

Strong Motion Instrumentation





TITAN SMA

STRONG MOTION ACCELEROGRAPH

The TitanSMA is a strong motion accelerograph designed for high precision observational and structural engineering applications, where scientists and engineers require exceptional dynamic range over a wide frequency band.

The TitanSMA features the same sensor as the Titan Accelerometer with its low noise floor, exceptionally low hysteresis, and industry leading dynamic range. The integrated digitizer and recorder facilitate both standalone and networked free-field monitoring deployments.

Ease of use features include:

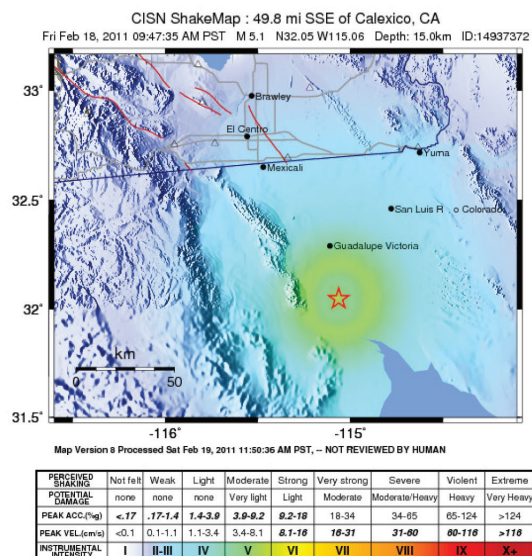
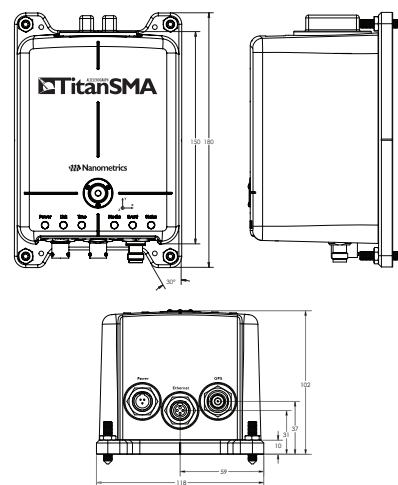
- Convenient data retrieval via removable SD card or local Ethernet in MiniSEED or ASCII formats
- Continual streaming of data to a central server or retrieved on demand from the central site
- HTTP data communications, which requires only Internet website access from within the host IT network to stream continuous or event data
- Instrument configuration/control via browser interface with Ethernet connection
- LED indicators that provide quick visual instrument status
- GNSS, PTP or NTP timing
- Full digitizer/ sensor response metadata files generated on-demand
- Site-to-site encrypted virtual private networks using OpenVPN®
- Easy integration of state-of-health information into existing tools using low bandwidth SNMP communications (Simple Network Management Protocol)

Civil Defense Applications

The TitanSMA provides all the necessary functionality to facilitate civil defense applications such as early warning systems and shake maps:

- Ultra-low latency configurations as low as .25 seconds
- Local real-time processing and transmission of PGA, PGV, and PGD data
- Ability to recognize P-wave events and broadcast warnings
- Network integration of multiple sensors for event triggers and voting

TitanSMA





TITAN EA STRONG MOTION ACCELEROGRAPH

The TitanEA is a strong motion Ethernet accelerograph with power-over-ethernet and Network Timing capabilities specifically designed for networked deployments on or in large civil structures such as nuclear reactors, multi-story buildings, bridges, and hydro-electric dams. The TitanEA features the same Titan triaxial sensor and digitizer/recorder technology as the TitanSMA. The TitanEA comes in two models: the TitanEA Server has a GNSS receiver to get timing from satellites and acts as a network time server to supply timing over Ethernet to TitanEA Clients.

Single cable Ethernet connectivity

Deploy the TitanEA in any structure with only a single Ethernet cable for all functions: power, precision timing, data, and management.

Ethernet connectivity eliminates the need to reroute expensive analogue cables throughout a structure and provides maximum flexibility in sensor placement.

Precision Time Protocol or Network time protocol

Precision Time Protocol (PTP) provides timing accuracy of $<5\mu\text{s}$:

- No need for GNSS antennas at every sensor
- Place the accelerograph anywhere in the structure
- Time inputs provided through the single Ethernet connection

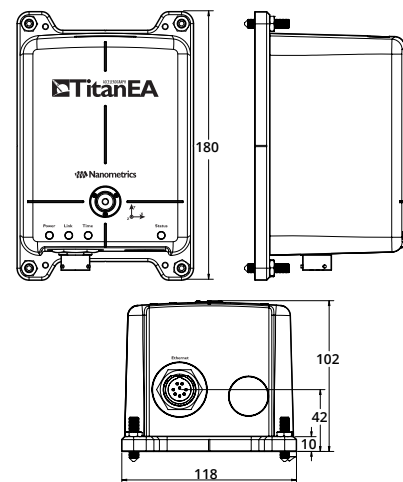
Network Time Protocol (NTP) permits the time source to be not on the same local LAN subnet.

Structural monitoring

The TitanEA facilitates central control room monitoring of a structure, allowing operators to monitor the PGA, PGV, PGD, and SA of all sensors in the network, in real-time, on a convenient display.

Each sensor in the network can be accessed independently using any mobile device with Internet access. Structural engineers can quickly view instrument status and events anywhere, anytime.

TitanEA



TECHNICAL SPECIFICATIONS TITAN SMA AND TITAN EA

*Specifications subject to change without notice

Specifications are applicable to both TitanSMA and TitanEA unless otherwise stated.

ACCELEROMETER TECHNOLOGY AND PERFORMANCE

Topology: Triaxial, horizontal-vertical

Feedback: Force balance with capacitive displacement transducer

Centering: Electronic offset zeroing via user interface

Full-scale Range: Electronically selectable range: $\pm 4g$, $\pm 2g$, $\pm 1g$, $\pm 0.5g$, $\pm 0.25g$, and $\pm 0.125g$ (nominal)

Sensitivity accuracy: $\pm 0.5\%$

Bandwidth: DC to 430 Hz

Dynamic Range: (Integrated RMS)

- 166 dB @ 1 Hz over 1 Hz bandwidth
- 155 dB, 3 to 30 Hz

Offset: Electronically zeroed to within $\pm 0.005g$

Non-linearity: $< 0.015\%$ total non-linearity

Hysteresis: $< 0.005\%$ of full scale

Cross-axis Sensitivity: $< 0.5\%$ total

Offset Temperature Coefficient:

Horizontal sensor: $60 \mu g/^{\circ}C$, typical

Vertical sensor: $320 \mu g/^{\circ}C$, typical

DIGITIZER PERFORMANCE & CAPABILITIES

Type: True 24-bit ADC per channel, simultaneous sampling

Dynamic Range: 142 dB @ 100 sps, 135 dB @ 500 sps (full-scale peak to RMS shorted-input noise)

Sensitivity: 2, 4, 8, 16, 32, and 64 digitizer counts per μg , $\pm 1\%$

Sample Rates: 1, 2, 5, 10, 20, 40, 50, 80, 100, 125, 200, 250, 500, 1000, 2000 sps

Dual Sample Rate: A second sample rate can be selected from the sample rates above

Decimation Filter: Selectable linear phase (non-causal) or minimum phase (causal)

Anti-alias Filters: -140 dB (linear phase) or -120 dB (minimum phase) at Nyquist frequency, 0 dB at 80% Nyquist

Digital Filters:

- User-configurable low-pass and high-pass
- 1st to 5th order, 0.1 mHz to Nyquist
- Different filters may be configured for primary and secondary sample rates

Orientation Correction: User configurable onboard 3-D data rotation for correcting azimuth and tilt

TIMING - GNSS & PRECISION NETWORK TIMING

Timing System: Internal DCXO clock disciplined to selectable timing source

Timing Source: Select from GNSS (TitanSMA and TitanEA Server), PTP (Precision Timing Protocol), NTP or free-running

Timing Server: Can serve as PTP or NTP time to other Centaur, Titan SMA/EA or Meridian

Timing Accuracy:

$< 5 \mu sec$ (GNSS Always on or PTP)

$< 100 \mu sec$ (GNSS duty cycled or local NTP)

GNSS Power: Selectable: Always on, duty cycled, or off

CALIBRATION

Waveforms:

Synthesized sine, step, and PRB signals

Playback user defined calibration files

EVENTS

Type: Bandpassed STA/LTA or threshold

Trigger Selection: Independent threshold or STA/LTA ratio for each channel

STA/LTA Trigger: Configurable STA, LTA, LTA latching, trigger, and de-trigger thresholds

Trigger Votes: User set votes assigned by channel, transmitted via IP multicast

Threshold Trigger: Selectable from 0.01% to 100% of full scale

Event Statistics: Peak ground acceleration, velocity, displacement, S_a (0.3, 1, 3 Hz)

COMMUNICATIONS

Web-based UI: Supports standard PC, tablet and mobile devices

Interfaces: 10/100 Base-T Ethernet

IP Addressing: Static IP, DHCP or link-local IP

Protocols: WebSocket, UDP/IP (unicast/multicast), or HTTP-based data streaming and SNMPv2c for state-of-health monitoring

VPN: OpenVPN®.

DATA RECORDING AND RETRIEVAL

Formats: MiniSEED

Internal Memory: 8 GB flash memory (32, 64, 128 or 256 GB options available)

Removable Media: SD card up to 256 GB (TitanSMA)

Data Retrieval: Direct download via Ethernet
Media exchange via SD card (TitanSMA)

Response Metadata: Generate and download full digitizer/sensor response files in RESP or Dataless SEED or StationXML format, or access from the SD Archive Media in StationXML format

PHYSICAL AND ENVIRONMENTAL

Housing: Aluminum, surface resistant to corrosion, scratches, and chips

Mounting: Single bolt keyhole mount

Leveling: Integrated bubble level

Adjustable locking leveling screws

Size: 180 mm (L) x 118 mm (W) x 102 mm (H)

Weight: 2.6 kg

Operating Temperature:

-20°C to +70°C (Standard Model)

-45°C to +60°C (Polar Certified Model) (TitanSMA)

Storage Temperature:

-40°C to +70°C (Standard Model)

-60°C to +70°C (Polar Certified Model) (TitanSMA)

Shock:

• 100 g half sine, 5 ms without damage, 6 axes

• No mass lock required for transport

Ingress protection: Rated to IP68 at 2 m for 72 hours when connectors mated or capped

Humidity: 0 to 100%

POWER - TITAN SMA

Supply Voltage: 9 to 36 V DC isolated input

Power Consumption: 2.0 W quiescent, 10 Base-T Ethernet, duty cycled GNSS

Protection:

- Reverse-voltage and over-/under-voltage protected
- Self-resetting over-current protection

Isolation: Supply power is isolated from signal ground

Grounding: Predrilled holes (4) for M4 x 5 grounding lug screw

Battery Manager: User-configurable low voltage shutdown and restart thresholds

POWER - TITAN EA (SERVER AND CLIENT)

Supply Voltage: 37 to 57 V DC (Power over Ethernet)

Supported Mode: Mode A and B

Power Consumption: 2.1 W quiescent, 10 Base-T Ethernet, duty-cycled GNSS

INTERFACE

Connectors:

- TitanSMA: Power (MIL-C-26482G Series 1), Ethernet (MIL-C-26482G Series 1), GNSS (TNC female), USB 2.0 (type A, female)
- TitanEA Server: Ethernet (MIL-DTL-26482G Series 1), GNSS (TNC female)
- TitanEA Client: Ethernet (MIL-DTL-26482G Series 1)

Status LEDs:

- TitanSMA: Overall Status, Power, Ethernet, Timing, Media, Event notification
- TitanEA: Overall Status, Power, Ethernet, Timing

Graphical User Interface:

- Provided via onboard web server
- Used for state-of-health and waveform monitoring, viewing and downloading events, calibration, configuration, and maintenance

AVAILABLE MODELS

Model:

- TSMA3: Strong Motion Accelerograph
- TEA3-M: Strong Motion Accelerograph, Timing Server
- TEA3-S: Strong Motion Accelerograph, Timing Client

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Listening to the Earth

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