupiter TMS. For typical record lengths and connection speeds, many tens of data acquisition files can be uploaded to the remote server per minute. Connections to local share drives typically support higher bandwidths and greater file transfer speeds. Recall that the "Comm" LED on the front panel of the Jupiter TMS unit is illuminated in green if the unit is able to communicate a "heartbeat" signal to the the remote server or share drive once per minute. Whenever a data acquisition file is successfully transferred to the remote server or share drive, the "Comm" LED will flash green three times rapidly. The flashing "Comm" LED provides the user with quick visual indication that the unit is actively transferring data. If a connection to the remote server or share drive is not available (the "Comm" LED will be illuminated red), Jupiter TMS will continue to try to transfer all available data files to the remote server or share drive once per minute. When the connection becomes available, the "Comm" LED will illuminate green and the files will successfully transfer.

10.3 Local Data Transfer & Visualization

If a network connection to the Jupiter TMS unit is not available, data may be downloaded, viewed, and deleted locally from the unit through the local Ethernet port. The Jupiter TMS data page is accessed by navigating to `192.168.1.70/records/`, or by clicking the "Data" link from the Control

Center (see Figure 15). A screenshot of the Jupiter TMS data page is shown in Figure 30.

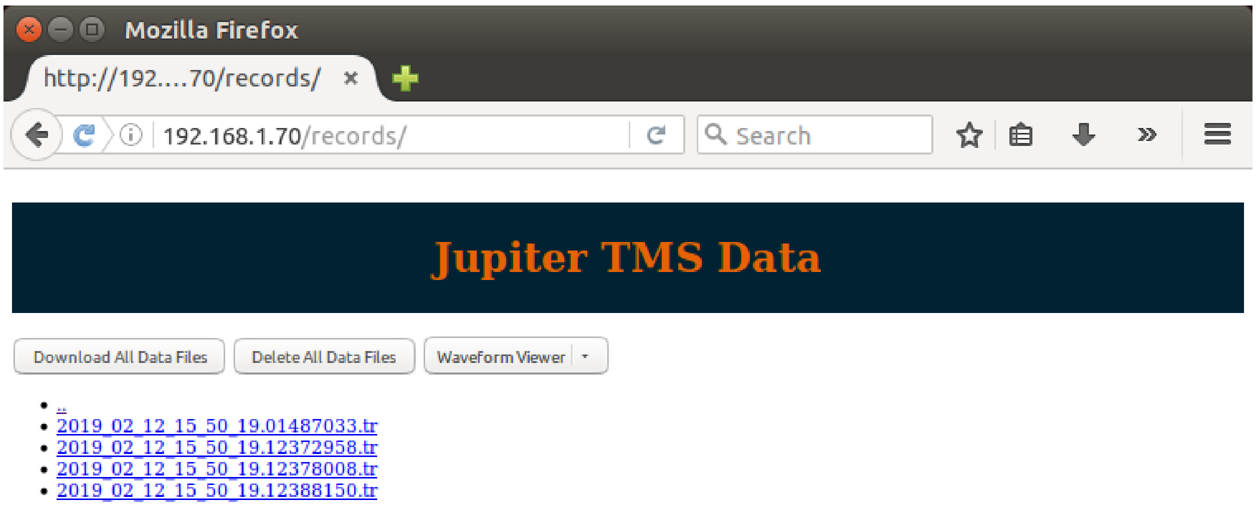


Figure 30: Screenshot of the Jupiter TMS data page where data files may be downloaded, viewed, and deleted locally. The Jupiter TMS data page is accessed by navigating to `192.168.1.70/records/`, or by clicking the "Data" link from the Control Center (see Figure 15).

The operation mode drop-down menu at the top of the page controls the function of the .TR file links listed on the page. By default, the drop-down menu is set to "Waveform Viewer". The second option is "File Download". When the selection is "Waveform Viewer", clicking on a .TR file link will launch a new browser tab where the waveform data contained in the .TR file are plotted. An example waveform display is shown in Figure 31. The waveform data from all four channels are plotted in individual plot axes. A table at the top of the page is population with important recording parameters and basic measurements on the recorded waveforms for each of the four channels. The "Channel Name", "Location", "Units", and "SPD Clamp Voltage" fields are extracted from the .TR file header. These fields are user-specified parameters that are defined during the data acquisition configuration of the Jupiter TMS unit (see Section 9.7). The .TR files are named according to the trigger time of the record. The file naming convention is "YYYY_MM_DD_HH_MM_SS.FFFFFFFF.tr", where "YYYY" is the four digit year, "MM" is the two digit month, "DD" is the two digit day of month, "HH" is the two digit hour (24 hour format), "MM" is the two digit minute, "SS" is the two digit second, and "FFFFFFFF" is the eight digit fractional second of the trigger time. The trigger time is also provided in the data table. When the .TR file is opened and processed, the absolute maximum and minimum data values (scaled to physical units using the multiplier defined in the data acquisition configuration) are displayed in the data table. For those cases where an SPD Clamp Voltage has been specified, an estimate of the SPD energy dissipation for the applicable channel(s) is also provided in the table (in units of Joules).

If the drop-down menu selection is set to "File Download", the user may download individual .TR files by clicking on an individual filename link. The user will be prompted to download the file (Figure 32), after which the file will be downloaded to the connected workstation over the Ethernet connection.

Download All

The "Download All" button will create an archive (.ZIP) file from all available .TR files in the directory. The user will be issued a download prompt to save the ZIP file (Figure 33). The file will then be automatically downloaded to the connected workstation over the Ethernet connection. Note this archive file may be very large if a large number of .TR files reside in the directory.

Delete All

The "Delete All" button will delete all .TR files in the directory. Users should ensure that all files are copied to external media (either the local workstation, remote server, or share drive) before performing this operation. The delete operation is permanent and files may not be retrieved afterwards. When the "Delete All" button is clicked, a confirmation box is launched that requires the user to click "Ok" before the delete operation is called.

Channel	Channel Name	Location	Trigger Time	Max	Min	Units	SPD Clamp Voltage	SPD Energy
1	Current Phase A	SLS Panel 12345	2019-02-12, 20:19:02.797148	0.61	-85.55	A	-	0.00 J
2	Current Phase B	SLS Panel 12345	2019-02-12, 20:19:02.797148	0.59	-83.64	A	-	0.00 J
3	Current Phase C	SLS Panel 12345	2019-02-12, 20:19:02.797148	0.63	-84.01	A	-	0.00 J
4	SPD Ground Current	SLS Panel 12345	2019-02-12, 20:19:02.797148	5.62	-455.81	A	600	0.56 J

Figure 31: Jupiter TMS waveform data visualization through the local browser-based application.

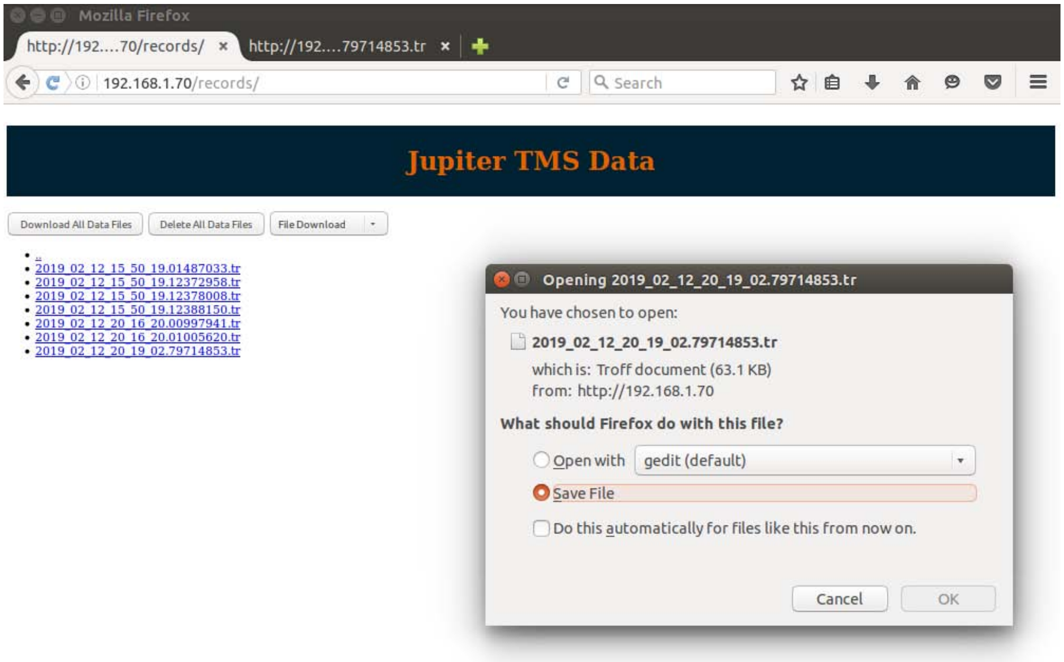


Figure 32: Screenshot of the Jupiter TMS data page when a single data file (.TR) link is clicked by the user, triggering a download prompt to be issued.

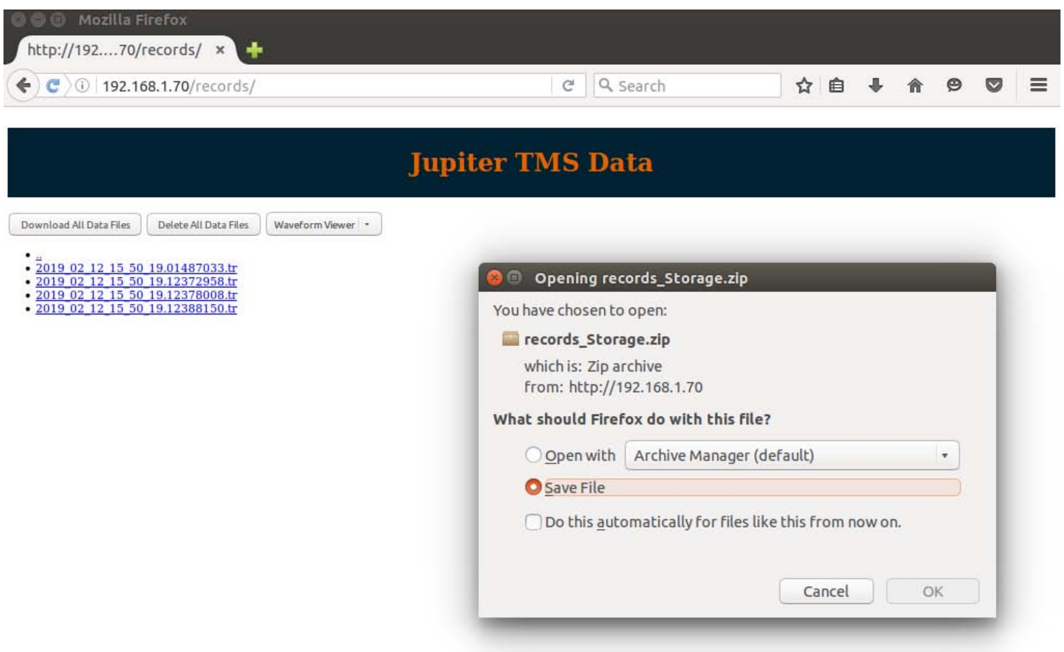


Figure 33: Screenshot of the Jupiter TMS ZIP file download prompt when the "Download All" button is clicked.

10.4 Status Reporting

Jupiter TMS generates an automated status report every six hours. The top portion of the status report contains the current acquisition status, including the time, arming status, gps status, the number of records captured since the system was last armed, and the number of records in RAM waiting to be saved to permanent storage. The lower section of the status report contains maximum and minimum values for internal power supply rails (voltages and currents), multiple internal temperature measurements, internal relative humidity measurements, internal atmospheric pressure measurements, and internal permanent storage usage. An example Jupiter TMS status report is shown in Figure 34. Jupiter TMS status reports are also automatically uploaded to the specified remote server address or share drive on the next whole minute after file creation. Remote server users may elect to receive Jupiter TMS status reports by email by selecting the appropriate notification settings in the "Preferences" menu under the online customer dashboard (see Section 11.3).

```
Jupiter TMS Status Report
Date = 20181023
Time = 180401

Acquisition Status:
{

  "time": "2018_10_23_18_04_08",

  "armed": 1,

  "gps_status": 15,

  "gps_locked": 1,

  "records_captured": 0,

  "records_unsaved": 0

}

Jupiter TMS Power/Environmental/Storage Status:

VCCINT Vmax = 1006 mV
VCCINT Vmin = 1004 mV
VCCINT Imax = 1359 mA
VCCINT Imin = 0 mA
VCCAUX Vmax = 1793 mV
VCCAUX Vmin = 1791 mV
VCCAUX Imax = 671 mA
VCCAUX Imin = 0 mA
VCC1V5 Vmax = 1490 mV
VCC1V5 Vmin = 1488 mV
VCC1V5 Imax = 656 mA
VCC1V5 Imin = 0 mA
VADJ Vmax = 2466 mV
VADJ Vmin = 2463 mV
VADJ Imax = 171 mA
VADJ Imin = 0 mA
VCC3V3 Vmax = 3315 mV
VCC3V3 Vmin = 3294 mV
VCC3V3 Imax = 62 mA
VCC3V3 Imin = 0 mA
USD90120 Tmax = 40.50 C
USD90120 Tmin = 0.00 C
Si7006 Tmax = 48.02 C
Si7006 Tmin = 40.33 C
Si7006 RHmax = 30.59 %
Si7006 RHmin = 16.34 %
MS5837 TMax = 47.86 C
MS5837 TMin = 40.09 C
MS5837 PMax = 1022.57 mB
MS5837 PMin = 1018.15 mB
Disk Total Space = 31531.52 MB
Disk Available Space = 26131.02 MB
Disk Percent Used = 17.1%
```

Figure 34: Example Jupiter TMS status report.

10.5 Alerts

Jupiter TMS is configured to generate automated alerts based on a variety of conditions and parameters. Jupiter TMS alerts are automatically uploaded to the specified remote server address or share drive on the next whole minute after file creation. A list of the alerting conditions is provided in Table 8 below along with the appropriate course of action. Remote server users may elect to receive Jupiter TMS alerts by email by selecting the appropriate notification settings in the “Preferences” menu under the online customer dashboard (see Section 11.3).

10.6 Disk Management

Data files, status report files, and alert files are automatically saved to the internal permanent storage of Jupiter TMS. These files are persistent on the unit after they have been copied to the remote server or share drive. Two automated disk management routines perform housekeeping tasks on the Jupiter TMS permanent storage media.

The data disk management routine runs once per day and surveys the disk usage of the data storage partition. If the disk usage exceeds 75%, the disk management routine begins to automatically delete data acquisition (.TR) files, oldest first, until the disk usage falls below 50%. Given the disk management routine only runs once daily, it is possible to completely fill the data partition of the Jupiter TMS permanent storage media prior to execution of the routine. Jupiter TMS will automatically generate an alert file if disk usage above 90% is detected. If this condition occurs, it is likely that a trigger threshold is set too low, a sensor has malfunctioned, or very long records are being captured where the permanent storage cannot hold a large number of data acquisition files (reference Table 6). If the data partition is filled, Jupiter TMS will continue recording data into RAM until the RAM has filled, but will be unable to transfer the recorded data into permanent storage until space is freed.

The status disk management routine also executes one per day and surveys the disk usage on the status partition. Note the status partition is independent of the data partition, and thus, alerts and status information can still be captured and transmitted even if the data partition is completely filled. The status disk management routine is programmed to automatically delete any files (status reports and alerts) that are older than 10 calendar days.

Table 8: List of Jupiter TMS alerting conditions and appropriate actions.

Alert Condition	Appropriate Action
Internal voltage rails that exceed pre-defined maximum/minimum thresholds.	Contact SLS and provide alert text.
Internal current draws that exceed pre-defined maximum/minimum thresholds.	Contact SLS and provide alert text.
Internal temperature values that exceed pre-defined maximum/minimum thresholds.	Check that ambient temperature where unit is installed is within allowable range. Verify operation of Jupiter TMS chassis fan on rear panel. If problem persists, contact SLS and provide alert text.
Internal relative-humidity values that exceed pre-defined maximum/minimum thresholds.	Check that the unit is being exposed to excessive moisture. If problem persists, contact SLS and provide alert text.
Internal permanent storage usage that exceeds the pre-defined maximum value.	Allow the automated disk management routine to execute. If storage must be freed immediately, delete .TR files through the local Ethernet port (see Section10.3).
Loss of communication to the remote server.	Check Internet connection to the Jupiter TMS unit. Verify network configuration settings (see Section9.4).
Automatic refresh of the default gateway for Jupiter TMS internet connection.	No action required. Communication was lost and was automatically reestablished.
Loss of GPS PPS signal.	Verify GPS antenna connection to Jupiter TMS chassis. Power cycle the unit. If problem persists, contact SLS.
Loss of analog-to-digital converter clock signals.	Power cycle the unit. If problem persists, contact SLS.
New Jupiter TMS configuration file copied from the remote web server.	No action required. Jupiter TMS obtained a new configuration file from the configuration interface on the remote server.
New Jupiter TMS configuration file loaded.	No action required. Jupiter TMS automatically loaded a new configuration file that was obtained from the remote server.
New Jupiter TMS software copied from the remote web server.	No action required. Administrative only. Remote Jupiter TMS software download.
New Jupiter TMS software loaded.	No action required. Administrative only. Remote Jupiter TMS software installation.

10.7 Data Acquisition System Test

Jupiter TMS has an integrated test tool for the data acquisition system that is accessed by navigating to `192.168.1.70/system_test/`, or by clicking the "System Test" link from the Control Center (see Figure 15). A screenshot of the Jupiter TMS system test page is shown in Figure 35. The system test is designed to exercise each of the differential data acquisition channel inputs (eight total inputs, +/- for each channel) utilizing the SLS handheld pulse generator (see part number SLS-GP-01 in Table 3). Note the system test tool is expecting a characteristic waveform from the SLS handheld pulse generator and will not return meaningful results if a different excitation source is used.

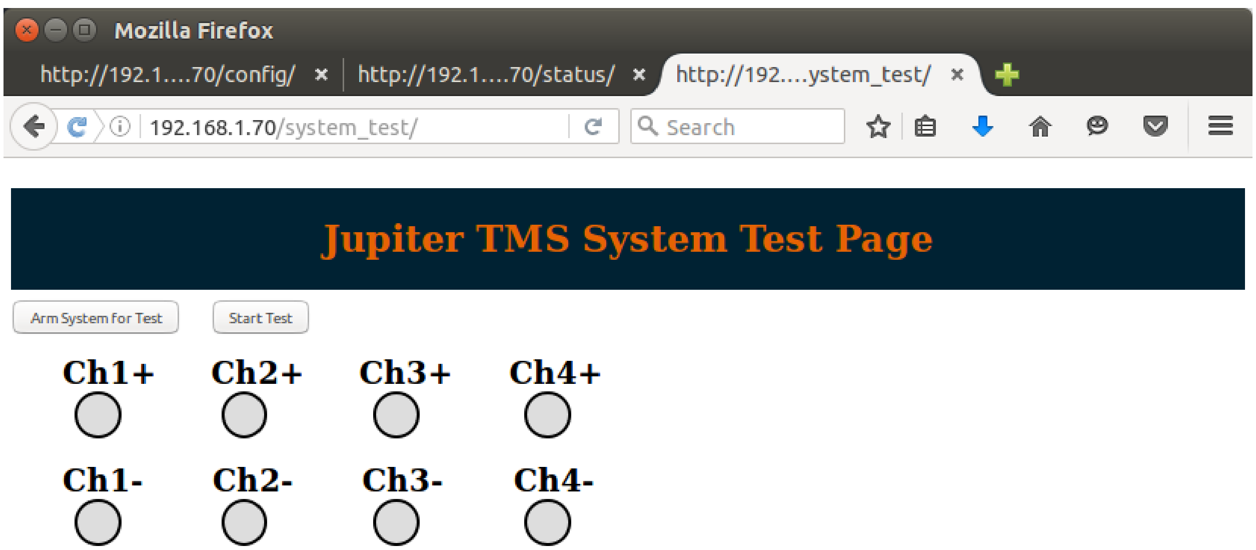


Figure 35: Screenshot of the Jupiter TMS system test page. The Jupiter TMS system test page is accessed by navigating to `192.168.1.70/system_test/`, or by clicking the "System Test" link from the Control Center (see Figure 15).

The following steps should be followed to execute the data acquisition system test:

1. Disconnect Jupiter TMS from the outside world network connection where acquired data files are not transferred from the unit.

2. Click the "Arm System For Test" button on the System Test page. When this button is clicked, the system will automatically load a system test configuration file.

3. When the data acquisition is armed (the "Status" LED on the Jupiter TMS front panel is illuminated green and the internal relays stop clicking), click the "Start Test" button.

4. Connect the pulse generator to Ch1+ using a short BNC coaxial cable and generate a single pulse.

5. The captured waveform is automatically processed and compared to pre-defined thresholds given the repeatable characteristics of the output signal from the pulse generator. If the waveform satisfies the pre-defined thresholds, the Ch1+ LED indicator on the page will illuminate green. If the test fails, the Ch1+ indicator will illuminate in red. A message will be printed to the screen alerting the user that the channel has passed or failed the excitation test (see Figure 36). The absolute maximum and minimum values of the recorded waveform are also displayed in the printed message. Users may access the recorded waveforms for further analysis by clicking the linked .TR file on the Jupiter TMS Data page (`192.168.1.70/records/`).

6. Connect the pulse generator to Ch1-.

7. Generate a single pulse with the pulse generator.

8. Examine the pass/fail output and the acquired waveform.

9. Connect the pulse generator to Ch2+.

10. Generate a single pulse with the pulse generator.

11. Examine the pass/fail output and the acquired waveform.

12. Connect the pulse generator to Ch2-.
13. Generate a single pulse with the pulse generator.
14. Examine the pass/fail output and the acquired waveform.
15. Connect the pulse generator to Ch3+.
16. Generate a single pulse with the pulse generator.
17. Examine the pass/fail output and the acquired waveform.
18. Connect the pulse generator to Ch3-.
19. Generate a single pulse with the pulse generator.
20. Examine the pass/fail output and the acquired waveform.
21. Connect the pulse generator to Ch4+.
22. Generate a single pulse with the pulse generator.
23. Examine the pass/fail output and the acquired waveform.
24. Connect the pulse generator to Ch4-.
25. Generate a single pulse with the pulse generator.
26. Examine the pass/fail output and the acquired waveform.

When a full successful system test has been completed, all channel status LEDs on the System Test page should be illuminated in green (Figure 37).

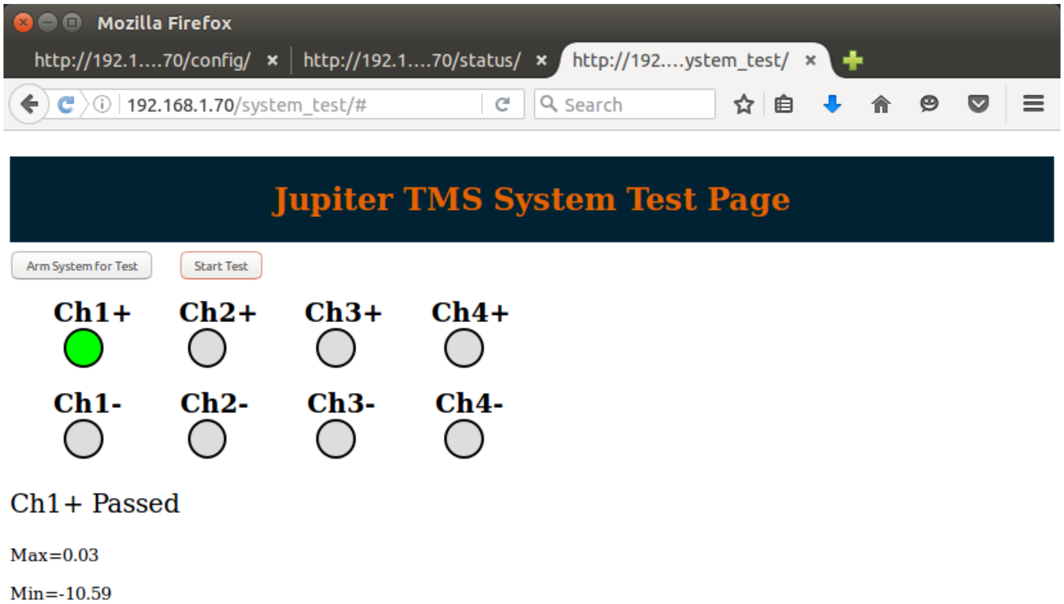


Figure 36: Screenshot of the Jupiter TMS system test page when a channel (C1+) has passed the excitation test. The absolute maximum and minimum values of the acquired waveform are also displayed

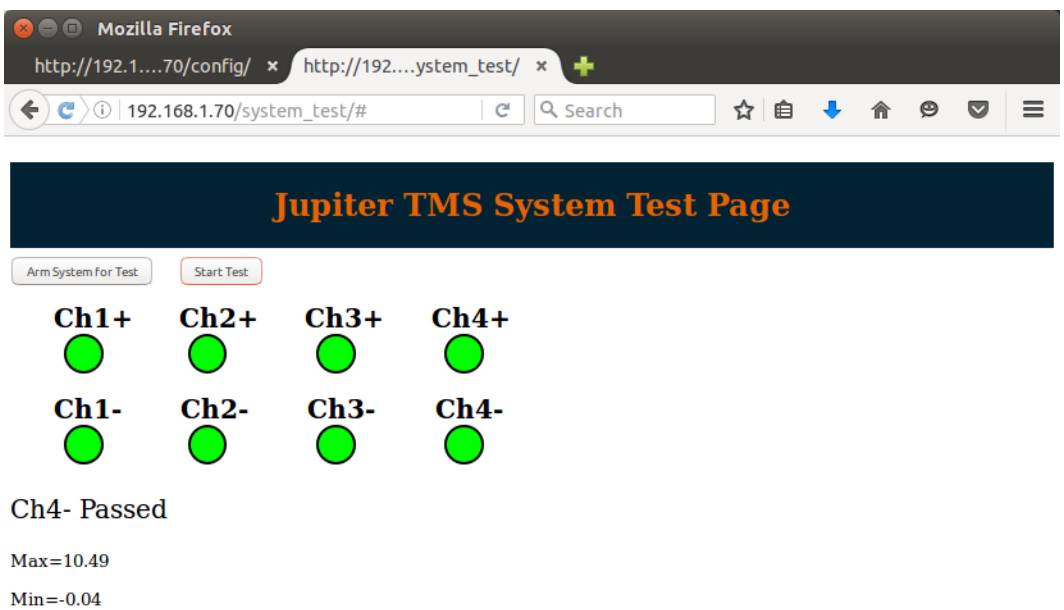


Figure 37: Screenshot of the Jupiter TMS system test page when a full successful system test has been completed. All channel LED indicators are illuminated in green.

11 Jupiter TMS Remote Web Server

Jupiter TMS can utilize a remote web server to provide users with immediate access to acquired data, system status information, and alerts. In addition, the remote web server supports a system configuration tool for updating data acquisition settings, a waveform display application where users can view acquired waveforms immediately after the data have been automatically uploaded, and a remote command tool to send specific commands to the Jupiter TMS unit. This section provides detailed information on server access, functionality, and available tools.

SLS provides the remote server to support Jupiter TMS for 6 months free-of-charge for new customers. Prior to shipping a Jupiter TMS unit to the customer, SLS pre-configures the remote server for the particular Jupiter TMS unit. If a customer already owns a Jupiter TMS unit, additional Jupiter TMS units may be integrated with the existing web server (or a new server can be established, per the customer requirement).

11.1 Accessing the Remote Server

The Jupiter TMS remote web server can be accessed from any internet-connected device (workstation, laptop, tablet, or mobile device). SLS will provide the IP address of the remote web server to the customer upon purchase of the Jupiter TMS unit. Recall the remote server address is also entered in the Jupiter TMS network configuration (Section 9.4). The remote server is accessed by navigating to `serverIPaddress/app` from a web-browser. When the server URL is accessed, the user will be routed to a login screen (Figure 38). SLS will be notified. When SLS approves the new account, the new user will receive an email notification. When the account has been approved, the new user may utilize their login credentials to access the Jupiter TMS remote server via the login page (Figure 38).

The remote server supports two levels of user access. System administrators should notify SLS which user accounts are to be provided with administrative access.

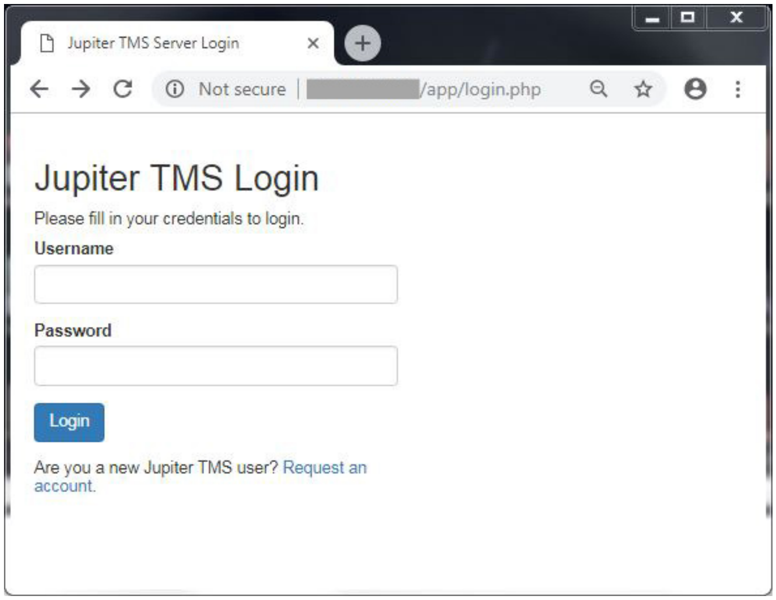


Figure 38: Jupiter TMS remote server login screen.

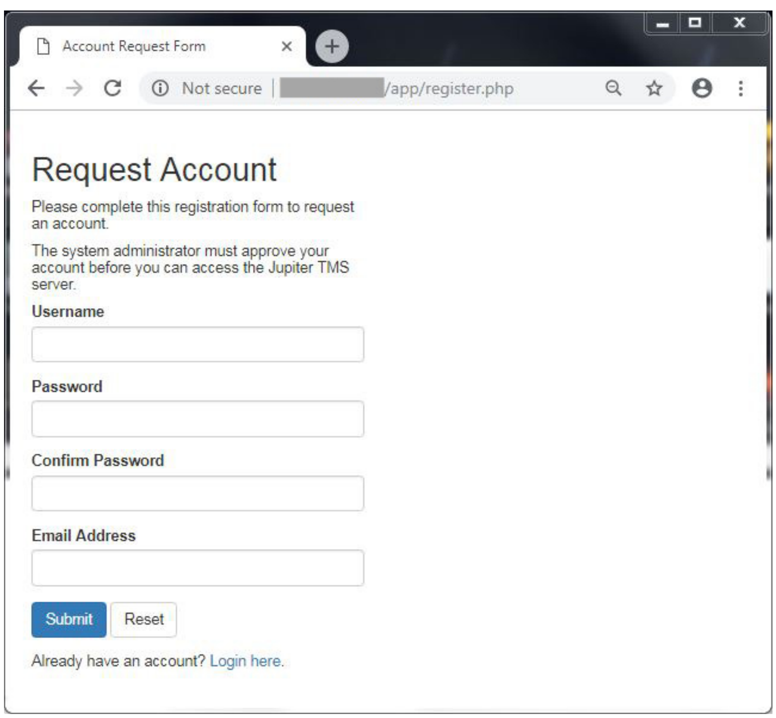


Figure 39: Jupiter TMS remote server request account page.

11.2 Customer Dashboard

After the Jupiter TMS user completes the server login process, the user will be directed to the Jupiter TMS dashboard page. A screenshot of the dashboard page is shown in Figure 40. The customer dashboard provides both file access and system status information.

Each Jupiter TMS unit that is linked to the remote server is shown at the upper left corner of the dashboard screen. The linked Jupiter TMS units are labeled according to serial number. In this example, Jupiter TMS units TMS-18-1, TMS-18-2, TMS-18-3, and TMS-18-4 are linked to the same server. If active communication between the Jupiter TMS unit and the remote server exists, the Jupiter TMS unit icon is outlined in green. Otherwise, the unit icon is outlined in red. In this case, Jupiter TMS units TMS-18-2 and TMS-18-3 have active connections to the server. Recall that each connected Jupiter TMS unit transmits a “heartbeat” signal to the remote server every minute to alert the remote server that the unit is online and communicating (see Section 9.5).

Each of the Jupiter TMS icons at the upper left corner of the customer dashboard can be selected individually to change the source of the files displayed in the file listing box. In this example, Jupiter TMS unit TMS-18-3 is selected. Below on the left-hand control panel, there are three file type selections (data files, alerts, and status reports). The user can select which type of file to display in the file listing box by selecting the appropriate file designation. In Figure 40, data files (.TR file extension) are being displayed. The file listing box displays the file name (listed in chronological order, oldest file first), the file modification date, and the file size.

The user can directly download individual files (either data files, status reports, or alerts) by clicking on the individual file name in the file listing box. The user will be prompted for a download location on their local computer/device in which the file will be saved. The user may also click on the check-boxes adjacent to any available file to select any combination of available files. Alternately, the user may

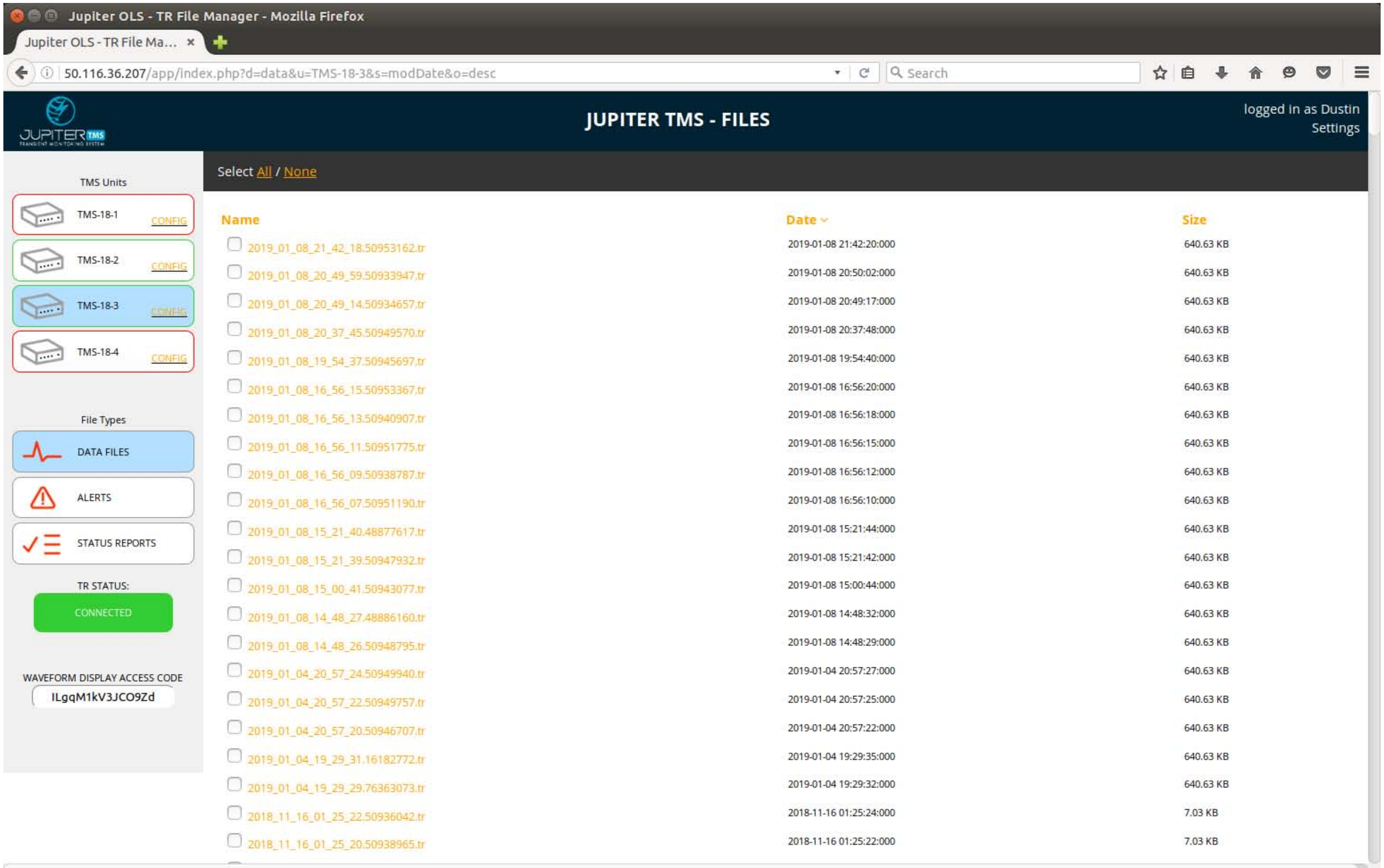


Figure 40: Jupiter TMS remote server customer dashboard.

click on the "All" link in the menu bar above the file listing box. This will select all the files in the the current directory. When files are selected (either using the individual check-boxes or using the "All" option), two additional options ("Download" and "Delete") are shown on the menu bar (Figure 41). If the user chooses the "Download" option, an archive (.ZIP) file will be automatically created that contains all of the selected files. The user will be prompted for a download location on their local computer/device in which the archive file will be saved. Note that the archive files can be substantially large if the folder contains a large number of data files. If the user chooses the "Delete" option, a confirmation window will be issued that requires the user's permission in order for the files to be permanently deleted. The "Delete" option is only accessible for system users that have been granted administrative privileges.

Once a user has downloaded a .TR data file, the file can then be opened and processed locally. Advanced users may wish to perform additional analysis or measurements on recorded waveforms. The file structure of the .TR file header is provided in Appendix B of this document. A fully parsed .TR file header is provided in Appendix C. Finally, fully-functioning MATLAB code that can be used to parse the .TR file header and create individual arrays of data for each of the four analog channels is provided in Appendix D.

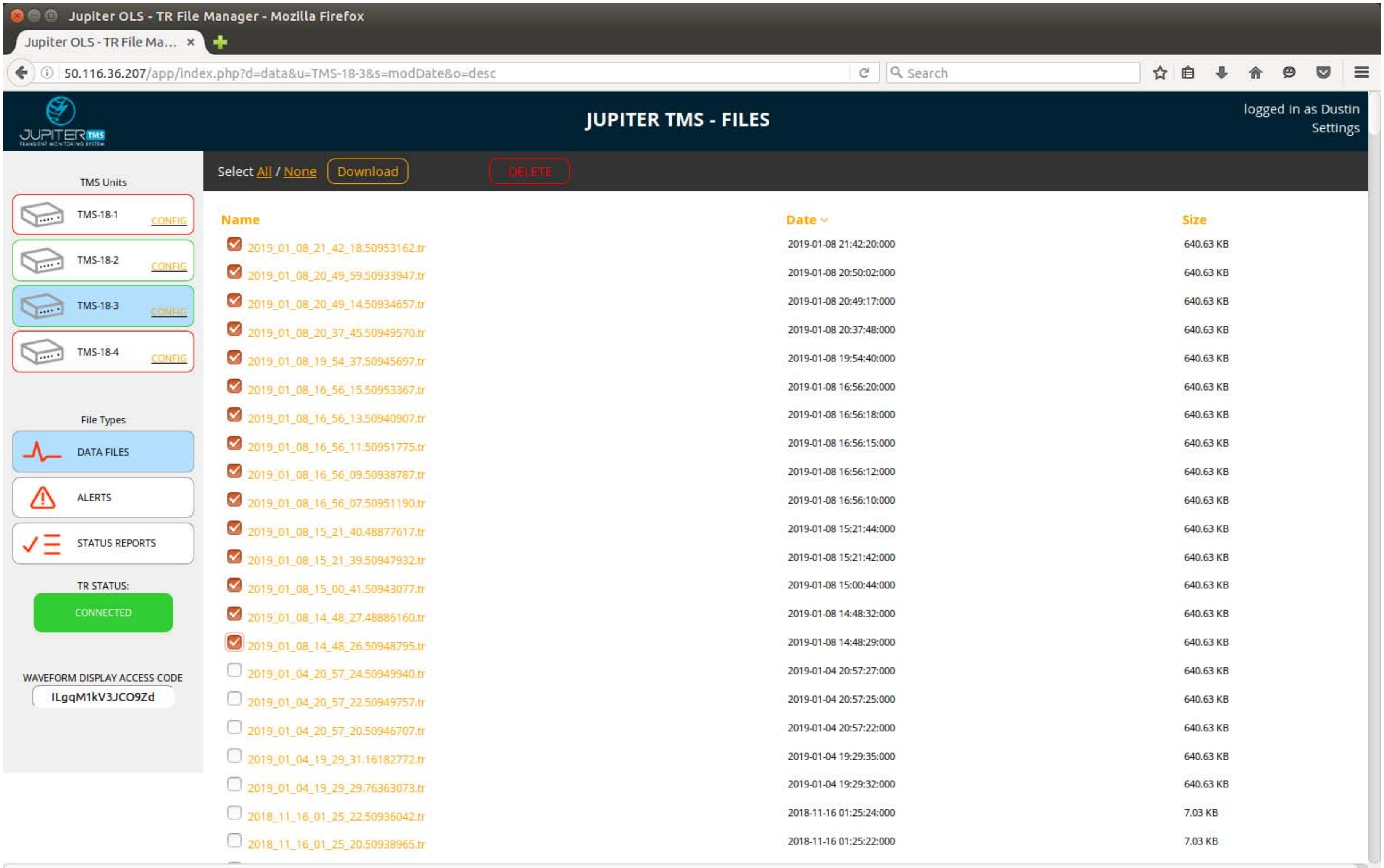


Figure 41: Jupiter TMS remote server file download/deletion functionality.

11.3 Customer Dashboard User Settings

Additional user settings, tools, and preferences are available under the "Settings" menu at the upper right corner of the Customer Dashboard. A screenshot of the "Preferences" page is shown in Figure 42. For standard users, the "Preferences" page will allow the user the enter an updated email address and to change notification settings individually for Jupiter TMS data files, status reports, and system alerts. For administrative users, the "Preferences" page will allow the administrator to turn on/off access for individual users, change email address and notification settings for individual users, and change access levels for individual users. Note the screenshot of the "Preferences" page shown in Figure 42 is for an administrative account login.

The "Settings" menu also provides links to the Jupiter TMS Remote Command utility (see Section 11.7), a password reset utility, and a logout button to logout of the customer dashboard.

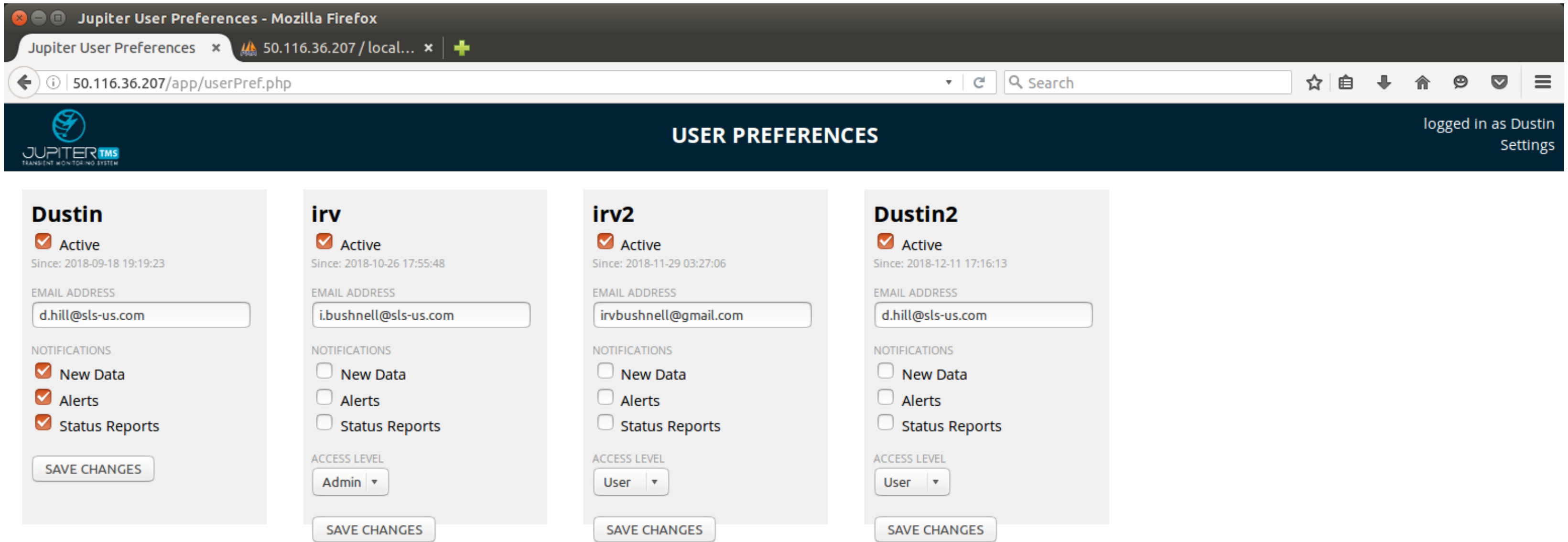


Figure 42: Jupiter TMS remote server user preferences page.

11.4 Remote Data Acquisition Configuration

Some Jupiter TMS units may be deployed in locations where accessing the unit locally can be difficult. Recall that the data acquisition configuration was performed locally to the Jupiter TMS unit by connecting an external computer to the unit via the Ethernet interface (see Section 9.7). An equivalent data acquisition configuration interface is available for users on the remote server. The configuration interface is accessed by navigating to `serverIPaddress/app/TMSSerial#/config` or by clicking on the "CONFIG" link inside the status indicator box for each connected Jupiter TMS unit on the left side of the customer dashboard (see Figure 40). A screenshot of the remote data acquisition configuration interface is shown in Figure 43. The data acquisition controls on the remote configuration interface mirror those on the local interface. Unlike the local interface, the remote configuration interface allows the user to save configuration files and then reload them at a later date. After a data acquisition configuration has been established (using the controls shown in Figure 43), the user can enter a file name for the configuration in the "Config File Name" field at the upper left corner of the page. When the user clicks the "Submit" button at the bottom of the page, the configuration file will be saved to the permanent storage of the Jupiter TMS unit. The file can then be recalled at any time by selecting the file from the "Load Existing Config File" drop-down menu located below the "Config File Name" field. This feature allows the user to quickly change configurations if required.

When a new configuration file is submitted through the remote configuration interface, the file is automatically downloaded by the Jupiter TMS unit on the next whole minute. The Jupiter TMS unit automatically loads the new configuration and re-starts the data acquisition using the new configuration settings. Jupiter TMS generates an alert when the new configuration file is received, and a subsequent alert when the file is loaded. The alerts are transmitted to the remote server to provide an immediately indication to the user that the operation was successful.

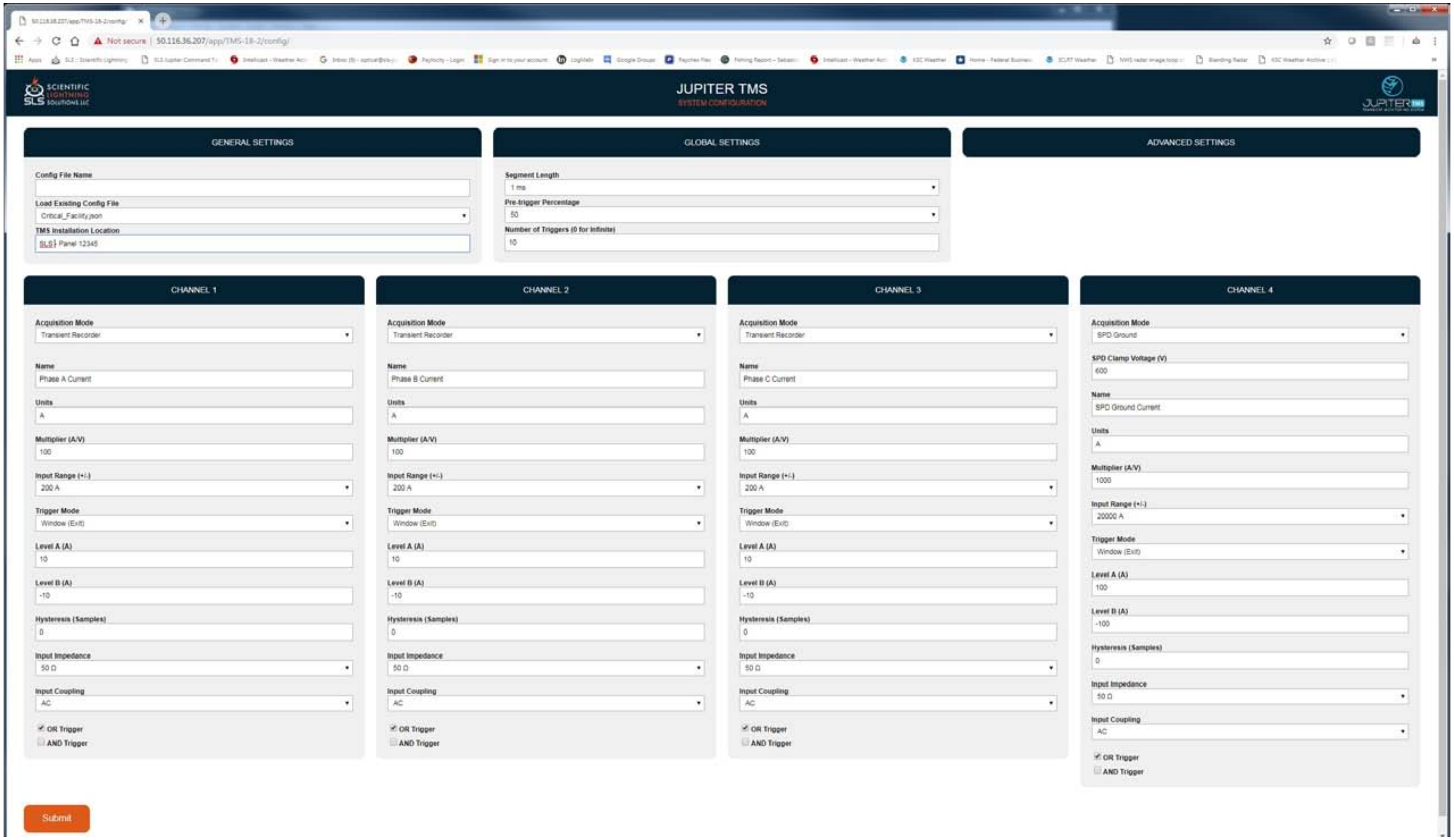


Figure 43: Jupiter TMS remote data acquisition configuration interface.

11.5 Waveform Display Application

When .TR data files are transferred to the remote server from each connected Jupiter TMS unit, the data files are made available to an online waveform display application. The waveform display application is accessed by navigating to `serverIPaddress/displayapp` from a web-browser. The waveform display application has a separate user login from the customer dashboard. A screenshot of the waveform display application login form in shown in Figure 44. To access the available waveform data, the user must enter their account username and a unique alpha-numeric 15-digit access code that is copied from the customer dashboard (see Figure 40). The access code is only valid during the current login session to the customer dashboard and becomes invalid when the user manually logs out (or the timeout window expires) from the customer dashboard. The user should click the "Submit" button in the waveform display application after entering the username and access code. If the information is correct, a green check-mark will appear to the right of the submit button.

A screenshot of the waveform display application is shown in Figure 45. The user can select the proper Jupiter TMS unit using the "Jupiter TMS System" drop-down menu at the upper left corner of the screen. In this case, Jupiter TMS unit TMS-18-3 is selected. When a Jupiter TMS unit is selected in the drop-down menu, the list of available .TR recording files will be automatically populated in the "Jupiter TMS Recording Files" drop-down menu below. When a .TR file is selected, the file is automatically opened and processed.

A table at the top of the page is population with important recording parameters and basic measurements on the recorded waveforms (for each of the four channels). The "Channel Name", "Location", "Units", and "SPD Clamp Voltage" fields are extracted from the .TR file header. These fields are user-specified parameters that are defined during the data acquisition configuration of the Jupiter TMS unit (see Section 9.7). The .TR files are named according to the trigger time of the record. The file naming convention is "YYYY_MM_DD_HH_MM_SS.FFFFFFFF.tr", where "YYYY" is the four digit year, "MM" is the two digit month, "DD" is the two digit day of month, "HH" is the two digit hour (24 hour format), "MM" is the two digit minute, "SS" is the two digit second, and "FFFFFFFF" is the eight digit fractional second of the trigger time. The trigger time is also provided in the data table. When the .TR file is opened and processed, the absolute maximum and minimum data values (scaled to physical units using the multiplier defined in the data acquisition configuration) are displayed in the data table. For those cases where an SPD Clamp Voltage has been specified, an estimate of the SPD energy dissipation for the applicable channel(s) is also provided in the table (in units of Joules).

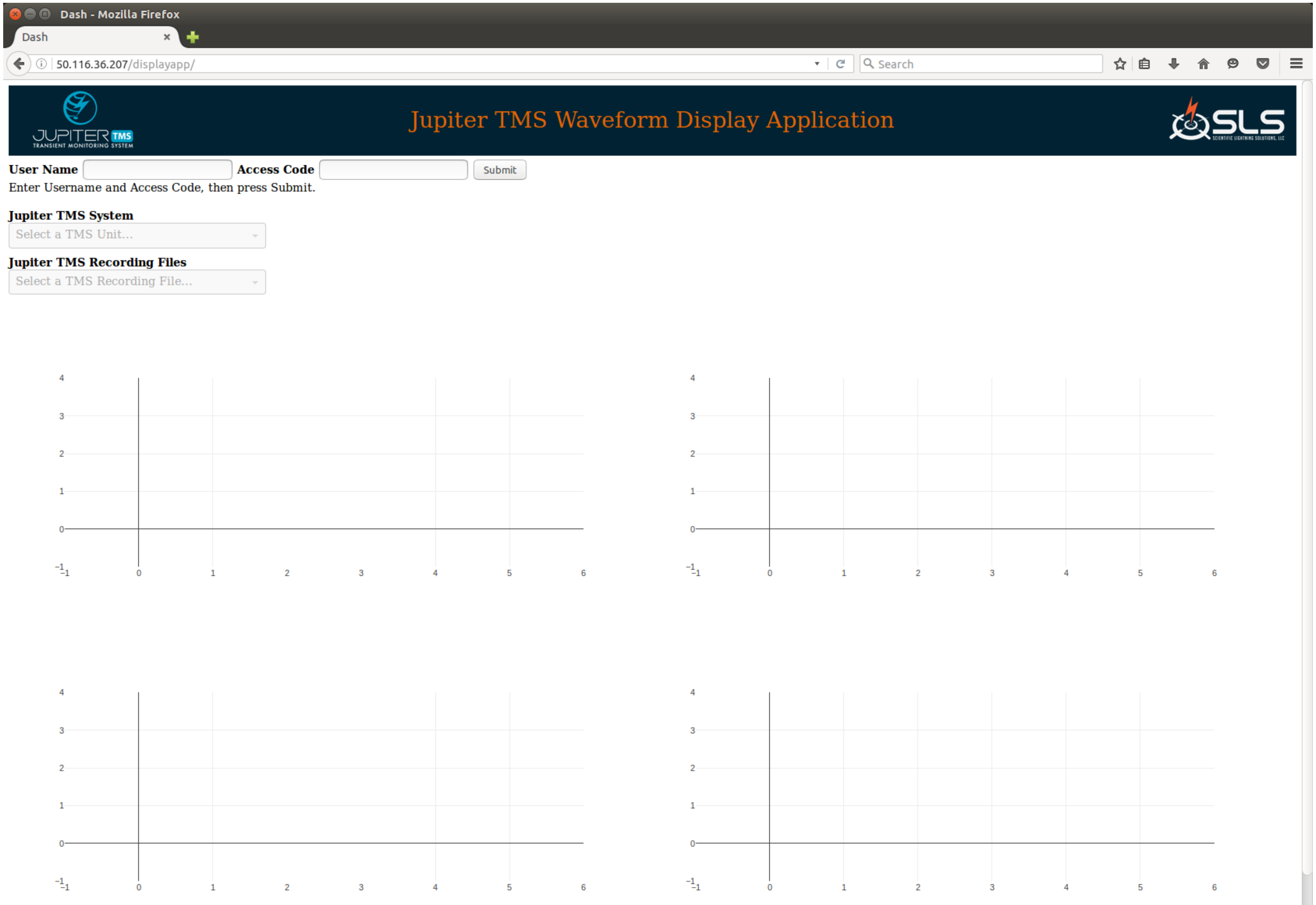
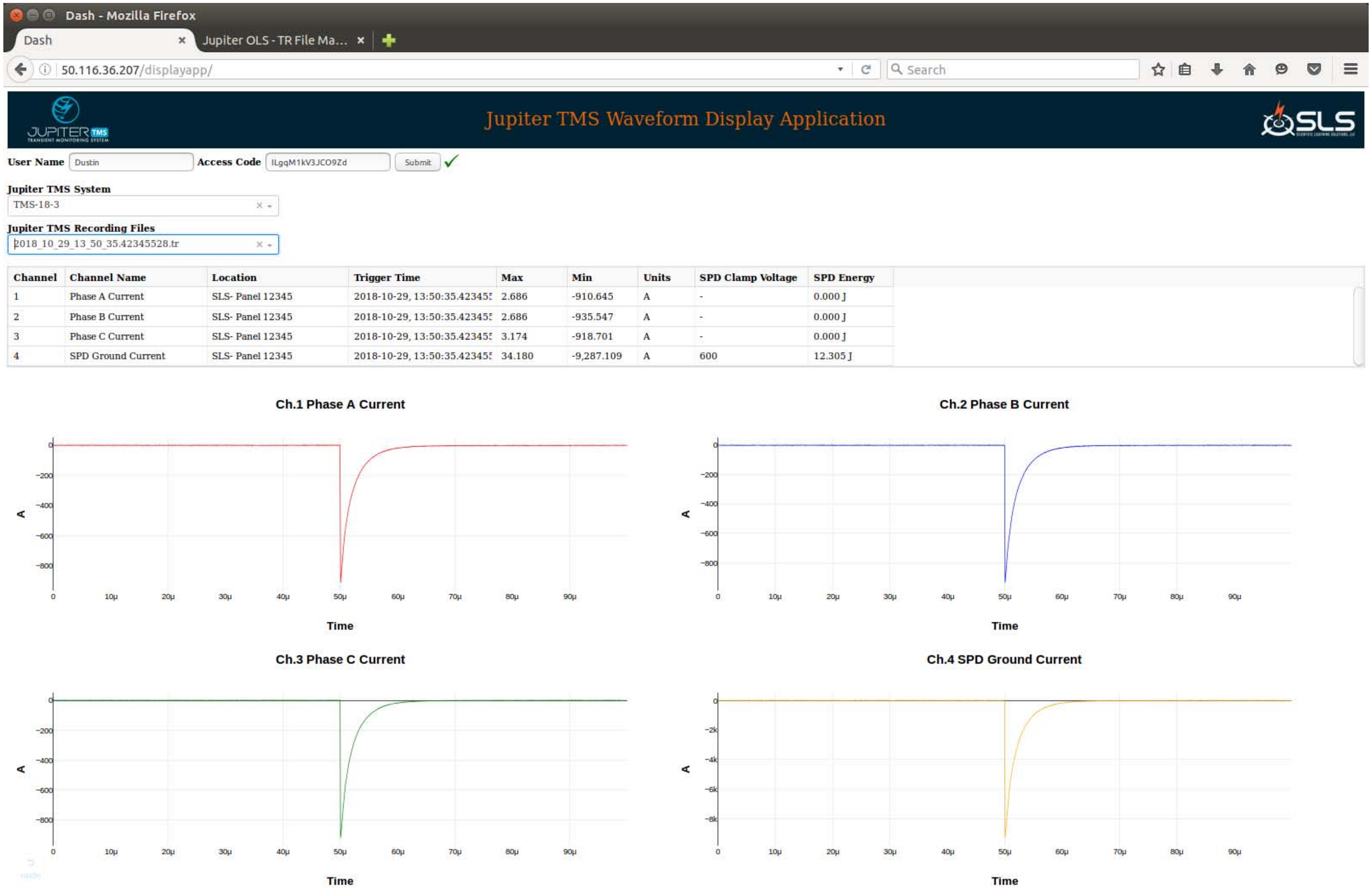


Figure 44: Jupiter TMS online waveform display application login screen.



Channel	Channel Name	Location	Trigger Time	Max	Min	Units	SPD Clamp Voltage	SPD Energy
1	Phase A Current	SLS- Panel 12345	2018-10-29, 13:50:35.42345	2.686	-910.645	A	-	0.000 J
2	Phase B Current	SLS- Panel 12345	2018-10-29, 13:50:35.42345	2.686	-935.547	A	-	0.000 J
3	Phase C Current	SLS- Panel 12345	2018-10-29, 13:50:35.42345	3.174	-918.701	A	-	0.000 J
4	SPD Ground Current	SLS- Panel 12345	2018-10-29, 13:50:35.42345	34.180	-9,287.109	A	600	12.305 J

Figure 45: Jupiter TMS online waveform display application.

The waveform data saved in the .TR data files are plotted below the data table in four individual plot axes. The plot titles and axis labels are obtained from the user-defined parameters that were written to the .TR file header. In the example waveforms shown in Figure 45, the four channels of a Jupiter TMS unit were excited with a handheld pulse generator (see the Jupiter TMS accessories list in Table 3).

A zoomed version of a Channel 1 waveform is shown in Figure 46. Each individual plot axes in the waveform display application has a series of controls (shown at the upper right corner of Figure 46) that allow for a variety of manipulations of the plot axes. These operations include panning and zooming on both the horizontal axis and vertical axis. When the plot axes are panned or zoomed, the horizontal and vertical axis labels are automatically updated accordingly. The plot axes can be zoomed to the sample-point level. In addition, hovering the mouse cursor over the plotted waveform will provide the horizontal and vertical axis values at each sample point (see Figure 46). Finally, clicking on the "camera" icon in the controls bar at the upper right corner will automatically export a snapshot of the current view of the plot axes to a .PNG file that can be saved to the local computer or device.

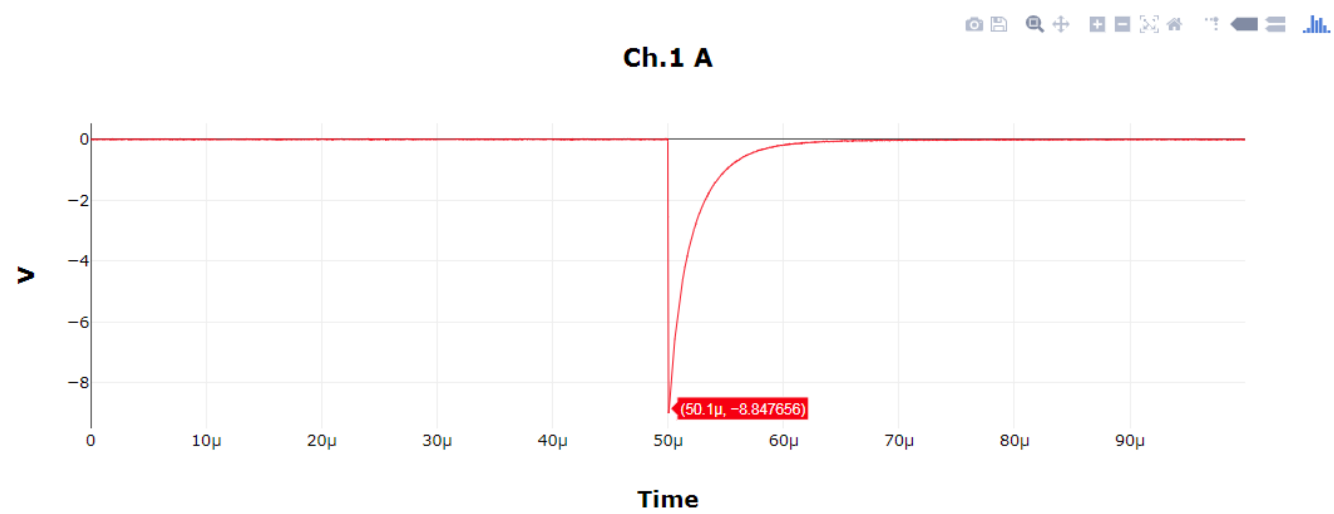


Figure 46: Zoomed plot of a Jupiter TMS waveform from the online waveform display application.

11.6 Automatic Report Generation

The remote server automatically detects when each connected Jupiter TMS unit uploads a new .TR data file. When a new file is detected, an automated report generation software is triggered. The software generates a PDF report that includes the information shown in the data table of the waveform display application. An example report is shown in Figure 47. If an SPD Clamp Voltage has been specified for a given channel, the reporting software automatically performs the SPD energy dissipation calculation for that channel and displays the calculated energy in the report.

Note that when a new user account is established for the Jupiter TMS unit, the user can select whether to add their email address to the distribution list for Jupiter TMS automated reports. The selection is made through the "Preferences" page under the customer dashboard (see Figure 42). Users on the data distribution list will receive the automated report (Figure 47) each time the unit triggers.

Jupiter TMS Transient Report

General Information

Jupiter TMS Serial:	TMS-18-2
Installation Location:	SLS- Panel 12345
Trigger Time:	2018-10-01, 21:16:01.670665 (UTC)

Channel 1

Name:	Phase A Current
Physical Units:	A
Absolute Maximum:	-0.293
Absolute Minimum:	-37.573

Channel 2

Name:	Phase B Current
Physical Units:	A
Absolute Maximum:	2.515
Absolute Minimum:	-35.547

Channel 3

Name:	Phase C Current
Physical Units:	A
Absolute Maximum:	1.392
Absolute Minimum:	-35.107

Channel 4

Name:	SPD Ground Current
Physical Units:	A
Absolute Maximum:	56.152
Absolute Minimum:	-393.066
SPD Clamp Voltage:	600 V
SPD Energy:	5.859 J

JUPITER TMS TRANSIENT MONITORING SYSTEM

SLS SCIENTIFIC LIGHTNING SOLUTIONS, LLC

info@sls-us.com | 321-607-6382 | www.sls-us.com

Figure 47: Example Jupiter TMS data report.

11.7 Remote Command Interface

Jupiter TMS users can control various functions of the instrument locally through the local Ethernet interface (via the "Status" page, see Section 9.8), including arming/disarming the data acquisition and performing manual triggers). In many cases, it is more convenient and efficient to execute these functions remotely. The Jupter TMS Remote Command Interface allows users to control instrument functionality remotely through a basic web-based user interface. A screenshot of the interface is shown in Figure 48. The remote command interface is accessed by navigating to `serverIPaddress/app/TMSSerial#/config/remote` from a browser window, or by selecting the "Remote Cmd" link under the "Settings" menu in the Customer Dashboard (see Figure 40).

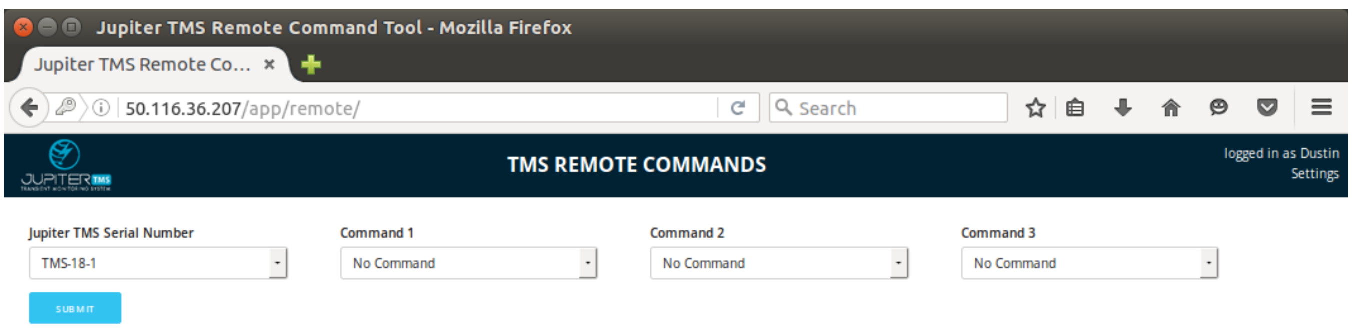


Figure 48: Jupiter TMS remote command interface.

The remote command interface includes four drop-down menus. At far left, the user can select which Jupiter TMS unit to control. If a user has multiple Jupiter TMS units connected to the same server, all connected Jupiter TMS units will be listed by serial number. The remote command interface allows up to three commands to be specified (corresponding to the three remaining drop-down menus). The commands are labeled "Command 1" ,"Command 2", and "Command 3". By default, the "No Command" option is selected. The following functions are available under each command drop-down menu.

1. **No Command:** Default condition, no remote command executed on instrument.
2. **Arm Acquisition:** Arm data acquisition.
3. **Disarm Acquisition:** Disarm data acquisition.
4. **Manual Trigger/Rearm:** Issue a single manual trigger, then rearm the data acquisition.
5. **Clear Data Folder:** Delete all data acquisition files in the data save directory. Note this function is useful if a trigger setting on the device is configured improperly, or local noise results in the instrument triggering rapidly, producing data records that are undesirable. By clearing the internal data save directory, the files will not be transferred to the remote server. Users should exercise care when clearing the data save folder to ensure that no recorded data files of interest are deleted.
6. **Send Status Report:** Command the instrument to compile and upload an on-demand status report to the remote server. Status reports are configured to be generated and uploaded every 6 hours by default.
7. **Reboot:** Reboot the Jupiter TMS instrument.

The three possible remote commands are automatically downloaded from the server by the appropriate Jupiter TMS unit. The commands are executed in order (Command 1, Command 2, then Command 3), separated in time by 15 seconds. Note that any commands following a "Reboot" command will not be executed. The Jupiter TMS unit polls the remote server every minute for new remote commands. Thus, the delay between when a set of remote commands are issued and when the command execution begins on the Jupiter TMS unit can be up to one minute.

12 Jupiter TMS Share Drive Utilities

The online, browser-based utilities that are available for Jupiter TMS units that are connected to a cloud-based remote server are not available for Jupiter TMS units that are connected to Linux/Windows share drives on a local network. However, standalone desktop applications for Jupiter TMS system configuration, waveform display, system status, and automatic report generation are available if the user is permitted to install third-party software on the the local network server/workstation. Jupiter TMS customers should discuss available software options with SLS for Jupiter TMS units that will be connected to Linux/Windows share drives on a local network.

Appendices

A Critical Facility Application Note

This application note addresses how Jupiter TMS can be used in data-centers or other critical facilities to monitor transient currents at the facility entrance, and/or at the electrical panel(s) that power the critical loads. If multiple Jupiter TMS units are installed, detected transients can be accurately traced and their propagation directions can be determined (due to the precision timing resolution of Jupiter TMS), helping to pinpoint the transient origin.

Jupiter TMS Installation

SLS recommends installing the Jupiter TMS unit on the last SPD-protected panel before the critical loads. The installation can occur at either the 480Y/277V or 208/120V level (Figure 49). In this configuration, Jupiter TMS monitors each of the phase currents feeding the critical loads in addition to the SPD ground current. If the electrical system has coordinated SPDs, the surge currents to the critical loads should be negligible. Thus, large amplitude transient currents measured on the phase conductors past the final SPD will be indicative of incorrect SPD coordination, failure of SPDs upstream, or transients entering the critical loads through unintended paths. SLS recommends current monitoring sensors that are rated at twice the SPD current and ten times the phase-rated current.

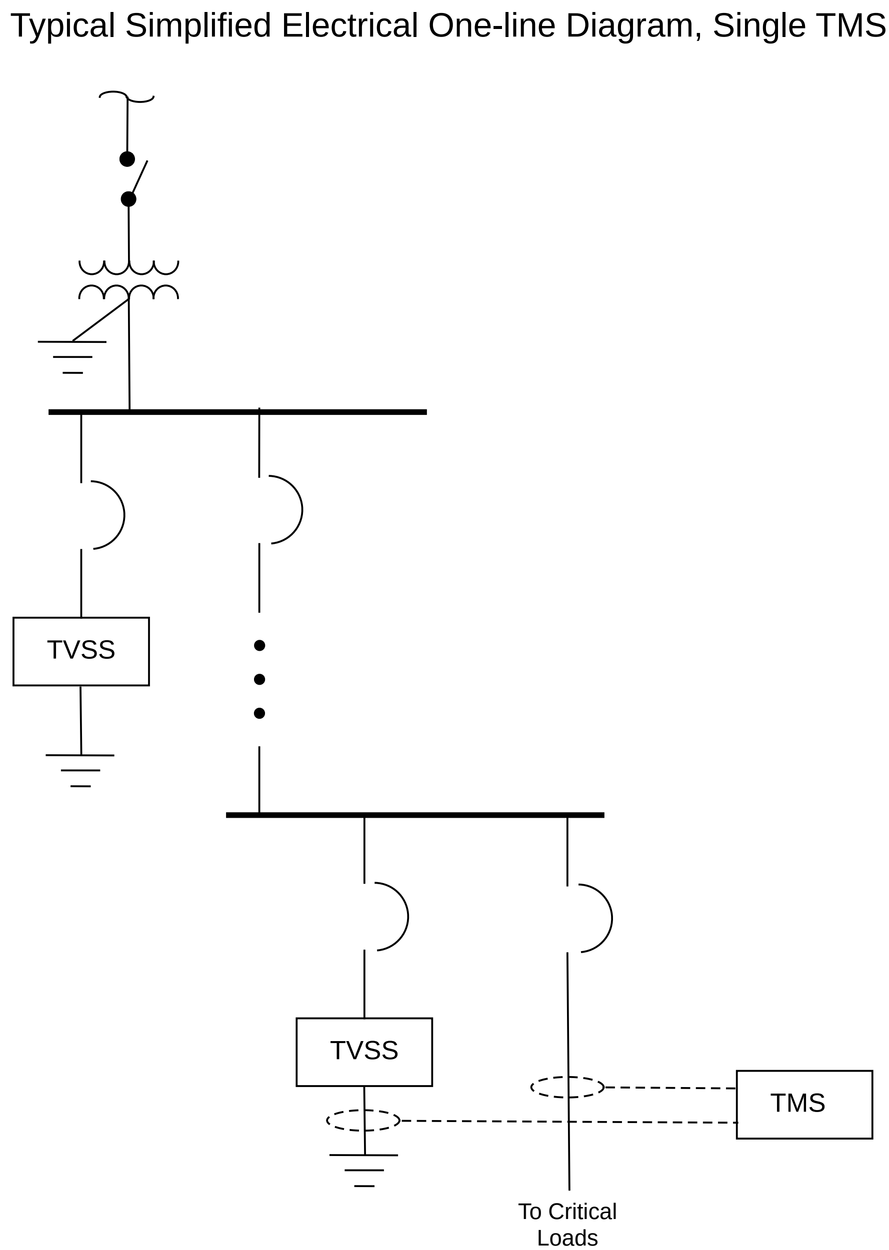


Figure 49: Single line diagram of Jupiter TMS installation on the last electrical panel before the critical loads. Jupiter TMS is used to monitor the three phase conductors and the SPD ground current.

Multiple Jupiter TMS units can be installed to provide coordinated transient monitoring of electrical panels from the facility entrance to the critical loads. When multiple Jupiter TMS units are installed, the coordinated measurements can be used to accurately pinpoint the origins of injected transients. Damaging transients often propagate into the facility on the incoming power mains (due to nearby lightning strikes or other external power interruptions), but may also be internally generated due to switching of certain inductive loads. A coordinated measurement approach with multiple Jupiter TMS units is shown in Figure 50.

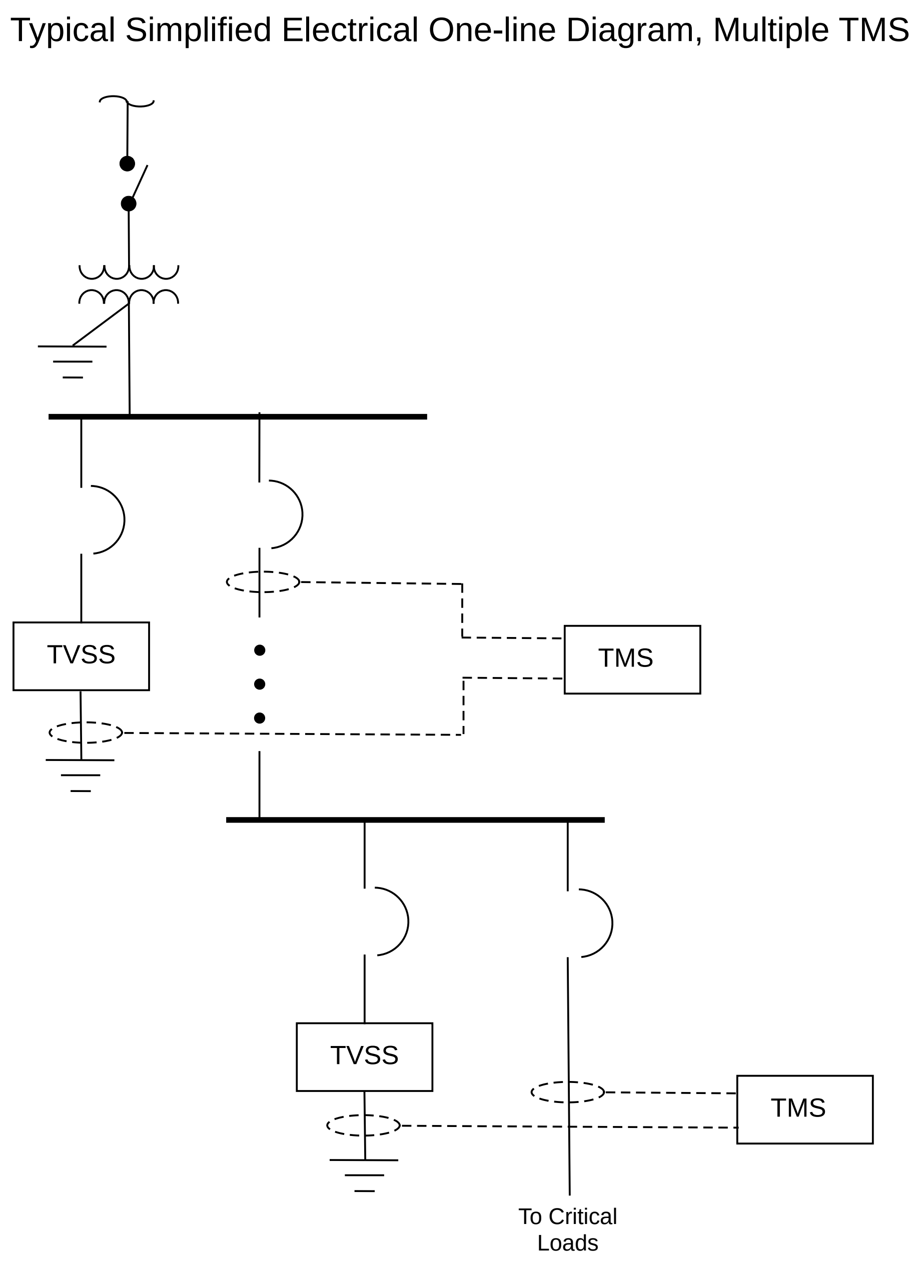


Figure 50: Single line diagram of Jupiter TMS installation including multiple units. This configuration can be used to accurately trace and pinpoint the origin of the injected surge.

Transient Current Measurement Concept The Jupiter TMS unit will digitize the outputs of four Rogowski coil current monitors, connected as follows:

- Ch1: Phase A current
- Ch2: Phase B current
- Ch3: Phase C current
- Ch4: SPD ground current.

SLS recommends that Jupiter TMS is configured to trigger if the phase currents exceed twice their rated current or the SPD ground current exceeds 5% of the SPD rated current. When a qualified trigger is detected (any of the thresholds above are exceeded), the data file is automatically generated, stored to the Jupiter TMS permanent storage, and then automatically transferred to the remote server (see Section 10.2). With user input of the SPD clamp voltage (see Section 9.7), the server executes an automated processing routine to calculate the SPD dissipated energy. If the SPD dissipated energy exceeds a predefined threshold, or the phase currents exceed their predefined thresholds (twice their rated current), a report is sent to the designated recipients.

The report includes the following parameters:

1. The panel reference designation where the transient current was measured
2. The peak current (per phase) of the measured transient
3. The SPD bank peak current
4. The energy dissipated by the SPD bank (J)

5. Accurate timing of the surge event (note, this accurate timing can be important for correlation with lightning detection network reports, such as those provided by the National Lightning Detection Network (NLDN), particularly if damage occurs that may result in the filing of insurance claims)

An example report was provided in Section 11.6.

B .TR File Header Structure

Table 9: Jupiter TMS data acquisition file (.TR) header definition.

Header Field	Data Type	Bytes	Description
h.GPSLock	bool	1	1=Lock, 0=No Lock
h.Timestamp_s	uint64	8	Trigger time seconds relative to Epoch (1/1/1970)
h.Timestamp_fsec	double	8	Trigger time fractional seconds
h.Pretrigger	uint32	4	Pre-trigger samples
h.Length	uint32	4	Total number of samples
h.Samplerate	uint32	4	Digitizer sample rate
h.PartNumber	char	11	Jupiter TMS part number
h.SerialNumber	char	10	Jupiter TMS serial number
h.FirmwareVersion	char	10	Jupiter TMS firmware version
h.InstallLocation	char	21	Jupiter TMS installation location
h.Ch1AcquisitionMode	uint32	4	Ch1 Acquisition Mode
h.Ch1ClampVoltage	uint32	4	Ch1 SPD Clamp Voltage
h.Ch1Name	char	21	Ch1 Name
h.Ch1Units	char	21	Ch1 Physical Units
h.Ch1Offset	int32	4	Ch1 DC Offset
h.Ch1Multiplier	double	8	Ch1 Multiplier
h.Ch1TriggerLevelA	double	8	Ch1 Trigger Level A
h.Ch1TriggerLevelB	double	8	Ch1 Trigger Level B
h.Ch1TriggerMode	char	15	Ch1 Trigger Mode
h.Ch1Hysteresis	uint32	4	Ch1 Hysteresis
h.Ch1InputImpedance	char	6	Ch1 Input Impedance

Table 9 continued from previous page

Header Field	Data Type	Bytes	Description
h.Ch1InputCoupling	char	5	Ch1 Input Coupling
h.Ch1Range	char	15	Ch1 Input Range
h.Ch1OrTrigger	char	7	Ch1 OR Trigger
h.Ch1AndTrigger	char	7	Ch1 AND Trigger
h.Ch2AcquisitionMode	uint32	4	Ch2 Acquisition Mode
h.Ch2ClampVoltage	uint32	4	Ch2 SPD Clamp Voltage
h.Ch2Name	char	21	Ch2 Name
h.Ch2Units	char	21	Ch2 Physical Units
h.Ch2Offset	int32	4	Ch2 DC Offset
h.Ch2Multiplier	double	8	Ch2 Multiplier
h.Ch2TriggerLevelA	double	8	Ch2 Trigger Level A
h.Ch2TriggerLevelB	double	8	Ch2 Trigger Level B
h.Ch2TriggerMode	char	15	Ch2 Trigger Mode
h.Ch2Hysteresis	uint32	4	Ch2 Hysteresis
h.Ch2InputImpedance	char	6	Ch2 Input Impedance
h.Ch2InputCoupling	char	5	Ch2 Input Coupling
h.Ch2Range	char	15	Ch2 Input Range
h.Ch2OrTrigger	char	7	Ch2 OR Trigger
h.Ch2AndTrigger	char	7	Ch2 AND Trigger
h.Ch3AcquisitionMode	uint32	4	Ch3 Acquisition Mode
h.Ch3ClampVoltage	uint32	4	Ch3 SPD Clamp Voltage
h.Ch3Name	char	21	Ch3 Name
h.Ch3Units	char	21	Ch3 Physical Units

Table 9 continued from previous page

Header Field	Data Type	Bytes	Description
h.Ch3Offset	int32	4	Ch3 DC Offset
h.Ch3Multiplier	double	8	Ch3 Multiplier
h.Ch3TriggerLevelA	double	8	Ch3 Trigger Level A
h.Ch3TriggerLevelB	double	8	Ch3 Trigger Level B
h.Ch3TriggerMode	char	15	Ch3 Trigger Mode
h.Ch3Hysteresis	uint32	4	Ch3 Hysteresis
h.Ch3InputImpedance	char	6	Ch3 Input Impedance
h.Ch3InputCoupling	char	5	Ch3 Input Coupling
h.Ch3Range	char	15	Ch3 Input Range
h.Ch3OrTrigger	char	7	Ch3 OR Trigger
h.Ch3AndTrigger	char	7	Ch3 AND Trigger
h.Ch4AcquisitionMode	uint32	4	Ch4 Acquisition Mode
h.Ch4ClampVoltage	uint32	4	Ch4 SPD Clamp Voltage
h.Ch4Name	char	21	Ch4 Name
h.Ch4Units	char	21	Ch4 Physical Units
h.Ch4Offset	int32	4	Ch4 DC Offset
h.Ch4Multiplier	double	8	Ch4 Multiplier
h.Ch4TriggerLevelA	double	8	Ch4 Trigger Level A
h.Ch4TriggerLevelB	double	8	Ch4 Trigger Level B
h.Ch4TriggerMode	char	15	Ch4 Trigger Mode
h.Ch4Hysteresis	uint32	4	Ch4 Hysteresis
h.Ch4InputImpedance	char	6	Ch4 Input Impedance
h.Ch4InputCoupling	char	5	Ch4 Input Coupling

Table 9 continued from previous page

Header Field	Data Type	Bytes	Description
h.Ch4Range	char	15	Ch4 Input Range
h.Ch4OrTrigger	char	7	Ch4 OR Trigger
h.Ch4AndTrigger	char	7	Ch4 AND Trigger

C Example Parsed .TR File Header

Table 10: Example of fully parsed .TR header file.

Header Field	Value
GPSLock	1
Timestamp_s	1538428561
Timestamp_fsec	0.670665638
Pretrigger	40000
Length	80000
Samplerate	80000000
PartNumber	TMS-I-18A
SerialNumber	TMS-18-2
FirmwareVersion	18.8.28
InstallLocation	SLS- Panel 12345
Ch1AcquisitionMode	0
Ch1ClampVoltage	0
Ch1Name	Phase A Current
Ch1Units	A
Ch1Offset	-24
Ch1Multiplier	100
Ch1TriggerLevelA	10
Ch1TriggerLevelB	-10
Ch1TriggerMode	window-exit
Ch1Hysteresis	0
Ch1InputImpedance	50ohm

Table 10 continued from previous page

Header Field	Value
Ch1InputCoupling	AC
Ch1Range	200
Ch1OrTrigger	TRUE
Ch1AndTrigger	FALSE
Ch2AcquisitionMode	0
Ch2ClampVoltage	0
Ch2Name	Phase B Current
Ch2Units	A
Ch2Offset	9
Ch2Multiplier	100
Ch2TriggerLevelA	10
Ch2TriggerLevelB	-10
Ch2TriggerMode	window-exit
Ch2Hystersis	0
Ch2InputImpedance	50ohm
Ch2InputCoupling	AC
Ch2Range	200
Ch2OrTrigger	TRUE
Ch2AndTrigger	FALSE
Ch3AcquisitionMode	0
Ch3ClampVoltage	0
Ch3Name	Phase C Current
Ch3Units	A

Table 10 continued from previous page

Header Field	Value
Ch3Offset	35
Ch3Multiplier	100
Ch3TriggerLevelA	10
Ch3TriggerLevelB	-10
Ch3TriggerMode	window-exit
Ch3Hysteresis	0
Ch3InputImpedance	50ohm
Ch3InputCoupling	AC
Ch3Range	200
Ch3OrTrigger	TRUE
Ch3AndTrigger	FALSE
Ch4AcquisitionMode	1
Ch4ClampVoltage	600
Ch4Name	SPD Ground Current
Ch4Units	A
Ch4Offset	3
Ch4Multiplier	1000
Ch4TriggerLevelA	100
Ch4TriggerLevelB	-100
Ch4TriggerMode	window-exit
Ch4Hysteresis	0
Ch4InputImpedance	50ohm
Ch4InputCoupling	AC

Table 10 continued from previous page

Header Field	Value
Ch4Range	20000
Ch4OrTrigger	TRUE
Ch4AndTrigger	FALSE

D Example MATLAB Code

```
function W =  Read_JupiterTMS_TRFile()

% Sampling rate
fs = 80E6;

% Select .TR file from local filesystem
[filename, pathName, FilterIndex] = uigetfile('*.tr','Multiselect','off');
cd(pathName);

%Load the entire recording
trFile = fopen(filename,'r');

h.GPSLock = fread(trFile, 1, 'bool');
h.Timestamp_s = fread(trFile, 1, 'uint64');
h.Timestamp_fsec = fread(trFile,1,'double');
h.Pretrigger = fread(trFile, 1, 'uint32');
h.Length = fread(trFile, 1, 'uint32');
h.Samplerate = fread(trFile, 1, 'uint32');

PartNumber=fread(trFile,11,'char');
h.PartNumber=char(PartNumber(1:find(PartNumber==char(10))-1))';

SerialNumber=fread(trFile,10,'char');
h.SerialNumber=char(SerialNumber(1:find(SerialNumber==char(10))-1))';

SoftwareVersion=fread(trFile,10,'char');
h.SoftwareVersion=char(SoftwareVersion(1:find(SoftwareVersion==char(10))-
1))';

InstallLocation=fread(trFile,21,'char');
h.InstallLocation=char(InstallLocation(1:find(InstallLocation==char(10))-
1))';

% Channel 1 Header Fields
h.Ch1AcquisitionMode = fread(trFile,1,'uint32');

h.Ch1ClampVoltage = fread(trFile,1,'uint32');

Ch1Name = fread(trFile,21,'char');
h.Ch1Name = char(Ch1Name(1:find(Ch1Name==char(10))-1))';

Ch1Units = fread(trFile,21,'char');
h.Ch1Units = char(Ch1Units(1:find(Ch1Units==char(10))-1))';

h.Ch1Offset = fread(trFile,1,'int32');

h.Ch1Multiplier = fread(trFile,1,'double');

h.Ch1TriggerLevelA = fread(trFile,1,'double');

h.Ch1TriggerLevelB = fread(trFile,1,'double');

Ch1TriggerMode = fread(trFile,15,'char');
```

```
h.Ch1TriggerMode = char(Ch1TriggerMode(1:find(Ch1TriggerMode==char(10))-1))';

h.Ch1Hystersis = fread(trFile,1,'uint32');

Ch1InputImpedance= fread(trFile,6,'char');
h.Ch1InputImpedance=
char(Ch1InputImpedance(1:find(Ch1InputImpedance==char(10))-1))';

Ch1InputCoupling= fread(trFile,5,'char');
h.Ch1InputCoupling= char(Ch1InputCoupling(1:find(Ch1InputCoupling==char(10))-
1))';

Ch1Range = fread(trFile,15,'char');
h.Ch1Range= char(Ch1Range(1:find(Ch1Range==char(10))-1))';

Ch1OrTrigger = fread(trFile,7,'char');
h.Ch1OrTrigger= char(Ch1OrTrigger(1:find(Ch1OrTrigger==char(10))-1))';

Ch1AndTrigger = fread(trFile,7,'char');
h.Ch1AndTrigger = char(Ch1AndTrigger(1:find(Ch1AndTrigger==char(10))-1))';

% Channel 2 Header Fields
h.Ch2AcquisitionMode = fread(trFile,1,'uint32');

h.Ch2ClampVoltage = fread(trFile,1,'uint32');

Ch2Name = fread(trFile,21,'char');
h.Ch2Name = char(Ch2Name(1:find(Ch2Name==char(10))-1))';

Ch2Units = fread(trFile,21,'char');
h.Ch2Units = char(Ch2Units(1:find(Ch2Units==char(10))-1))';

h.Ch2Offset = fread(trFile,1,'int32');

h.Ch2Multiplier = fread(trFile,1,'double');

h.Ch2TriggerLevelA = fread(trFile,1,'double');

h.Ch2TriggerLevelB = fread(trFile,1,'double');

Ch2TriggerMode = fread(trFile,15,'char');
h.Ch2TriggerMode = char(Ch2TriggerMode(1:find(Ch2TriggerMode==char(10))-1))';

h.Ch2Hystersis = fread(trFile,1,'uint32');

Ch2InputImpedance= fread(trFile,6,'char');
h.Ch2InputImpedance=
char(Ch2InputImpedance(1:find(Ch2InputImpedance==char(10))-1))';

Ch2InputCoupling= fread(trFile,5,'char');
h.Ch2InputCoupling= char(Ch2InputCoupling(1:find(Ch2InputCoupling==char(10))-
1))';
```

```
Ch2Range = fread(trFile,15,'char');
h.Ch2Range= char(Ch2Range(1:find(Ch2Range==char(10))-1))';

Ch2OrTrigger = fread(trFile,7,'char');
h.Ch2OrTrigger= char(Ch2OrTrigger(1:find(Ch2OrTrigger==char(10))-1))';

Ch2AndTrigger = fread(trFile,7,'char');
h.Ch2AndTrigger = char(Ch2AndTrigger(1:find(Ch2AndTrigger==char(10))-1))';

% Channel 3 Header Fields
h.Ch3AcquisitionMode = fread(trFile,1,'uint32');

h.Ch3ClampVoltage = fread(trFile,1,'uint32');

Ch3Name = fread(trFile,21,'char');
h.Ch3Name = char(Ch3Name(1:find(Ch3Name==char(10))-1))';

Ch3Units = fread(trFile,21,'char');
h.Ch3Units = char(Ch3Units(1:find(Ch3Units==char(10))-1))';

h.Ch3Offset = fread(trFile,1,'int32');

h.Ch3Multiplier = fread(trFile,1,'double');

h.Ch3TriggerLevelA = fread(trFile,1,'double');

h.Ch3TriggerLevelB = fread(trFile,1,'double');

Ch3TriggerMode = fread(trFile,15,'char');
h.Ch3TriggerMode = char(Ch3TriggerMode(1:find(Ch3TriggerMode==char(10))-1))';

h.Ch3Hystersis = fread(trFile,1,'uint32');

Ch3InputImpedance= fread(trFile,6,'char');
h.Ch3InputImpedance=
char(Ch3InputImpedance(1:find(Ch3InputImpedance==char(10))-1))';

Ch3InputCoupling= fread(trFile,5,'char');
h.Ch3InputCoupling= char(Ch3InputCoupling(1:find(Ch3InputCoupling==char(10))-
1))';

Ch3Range = fread(trFile,15,'char');
h.Ch3Range= char(Ch3Range(1:find(Ch3Range==char(10))-1))';

Ch3OrTrigger = fread(trFile,7,'char');
h.Ch3OrTrigger= char(Ch3OrTrigger(1:find(Ch3OrTrigger==char(10))-1))';

Ch3AndTrigger = fread(trFile,7,'char');
h.Ch3AndTrigger = char(Ch3AndTrigger(1:find(Ch3AndTrigger==char(10))-1))';

% Channel 4 Header Fields
h.Ch4AcquisitionMode = fread(trFile,1,'uint32');
```

```
h.Ch4ClampVoltage = fread(trFile,1,'uint32');

Ch4Name = fread(trFile,21,'char');
h.Ch4Name = char(Ch4Name(1:find(Ch4Name==char(10))-1))';

Ch4Units = fread(trFile,21,'char');
h.Ch4Units = char(Ch4Units(1:find(Ch4Units==char(10))-1))';

h.Ch4Offset = fread(trFile,1,'int32');

h.Ch4Multiplier = fread(trFile,1,'double');

h.Ch4TriggerLevelA = fread(trFile,1,'double');

h.Ch4TriggerLevelB = fread(trFile,1,'double');

Ch4TriggerMode = fread(trFile,15,'char');
h.Ch4TriggerMode = char(Ch4TriggerMode(1:find(Ch4TriggerMode==char(10))-1))';

h.Ch4Hystersis = fread(trFile,1,'uint32');

Ch4InputImpedance= fread(trFile,6,'char');
h.Ch4InputImpedance=
char(Ch4InputImpedance(1:find(Ch4InputImpedance==char(10))-1))';

Ch4InputCoupling= fread(trFile,5,'char');
h.Ch4InputCoupling= char(Ch4InputCoupling(1:find(Ch4InputCoupling==char(10))-
1))';

Ch4Range = fread(trFile,15,'char');
h.Ch4Range= char(Ch4Range(1:find(Ch4Range==char(10))-1))';

Ch4OrTrigger = fread(trFile,7,'char');
h.Ch4OrTrigger= char(Ch4OrTrigger(1:find(Ch4OrTrigger==char(10))-1))';

Ch4AndTrigger = fread(trFile,7,'char');
h.Ch4AndTrigger = char(Ch4AndTrigger(1:find(Ch4AndTrigger==char(10))-1))';


%Assign header to output structure
W.header = h;
n =  4*h.Length;

%Range variables for each channel
rangeA = [1:4:n-3];
rangeB = [2:4:n-2];
rangeC = [3:4:n-1];
rangeD = [4:4:n];

%Read the data bytes
AllChannels=fread(trFile, n,'int16');

%Assign channel data to output structure
```

```
W.ChannelA = AllChannels(rangeA);
W.ChannelB = AllChannels(rangeB);
W.ChannelC = AllChannels(rangeC);
W.ChannelD = AllChannels(rangeD);
```

E 3-axis B-dot Antenna Datasheet

3-Axis B-dot Sensor

Sensor Specifications	
Part #	*SR-BDT-1L-200*
Sensitivity	*101.32 A/m/μs/V*
Output	*Differential*
Connectors	*Female N-type (6x)*
Bandwidth	*>25 MHz*
Mounting	*Vertical, Horizontal, Pole*
Base Material	*6061 Aluminum*
Base Coating	*Anodized*

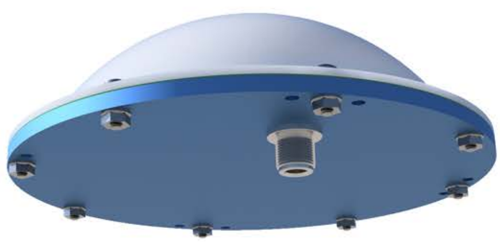
Scientific Lightning Solutions, LLC
1417 Chaffee Drive, Suite 4
www.sls-us.com
321-607-6382

F Flat-Plate D-dot Antenna Datasheet

DATASHEET SR-DDT-105-GP-04

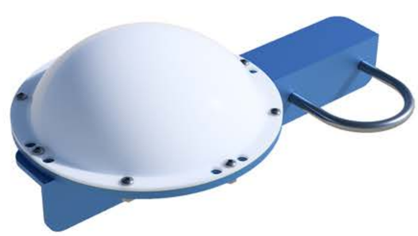
D-Dot Sensor

ELECTRIC FIELD SENSOR



SPECIFICATIONS

MODEL	SR-DDT-105-GP-04
SENSITIVITY	105.5 kV/m/µs/V
OUTPUT	Single-Ended
CONNECTOR	Female N-Type
BANDWIDTH	> 25 MHz
MOUNTING	Horizontal, Pole, Custom
SENSING ELEMENT	353 Brass
INSULATOR	PVC
CONSTRUCTION	Anodized Aluminum, 6061
PROTECTIVE DOME	Acrylic



▲ Example Mounting Configuration

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JUPITER TMS

TRANSIENT MONITORING SYSTEM

Scientific Lightning Solutions, LLC
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Jupiter TMS User Manual
Rev. 19.2, February 2019
Firmware Version: 19.2.18