Chapter 2 Quantum NODE

Quantum Node (QN)

The Quantum Node is designed to work without the need for radio communication with the Central Recording System. The node acquires GPS signal for timing and communicates locally to the user through Bluetooth Low Energy (BLE) network.

The Quantum Node consist of 16GB local data storage, internal battery and integrated vertical 5Hz or 10Hz high-sensitivity phone or a MEMS sensor (Accuseis).

The rugged waterproof housing protects the ground station electronics from rough handling of seismic field crews.

Features

- Compact design and light weight allow easier equipment deployment across challenging terrains and dense vegetation

- Rugged watertight casing provides additional protection of ground electronics for extended product life

- Bluetooth Low Energy (BLE) technology – delivers communication between the user and equipment to improve field operations involving deployment and equipment status collection with minimal power consumption

High-speed USB interface is also included for routine data downloading when connected to the iX Transcriber computer:

- Positive Operation LEDs provide instant verification of Node and Sensor Health, Quality of GPS Signal, Battery Voltage

- Low power consumption allows up to 50+ days of continuous seismic data recording

- Hibernation Mode

Hibernation Mode

Normally the Node will not be powered on when laying on any side or on upside-down position. Once a node is in upright position, it turns on automatically see: See Node Deployment

Typically, the Quantum Node is stored, transported, and carried for deployment in a “Node Carrier” as pictured below. This ensures the Node does not power up (and consume battery) unnecessarily or have false deployments while going to the receiver location.

As in the picture below, where a user or shipper handler may mistakenly turn the container on its side. This would result in half the Nodes in “normal operating mode” to be in a “ON” setting and searching for GPS trying to get ready for recording and consuming Battery

Hibernation mode is a selection made by the user while the Node is in the Download/Charge rack. On “hibernate”, see Connectivity

A Node set to “Hibernate” will not turn on, no Bluetooth, no GPS and very low battery consumption.

Nodes will **exit** hibernation mode at the time when the unit(s) is docked in a Download and Charge rack.

From that point on, unit(s) resume the Quantum's normal operational behaviors

Quantum Node Specifications

Quantum Node built in **Geophone**

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FEATURES

- All-in-one single component recording unit
- Lightweight node weighing only 650g
- 50 days typical, 24 Hr operation
- Local 16 GB data storage
- Optional HyperQ long range wireless QC using technology

GENERAL SPECIFICATIONS

No.of Analog Channels:	1
Data Storage Capacity:	16 GB non-volatile flash memory
Integrated Battery:	Rechargeable Li-ion
Battery Life:	50 days typical, 24 Hr operation
	42 days typical, 24 Hr operation (with HyperQ)
Wireless Communication:	Bluetooth LE, Optional HyperQ
GPS:	L1-GPS/QZSS, GLONASS,
	BeiDou, Galileo
Timing Accuracy:	+-5 µs
Sensor:	Vertical 5Hz or 10Hz
	high-sensitivity geophone
Charging Temperature:	+5 °C to + 40°C
Operating Temperature:	-40 °C to + 70 °C
Water Immersion:	IP68

PHYSICAL

Size:	10.9 cm x 9.8 cm x 10.7cm
	(Excl. spike) (4.4" x 3.9" x 4.2")
Weight:	0.65 kg (1.43lbs) incl internal battery
	and geophone

ANALOG SPECIFICATIONS

A/D Converter:	24-bit
Sample Rates:	1 ms, 2 ms, or 4 ms
Gains:	0 dB, 6dB[1], 12 dB, 18dB[1], 24dB[1]
Maximum Input Signal (RMS):	3.535 V @ 0 dB , 1.768 V @ 6 dB
	0.884 V @ 12 dB, 0.442 V @18dB
	0.221 V @ 24 dB
Equivalent Input Noise* (RMS):	1.408 µV @ 0 dB
	0.712 µV @ 6 dB, 0.368 µV @ 12 dB
	0.202 µV @ 18 dB, 0.132 µV @ 24dB
Instantaneous Dynamic Range*:	128 dB @ 0 dB,128 dB @ 6 dB
	128 dB @ 12 dB,127dB @ 18 dB
	124 dB @ 24 dB
System Dynamic Range*:	148 dB
Total Harmonic Distortion:	<0.1% with 10Hz HS phone
	<0.2% with 5Hz HS phone
Channel Matching:	Better than 1%
Anti-Alias Filter:	3dB @ 0.876 ƒN (Nyquist)
Filter Options:	Minimum and Zero Phase

AUTOMATED TESTS

Unit temperature, sensor tilt, system equivalent input noise, sensor noise, dynamic range, geophone DC resistance, THD, natural frequency, damping, sensitivity

[1] Gain option when operating in hybrid with G3i® HD

*Typical specifications @ 2 ms @ 25°C

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Quantum Node with external connector

This node can be configured (using Quantum Config) to use either the internal built in Geophone or an external geophone such as a Marsh phone.

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External Connector

FEATURES

- Single component recording unit with external geophone connector
- Supports deployment in marsh evironments using marshphones
- Operated through iX1 command and control software
- Compatible with current Quantum units and system infrastructure
- Ability to operate in hybrid mode with G3i HD

NODE SPECIFICATIONS

- External Connector type: KCK
- Geophone configurations supported: 6x2 array, single high-sensitivity geophone and single high-sensitivity marshphone
- Integrated Battery: Rechargeable Li-ion
- Data Storage Capacity: 16GB non-volatile flash memory
- Wireless Communication Interfaces: Bluetooth LE
- GPS: L1-GPS /QZSS, GLONASS, BeiDou, Galileo

NODE FLOAT (OPTIONAL)

- Node floation device suitable for marsh nodal operations
- Size: 30.48 cm x 30.48 cm x 7.92 cm
  (12" x 12" x 3.12")
- Weight 1.2 kg (2.64 lbs)

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Quantum Node, internal MEMS Sensor - Accuseis

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ACCUSEIS SENSOR OPTION

FEATURES

- All-in-one single component recording unit with internal MEMS sensor
- Operated through INOVA's iX Studio command and control software
- Patented MEMS accelerometer and custom electronics to record P-wave data
- Offers flat amplitude and phase response over a wide frequency range
- Insensitivity to tilt-degradation enables faster deployment
- Automatic tilt correction and updating of measured tilt

GENERAL SPECIFICATIONS

No.of Digital Channels:	1
Data Storage Capacity:	16 GB non-volatile flash memory
Integrated Battery:	Rechargeable Li-ion
Battery Life:	23 days typical, 24 Hr operation
Wireless Communication:	Bluetooth LE, HyperQ
GPS:	L1-GPS /QZSS, GLONASS, BeiDou, Galileo
Timing Accuracy:	+-20 µs
Charging Temperature:	+5 °C to + 40°C
Operating Temperature:	-40 °C to + 70 °C
Water Immersion:	IP68

SENSOR SPECIFICATIONS

Digital Quantization:	24-bits
Sample Rate:	1 ms, 2 ms, or 4 ms
Time Standard:	Phase locked to GPS clock
Full Scale (Peak):	Normal Mode: 3.3 m/s2 (335mG) Large Signal Mode: 4.9 m/s2 (500mG)
Noise:	Normal Mode:0.3 µm/s2/√Hz (30nG/√Hz) 3 Hz to 400 Hz
Dynamic Range:	118 dB (normal mode)
Frequency response:	0 to 400 Hz
Digital High-Cut Filter:	0.82 Nyquist
Total Harmonic Distortion:	< -100 dB
Filter Options:	Minimum or Zero Phase

PHYSICAL

Size:	10.9 cm x 9.8 cm x 8.61 cm [Excl. spike] (4.4" x 3.9" x 3.4")
Weight:	0.52 kg (1.14lbs) incl internal battery and MEMS accelerometer

AUTOMATED TESTS

Unit temperature, sensor tilt, sensor noise , auto DC offset calibration, response accuracy test.

Operation

The Quantum Nodes are typically placed at every receiver station. The node turns on automatically after placing it on the ground in upright position. The node LED is flashing orange at the beginning while it runs tests and acquires GPS time fix.

Normally after GPS fix is made, the LED starts flashing green (slow) indicating that node is awake and working properly. When LED is flashing red, the node is tilted more than 10° from the vertical position or other error has occurred.

The QC Tool can be used to connect to the unit to finish the deployment, perform QC, collect status data or troubleshoot, if required.

Quantum Field Deployment, Harvest and QC Tools

The QC Tool is used for local communication with the Quantum Nodes (QN). The QC Tool is a rugged Tablet device running the QC Tool software or can be installed on an Android Tablet (OS version 7.0 or greater) supporting BLE (version 4.0 or greater).

The QC Tool uses Bluetooth Low Energy (BLE) communication protocol and can quickly acquire QC and status information from the deployed nodes.

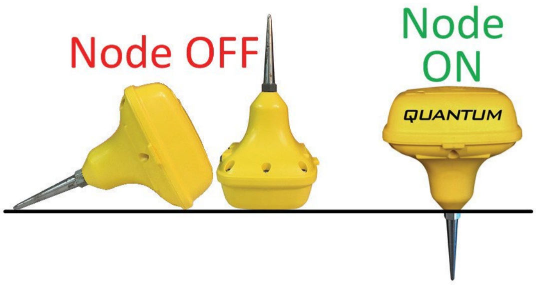
The QC Tool can also be used to monitor real-time seismic data acquisition by Quantum Nodes in the field.

Node Deployment

Note

Before deployment, the nodes should be fully charged and must be pre-configured with survey specific parameters while plugged into docking station and connected to the iX1 Transcriber.

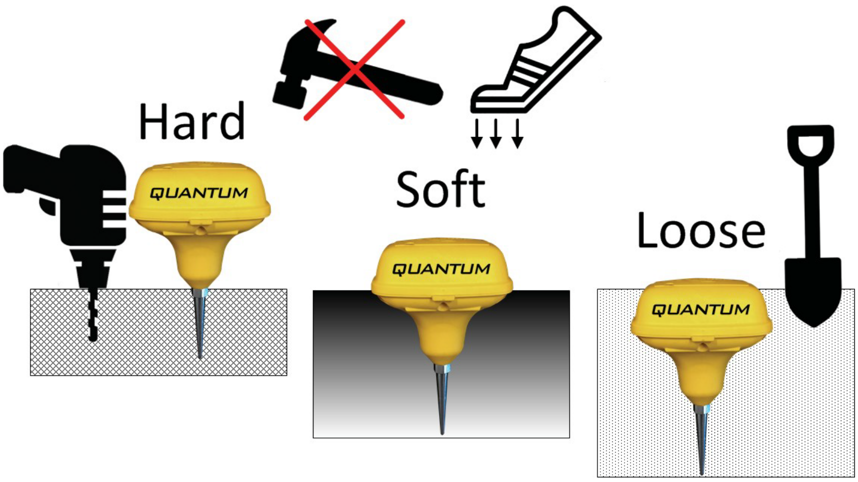
The node is off service when laying on any side or on upside-down position. Once node is in upright position, it turns on automatically. Refer to the figure below.



Note

INOVA recommends to keep the nodes off service before actual deployment.

Depending on the ground condition, there are different scenarios of the node installation. Refer to the figure below.



- Optimally, the top of the node should be flushed with the ground. If desired, the node can be buried under a few centimeters of soil.
- On the hard surfaces a hole can be drilled to the depth of the spike before installation.
- In case of the loose gravel, the shovel can be used to dig a hole which then can be refilled with the same material after node installation.

Warning!

Do not use impact tools such as hammers during the node layout.

Important!

If the nodes have been transported by more than a few hundred kilometers from the last deployment position, it is important to re-acquire the GPS almanac before starting a new project. The nodes must be placed outside with a good sky view. It may take up to 20 minutes to update the GPS satellite almanacand ephemeris data.

After setting the node vertically on the ground, it turns on automatically and the LED starts flashing orange while it performs a self-test and acquires a GPS Fix. Once a GPS Fix is acquired, the LED starts flashing green (slow) indicating that node is in the data acquisition mode.

Now the node can be accessed by the QC Tool over Bluetooth Low Energy (BLE) network to gather the QC/Status data or troubleshooting, if required.

Deep Sleep Mode

- Ultra low-power mode
- No data acquisition or GPS timing
•

This mode is automatically initiated when node is tilted more than 30° of upright vertical position

Self-Test Mode

- Node performs the self-tests
- LED is flashing green and orange (once per second)

Orange is a combination of a green and red LEDs flashing simultaneously.

GPS Fix or Warning Mode

- Node is acquiring the GPS Fix
- LED is flashing orange (once per second)

Data Acquisition Mode

- Node already passed the self-test and acquired GPS Fix
- Node is acquiring the seismic data
- LED is flashing green (every five seconds)

Error Mode

- Node is tilted more than 10° from the vertical upright position
- Other error has occurred
- LED is flashing red (once per second)

NOT Configured - Error Mode

- Node has no configuration
- Orange LED quick flashes then to Red
- LEDs are flashing Orange to Red (once per second)

Self-Test Error Mode

- Node failed the self-test
- LED is flashing green or orange with immediately following red
- All operations still continue as normal

QC Status Transfer Mode

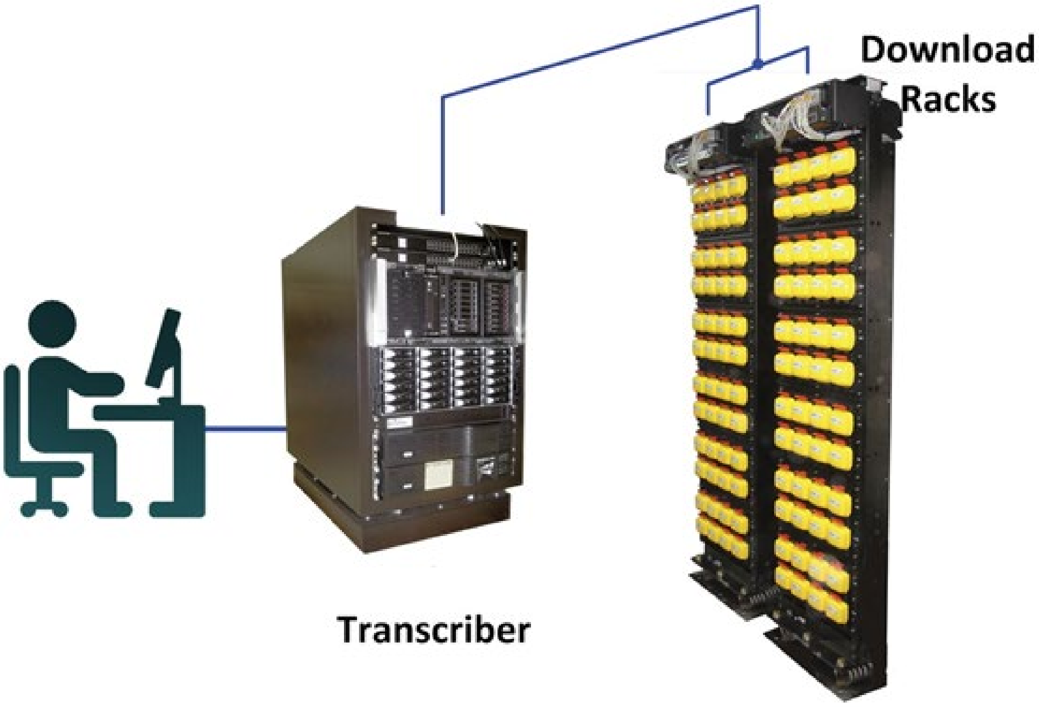
- Node connected to Field QC Tool
- LED is flashing green and red (fast)

Quantum Data Download System

The Quantum Data Download System consists of a Transcriber computer and data download racks, which house the nodes for:

- Data off-load
- Battery charging
- Re-configuration including firmware upgrade.

Refer to” Transcriber (TX1)” for additional information.



Quantum Data Download Racks

Features and Specifications

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DOWNLOAD AND CHARGE RACKS

STANDARD RACK FOR QUANTUM

FEATURES

- Integrated Quantum data download and battery charging
- Suitable for TPM and CPM Standard, TPM Lite or CPM Lite Systems
- Supports up to 48 Quantum nodes

SPECIFICATIONS*

Capacity:	48 Quantum units
Interface:	Ethernet
Power and Voltage:	1350W, 110 to 240 VAC
Operating Temperature:	0 °C to +40 °C
Storage Temperature:	-15 °C to +50 °C

PHYSICAL

Size:	203.2 cm x 56.64 cm x39.37 cm 80" x 22.3" x 15.5
Weight :	95.8 kg (211 lbs)

PORTABLE RACK FOR QUANTUM

FEATURES

- Integrated Quantum data download and battery charging
- Suitable for TPM or CPM Ultra-lite Systems
- Supports up to 16 Quantum nodes
- Portable for easy transporation and setup

SPECIFICATIONS*

Capacity:	16 Quantum Units
Interface:	Ethernet
Power and Voltage:	600W, 110 to 240 VAC
Operating Temperature:	0 °C to +40 °C
Storage Temperature:	-15 °C to +50 °C

PHYSICAL

Size:	76.2 cm x 38.1 cm x 50.8 cm 30" x 15" x 20"
Weight:	17.5 kg (38.6 lbs)

* INOVA reserves the right to change specifications without notice

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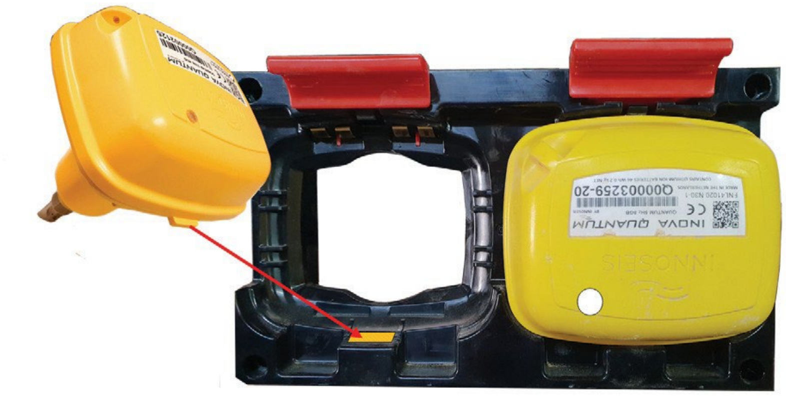
Operations

The nodes are detected by the system automatically and battery charging process starts immediately after docking. The node LED indicates the charging and off-loading statuses. See below.

Node LED Status (Docked)

The node can be easily placed into the download rack by clicking it into a docking station.

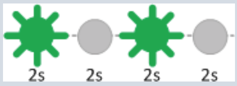
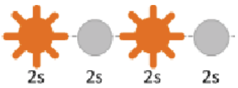
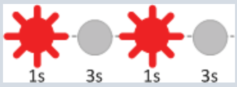
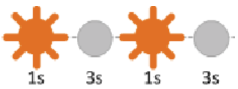
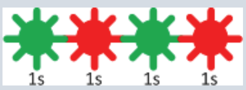
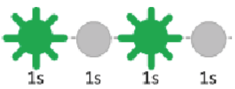


To place the node into the docking station:

- Position wide lip in the backside of the docking station
- Push the node into the docking station towards the wall

To extract the node from the docking station:

- Pull red handle away from the node
- Take the node out of the docking station

LED Status	Description
	**Fully Charged and Off-Loaded** • The battery is fully charged • Data is off-loaded from the node • Node is ready for deployment
	**Charging and Off-Loaded** • The battery is charging • Data is off-loaded
	**In Bootloader Mode** • Node is in Bootloader Mode • Node Firmware is not loaded
	**Fully Charged, Not Off-Loaded** • The battery is fully charged
	**Charging, Not Off-Loaded** The battery is charging
	**Charge Warning** • The battery temperature is out of limits • The charge current is too high
	**Docked, Not Charging** • Connection is established • Battery is not charging (warning)
	**Data Off-Loading / Firmware Upgrade** • Connection is established • Data is off-loading from the node • Firmware update is in progress
	**Node Location** • Node location is requested by system

Quantum Self-Tests

For Accuseis Quantum Nodes- see "Quantum with Accuseis BITS"

Test Overview (Geophone)

Each Quantum Node is equipped with an internal calibration and testing circuit. This includes a signal generator (DAC-digital-to- analog converter) that provides the signals required to test the node's electronics and sensor (geophone). Using a series of switches and several signals generated by the DAC, various tests are performed to characterize the performance and quality of the node.

An automatic QC test is performed by the node at each start up during deployment. Also, the node can be programmed to run additional QC tests according to the schedule which is defined in the iX Studio (Quantum Config) and transferred to iX Transcriber to configure the nodes before deployment.

> Note
> *Due to the expected very noisy conditions near the download racks, some sensor tests are irrelevant (tilt, ambient noise) and others impractical when node is docked.*

The Quantum Node runs the following group of internal tests:

Channel Test	Name in Reports		Deployment		Docked	
	iX Transcriber	iX Studio	BITs	QC	BITs	History BITs
Equivalent Input Noise	EIN at XX dB Gain	Full Band	X	X	X	X
Dynamic Range	DR at XX dB Gain	DR	X	X	X	X
Front-End Offset	Offset at XX dB Gain		X		X	X
Gain Accuracy	Gain at XX dB Gain	Gain	X	X	X	X
Geophone Test	**Name in Reports**		**Deployment**		**Docked**	
	iX Transcriber	**iX Studio**	**BITs**	**QC**	**BITs**	**History BITs**
DC Resistance	GeophoneResistance	Resistance	X	X	X	X
Ambient Noise	Sensor Noise	Noise	X	X		X
Tilt[3]	Tilt Angle	Tilt	X	X		X
Distortion[1]	Sensor THD		X			X[2]
Sensitivity	Sensitivity		X			X[2]
Resonance Frequency	Nat. Frequency		X			X[2]
Damping	Damping		X			X[2]

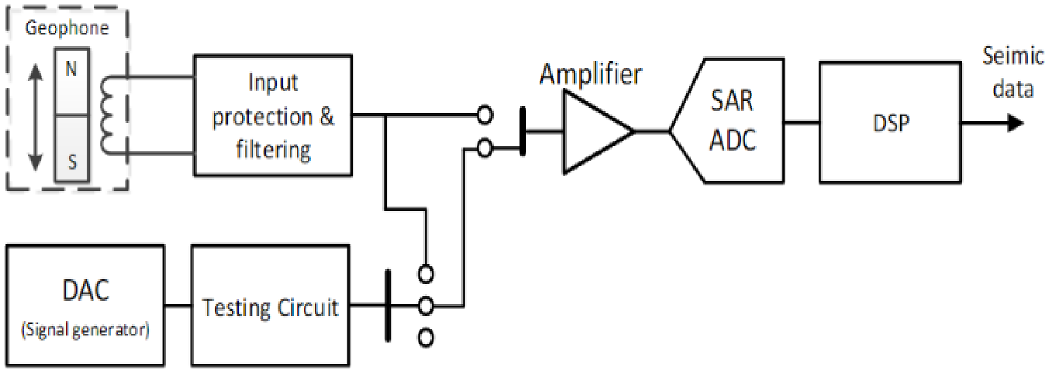
[1] Test evaluates a total harmonic distortion of the geophone and input channel.

[2] Tests are evaluated during the data download and charge processes and can be viewed only in the Quantum History BITs domain.

[3] Sensor tilt is evaluated and recorded continuously.

Channel Tests

Gain Test



The **Gain Test** is designed to ensure that all nodes across the spread have consistent gain values. The test includes the following steps:

1. The channel input is isolated from the sensor.
2. The channel input is connected to the internal signal generator (DAC) and constant voltage is applied
3. In Field, one second of data is recorded at the Node configured preamp gain using production filter and sample settings.
4. The BITS initiated from TX1 test all the available gains
5. The gain factor is calculated using the following formula:

$$Sum = \sum_{i=N_{Skip}}^{N} X_i$$

$$Gain\ Test\ Result = Average = \frac{Sum}{(N - N_{Skip})}$$

6. The test results are compared against manufacturer's tolerances.

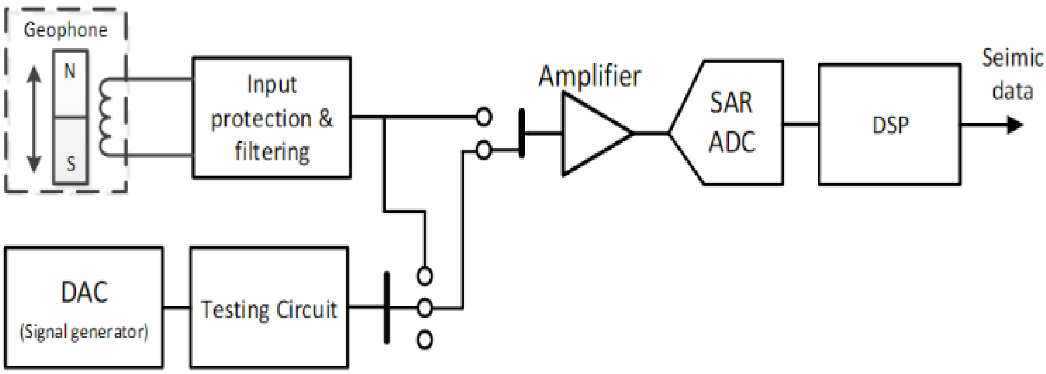
Test	Bound	0dB	6dB	12dB	18dB	24dB
Gain (factor)	Upper	1.171	2.198	4.278	8.303	16.620
	Lower	0.869	1.798	3.680	7.321	14.846

The trace data of gain test is identified by the byte 218 of its trace header being 0x01 in hex or 1 in decimal. If using INOVA plotter, it shows simply “Gain” test in the field.

In the **TX1**, in the **Quantum BITs history** or **NODE Status**, Columns to display as well as Threshold tolerance may be chosen, example below:

Gain 0dB	Gain 6dB	Gain 12dB	Gain 18dB	Gain 24dB
1.02	0.00	0.00	0.00	0.00
1.02	0.00	0.00	0.00	0.00
1.02	1.99	4.00	7.83	15.85
1.02	1.99	4.01	7.82	15.85
1.02	0.00	0.00	0.00	0.00
1.02	1.99	4.01	7.82	15.84
1.02	0.00	0.00	0.00	0.00
>=0.869 & <=1.171	>=1.798 & <=2.198	>=3.68 & <=4.278	>=7.321 & <=8.303	>=14.846 & <=16.62

Front-End Offset and Equivalent Input Noise Tests



The test data is acquired for both tests simultaneously. Front-end offset is a measure of the displacement of the DC signal with respect to zero for a given preamp gain. Equivalent Input Noise (EIN) test result shows the smallest possible signal that can be measured by the channel.

The test includes the following steps:

1. The channel input is isolated from the sensor.
2. The channel input is connected to a low-value termination resistor in the testing circuit.
3. One second of data is recorded at configured preamp gain using production filter settings.
4. The values for offset and noise are calculated by taking the mean and standard deviation of the measurements respectively.

$$V_{offset} = Mean\,(V_{measured})$$

$$V_{noise} = Std\,(V_{measured})$$

The trace data of offset/noise test is identified by the byte 218 of its trace header being 0x02 or 2. The test results are compared against manufacturer's tolerances.

In the TX1, in the **Quantum BITs history** or **NODE Status**, Columns to display as well as threshold tolerances may be chosen, example below

Drag a column header here to group by that column

	EIN at 0dB, uV	EIN at 6dB, uV	EIN at 12dB, uV	EIN at 24dB, uV	Offset 0dB, uV	Offset 6dB, uV	Offset 12dB, uV	Offset 24dB, uV
4	1.47	0.00	0.00	0.00	-86.87	0.00	0.00	0.00
5	1.26	0.00	0.00	0.00	-86.60	0.00	0.00	0.00
6	1.42	0.67	0.38	0.14	-86.51	-55.02	-37.79	-25.75
7	1.42	0.74	0.38	0.13	-83.91	-88.52	-90.57	-93.18
8	1.42	0.00	0.00	0.00	-82.48	0.00	0.00	0.00
9	1.47	0.71	0.37	0.13	-82.39	-87.28	-89.26	-91.81
10	1.37	0.00	0.00	0.00	-81.50	0.00	0.00	0.00
	2 ms<=2.686	2 ms<=1.358	2 ms<=0.7	2 ms<=0.253	>=-300 & <=300	>=-600 & <=600	>=-1100 & <=1100	>=-4600 & <=4600

Instantaneous Dynamic Range

The equivalent input noise values are also used to calculate the channel instantaneous dynamic range as the ratio between the largest signal input value and the smallest equivalent input noise value. Data from the noise test and Gain tests are used

$$DR(dB) = 20Log_{10}\left(\frac{V_{peak}}{\sqrt{2} \times V_{noise}}\right)$$

Table 3. DR (minimum) Thresholds

	Preamp Gain (dB)					Sample Rate (ms)
	0	6	12	18	24	
DR Min (dB)	119.0	118.9	118.6	117.8	115.5	**1**
	122.0	121.9	121.6	120.8	118.5	**2**
	125.0	124.9	124.6	123.8	121.5	**4**

In the TX1, in the Quantum BITs history or NODE Status, Columns to display as well as threshold tolerances may be chosen; an example is shown below:

Drag a column header here to group by that column

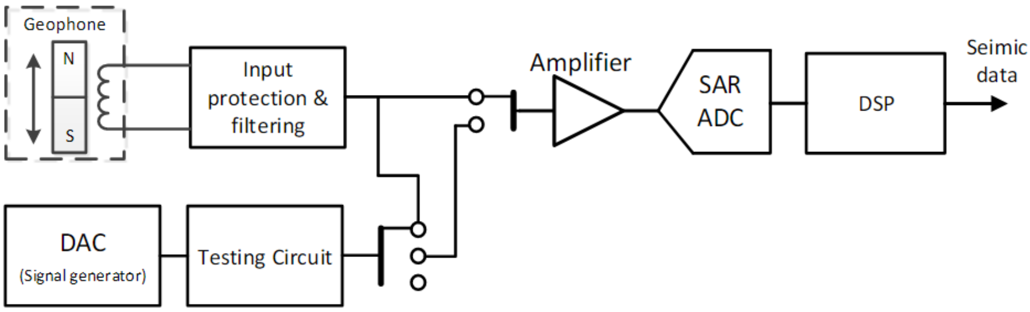
	DR 0dB, dB	DR 6dB, dB	DR 12dB, dB	DR 18dB, dB	DR 24dB, dB	DR at Config Gain, dB
4	127.5	0.0	0.0	0.0	0.0	127.6
5	128.8	0.0	0.0	0.0	0.0	129.0
6	127.8	128.5	127.4	127.5	124.3	127.9
7	127.7	127.6	127.2	126.8	124.8	127.9
8	127.8	0.0	0.0	0.0	0.0	128.0
9	127.5	128.0	127.5	126.5	124.6	127.6
10	128.1	0.0	0.0	0.0	0.0	128.3
	2 ms>=122	2 ms>=121.9	2 ms>=121.6	2 ms>=120.8	2 ms>=118.5	>=122

Geophone Tests

In the **TX1 Quantum BITs history** window, columns for the user to display and threshold tolerances may be chosen, an example below:

	Geophone Model	Geophone Resistance, Ohms	Sensor THD, %	Nat. Frequency	Damping	Sensitivity	Sensor Noise, uV	Tilt Angle	BITs Type
237	PS_5GR	1833	0.037	4.90	0.609	78.1	1083.8	91.0	In Rack
238	PS_5GR	1817	0.076	5.04	0.612	81.8	614.8	1.3	In Field
239	PS_5GR	1822	0.076	5.04	0.612	81.8	614.8	1.4	In Rack
240	PS_5GR	Open	0.029	0.00	0.000	0.0	1.6	1.2	In Field
241	PS_5GR	1888	0.037	4.90	0.609	78.1	1083.8	1.6	In Field
242	PS_5GR	1841	0.033	4.98	0.589	80.9	603.5	2.0	In Field
243	PS_5GR	1849	0.039	4.97	0.589	80.9	428293.7	2.2	In Field
		>=1758 & <=1943	<= 0.200000002980232	>=4.65 & <=5.35	>=0.56 & <=0.64	>=76.00 & <=84.00		<=10	

DC Resistance Test



The **DC Resistance Test** easures the geophone resistance. The test includes the following steps:

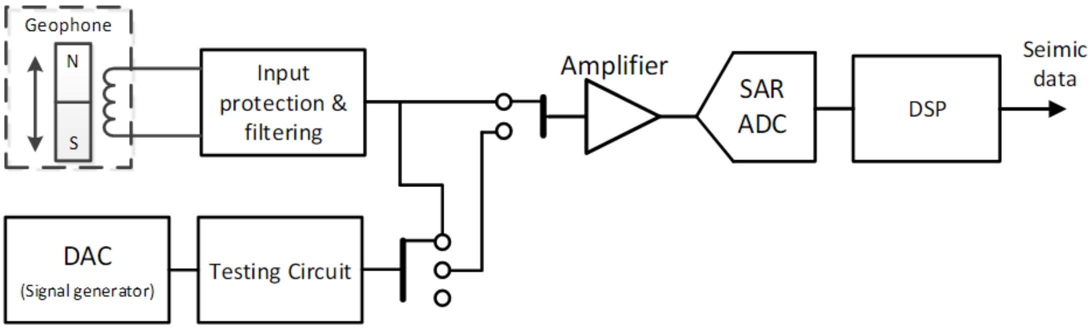
1. The channel input is connected to the sensor.
2. The channel input is driven by an internally generated DC voltage (***VDAC***=+4.6875V, ***Rsource***=2 kΩ).
3. One second of data is recorded at 0dB preamp. gain.
4. The sensor resistance is calculated from the measured DC voltage (***VADC***) using the following formula:

$$R_{geophone} = \frac{V_{ADC} * R_{source}}{V_{DAC} - V_{ADC}}$$

5. The test results are compared against the geophone test tolerances.

The trace data of resistance test is identified by the byte 218 of its trace header being 0x04, 4 decimal, or "Resistance" test on the plotter. The trace will be in the SEGY file at the configured sample rate.

Distortion Test



The **Distortion Test** measures the total harmonic distortion of the sensor using a signal generated by the DAC. The response to this signal is analyzed and compared with the fundamental frequency of the applied signal.

The test includes the following steps:

1. The channel input is connected to the sensor.
2. The channel input is driven by an internally generated sine wave of 11.9048Hz with an amplitude corresponded to 0.7 inch/s coil-to-case velocity.
3. One second of data is recorded at 0dB preamp. Gain and 1 msec sample rate.
4. The FFT analyses with Kaiser window is performed to calculate the energy of the fundamental, and up to the fifth harmonic after data is harvested from the node. The THD is then calculated using the following formula:

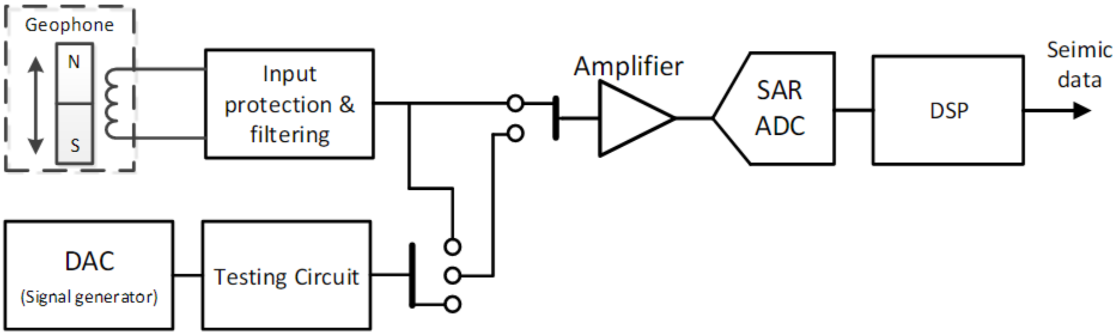
$$THD = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + V_5^2}}{V1}$$

Where Vn is the RMS value of the nth harmonic voltage and $V1$ is the RMS value of the fundamental frequency, which is the 11.9048Hz test frequency in this case.

5. The test results are compared against the geophone test tolerances.

The trace data of THD test is identified by the byte 218 of its trace header being 0x81 or 129.

Noise Test



The **Noise Test** measures the ambient noise recorded from the geophone.

The test includes the following steps:

1. The channel input is connected to the sensor.
2. One second of data is recorded at 0dB preamp. gain.
3. The standard deviation of one second record is calculated using the following formula:

$$V_{\text{geophone\_noise}} = Std\left(V_{\text{measured}}\right)$$

4. The test results are compared against the geophone test tolerances.

The trace data of sensor noise test is identified by the byte 218 of its trace header being 0x80 in hex, 128 in decimal and "Sensor Noise" test on the plotter.

Tilt Test

The geophone tilt (inclination) measurements are constantly performed to ensure that node is in upright position within the geophone tilt specification (less than 10º from vertical position). It is measured by using a dedicated accelerometer which is mounted on board of the internal PCB.

Note

The node LED flashes red indicating that geophone is tilted beyond the specification.

The tilt values are also recorded in the node's metadata file.

Impedance Test

(Sensitivity, Damping, Natural Frequency)

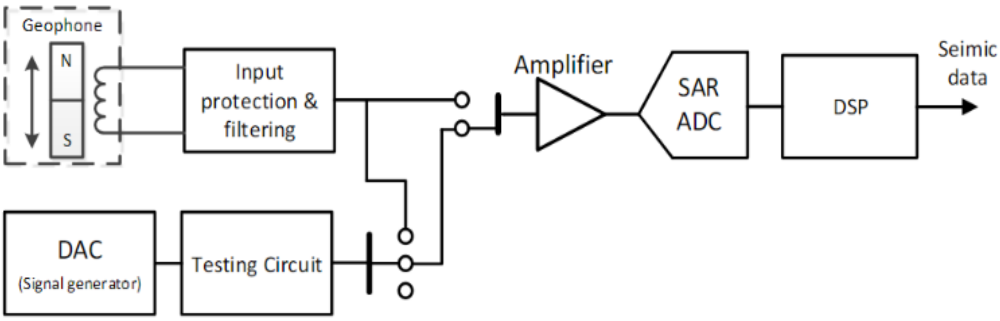


Image A (refers to items 1 and 3 below)

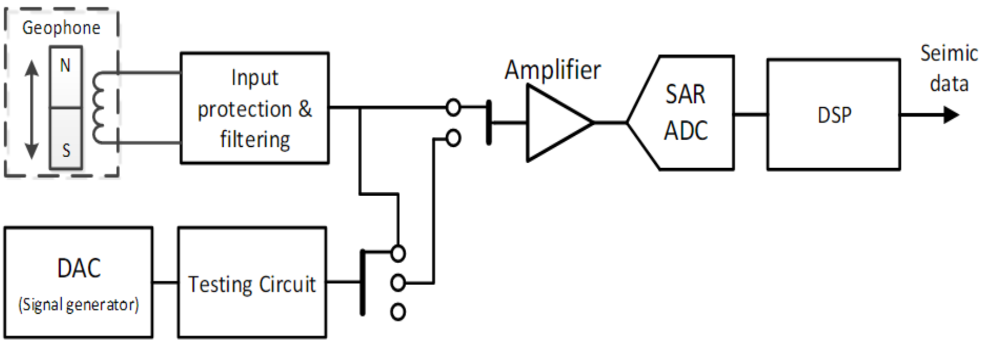


Image B (refers to items 2 and 4 below)

Four Sine wave signals are used for this test. All traces are second in length @ 1msec sample rate.

1. 5Hz internal (DAC) **no sensor /Geophone connected (* image A)**
2. 5Hz internal **with sensor /Geophone connected (* image B)**
3. 10Hz internal (DAC) **no sensor /Geophone connected (* image A)**
4. 10Hz internal **with sensor /Geophone connected (* image B)**

The data collected are processed following INOVA proprietary algorithm in the frequency domain and the processing will result in the measurements of natural frequency/damping/sensitivity.

The trace data of the four sine waves in the test are identified by the Byte 218 of its trace header being 0x82 / 0x83 / 0x84 / 0x85 in hex or 130/131/132/133 in decimal.

Quantum with Accuseis BITS

Receiver QC details

Accuseis Node Test	Name in Reports		Deployment		Docked	
	iX Transcriber	iX Studio	BITs	QC	BITs (run)	History BITs
Sensor Noise [1]	Noise,ug	Geophone Noise	**X**	**X**		**X**
Response Accuracy	Response,dB	Response	**X**	**X**		**X**
Sensor Tilt [2]	Tilt Angle	Tilt	**X**	**X**		**X**
Auto DC offset Calibration	TBD	TBD				

[1] Test evaluates total noise of Node data channel.

[2] Sensor tilt is evaluated and recorded continuously.

Sensor Noise *(Accuseis)*

This test records a time record of data and calculates the RMS value for that time series. A check is performed against a user configurable upper limit to determine pass or fail.

The trace data of sensor noise test is identified by the byte 218 of its trace headers.

Refer to the document "INOVA Disk Tape and Tape Image Formats .pdf" included in the base software install package

Response Accuracy Test (Accuseis)

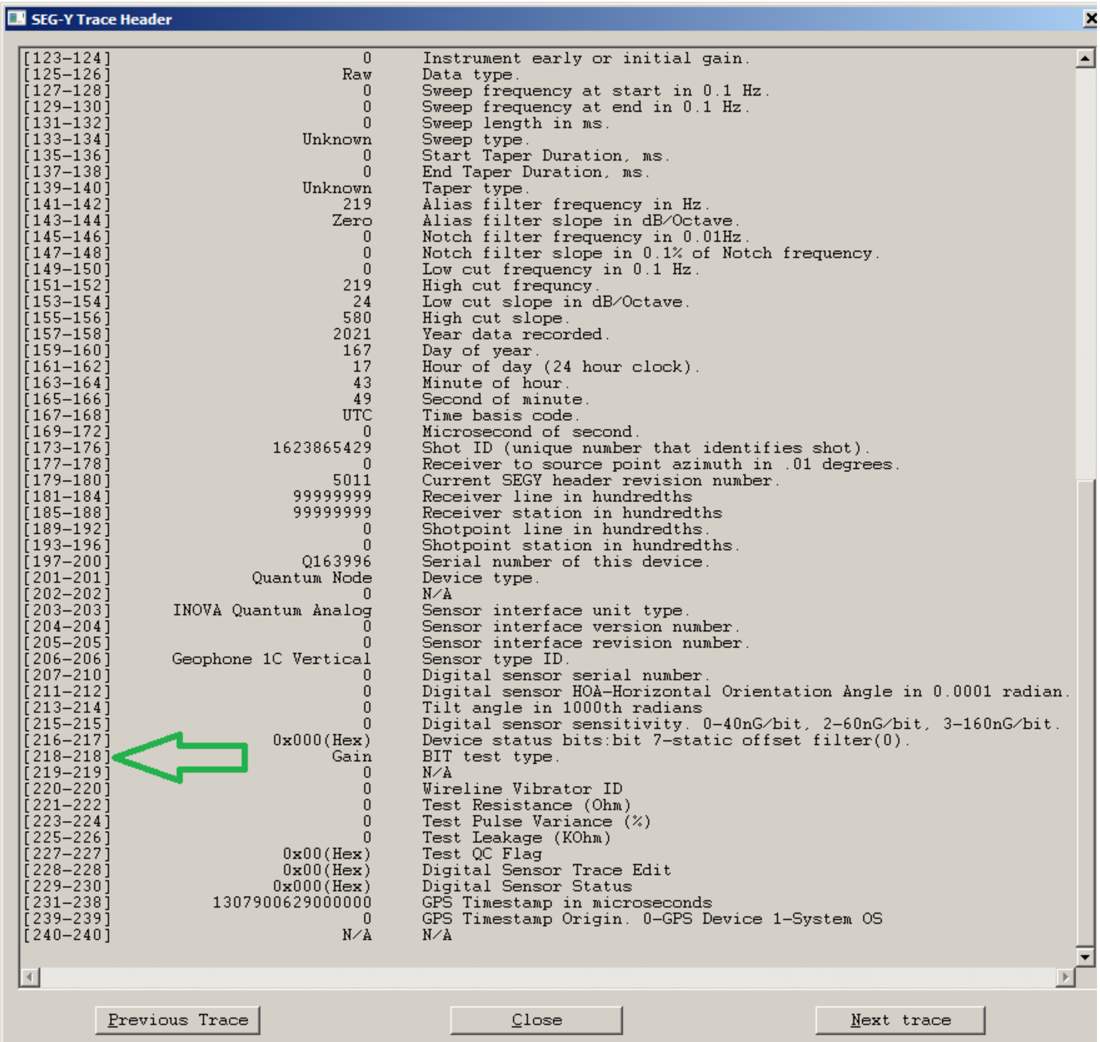
The MEMS sensor operates within a forced feedback mode with the electronics. As such, the output of the forced feedback operation is telling in terms of its overall function. By injecting a sinusoidal test signal of a programmed amplitude and frequency into the MEMS sensor, one can measure the response of the MEMS and determine through one test – it's sensitivity, forced feedback operation, amplitude and phase response. The response from MEMS is digitized, filtered and recorded, converted into frequency domain, the amplitude of the known frequency harmonics is evaluated against an expected range to determine a pass or fail. This test is the equivalent of all the following geophone tests: natural frequency, sensitivity, damping and THD.

The trace data of Response test is identified by the byte 218 of its trace header.

Refer to the document "INOVA Disk Tape and Tape Image Formats .pdf" included in the base software install package

Sensor Tilt - same method as Geophone tilt- see Tilt test

Byte 218 Trace header



SEG-Y Trace Header

[123-124]	0	Instrument early or initial gain.
[125-126]	Raw	Data type.
[127-128]	0	Sweep frequency at start in 0.1 Hz.
[129-130]	0	Sweep frequency at end in 0.1 Hz.
[131-132]	0	Sweep length in ms.
[133-134]	Unknown	Sweep type.
[135-136]	0	Start Taper Duration, ms.
[137-138]	0	End Taper Duration, ms.
[139-140]	Unknown	Taper type.
[141-142]	219	Alias filter frequency in Hz.
[143-144]	Zero	Alias filter slope in dB/Octave.
[145-146]	0	Notch filter frequency in 0.01Hz.
[147-148]	0	Notch filter slope in 0.1% of Notch frequency.
[149-150]	0	Low cut frequency in 0.1 Hz.
[151-152]	219	High cut frequency.
[153-154]	24	Low cut slope in dB/Octave.
[155-156]	580	High cut slope.
[157-158]	2021	Year data recorded.
[159-160]	167	Day of year.
[161-162]	17	Hour of day (24 hour clock).
[163-164]	43	Minute of hour.
[165-166]	49	Second of minute.
[167-168]	UTC	Time basis code.
[169-172]	0	Microsecond of second.
[173-176]	1623865429	Shot ID (unique number that identifies shot).
[177-178]	0	Receiver to source point azimuth in .01 degrees.
[179-180]	5011	Current SEGY header revision number.
[181-184]	99999999	Receiver line in hundredths
[185-188]	99999999	Receiver station in hundredths
[189-192]	0	Shotpoint line in hundredths.
[193-196]	0	Shotpoint station in hundredths.
[197-200]	Q163996	Serial number of this device.
[201-201]	Quantum Node	Device type.
[202-202]	0	N/A
[203-203]	INOVA Quantum Analog	Sensor interface unit type.
[204-204]	0	Sensor interface version number.
[205-205]	0	Sensor interface revision number.
[206-206]	Geophone 1C Vertical	Sensor type ID.
[207-210]	0	Digital sensor serial number.
[211-212]	0	Digital sensor HOA-Horizontal Orientation Angle in 0.0001 radian.
[213-214]	0	Tilt angle in 1000th radians
[215-215]	0	Digital sensor sensitivity. 0-40nG/bit, 2-60nG/bit, 3-160nG/bit.
[216-217]	0x000(Hex)	Device status bits:bit 7-static offset filter(0).
[218-218]	Gain	BIT test type.
[219-219]	0	N/A
[220-220]	0	Wireline Vibrator ID
[221-222]	0	Test Resistance (Ohm)
[223-224]	0	Test Pulse Variance (%)
[225-226]	0	Test Leakage (KOhm)
[227-227]	0x00(Hex)	Test QC Flag
[228-228]	0x00(Hex)	Digital Sensor Trace Edit
[229-230]	0x000(Hex)	Digital Sensor Status
[231-238]	1307900629000000	GPS Timestamp in microseconds
[239-239]	0	GPS Timestamp Origin. 0-GPS Device 1-System OS
[240-240]	N/A	N/A

Previous Trace Close Next trace

Quantum Auxiliary Box

INOVA QUANTUM AUX KIT (FNL41090)

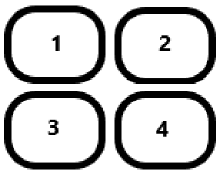
Included with the Quantum Aux Box Kit are 4 Quantum Nodes specially adapted to enable external connection of signals. They have a 2 pin Lemo connector

 *(these are push in connectors, do not no twist)*

The Geophone portion of the nodes have been disabled.

An 8 pin “Input” connector is on the right side of the case

The Nodes are arranged in the following order:



4 Nodes

Auxiliaries are normally used to acquire signals such as:

- Timebreak
- Dynamite Uphole
- Vibrators signals such as Sweep (TREF or Pilot), Ground Force and others.

Nodes will need to be removed from the Aux box for **Config**, **Data Download** and

Battery charging. Simply lift the Node upward from the foam and disconnect the LEMO connector.

When the NODES are in the download/charge Rack they should be selected and configured as "Aux/Wireline"

When configuring an AUX/ Wireline the Sensor type and Location information will be ignored.

When preparing to download the Aux Nodes you may need to assign channels,

This is done in the Unit Deployment History Domain, see Assign Aux / Wireline of Deployment

NOTE: During a Project, once a Node has been assigned, subsequent deployments and reconnecting the NODE for future downloads the config and channel assignment will be retained.

Included with the Kit is a Generic Interface cable see SFL41036 – this cable allows for direct BNC single channel inputs to each NODE.

Note due to input limitations of the NODE, attenuation of the signals may be required.

See Node Specifications

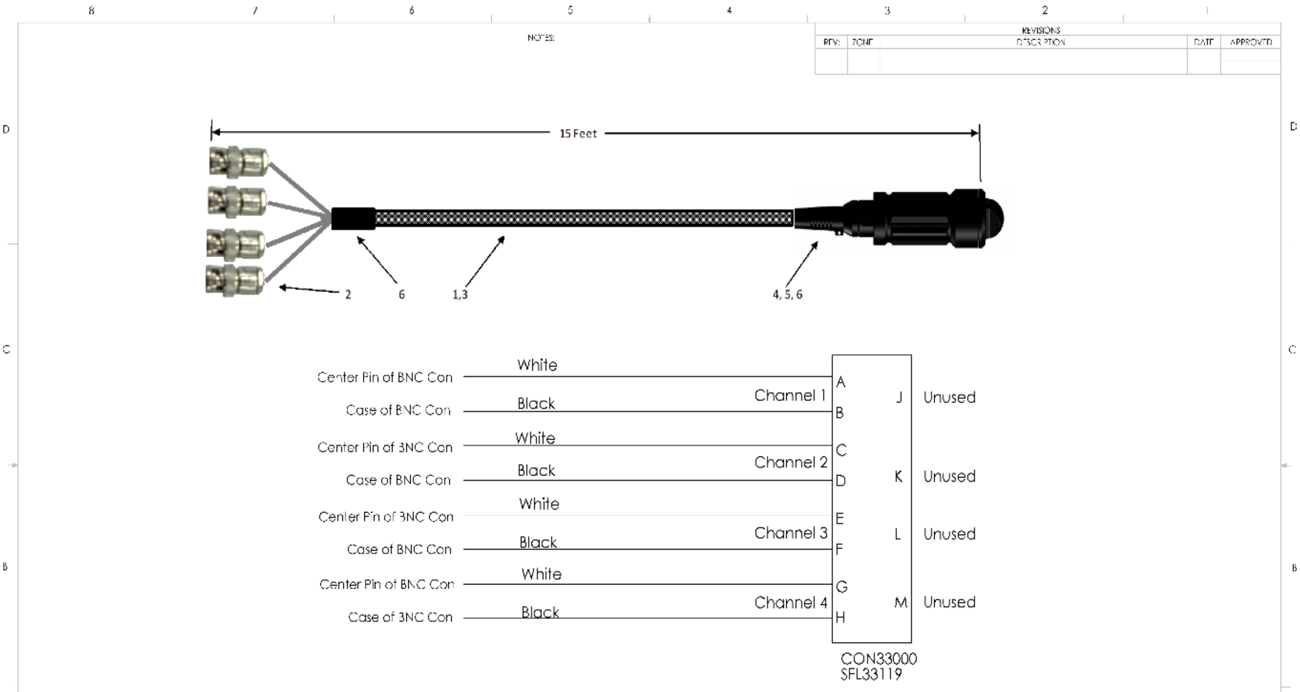
Pre- attenuated Optional Cables include:

- P/N SFL30090 VibPro HD to Quantum Aux Box cable - used at VibPro HD Encoder
    - P/N SFL30091 ShotPro HD to Quantum Aux Box Cable - used at ShotPro HD Encoder
    - P/N SFL30099 VibPro HD Scaled Output to Quantum AUX Box Cable

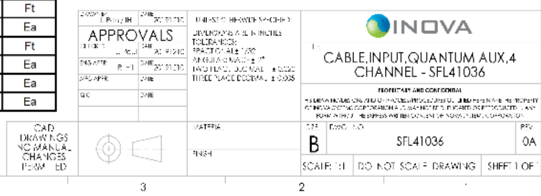
SFL30099 may be used at the Vibrator, connected to the VPHD Scaled Output Connector, this is considered a test cable to acquire Vibrator signature signals for validation.

Typically, **Vibrator Source Signature** files (VSS) are stored internally within the VibPro HD and transferred via USB flash.

SFL41036



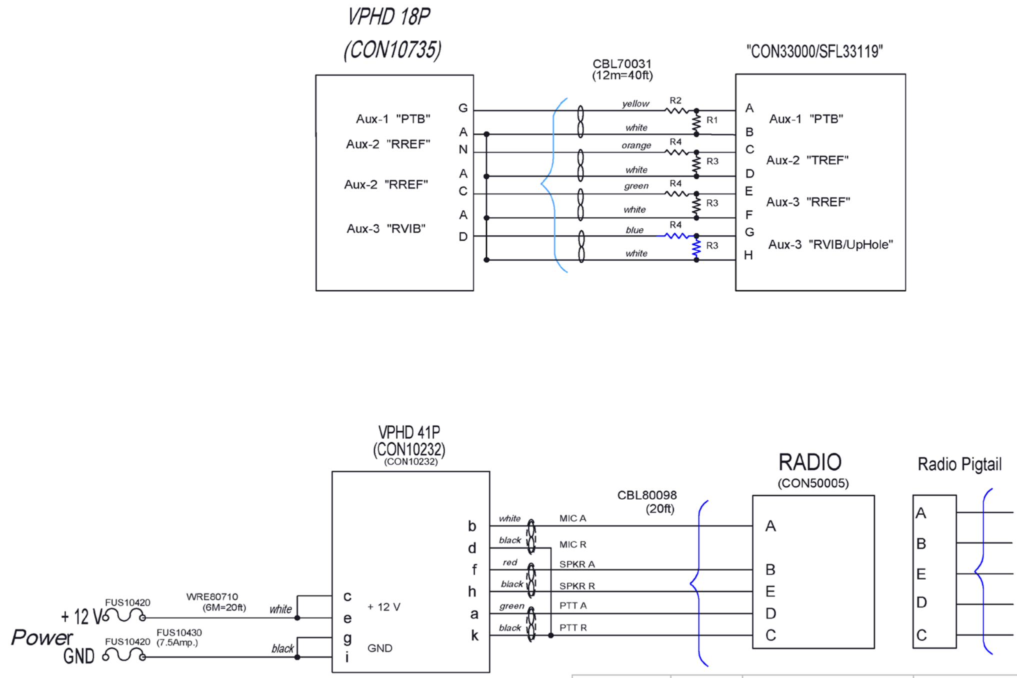
Item No.	INOVA P/N	DESCRIPTION (Syteline)	QTY	U/M
1	200-00890	CABLE,TWISTED PAIR,SNGL,#28,SHLD,3302	60	Ft
2	CON41016	CON,BNC,PLUG,MALE,50 OHM,SOLDER	4	Ea
3	PKG94009	EXPANDABLE NYLON BRAID	12	Ft
4	CON33000	G3i,CBL Head Assy	1	Ea
5	SFL33119	G3i,12 PIN CM Insert	1	Ea
6	MIS80244	HEATSHRNK,EPS-300,ADH1/2"	0.042	Ea



SFL30090

NOTES: 1. Do not tape the top portion of the cables to the bottom portion of cables during manufacturing.

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
1B	- To delete radio pigtail (SFL97932) from the BOM and drawing. - To delete CON50015 from BOM.	20200210	Frank Z. ECN40520
1C	- To change resistor values (replaced three R1 with three R3 and replaced three R2 with three R4).	20200226	Frank Z. ECN40526
1D	- To add radio pigtail (SFL97932) back the BOM and drawing. - To increase length of CBL70031 from 6m to 12m. - To add a clear note to tape the cable properly.	20200922	Frank Z. ECN40559
E	- Previous drawing has a missing connection line from G3i cable head (pin B, D, F and H) to pin A of the CON10735 connector.	20210817	Asher Shushan ECN50537



NOTES:

R1=1kOhms (RES21184), R2= 10 kOhms (RES20870), R3=75 Ohms, R4=3.4kOhms

Symbol indicates **Shielded** twisted paired wires

Symbol indicates twisted paired wires

DRAWN BY	FZ/JH	DATE	20210817
APPROVALS			
CHECKED	JH	DATE	20210817
ENG APPR.	AS	DATE	20210817
MFG APPR.		DATE	
Q.C.		DATE	

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/32
ANGULAR: MACH ± 2°
TWO PLACE DECIMAL ± 0.020
THREE PLACE DECIMAL ± 0.005

INOVA

TITLE: VPHD to Quantum Aux Cable - SFL30090

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CAD DRAWING NO MANUAL CHANGES PERMITTED

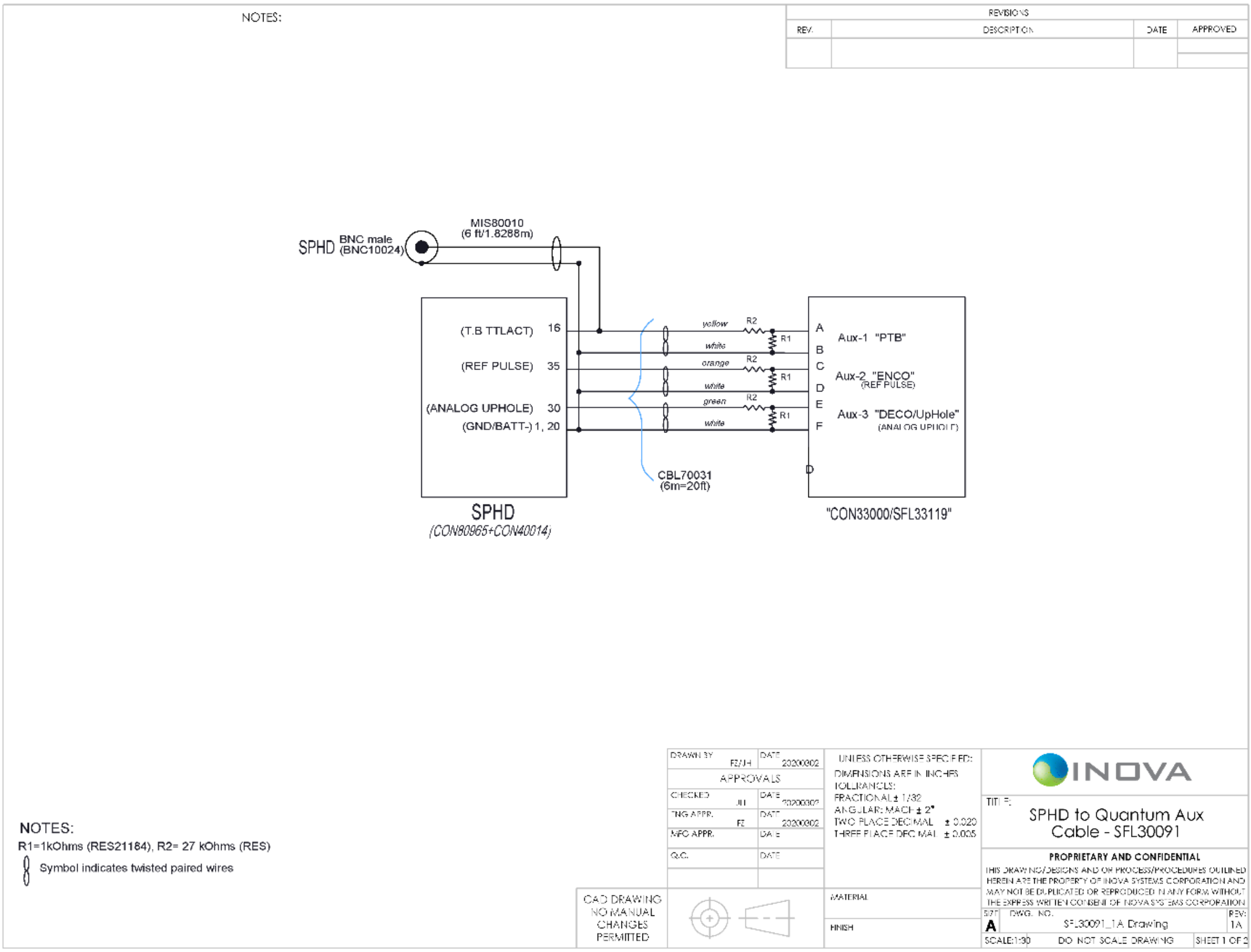
MATERIAL

FINISH

SIZE A | DWG. NO. VPHD to Quantum Aux Cable - SFL30090_E | REV: E

SCALE:1:30 | DO NOT SCALE DRAWING | SHEET 1 OF 2

SFL30091


NOTES:
REVISIONS
REV.
DESCRIPTION
DATE
APPROVED
SPHD
BNC male
(BNC10024)
MIS80010
(6 ft/1.8288m)
(T.B TTLACT) 16
(REF PULSE) 35
(ANALOG UPHOLE) 30
(GND/BATT-) 1, 20
yellow
white
orange
white
green
white
R2
R1
A
B
C
D
E
F
Aux-1 "PTB"
Aux-2 "ENCO"
(REF PULSE)
Aux-3 "DECO/UpHole"
(ANALOG UPHOLE)
CBL70031
(6m=20ft)
SPHD
(CON80965+CON40014)
"CON33000/SFL33119"
NOTES:
R1=1kOhms (RES21184), R2= 27 kOhms (RES)
Symbol indicates twisted paired wires
DRAWN BY
FZ/JH
DATE
20200302
APPROVALS
CHECKED
JH
ENG APPR.
FZ
MFG APPR.
Q.C.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/32
ANGULAR: MACH ± 2°
TWO PLACE DECIMAL ± 0.020
THREE PLACE DECIMAL ± 0.005
INOVA
TITLE:
SPHD to Quantum Aux
Cable - SFL30091
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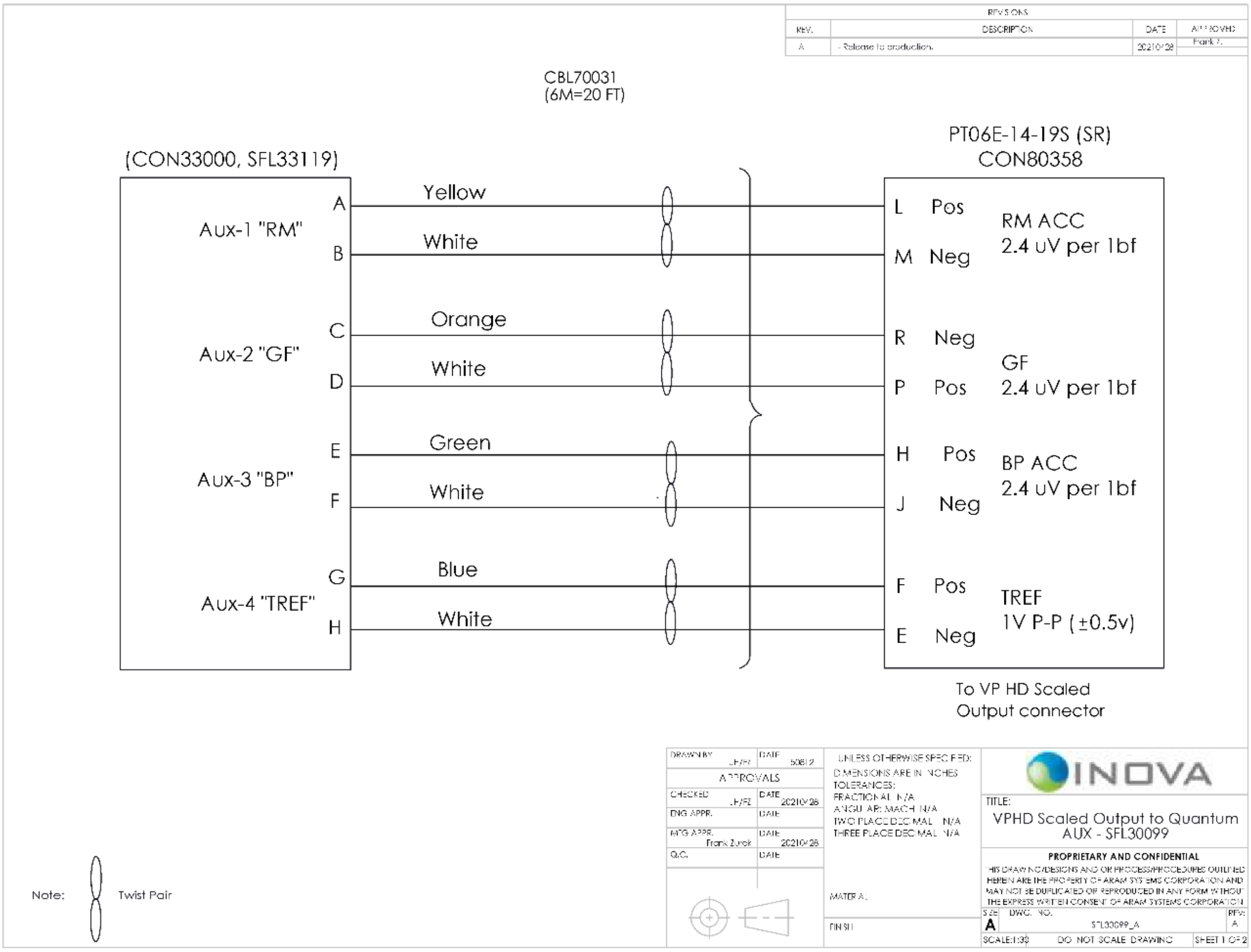
CAD DRAWING
NO MANUAL
CHANGES
PERMITTED
MATERIAL
FINISH
SIZE
A
DWG. NO.
SFL30091_1A Drawing
REV:
1A
SCALE:1:30
DO NOT SCALE DRAWING
SHEET 1 OF 2

SFL30099


CBL70031
(6M=20 FT)
PT06E-14-19S (SR)
CON80358
(CON33000, SFL33119)
A
Aux-1 "RM"
B
C
Aux-2 "GF"
D
E
Aux-3 "BP"
F
G
Aux-4 "TREF"
H
Yellow
White
Orange
White
Green
White
Blue
White
L Pos
M Neg
RM ACC
2.4 uV per lbf
R Neg
P Pos
GF
2.4 uV per lbf
H Pos
J Neg
BP ACC
2.4 uV per lbf
F Pos
E Neg
TREF
1V P-P (±0.5v)
To VP HD Scaled
Output connector
Note:
Twist Pair
INOVA
TITLE:
VPHD Scaled Output to Quantum
AUX - SFL30099
PROPRIETARY AND CONFIDENTIAL
A
SCALE:1:30
DO NOT SCALE DRAWING

“Compliance Statements”

Federal Communications Commission

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1) This device may not cause harmful interference, and
2) This device must accept any interference received, including interference that may cause undesired operation.

To comply with FCC exposure limits for general population / uncontrolled exposure, this device should be installed at a distance of 20 cm from all persons and must not be co-located or operating in conjunction with any other transmitter.

Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Innovation, Science and Economic Development Canada

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1) This device may not cause interference.
2) This device must accept any interference, including interference that may cause undesired operation of the device.

This device should be installed and operated with minimum distance 0.2 m from human body.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1) L'appareil ne doit pas produire de brouillage.
2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet appareil doit être installé et utilise à une distance minimale de 0.2 m du corps humain.