



CODEVINTEC

Tecnologie per le Scienze della Terra e del Mare

45° 27' 39.384" N
9° 07' 30.145" E

Titan Strong Motion Instrumentation



**Reliable seismic data
in real-time and post event
to determining the state-
of-health of a structure**

Nanometrics and Codevintec provide hardware, software and project management expertise to monitor:

- > Large Structures
- > Dams
- > Bridges
- > Nuclear Reactors
- > Power Plants
- > Multi-storey buildings
- > New Buildings
- > Historical Buildings & Structures



TitanSMA

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:

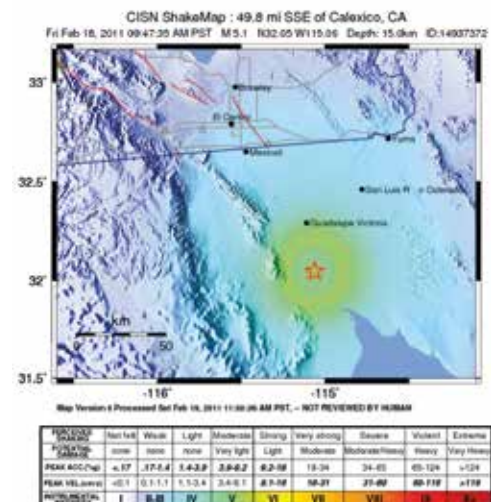
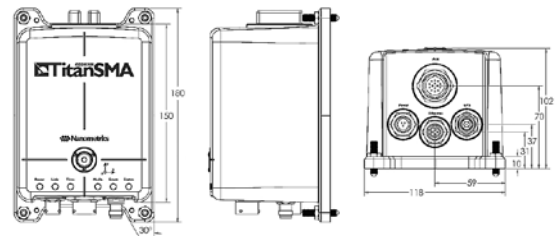
- > Convenient data retrieval via removable SD card or local Ethernet in MiniSEED or ASCII formats
- > Continual streaming of data to a central server or retrieved on demand from the central site
- > HTTP data communications, which requires only Internet website access from within the host IT network 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



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





TitanEA

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 Master has a GNSS receiver to get timing from satellites and acts as a network time master to supply timing over Ethernet to TitanEA Slaves.

Single cable Ethernet connectivity

Deploy the TitanEA in any structure with only a single Ethernet CAT5 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 $<100\mu\text{s}$:

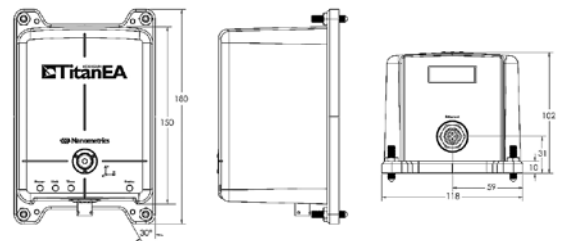
- > No need for GNSS antennas at every sensor
- > Place the accelerograph anywhere in the structure
- > Time inputs provided through the single Ethernet connection

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.





Technical specifications

 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: ± 4 g, ± 2 g, ± 1 g, ± 0.5 g ± 0.25 g, and ± 0.125 g (nominal)
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 ± 0.005 g
Non-linearity	$< 0.015\%$ total non-linearity
Hysteresis	$< 0.005\%$ of full scale
Cross-axis Sensitivity	$< 0.5\%$ total
Offset Temperature	Horizontal sensor: $60 \mu\text{g}/^\circ\text{C}$, typical
Coefficient	Vertical sensor: $320 \mu\text{g}/^\circ\text{C}$, 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 Master), 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	$< 5 \mu\text{sec}$ (GNSS Always on), $< 100 \mu\text{sec}$ (GNSS duty cycled, PTP or local NTP)
GNSS Power	Selectable: Always on, Duty cycled, or off

Calibration

Waveforms	Synthesized sine, PRB signals Playback user defined calibration files
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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 or DHCP or link-local IP
Protocols	UDP/IP (unicast/multicast), or HTTP data streaming

Data Recording and Retrieval

Formats	MiniSEED
Internal Memory	8 GB flash memory (32 or 64 GB options available)
Removable Media	SD card up to 64 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 format

Physical and Environmental

Housing	Aluminum, surface resistant to corrosion, scratches, and chips
Mounting	Single bolt keyhole mount
Leveling	Integrated bubble level Adjustable locking levelling screws
Size	Length: 180 mm Width: 118 mm Height: 102 mm
Weight	2.6 kg
Operating Temperature	-20°C to $+60^\circ\text{C}$ (TitanSMA: Ultra-low temperature option available. Please contact)
Storage Temperature	-40°C to $+70^\circ\text{C}$
Humidity	0 to 100%
Ingress protection	Rated to IP68 at 2 m for 72 hours

Power – TitanSMA

Supply Voltage	9 to 36 V DC isolated input
Power Consumption	2.0 W quiescent, 10 BaseT 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 – TitanEA (Master and Slave)

Supply Voltage	37 to 57 V DC (Power over Ethernet)
Supported Mode	Mode A and B
Power Consumption	2.1 W quiescent, 10 BaseT Ethernet

Interface

Connectors	TitanSMA: Power (MIL-C-26482G Series 1), Ethernet (MIL-C-26482G Series 1), GPS (TNC female), USB 2.0 (type A, female) TitanEA Master: Ethernet (MIL-DTL-26482G Series 1), GPS (TNC female) TitanEA Slave: 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
Interface	Used for state-of-health and waveform monitoring, viewing and downloading events, calibration, configuration, and maintenance