

SCIMPI
(Simple Instrument for Measuring Parameters In Situ)

User Manual

Version 1.1



THE
UNIVERSITY
OF RHODE ISLAND

Transcendev

Woods Hole
Marine Systems, Inc.

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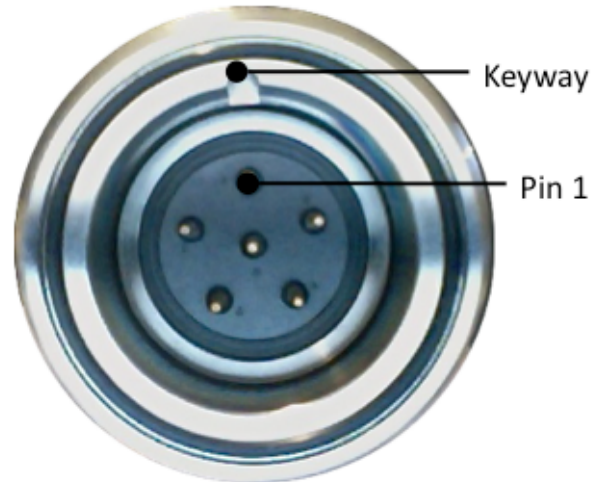
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Handling and Storage Precautions

Do not allow anything electrically conductive to come in contact with pin 1 of the Seacon Metal Shell Series (MSS-L) connector at either end of a SCIMPI Measurement Module. Pin 1 is identifiable by its alignment with a mechanical keyway on the inside surface of the connector barrel. SCIMPI modules that contain internal battery packs provide live voltage (+14.4 VDC) to pin 1. Shorting this pin to any other connector pin or with anything on the stainless steel surface of the pressure housing, including the electrical resistivity sensor contacts, can result in damage to the internal electronics as well as possible fire or explosion hazard.

If it is discovered that pin 1 of any module has been electrically shorted to any other conductive surface on the module for long enough to significantly discharge the internal battery, caution should be exercised when disassembling the module because high pressure or toxic gases may have built up inside as a result of rapid battery discharge.



Seacon 6-Pin MSSL Connector

Overview

The acronym SCIMPI stands for Simple Cabled Instrument for Measuring Parameters In situ. SCIMPI is a permanently emplaced borehole monitoring system for unconsolidated sediment that provides a relatively inexpensive alternative to straddle-packer based systems. Emplaced in the seafloor via drill ship, the modular SCIMPI system provides flexibility in both the number of modules and the spacing between them. It can be connected to cabled observatory infrastructures or powered by internal batteries and serviced via ROV to retrieve logged data.

SCIMPI is designed for hydrogeological conditions in which the borehole will collapse around the device once the drill string through which it is emplaced is withdrawn. Borehole relaxation occurs because of two different processes: slower, creep-dominated deformation in fine-grained clays and shales and immediate collapse in uncemented coarse-dominated sediments.

A SCIMPI string consists of multiple Measurement Modules and a Command Module connected by varying lengths of cable. It is powered and controlled via wet-mateable connection to either a ROV-replaceable Command Module or to cabled observatory infrastructure. The physical arrangement of modules is serial, but the two-wire RS-485 communications and 12-48 VDC power interfaces are bus-oriented.

SCIMPI is modular at multiple levels of the system hierarchy. At the highest level, a SCIMPI's modular design enables sensor emplacement at custom depth intervals, to intersect and monitor any stratigraphic horizons the user chooses to target.

SCIMPI is deployable through an IODP drill string directly into the borehole without re-entry or a ROV. Thus, no re-entry cone, casing hangers, or other heavy borehole infrastructure is required. Eventual borehole collapse provides intimate contact between SCIMPI and the formation. SCIMPI is therefore suitable only in sediments in which an unlined borehole will eventually collapse. SCIMPI can be powered via either connection to cabled observatory infrastructure or from modular internal battery packs. When not connected to a cabled observatory, data are retrieved and power supply is replenished via ROV.

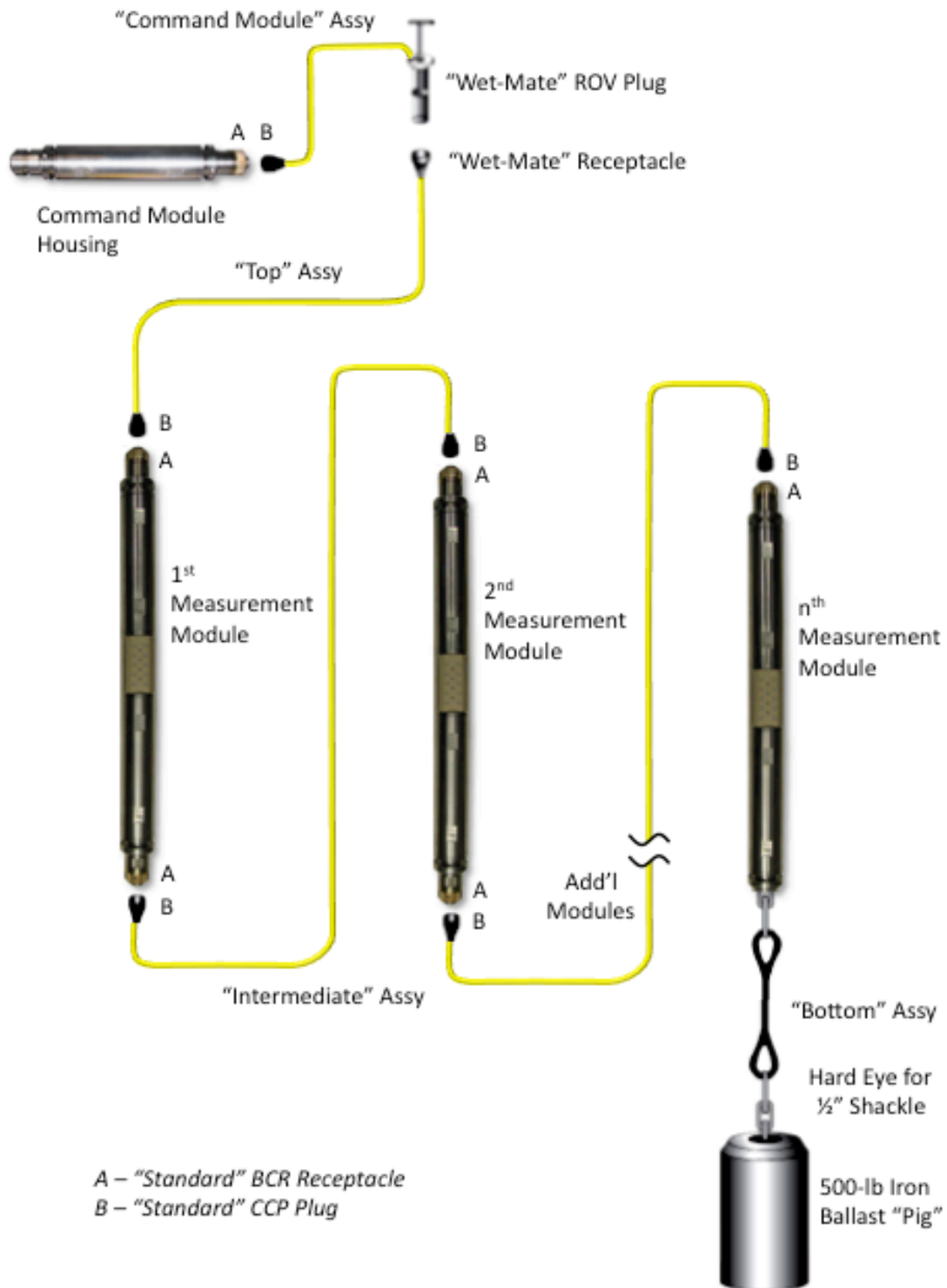
SCIMPI was developed with funding from IODP-MI by a team led by University of Rhode Island Graduate School of Oceanography (URI-GSO) and which included Transcendev, Woods Hole Marine Systems, Inc., Stress Engineering, and Lamont-Doherty Earth Observatory.

Anatomy of a SCIMPI String

From the bottom up, a SCIMPI string typically consists of:

- A 500-lb ballast weight to maintain cable tension and provide a sensible decrease in tension to the deployment winch operator when target depth is reached.
- A length of structural cable between the ballast weight and the bottom measurement module.
- Any number of Measurement Modules with Intervening Buoyant Cable and syntactic foam floats attached to the cable.
- A topmost length of Bouyant Cable with an integral ROV-serviceable wet-mate connector

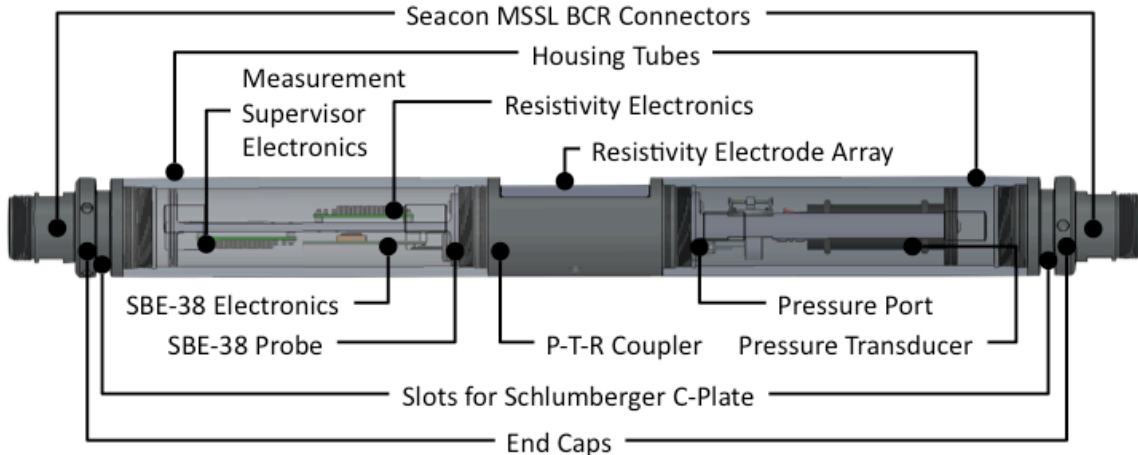
- Additional cable extending from the wet-mate connector to a seafloor Command Module or cabled observatory infrastructure
- Buoyancy provided by the syntactic foam beads maintains cable tension and keeps the wet-mate connector and Command Module above seafloor while the drill pipe is “stripped” from the borehole.



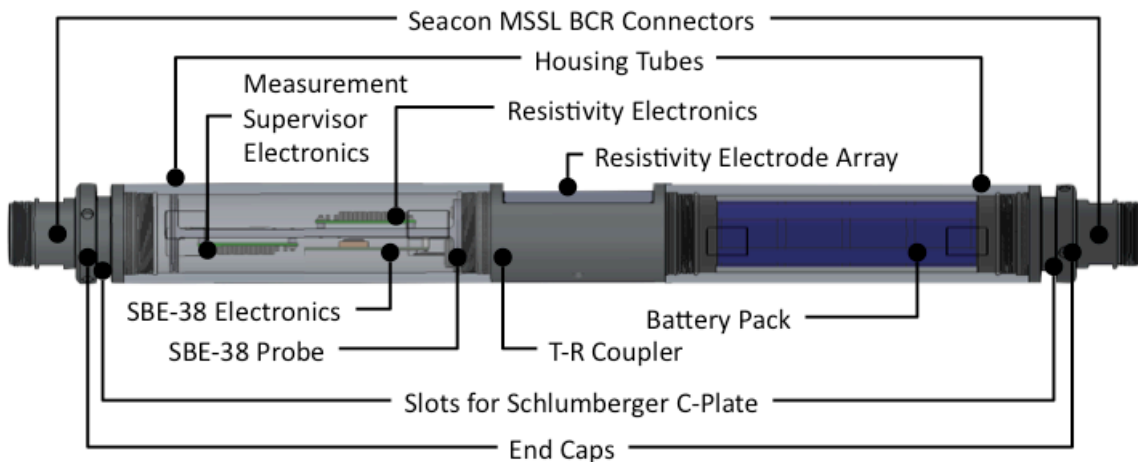
Anatomy of a SCIMPI Measurement Module

Measurement Modules and Command Modules are themselves modular and, in addition to including sensors, can include battery packs connected in parallel to the DC power bus in any number and combination. Pressure housings for SCIMPI modules can be constructed modularly and all consist of a small number of distinct parts that are interchangeable. These include tubes, end caps, and couplers that are either passive or instrumented. Most Measurement Modules have two chambers (one for batteries and another for sensors), consisting of two tubes, an instrumented coupler (providing for sensor contact with the environment), and two end caps (with connectors for intra-module cabling). The first SCIMPI pressure housing components were made of 17-4 PH stainless steel, hardened to condition H1025. However, they can be made of alternate materials (titanium, etc.) depending on site and deployment requirements.

Cutaway views of a P-T-R (Pressure-Temperature-Resistivity) Measurement Module and a T-R-B (Temperature-Resistivity-Battery) Measurement Module are shown below. Both use substantially the same 2-chamber housing configuration, except that the T-R-B module uses a temperature-resistivity coupler that differs from the P-T-R coupler by the absence of a pressure sensing port.

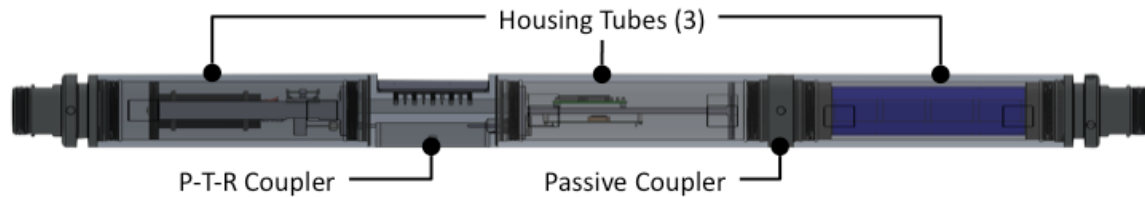


Cutaway View of a P-T-R Measurement Module



Cutaway View of a T-R-B Measurement Module

An unlabeled view of a 3-chamber P-T-R-B (pressure-temperature-resistivity-battery) module is shown below. It includes a passive coupler in addition to the P-T-R coupler.



3-Chamber P-T-R-B Measurement Module

Measurement Supervisor

Each Measurement Module contains an embedded microcontroller called a Measurement Supervisor (MS), which is responsible for interacting with up to 4 sensors. The Measurement Supervisor queries these sensors and makes the results available via an RS485 Modbus network that exists between the system Master Controller and all of the MSs.

Power to all of the MSs is controlled via a single wire from the logger. When the logger pulls this line logic high (Bus V+) via a GPIO, all of the power supplies on the bus will turn on and consequently the Measurement Supervisor will boot and begin to process code. To conserve electrical power, the Measurement Supervisor must be addressed by the Master Controller within 2 seconds or it will lower its power consumption to the lowest possible state.

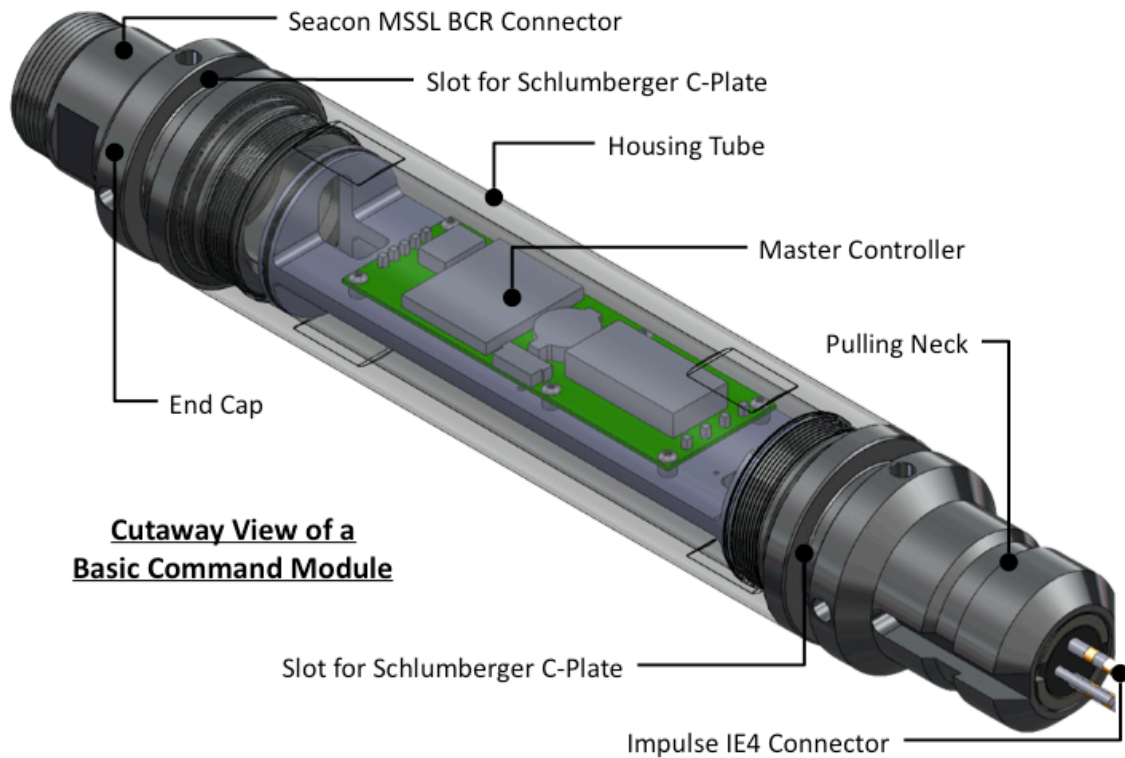
The Measurement Supervisor has table structures that define operation in compliance with the Modbus RTU protocol. The tables contain general information such as the device address (for Modbus messaging) and other Measurement Supervisor operational data.

The Measurement Supervisor accepts and responds to two Modbus message types. These commands are function code 0x3 (Read Holding Registers) and function code 0x10 (Preset Multiple Registers). These two commands encompass all functional requirements. Function 0x10 can be used to write a single register, used to trigger sensor interaction. A Master Controller that understands the protocol for writing and reading table entries that trigger the needed Measurement Supervisor interactions with sensors and report results must be used to acquire data. The Master Controller may be physically contained within a Measurement Module but typically is in a separate Command Module, as described below.

Anatomy of a SCIMPI Command Module

The SCIMPI Command Module is the ROV service-cable component that lies on the seafloor when SCIMPI is deployed in a borehole. It always contains a SCIMPI Master Controller. To log data from a SCIMPI that is not connected to cabled observatory infrastructure the embedded Master Controller is always required. When placed in-line with a cabled SCIMPI deployment, the Master Controller provides an easy way to acquire data from SCIMPI's Measurement Modules and provide an ASCII-formatted stream to the cabled observatory via RS-485 serial communication. A see-through view of a basic Command Module is shown below. The Command Module can optionally contain one or more battery packs and/or a Measurement Supervisor board as well as sensors in additional chambers using modular SCIMPI pressure housing parts. Multi-chamber

SCIMPI modules are shown in the Anatomy of a SCIMPI Measurement Module section of this manual.



Master Controller

The Master Controller is the main processing and data storage component in the SCIMPI system. It consists of a Datalogger based on the GHI EMX single board computer module with 72Mhz processor running Microsoft Micro Framework and a Supervisor based on a TI MSP430. The operational schedule for the Datalogger is mainly controlled by the Supervisor. The Supervisor is responsible for waking and shutting down the Datalogger. The Datalogger is responsible for telling the Supervisor when it is to be shut down, specifically when it has completed an acquisition and logging cycle. The Datalogger is also responsible for sending data to the surface during deployment, communication with all Measurement Supervisors, communication with the Supervisor, and managing data for the entire system.

Upon boot the Datalogger determines the state of the deployment signal. If in deployment mode (connected to external power through the Command Module's *upline* interface) the Datalogger will continuously poll all of the sensors on the bus and relay that information in ASCII format to the *upline* RS-485 serial bus connected to a drill ship or cabled observatory.

If the deployment line is low, the logger will wake the SCIMPI power bus and begin executing the user-defined Instruction Set. When the logger is done querying it writes the next sleep duration to the Supervisor and initiates the next sleep cycle.

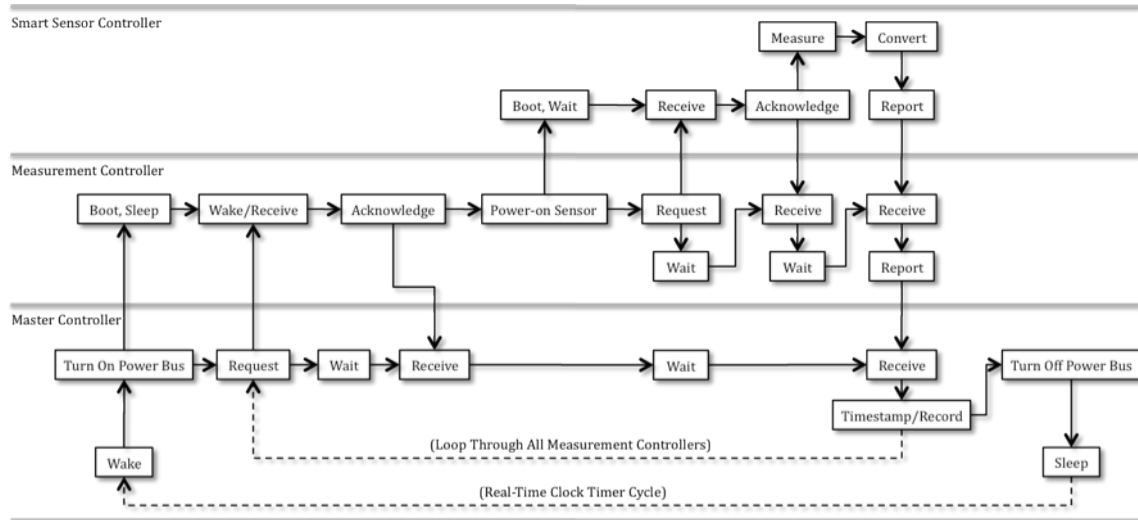
SCIMPI Communication, Control, and Power Architecture

The SCIMPI logical architecture of Measurement and Command Modules is highly modular to maximize flexibility in the physical configuration and combination of modules, and minimize overall power consumption by optimizing the pattern of components that must be powered on at any given time. The modularization also renders the architecture highly scalable and distributable, to support future additional measurement functions, single-module datalogging, and tight integration with the emerging architecture of the Ocean Observatories Initiative (OOI) Cyber Infrastructure (CI).

Whether embodied in several Measurement Modules under the control of a single Command Module, or as is a stand-alone single-module with embedded master controller/datalogger, the SCIMPI architecture includes functional units for the following logical processes:

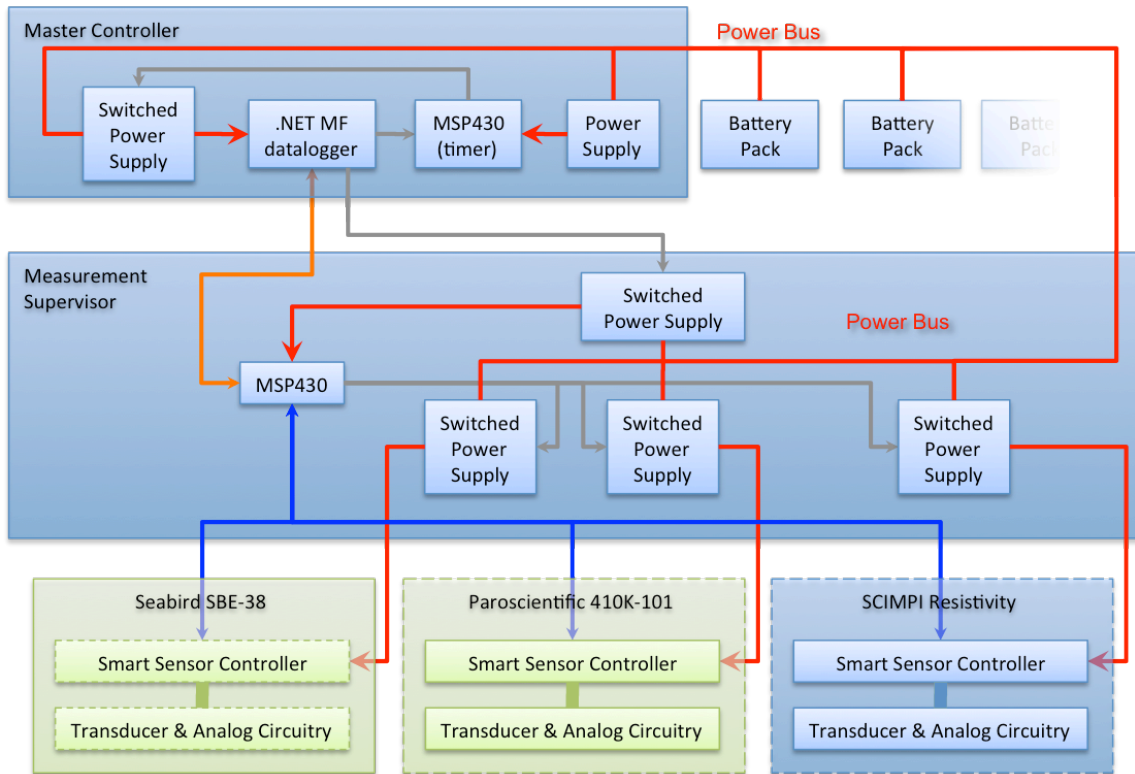
1. Smart Sensor Controller (SSC) – component of a smart sensor that makes a transducer it "smart." Typically a SSC interfaces to the sensor transducer circuitry, controls electrical excitation of the transducer, performs digital-to-analog conversion of the transducer output, maintains and applies calibration coefficients or other metadata necessary to convert transduction output to relevant physical units, and handles communication with a host via a defined serial messaging protocol. Each *smart sensor* is composed of a transduction mechanism paired with to a SSC. A SCIMPI will include three discrete SSCs. They are communicated with via serial ASCII over an internal RS-485 bus confined within each Measurement Module.
2. Measurement Supervisor – aggregates the logical functions of three or more third party smart sensors, each with its own power requirements and serial messaging protocol, into a single logical address and messaging protocol (message normalization), controls power individually to the smart sensors, communicates individually with the smart sensors and with a single master (either a Master Controller process or PC application).
3. Master Controller – controls one or more Measurement Supervisors, determines the wake/sleep status of all Measurement Supervisors at once, remembers the addresses of and communicates with multiple Measurement Supervisor to acquire measurements, and reads and writes entries in the Modbus tables of the Measurement Supervisor via the external RS-485 serial data bus. The Master Controller is capable of acquiring, time-stamping, and logging data from the MSs on a programmable schedule. The Master Controller includes a real-time clock, implements an ultra low power sleep mode, and include removable media storage to both manage overall SCIMPI energy consumption and function as a programmable datalogger. The Master Controller's functions are divided between a Microsoft .NET Micro Framework (.NET MF) single-board computer and a TI MSP430 ultra low power microcontroller. The .NET MF Datalogger implements the datalogging and external communications functions, and shuts down entirely between measurement cycles, informing the MSP430 Supervisor of its next waking time and state. The MSP430 acts as an alarm clock for switching on power to the .NET MF datalogger, and informs the datalogger of its (post-boot) waking state when asked. In a Regional Cabled Observatory (RCO) deployment scenario, the resources and process represented by a SCIMPI Master Controller may be embodied in a RCO Data Acquisition node.

Below is an activity diagram of the basic actions involved in a SCIMPI measurement cycle. Time progresses from left to right, and the logical processes whose activities are described above are arranged vertically. For simplicity, handling of communications errors and timeouts is not shown.



A SCIMPI physical block diagram is shown below. DC power is represented by red lines, RS-485 communications by orange (system) and blue (module internal) lines, and direct digital input/output (DIO) and/or SPI communications by gray lines. Large, enclosing blue boxes represent SCIMPI specific components, and green boxes represent third party components.

SCIMPI Physical Block Diagram



There is a one-to-one correspondence between a Measurement Supervisor process and a physical Measurement Module. Each Measurement Module appears to a Master Controller process as a single Measurement Supervisor having a single logical address. All MSs utilize the same messaging protocol. A Master Controller can be embedded in a Command Module as described in the Anatomy of a SCIMPI Command Module section of this manual, or the SCIMPI Config Windows desktop application can serve as a Master Controller.

COLOR KEY

- SCIMPI Component
- 3rd Party Component
- DC Power
- RS-485 (system)
- RS-485 (module)
- Digital I/O

SCIMPI Sensors

Temperature Sensor

SCIMPI Measurement Modules that are equipped for temperature, integrate a modified SBE-38 precision oceanographic thermometer from Seabird Electronics (www.seabird.com). The stock Sea-Bird pressure housing has been discarded to mount the thermometer in the SCIMPI module. This process requires unsoldering the thermometer leads from the unit's electronics and re-soldering the connections after mounting the thermometer in a SCIMPI part. No other modifications are made.

The SBE-38 has a range of -5 to +35 °C. Users are referred to the SBE-38 Users Manual for more detailed information on operation of the SBE-38.

Pressure Sensor

SCIMPI Measurement Modules that are equipped for pressure, integrate a Paroscientific 410K-101 Digiquartz™ transducer and a 1764-001 Intelligent Interface card by default (www.paroscientific.com). The 410K-101 has a range of 0-10000psi. Digiquartz transducers in other pressure ranges are also available at the time of new system specification.

Users are referred to the Paroscientific user documentation for more detailed information on operation of the pressure sensing subsystem.

Electrical Resistivity Sensor

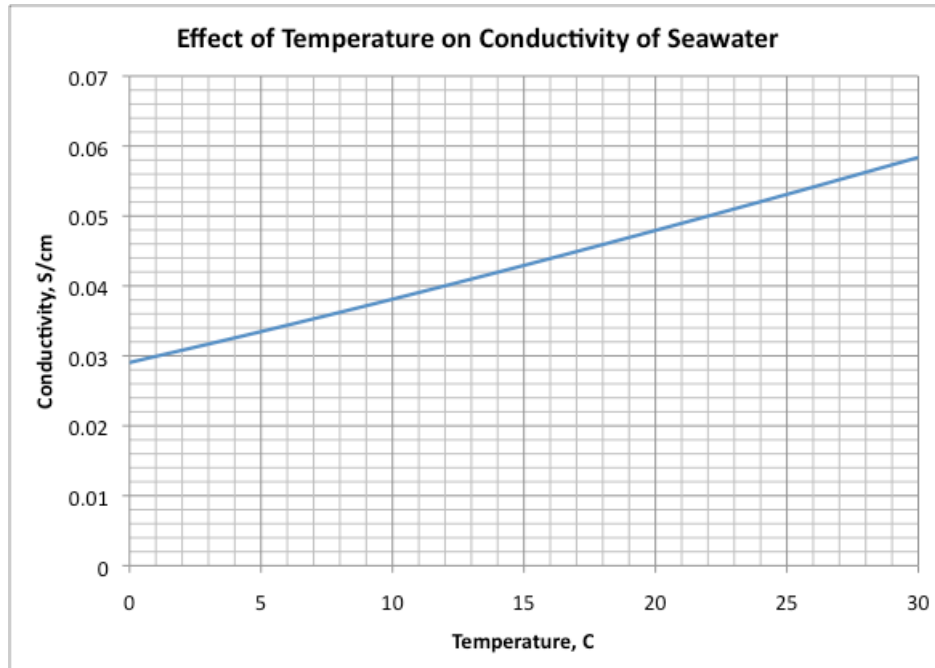
SCIMPI Measurement Modules that are equipped for electrical resistivity integrate a Transcendev ERSS (Electrical Resistivity Smart Sensor) (www.transcendev.com). The ERSS is a compact, low power smart sensor that acquires readings from any 4-electrode galvanically coupled (Wenner-style) array supplied by the integrator. A user configurable parameter stored in ERSS memory accounts for the electrode geometry. In SCIMPI, the electrodes are 0.25 in (10mm) in diameter and separated by 0.75 in (30mm).

ERSS in SCIMPI is configured for a default measurement range of 0.1-100 ohm-m and to alternate the polarity of the signal applied to the outer electrodes at a rate of 100 Hz.

Other configurations are available at time of SCIMPI system specification. Users are referred to the ERSS Users Manual for more detailed information on configuration, calibration, and operation of the ERSS.

Temperature Effects

The electrical conductivity (inverse of resistivity) of seawater and other materials, including marine sediments, varies with temperature. The chart below shows the magnitude of the temperature effect for seawater.



The ERSS measures and reports resistivity at the prevailing ambient temperature, which should be independently ascertained if the user desired to compute a temperature compensated resistivity value. The ERSS does not provide on-board temperature compensation because the relationship of resistivity to temperature varies as a function of the medium. Since the ERSS does not know what medium it is deployed in, it is up to the user to perform temperature corrections of the reported electrical resistivity for the given medium.

Sensor Calibration

All sensors in SCIMPI are factory calibrated by the individual sensor manufacturers.

Power Requirements

SCIMPI Measurement Modules are powered by connection to the common DC power bus, which may be fed by any battery pack present inside any connected module. All measurement modules are simultaneously signaled to power up and power down via a DC signal voltage on a separate power conductor as needed to acquire measurements. Power-up occurs gracefully in response to changes in signal state. Modules will handle input voltages from 9 to 48 volts.

Power Management

SCIMPI power management is fairly straightforward yet highly efficient. When a reading is desired, a voltage controlled wake signal from the Command Module activates a power latching circuit embedded in each Measurement Module. This provides power to boot the Texas Instruments MSP430 ultra-low power microcontroller embedded in each Measurement Module that executes the functions of a logical process known as the Measurement Supervisor. The Measurement Supervisor monitors the RS-485 communications bus for data requests and responds accordingly. The Master Controller process running on the datalogger itself shuts down between measurement events, leaving on only a real-time clock (which is button cell battery backed for shelf life) and an ultra low power MSP430 that acts as a supervisor to keep time between acquisition intervals and wake the datalogger as needed.

Internal Battery Packs

Each T-R-B or P-T-R-B module contains one internal battery pack. P-T-R modules do not contain batteries. ("B" in the module designation stands for "battery".) Each original equipment battery pack comprises 12 C-sized primary lithium thionyl chloride cells in 3 parallel stacks of 4 cells in series to provide 26 amp hours at 14.4 volts DC (nominal). The batteries are not rechargeable.

If SCIMPI modules are stored for more than one year, their internal battery packs should be replaced or, at a minimum, thoroughly tested prior to deployment. Replacement battery packs can be obtained from Transcendev (www.transcendev.com), or from any custom battery pack manufacturer from which cell chemistries with sufficient energy density are available.

Serial Communications

Serial communications between Measurement and Command Modules (or between Measurement Supervisors and a Master Controller) utilize a Modbus RTU compliant protocol over a RS-485 two-wire bus at 9600 baud, no parity, with one stop bit. The Modbus protocol is visible in the sensor data monitoring window of the SCIMPI Config Windows desktop application.

Configuring SCIMPI

SCIMPI is configured via a Windows personal computer application called SCIMPI Config that is compatible with Windows XP, Vista, and Windows 7.

SCIMPI Config enables the user to develop and test Master Controller Instruction Sets that are executed each time the Master Controller wakes to acquire data from a SCIMPI string. These Instruction Sets can be stored on the computer's hard drive or other media and downloaded to a SCIMPI Master Controller via serial interface to the computer. Instructions sets can also be fed to the Master Controller by saving or transferring to a Secure Digital (SD) memory card and inserted into the Master Controller's SD card slot. Four types of instructions can be included in Instruction Sets or executed individually against serially connected modules from within SCIMPI Config. An addressed measurement module can be instructed to:

- Turn power on or off to individual sensors within a module,
- Issue a serial command to an individual sensor,
- Acquire and parse a serial response string from an individual sensor, and
- Wait a specified number of milliseconds before executing the next of the other three instruction types.

Each execution of an Instruction Set results in the PC or Datalogger generating one timestamped serial ASCII record in the data log. This record contains the system timestamp in coordinated universal time (UTC) followed by the parsed responses from all sensors read in the order in which they were read.

SCIMPI Config also allows the user to assign a logical address to a singularly connected Measurement Module via serial communication, to specify the time that the Datalogger sleeps between each execution of its Instruction Set *in situ*, and to specify the time between executions of the Instruction Set when the Master Controller is receiving power from a source external to the SCIMPI string through the IE4-BC connector on the Command Module.

SCIMPI Config also provides several troubleshooting capabilities, including:

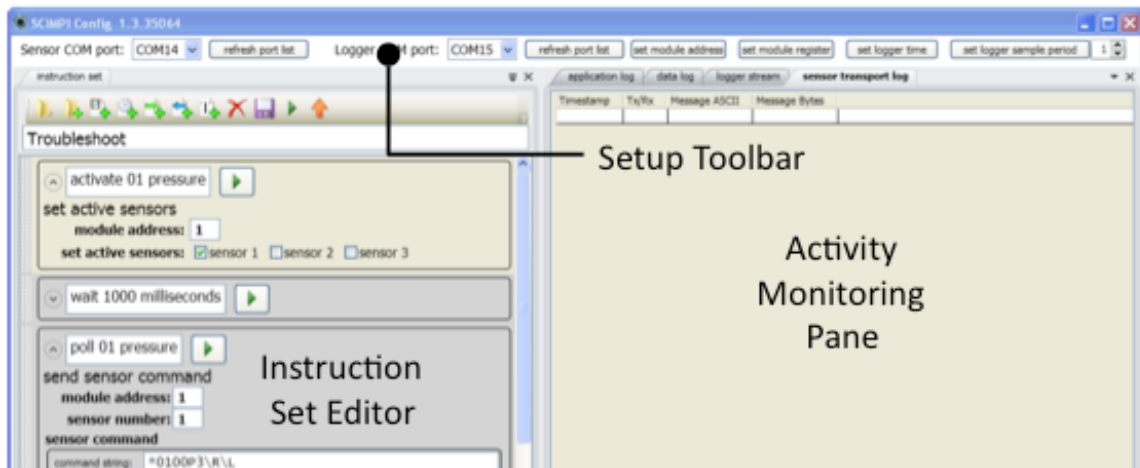
- Reporting when a Measurement Module has not responded in a reasonable amount of time.
- Reporting when an illegitimate communication has been received from a Measurement Module.
- Recording a session log of all communications between the SCIMPI Config program and a string of Measurement Modules.

Below is a screen shot showing the major components of the SCIMPI Config user interface. The program setup toolbar is at the top of the screen and allows the user to choose the COM ports to which the Master Controller (in Command Module) and/or Measurement Supervisors (in Measurement Modules) are attached, set a Measurement Module address, set the Datalogger (Master Controller) real-time clock to the computer's system time, and set the sampling period (time between wake cycles) of the Datalogger when it is in *in situ* mode (not powered from the *upline* interface).

Note: When connecting to a datalogger, a serial port (RS-485 interface) on the PC must be connected to the Datalogger's *upline* interface. A separate

serial port is used to connect to Measurement Modules. Do not connect a Datalogger to the same RS-485 bus as a PC and Measurement Modules since data collisions will result from there being two Master Controllers (the Datalogger and the PC) on the bus.

The activity-monitoring panel on the right half of the screen has several tabs that can be selected to view the activity being written to various log files on the hard drive. The application log contains information about execution of the SCIMPI Config program, error codes, etc. The data log is a time stamped, comma separated list of parsed sensor responses that is identical to the file that will be recorded by the Datalogger in the field and the ASCII data stream echoed to the *upline* RS-485 bus during deployment. The logger stream shows data being streamed from any connected Datalogger (Master Controller) in deployment mode. And the sensor transport log shows the actual Modbus traffic between the PC and any connected Measurement Modules.



SCIMPI Config User Interface

Editing Instruction Sets

The Instruction Set Editor occupies the left half of the screen and includes at the top the Instruction Set Editor Toolbar shown below.



Instruction Set Editor Toolbar

The functions of the various buttons in the Instruction Set Editor Toolbar, from left to right, are:

1. Load a saved Instruction Set
2. Create a new Instruction Set
3. Add a sensor power control instruction
4. Add a time delay instruction

5. Add a write to sensor instruction
6. Add a read from sensor instruction
7. Add a logger test instruction
8. Delete the highlighted instruction
9. Save the current Instruction Set to disk
10. Run the current Instruction Set
11. Download the current Instruction Set to a connected Datalogger

The name of the Instruction Set can be entered into the box below the Instruction Set Editor Toolbar and will be the default name of the file when the Instruction Set is saved to disk.

A user creates Instruction Sets by inserting instructions in the order in which they are to be executed by the Datalogger.

Each instruction inserted displays user-editable fields for addressing the module to which the instruction applies, checking sensors that are to be activated, entering serial communications strings in the language of the individual sensor, etc. Sensor reading instructions allow the user to select which bytes in the sensor's ASCII response to write to the data log.

The order of instructions can be changed by clicking and dragging on the dimpled pattern at the left side of each instruction, and instructions can be tested individually by clicking the green triangle to the right of the user-editable description.

Once Instructions Sets have been created and tested against a collection of connected Measurement Modules, they can be either uploaded to a connected datalogger where they will be written to the datalogger's SD card as the default Instruction Set file to execute during *in situ* logging, or saved to disk for later recall or direct transfer to a SD card to be inserted into a datalogger thereby provide it the instruction set.

Deployment

SCIMPI is designed to be deployed into a borehole from the drill ship JOIDES Resolution (JR). SCIMPI will be emplaced in an unlined borehole created by the JR, by lowering it through the drill string while the JR remains on station. Instrument function *in situ* is verified via communication through the JR's Schlumberger wireline umbilical prior to releasing the tool, recovering drill pipe, and vacating the station. Design innovations have allowed for a small enough Command Module to deploy through the drill pipe by distributing small battery packs in parallel throughout SCIMPI's downhole Measurement Modules rather than in a single pressure housing on the seafloor. Thus the slim, attached Command Module can accompany the Measurement Modules through the drill string during initial deployment, obviating the need for an ROV and crew on the deployment cruise. The concept of operations is detailed below as sequences of steps required for pre-deployment preparation and deployment (while on station).

Pre-Deployment Preparation

1. Verify proper function of SCIMPI sensors and communications using fully assembled string prior to cruise,
2. Ship disassembled system to IODP port of call,
3. Receive and load unassembled SCIMPI onto drill ship (JR),
4. Conduct shipboard functional testing of SCIMPI modules en route to drilling destination (optionally assembling/testing/disassembling system on deck if schedule allows),
5. Determine float spacing and numbers per anticipated depth and module spacing (floats listed in Appendix are rated to 1500 m only). This task should be completed during cruise planning phase.
6. Connect floats to cables using the included Band It hand tools and bands. Zip ties can also be used for this purpose.
7. Stage SCIMPI components and deployment equipment on deck (before or during drilling),
8. Deploy according to the procedure below.

SCIMPI Deployment Procedure

1. Drill borehole to target depth (use of drilling mud to keep borehole open is discretionary) using a bit of diameter 9-7/8"
2. Optionally deploy re-entry cone
3. Drop bit downhole
4. Assemble SCIMPI sections on deck
5. Assemble SCIMPI on deck while feeding completed sections into the top of the drill string, hanging alternately from makeup plate and overhead rigging as assembly progresses
 - a. SCIMPI will hang in the makeup plate while each new grip on the cable is established

- b. Repeat until full SCIMPI string hangs from makeup plate, with command module at top
6. Mate assembled MFTM and ERS overshoot to pulling neck of SCIMPI command module, hanging in Schlumberger makeup plate. MFTM and ERS will be connected to 26,000-ft spooled armored Schlumberger wireline logging cable.
7. Test communications through wireline cable with all measurement modules in fully assembled string
8. Lower SCIMPI through drill pipe to target depth, sensing TD attainment via combination of wireline spool metering and tension spool
9. Verify communications through wireline cable with all measurement modules in fully assembled string
10. Activate the SCIMPI release tool in the ERS (use DC current from shipboard to drive the DC release motor)
11. Withdraw wireline cable
12. Strip drill pipe. After this point, the SCIMPI seafloor tether should be free floating from the wellhead or, optionally – if the inline battery arrangement is used – the Command Module should be attached and either free floating (pending the syntactic foam distribution) or lying on the seabed.
13. Vacate Station

Power and Communications During Deployment

When not connected to cabled observatory infrastructure, SCIMPI utilizes battery packs distributed throughout its Measurement Modules (or in a Command Module) for power. This power is carefully conserved to last for deployment periods on the order of years. SCIMPI therefore receives its power during deployment (when it is necessary to frequently monitor SCIMPI's operational status) from the surface vessel via the wireline umbilical to which it is tethered. SCIMPI automatically switches between a *frequent* measurement and *reporting* mode and an *infrequent* measurement and *recording* mode on the basis of whether or not power is present at the IE4-BC connector on the command module. The sequence of physical events and corresponding SCIMPI mode and condition changes are as follows:

- The SCIMPI Measurement Modules will begin in a non-operating state. The measurement modules will not operate except when signaled to wake via voltage on the wake signal conductor of the *downline* interface. The battery packs within them, however, still supply power to the *power bus*.
- The Master Controller hosted within the SCIMPI Command Module will begin in a deep sleep state in *in situ* mode, *recording* and *non-echoing condition*. Its internal ultra low power supervisory microcontroller will be powered by an internal lithium button cell, and will be executing the *in situ* mode sleep/acquisition schedule. However, prior to awakening the internal .NET MF system that hosts the Master Controller process, if the command module is not connected to any outside power supply, the supervisor will sense the voltage level of the *internal power bus* and, finding insufficient voltage on the bus, will not wake the .NET MF system and will instead enter another sleep interval.
- When the chain of SCIMPI Measurement Modules is assembled and suspended in the drill string from the Schlumberger C-plate, there is no load on the

distributed battery power supply because no Datalogger is connected and instructing the Measurement Modules to wake.

- The SCIMPI Command Module will be the last module connected to the string; it is attached above the Measurement Modules via a Seacon MSSL connector, with a wet-mate connector in line between it and the rest of the string. At this time, the Command Module and internally hosted Master Controller process will power up from the battery power supply connected to the *downline* electrical interface and, sensing no supplied power at the *upline* electrical interface (e.g., the IE4-BC connector in the pulling neck), will enter *in situ* mode, in which it infrequently boot up, signal the connected Measurement Modules to wake, acquire a round of measurements, then re-enter a deep sleep condition.
- With the SCIMPI Command Module hanging in the C-plate, the ERS/MFTM will be attached to the SCIMPI pulling neck and *upline* electrical interface. This action will make electrical connection between the MFTM and SCIMPI, after which 12VDC power to SCIMPI's *upline* electrical interface will be switched on from the MFTM. This power will cause the Command Module's *upline* interface isolation circuit to complete the power and communications circuits with the SCIMPI Master Controller host, which will awaken the Master Controller from its deep-sleep condition. The Master Controller will sense the presence of power supplied at the *upline* interface and will execute *frequent* measurement and *reporting* using power supplied to the *upline* interface which it also provides to the *internal power bus* to power the Measurement Modules at higher voltage than the internal battery packs to prevent them from discharging.
- The entire SCIMPI and ERS/MFTM are then lowered down the drill string on the Schlumberger wireline umbilical, during which time power to the SCIMPI from MFTM remains on and SCIMPI remains in *frequent* measurement and *reporting* mode, taking measurements at intervals of 2 to 10 seconds and echoing them to surface diagnostic equipment via the *upline* interface and MFTM. During this time, the Master Controller will also continually sense the power supplied to the Command Module's *upline* interface, and if an insufficient power condition is sensed it will switch to *infrequent* measurement and *recording*. If power is again restored, it will wake the Master Controller into *frequent* measurement and *reporting* mode.
- When target depth is achieved and a drop in cable tension is sensed by the MFTM, the MFTM will be commanded from the surface to switch off power being supplied to the SCIMPI via the command module *upline* interface. This action, necessary to avoid exposing powered conductors to seawater upon release of the SCIMPI, will cause the SCIMPI Command Module and internally hosted Master Controller to switch to *infrequent* measurement and *recording*. The loss of power at the *upline* interface will open the *upline* interface isolation circuit and sever electrical contact between the *upline* interface and the Datalogger and measurement modules.
- Power will be delivered to the ERS motor through the umbilical from the surface to actuate the release mechanism, and SCIMPI will separate from the ERS, unplugging the now inactive IE4 connector.
- ERS/MFTM will be retrieved and drill pipe will be stripped, leaving SCIMPI *in situ* until serviced by an ROV.

Appendix A

SCIMPI Internal Wiring Key

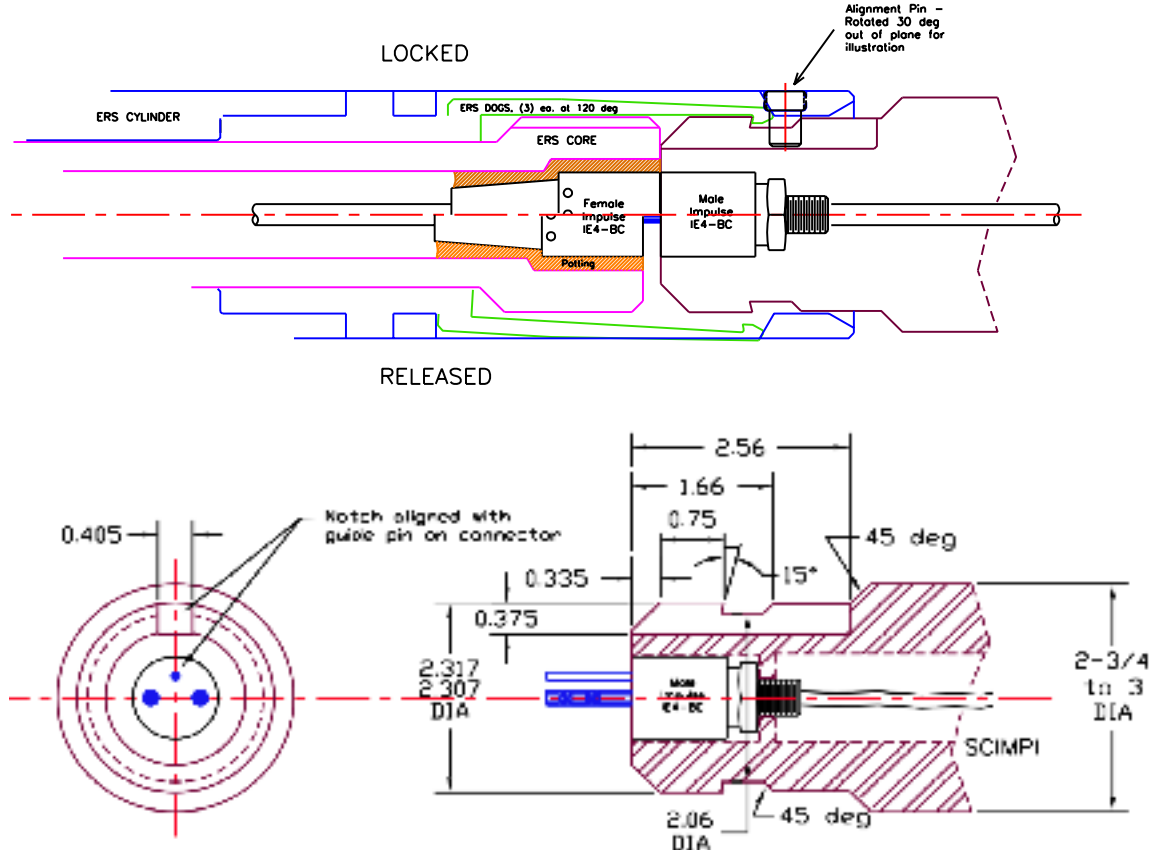
Resistivity Leads (26 AWG stranded copper)	Molex C-Grid Connector Pin SL 70066/70634
Excitation+: Orange (toward battery/pressure end)	1
Sense+: Purple	2
Sense-: Brown	3
Excitation-: Gray (toward temperature/Measurement Supervisor end)	4
Sensor Bus (module internal)	Hirose DF3 Connector Pin
+V (Power): Red 22 AWG stranded	1
Common: Black 22 AWG stranded (U11/U22)	2
RS-485 + (A): White 24 AWG stranded	3
RS-485 - (B): Green 24 AWG stranded	4
Power Bus	Seaconn MSSL Connector Pin
+V (Power): Red 22 AWG stranded (U6/U18)	1
Return (Common): Black 22 AWG stranded (U11/U22)	2
+V Wake: Green/yellow 24 AWG stranded (U10/U21)	3
RS-485 (24 AWG, 3 twists per inch)	Seaconn MSSL Connector Pin
+(A) White (U9/U20)	4
-(B) Green (U7/U19)	5
Command Module Up-hole End	Impulse IE-4-BC Connector Pin
+V (Power): Red 22 AWG stranded	2 (White)
Return (Common): Black 22 AWG stranded	4 (Green)
RS-485 + (A): White 24 AWG stranded	1 (Black)
RS-485 - (B): Green 24 AWG stranded	3 (Red)

Appendix B

SCIMPI Interface to ERS and MFTM

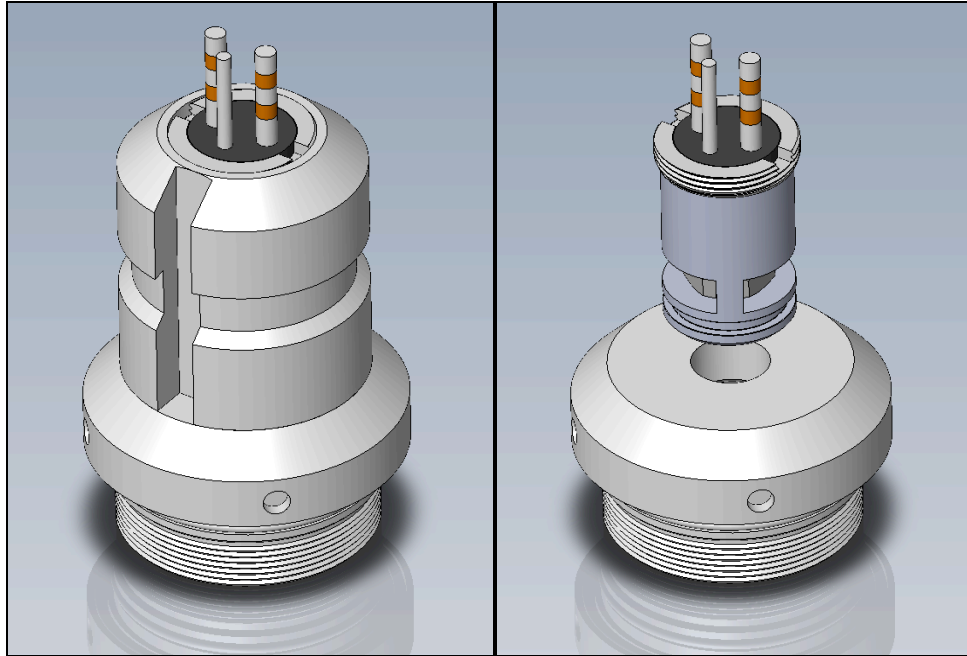
SCIMPI is deployed into a borehole using a customized ERS release mechanism from the IODP tool inventory below a Multi-Function Tool Module (MFTM) developed by Lamont Dougherty Earth Observatory (LDEO) on the JIODES Resolution's (JR) Schlumberger wireline logging string. The MFTM mediates shipboard communications with SCIMPI through the wireline system and controls activation of a DC electric motor in the ERS to release SCIMPI from the wireline string once into position in the borehole.

SCIMPI will interface mechanically and electrically to the ERS. The electrical and mechanical coupling components are co-axially arranged, with a male Impulse IE4-BC electrical connector up through the center of the SCIMPI “pulling neck” (male) that is engaged by locking dogs in the barrel of the ERS (female). The interface is depicted conceptually in the drawings below. A female IE4-BC connector is recessed within the lower end of the ERS. Dimensions shown are notional. The wiring key for the IE4-BC connector appears in Appendix of this manual.



The pulling neck of the SCIMPI, depicted below, is cylindrical with a mushroom shaped head and a circumferential groove for engaging with the ERS locking dogs. It includes an axially aligned notch that must align with a pin on the interior of the ERS barrel to assure correct mating of the Impulse IE4-BC connector pair and to prevent random torque being applied to the electrical connector during deployment. The orientation reference direction for alignment is based on the IE4-BC connector guide pin. The design of the SCIMPI pulling neck assembly allows the user to control alignment of the IE4-BC

pins with the slot in the next to match the mating ERS. The IE4-BC is threaded into a cylindrical cartridge that is inserted into the top of the pulling neck and held in place by a retaining nut. This allows the user to control alignment of the IE-4 pin pattern relative to the slot in the pulling neck that controls alignment between SCIMPI and the ERS. Slots in the cartridge provide access to the hex flange on the IE4-BC so that it can be tightened into place. The right hand drawing is a cutaway of the left hand drawing revealing the form of the cartridge and retainer nut. The cartridge includes both face and bore seals to ensure integrity of the command module pressure housing.



The SCIMPI pulling neck is ordinarily made of 17-4 PH stainless steel, hardened to condition H1025. Like other housing components, the neck can be made of alternate materials (titanium, etc.) depending on site and deployment requirements.

The Impulse IE4 is a two-pin, 4-conductor wet connector. The bulkhead IE4 connector on the SCIMPI housing is male, as the female connector of this model is not open-face pressure qualified. This requires the in-line connector on the ERS to be female, which is a reversal of the usual convention for exposed live conductors in a submerged marine environment. The SCIMPI command module automatically severs its electrical connection to the exposed male IE4 once it loses power from the ERS. This is accomplished by the use of a photo-coupled solid state relay (SSR) so there are no moving parts. Mating the SCIMPI to the ERS provides power through the IE4-BC that will be conditioned within the command module to provide a low voltage signal to the internal LED of the SSR. This LED activates an internal photo-sensitive diode connected to the gate of a MOSFET (metal-oxide-semiconductor field-effect transistor) that connects the main power conditioning circuit to the ERS-supplied power. It performs a DC-to-DC conversion that keeps the output voltage on the SCIMPI unswitched power bus above the nominal internal battery pack voltage so that all current comes from the ERS rather than the batteries whenever SCIMPI is powered from the ERS. The MFTM and ERS are powered through the 7-conductor Schlumberger wireline cable and 31-pin connector. DC power at 12 or 24 volts is provided to SCIMPI from the MFTM, through the ERS. The SCIMPI command module can accept DC power from 9 to 40 volts through the IE4-BC and draws less than 1 amp at 12 volts.

Appendix C

SCIMPI Flotation Specifications

As with cabling, SCIMPI flotation is purchased separately. Flotation for the first SCIMPI prototype was provided by CMT Materials, Inc. of Attelboro, MA (508) 226-3901. The design was based on a performance specification as follows:

GENERAL

Vendors are asked to propose detailed solutions, dimensions, air weight and displaced volume, itemized costs, terms and delivery times for modules per this specification.

Depth rating for all components must be minimum 6000 meters sea water (approximately 8759 psi or 604 Bar).

MECHANICAL

Modules will be cylindrical, with provision for clamping onto electro-mechanical cables in the SCIMPI system. Diameter should within 0.10" of the nominal diameter of 3.0", without obvious changes in diameter over the length.

For the prototype system a total net buoyancy in seawater of at least 150 lbs will be required, with a pressure rating of 6000 msw (604 Bar). URI anticipates modules between 12" and 18" long with net buoyancy of approximately 1 lb. each, but the Vendor is requested to specify lengths as preferred, up to a maximum length of 20".

Modules must assemble into 3" cylinders, with a hole through the center on axis to accept and grip onto a cable with a polyurethane jacket and a nominal diameter of 0.640". URI suggests that the modules be made up in halves, to assemble and clamp onto the cable. Appropriate hardware must be provided to clamp the pieces together. Assembly must be practical on the deck of a ship with hand tools, but quick-acting latches and hinges are not required. The hardware must not protrude beyond the envelope of the module body. Stainless steel socket head cap screws and threaded inserts are suggested. Stainless steel band clamps would be acceptable, if the hardware can fit flush and assembly on the deck of a ship with simple tools is still practical. Disassembly will not be a priority, as the systems will be deployed once and never recovered. Vendor proposal should indicate means of clamping. Spares for any loose or easily damaged components for the clamping hardware should be offered as part of the proposal.

TAPER AND FINISH

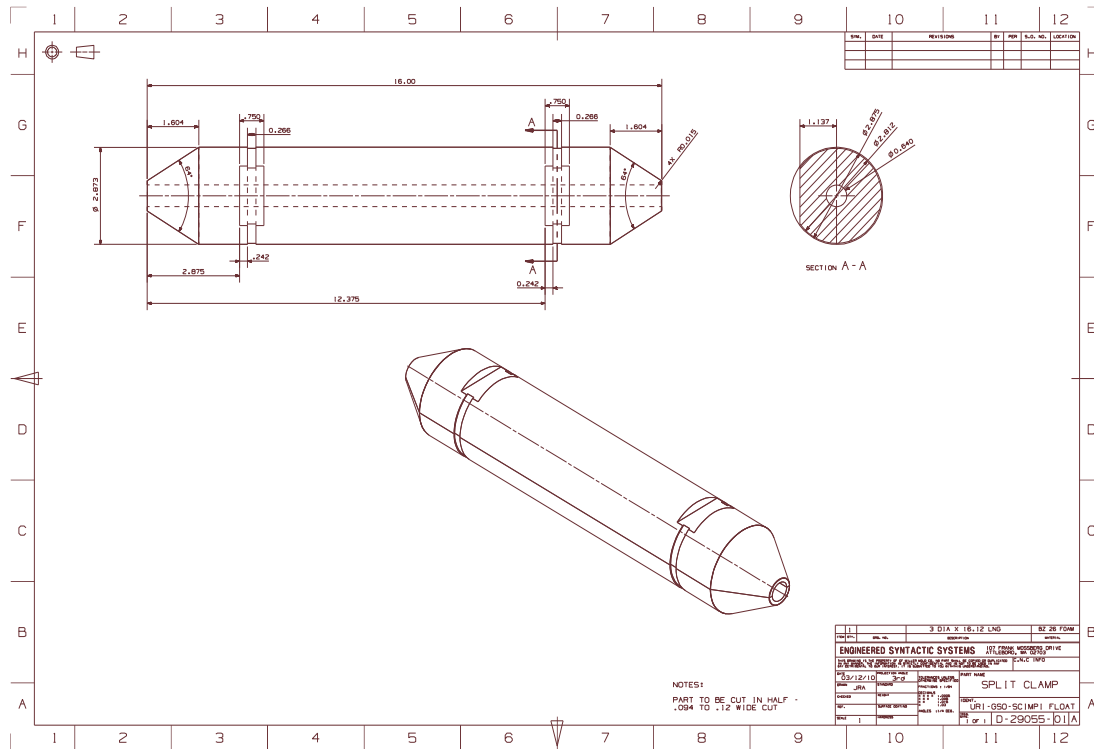
The modules, as part of the assembled SCIMPI instrument, will be deployed through a drill string, and avoiding hang-ups when the end of the pipe moves past the modules is critical. To this end, the ends of each buoyancy module should be tapered over approximately 1.6" of length or approximately 30 degrees from the axis of the cylinder. All corners should be rounded. Finished surface conditions should be chosen for a relatively low coefficient of friction.

TESTING

We suggest the following testing regimen and acceptance criteria. Deviation from this may be accepted if specified by the vendor as part of their proposal.

A random sample of the modules totaling 5% of the modules or five modules, whichever is the greater number, should be pressurized to the rated depth for at least six hours.

Following the test the modules must meet the weight/buoyancy specification proposed, and be free of cracks. No dimples should be deeper than 0.20 inches. If there are larger dimples or other obvious failures in one of more samples then all modules will be pressure tested and only those modules meeting the acceptance criteria will be accepted. URI reserves the right to observe the testing and the vendor will provide reasonable notice of its schedule.



SCIMPI Flotation Clamping and Ties

SCIMPI flotation can be secured by metal or plastic ties. Band-It metal ties (product L20499, <http://www.band-it-idex.com/en/about/index.html>) are recommended due to strength and reliability. They can be applied with the Band-It Hand Tool (p/n C00169) or the Bantam Tool (p/n C07569). Additional ties should be purchased prior to deployment.

The process of connecting the floats to the cable is time consuming but can be completed en route prior to deployment. Waiting until aboard the ship to connect flotation is recommended to reduce the space required for storage.