EM-0

Miniature Acoustic Modem, Transponder & Data Collection Module

Technical Reference Manual

The EM-0 Module Serves As A Whale Tracking Tag For The University Of California, Santa Cruz

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1. Introduction

The DiveTracker™ EM-0 electronics module is a miniature acoustic modem, sonar transponders and data acquisition subsystem. The module is designed to be used as a digital underwater communication device, a navigation sensor or a data logger within a larger system. Typical applications include oceanographic instrumentation, and ROV, animal or diver tracking.

This module always requires a certain amount of system integration, including the connection of sonar transducer(s) and a power supply. Do not use this module if you are looking for a 'turn-key' solution.

- Bare electronics module, no housing.
- Designed for integration into ROVs, AUVs, autonomous instruments, etc.
- Single channel sonar receiver, multi channel sonar transmitter.
- 512 Kbyte FLASH memory for data logging.
- Real-Time clock & calendar.
- 'Zero-Power' sleep mode.
- Eight channel 8-bit A/D converter
- One differential amplifier for depth or other resistive bridge sensor.
- Seven gain programmable single-ended instrumentation amplifiers.
- Powered by a 7V to 16V DC source. 20 mA consumption in receive mode.
- Capable of exchanging data with a 'host' computer through an asynchronous serial interface.
- Size: 3.8" x 1.6".

DiveTracker™ Model EM-0 Design Characteristics

A DiveTracker™ model EM-0 is shown in figure 1.

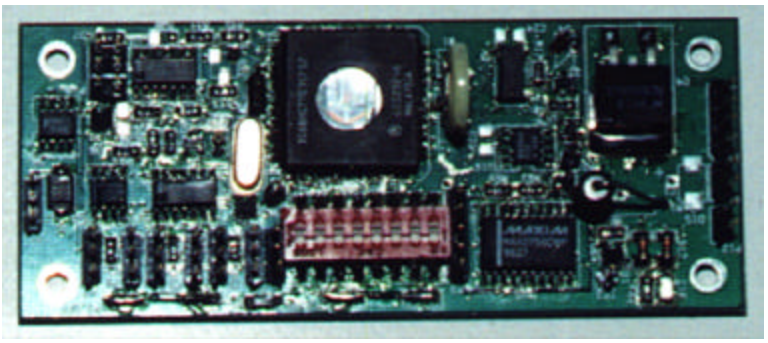

Figure 1: EM-0 Micro Sonar Transponder And Data Acquisition Module

Model EM-0M: A Low Cost Acoustic Modem

The model EM-0M is a stripped-down version of the EM-0 which is designed for acoustic modem applications only. Models EM-0 and EM-0M use the same design, but some features that are not needed in an acoustic modem are not implemented in the EM-0M version. The missing features are:

- No FLASH memory. Do not use the EM-0M for data logging applications.
- No sensor channels. Do not use the EM-0M for data acquisition applications.
- No depth sensor. Do not use the model EM-0M for navigation applications.
- No real-time-clock. Do not use the model EM-0M when sleep mode is required.

2. Unpacking

Please ensure that your shipment does contain these components.

- 1 ea. module EM-0
- 1 ea. depth sensor (model EM-0 only)
- One 2-pin and two 3-pin modular connector housings plus 10 crimp contacts (model EM-0M)
- One 2-pin and eight 3-pin modular connector housings plus 30 crimp contacts (model EM-0)
- 1 ea. LINK-EM0 data exchange cable
- 1 ea. TDCR-T40 (40 kHz) or TDCR-T70 (70 kHz) sonar transducer
- 1 ea. Status LED
- 3.5” disk with DiveTracker™ software utilities for Windows 95/NT (optional)
- This manual.

DiveTracker™ EM-0 Component List

If a shipment is incomplete, please immediately contact Desert Star Systems. If you are missing any components required for system operation, obtain these components before proceeding.

3. Module Installation

Your DiveTracker™ model EM-0 is an electronics module without housing. It always requires mechanical and electrical installation before it can be used.

Installation of the module involves these steps.

- Mount the DiveTracker™ module in an appropriate location.
- Mount the sonar transducer.
- Mount the depth sensor.
- Wire the power, sonar transducer, depth sensor, ON/OFF switch, amplifier and data cables.
- Configure the module.

DiveTracker™ EM-0 Installation

Once installed, the module can be regarded as a ‘black box’ which needs no further configuration or ‘boot procedure’. Activation and booting will automatically occur whenever power is applied and the ON switch is closed.

Mechanical installation, and wiring is discussed in this section. Chapter three explains the hardware configuration process, and chapter four deals with software installation issues. Refer to figure 2 for the location of the module’s jumpers and connectors. A summary of the module’s connector functions is listed in figure 3.

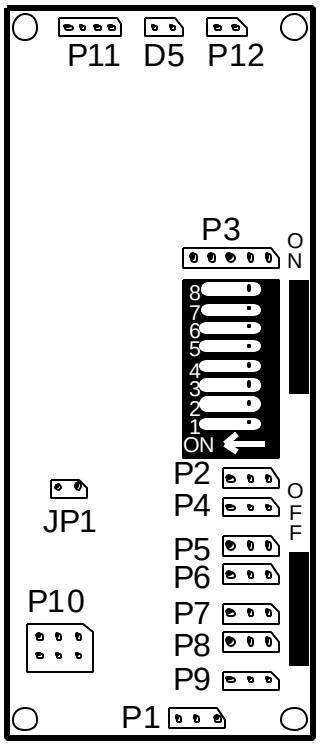

Figure 2: EM-0 Hardware Layout, Connectors And Jumpers

Connector	Function	Refer to
P1	Battery Connector	2.3.2.
P2, ON, OFF	ON/OFF Switches	2.3.3.
P3	Serial Data Port	2.3.4.
P4-P9	Analog Sensor Data Inputs	2.3.7.
P10	Depth Sensor	2.2., 2.3.5., 2.3.7.
P11	Sonar Power Transformer	2.2., 2.3.1.
P12	Sonar Transducer	2.2., 2.3.1.
D5	Status LED	2.3.6.
JP1	Special Mode Select	2.3.8.

Figure 3: EM-0 Connector Summary

3.1. Mounting The EM-0 Module

Start the installation process by selecting a good location for the electronics module and mounting the module following these instructions.

- The module measures 3.8"L x 1.6"D, overall. Additional room may be needed for connector and cable assemblies. A 1.6" diameter disk is mounted on one end of the printed circuit board to support the sonar power transformer.
- The mounting area must be free of water and condensation (humidity less than 95%).
- The temperature in the mounting area must be no less than 0 degrees Celsius, and no more than 70 degrees Celsius.
- The module's sonar receiver works with microvolt level signals. Minimize interference by mounting the module well away from electrical noise generators such as switching power supplies, motors, relays, transmitters, processor boards etc. Use a grounded metal shield around the module if interference may be a problem.
- Mount the module such as to minimize the length of the depth and sonar transducer cables.

Mounting The EM-0 Electronics Module

3.2. External Component Mounting

The EM-0 module is designed to be installed inside a pressure (watertight) housing. However, certain components need to be mounted externally and appropriate feed-throughs or connectors must be provided.

WARNING!

Be sure to perform a thorough leakage test after the installation of any through-hole components or connectors. Failure to do so may well result in expensive equipment flooding during operation. The leakage test should repeatedly cycle through pressures ranging from atmospheric to a pressure in excess of the upper operational limit. **Do not deploy a system until you are 100% sure that no leakage will occur. Desert Star Systems is not responsible for equipment leakage or the consequences thereof. The connectors, sensors and other components requiring through-hole fittings which are a part of your system are not tested by us for structural integrity or leakage. Water and pressure tight seals are your responsibility.**

The external components are:

- **The sonar transducer(s)** serve as the antenna of the system. A sonar transducer must be installed whenever you intend to use EM-0 for navigation or communication functions. The TDCR-T40 transducer is designed for hard-mounting on the outside surface of your pressure housing. A 3/16-16 UNF threaded hole and an O-ring groove must be machined into the pressure housing. A cage assembly is recommended to protect the transducer.

- **The depth sensor** measures water pressure to determine the depth of the instrument or vessel. Depth measurement is used as a component in navigation. In some applications where depth is not of importance or where depth is measured by other means, the sensor is not needed. The depth sensor requires a through hole in the pressure housing wall.

EM-0 External Components

The following sections provide instructions on how to mount the external and through-hole components.

The Sonar Transducer

The sonar transducer serves as the 'antenna' of the EM-0 module. The sonar transducer must be mounted in clear water, outside of the housing.

The transducer has a 3/4-16 UNF threaded stem. The stem is 0.75" long. Machine a suitable threaded or unthreaded hole into your pressure vessel. Provide a flat seating area with a diameter of no less than 1.38" around the mounting hole. A size 2-017 O-ring is used to seal the transducer. Two O-rings (one spare) is included in the shipment. Use Parker O-rings for replacement. We recommend compounds E540-80 (Ethylene Propylene) or N674-70 (BUNA N) for sea water applications. Use N674-70 for gasoline, diesel and motor oil applications (fuel tank inspections). Machine an O-ring groove into the pressure vessel. The groove must be concentric with the transducer hole. The groove inside diameter must be 0.860", the groove width is 0.095" and the groove depth is 0.052". All tolerances are +/- 0.002". The roughness of the O-ring groove surface must not exceed 63 micro inches.

DANGER!

The sonar transducer will break off if knocked hard enough. Transducer breakage will compromise the O-ring seal and cause your pressure vessel to be flooded. We strongly recommend the use of a protective cage if the sonar transducer is mounted in an exposed location.

CAUTION!

Do not attach anything, drill into or obscure the black cylindrical part of the transducer. This is the active element which must be able to transmit and receive sonar signals.

Using The TDCR-E40 Ceramic Transducer Element

On special request, the EM-0 module may be shipped with the TDCR-E40 ceramic sonar transducer element. This element is a hollow ring which must be potted appropriately before it can be used as a sonar transducer. A typical use of the element is the manufacture of one-time-use tags using a syntactic foam mold. The typical potting compound for sonar transducers are hard polyurethanes and epoxies. However, syntactic foams may be used as well.

Prior to potting, glue a cap onto each end of the transducer ring. The function of the ring is to preserve the air cavity inside the element during potting. The cavity must be maintained for proper transducer operation. The cap must be strong enough to withstand the maximum working pressure of the transducer. For example, the TDCR-T40 transducer is using a PVC cap which is 0.1" thick The polyurethane mold itself works an additional stiffener. This assembly withstands pressures to 1500 PSI.

The ceramic element radiates out of the sides of the ring. During transmission, the ring will contract and expand. For greatest sensitivity, do not make the layer of epoxy around the sides of the ring too thick. The TDCR-T40 element uses a 0.08" (2 mm) layer of polyurethane around the sides.

Be aware that the design of the transducer (potting material & thickness, end cap design etc.) will affect the sensitivity and beam pattern of the transducer. It is standard practice to run transmit response, receive sensitivity and beam pattern tests on an new transducer design. Desert Star Systems can recommend laboratories that test sonar transducers.

The Depth Sensor:

CAUTION!

Each depth sensor is calibrated by Desert Star Systems for a specific EM-0 module. Please make sure that the serial number of the depth sensor and the electronics module match before you start installation.

A SCC300AHO pressure sensor manufactured by SenSym, Inc. (Milpitas, CA) is shipped with the module. The sensor is used to measure the depth of the instrument and establish the depth/time profile of a dive. The sensor is calibrated for use with the module. Make sure the serial number on the transducer cable matches the serial number of your EM-0 module.

The sensor is mounted in a TO-5 transistor style housing with a RTV separation membrane. It must be mounted such that the membrane faces the ambient pressure (the water). Machine a 0.25" diameter through-hole. Counter-bore from the outside to a diameter of 0.430" +0.000"/- 0.002" and a depth of 0.40" or more. (A counter bore depth of 0.53" allows sufficient space for connecting an external fixture for depth sensor re-calibration). An edge chamfer (0.020") should be provided to aid O-ring insertion.

The sensor's 6-pin modular connector will not fit through the 0.25" through hole, so the connector housing must be removed. Simultaneously press the locking tongue of a contact and slide the contact out of the housing.

Two O-rings of Parker size 2-011 are shipped. Apply a thin film of silicone grease and to both O-rings and slide them over the sensor housing. Feed the sensor wiring through the hole and slide the sensor into the hole. Use a dull tool to push the O-ring all the way to the bottom. Now, press-fit the protective plate in place over the sensor. Push it down all the way against the sensor, thus immobilizing the sensor. Further

immobilize the sensor by applying a drop of 5 Minute epoxy onto the sensor hole from the INSIDE of the housing.

CAUTION!

Due to the lack of an O-ring groove on the sensor, the sensor will not seal if it does not sit flat in the mounting hole. It is very important to immobilize the sensor through the use of the protective plate and 5 Minute epoxy as described above.

CAUTION!

Never touch the depth sensor's protective membrane. This membrane is made from a jelly like RTV which will be cut by so much as a contact with your finger nail. When pressure testing, always ramp pressure down slow (<10 PSI per second). The depth sensor is known to develop an embolism (bubbles) if pressure is reduced too rapidly.

Mount the gold contacts back in the 6-pin modular plastic housing after sensor installation. Use a small flat-head screwdriver to bend the locking tongue on each contact out somewhat before installation. The following connection table applies.

Diagram	P3 Pin Assignment	SCC300AHO Sensor Wire
5 3 1  6 4 2	1: V supply #1 2: V supply #2 3: Output - 4: Ground 5: Output+	Black Brown Orange Yellow Green

Figure 4: Connector P10 Pin Assignment (Depth Sensor)

How To Select A Sensor Pressure Rating

The EM-0 Module is supplied with a 300 PSI depth sensor. This sensor allows dives to depths of at least 673 feet, i.e. enough for most dives by humans. A 100 PSI sensor is available as an option. The accuracy of the depth transducer is specified as +/- 1% of full scale. Consequently, the 300 PSI sensor has an accuracy of +/- 6.7 feet while the 100 PSI model is good to +/- 2.2 feet. The software compensates for any offset errors at power-on to achieve better accuracy. However, in applications where dives in excess of 224 feet are not expected, the 100 PSI sensor should be ordered.

3.3. Electrical Connections

All module installations require at least a sonar transducer hook-up, a power connection, a means to close the module's ON switch and the connection of the data exchange cable. In most cases, you will also install the depth sensor. The following sections describe all electrical connections.

Making Cables For EM-0

The EM-0 module is equipped with several connector headers (group of gold stakes). The headers are used to connect external sensors, transducers, switches and power sources. Each header mates to a modular connector which is manufactured by Molex. Since cabling of the EM-0 module is application specific, we have not provided ready-made cables. Instead, use the supplied Molex connector housings and gold contacts to manufacture cables as needed for your job.

Each EM-0 and EM-0M module is shipped with an appropriate number of housings and gold contacts. The gold contacts will fit wires of size AWG24 to AWG30. Strip about 0.1" of insulation off the end of each wire. Insert the wire into the gold contact such that the rear ears of the contact clamp around the insulation (for strain relief) and the forward ears clamp around the bare wire. Crimp the contact using a Molex hand crimper part # 11-01-0209 or a similar tool. For added reliability, apply a small amount of solder to the front ears only. Avoid applying heat too long as the wire insulation may melt and destroy the strain relief.

Molex connectors are widely available. One supplier is Digi-Key at 1-800-DIGI-KEY. Use these parts numbers:

Gold Contacts for AWG24-AWG30 Wire:	Molex 16-02-0097	Digi-Key WM2513-ND
2 x 1 Contact Connector Housing:	Molex 50-57-9002	Digi-Key WM2800-ND
3 x 1 Contact Connector Housing:	Molex 50-57-9003	Digi-Key WM2801-ND
5 x 1 Contact Connector Housing:	Molex 50-57-9005	Digi-Key WM2803-ND
3 x 2 Contact Connector Housing:	Molex 22-55-2061	Digi-Key WM2520-ND
Hand Crimper Tool:	Molex 11-01-0209	Digi-Key WM9919-ND

3.3.1. The SONAR Transducer

The sonar transducer serves as the 'antenna' of the EM-0 module. The transducer has a threaded stem and is designed for mounting on the outside surface of a pressure vessel. The transducer has two wires protruding from the base. The transducer ground or '-' terminal is connected to the black wire, the signal or '+' terminal is hooked up to the red wire. If the transducer wire is too short, extend it using either a twisted wire pair or coaxial cable. Crimp two gold contacts to the end of the cable and insert the contacts into the 2-pin connector housing which is provided with your module.

Plug the connector into P12, so that the black wire is aligned with pin 1 (square pin, beveled corner on silk screen) and the red wire is aligned with pin 2.

Diagram	Pin Assignment
2 1 	1: Sonar Ground 2: Sonar Signal

Figure 5: Sonar Connector P12 Pin Assignment

A transformer is used to match the sonar transmitter aboard the EM-0 module to the sonar transducer. This transformer is connected to connector P11. The primary winding of the transformer connects to pins P11-1 and P11-2. The secondary windings connect to P11-3 and P11-4. The transformer is factory installed. However, a transformer change may be necessary if the DiveTracker™ module is to be used with a custom sonar transducer. The transformer is factory installed on all EM-0 modules.

3.3.2. Power Hookup

EM-0 requires a power source of 9V to 16V. The module consumes 26 mA in receive mode (21 mA for EM-0M) and - in extreme cases only - up to 2 Ampere in transmit mode. (The module will consume up to 1 Ampere when used for navigation applications. Higher consumption may be seen in telemetry applications). Make sure that your battery or power supply can supply the maximum expected current. The power supply may be unregulated, but you must ensure that there are no noise spikes in excess of about 10 mV on the

supply or ground line. Such spikes are common on power supplied by switching regulators. These spikes can induce noise into the sonar receiver section and impede performance. If this is a problem, use an automotive style choke in line with your power and ground lines.

P1 is the power connector. Two separate power sources may be connected here. Pin 1 is the '-' terminal for both sources. Pins 2 and 3 are the '+' terminals for the two power sources. In most case, the EM-0 is powered by a single battery or a single power supply. Use pins 1 (-) and 2 (+) for this basic connection.

CAUTION!
Do not supply more than 16V DC to the power connector. Higher voltages may damage the EM-0 module.

1: Ground Terminal
2: +9V - +16V DC (primary)
3: +9V - +16V DC (secondary)

Figure 6: Connector P1 Pin Assignment (Power)

3.3.3. ON and OFF Switches

The EM-0 module can be switched ON and OFF by either shorting pins on the P2 connector or by applying a magnetic field to the ON and OFF magnetic switches along the side of the module. Electric switching is normally preferred when the EM-0 is part of a larger instrument. Magnetic switching is a convenient and reliable method to activate or de-activate an EM-0 module which is mounted inside a pressure housing.

The EM-0 module will also automatically switch itself OFF and ON when it enters or exits sleep mode.

Two options exist for wiring the P2 power switch connector.

- Pins 1 and 2 of connector P2 may be permanently connected using a jumper (shunt). In this mode, EM-0 will power-up and RESET whenever power is applied to the power connector. Similar, the module will shut down whenever power is removed from the power connector. This mode of operation does **not** allow EM-0 to enter the sleep mode. This option should **not** be used in power sensitive applications (instrumentation buoys, etc.) that rely on the sleep mode to conserve power. If pins 1 and 2 are shorted, temporarily shorting pins 1 and 3 of P2 will RESET the EM-0 module.

- Power may be 'permanently' applied to the EM-0 power connector. The unit is activated whenever power is present and pins 1 and 2 of the P2 connector on the CPU board are shorted for about two seconds or a magnetic field is applied to the ON switch. After that time, the processor will automatically 'latch' the power-on condition and the short on P2 or the magnetic field may be removed. In this mode of operation, EM-0 is switched off under software control and may awake automatically through an alarm from the on-board real-time clock. You can also force the module off by shorting pins 1 and 3 of P2 or applying a magnetic field to the OFF switch. Use this mode of operation whenever you want to make use of the EM-0 sleep mode and alarm functions. This mode is especially useful in power sensitive long-term deployment applications.

Two Wiring Options For ON, OFF and RESET Functions

An open collector transistor switch which pulls pin 2 of P2 to ground may be used to activate DiveTracker under control of a main computer or another intelligence.

The pin assignments of P2 is shown in figure 7.

1: Ground
2: Power ON (short to pin 1)
3: Power OFF or RESET (short to pin 1)

Figure 7: Connector P2 Pin Assignment (ON/OFF/RESET Switch)

3.3.4. The Data Exchange Port And Data Link Cable

The EM-0 module includes an asynchronous serial data interface. The interface can be used to configure the module, to retrieve sensor data from the FLASH memory and to communicate with the module in acoustic modem and telemetry applications. The interface operates at 9600 Baud, 8 Data Bits, No Parity, 1 Stop Bit (8N1). The interface uses TTL voltage levels.

Each EM-0 module is shipped with a data exchange cable (Part # LINK-EM0) through which the EM-0 module can be connected to a PC. The data exchange cable incorporates a level converter which converts the TTL voltage levels used by the module into the RS232C voltage levels that are used by personal computers.

To communicate with the EM-0 module , plug the 5-pin modular connector of the data exchange cable into connector P3 so that the black wire is aligned with pin 1. Pin 1 has a square pad and is also marked by a beveled corner on the P3 silk screen.

The cable connection needs not be permanent if the serial port is only used for module configuration or data retrieval.

Diagram	Pin Assignment
	1: Ground 2: Transmit Data (TXD) 3: +5V Supply Output 4: Receive Data (RXD) 5: Ground

Figure 8: Serial Data Connector P2 Pin Assignment

The pin assignment on the DB25 connector of the data exchange cable is as follows. The directions are as seen from the device that is connected to the connector, not as seen from the connector itself.

Pin Number	Signal Name (Direction)	Comment
2	Transmit Data (Output)	Data from the PC
3	Receive Data (Input)	Data to the PC
4	Request To Send (Output)	Tied to pin 5
5	Clear To Send (Input)	Tied to pin 4
6	Data Set Ready (Input)	Tied to pin 20

7	Ground	
20	Data Terminal Ready (Output)	Tied to Pin 6

Figure 9: DB25 Connector Pin Assignment

3.3.5. The Depth Sensor

A SCC300AHO series pressure sensor manufactured by SenSym, Inc. is shipped with the module. The sensor is used to measure the depth of the instrument or vehicle which carries the module. In navigation applications, a mobile station's depth is transmitted as telemetry to the surface. It is indicated on the DiveBase™ dive site display and is also used in the calculation of the position of the mobile station. In some cases you may not need the depth transducer. This may be the case if you do not use your system for navigation or if you operate over a largely horizontal path where the depth reading has little effect on the horizontal position computation.

The sensor is calibrated for use with the module. Make sure the serial number on the transducer cable matches the serial number of your EM-0 module.

The sensor must be mounted with the pressure port facing the water. Follow the mechanical mounting instructions in section 2.2.

Connect the SCC300AHO sensor to connector P10. P10 accepts 4-pin or 5-pin 'Whetstone' resistive bridge sensors.

Diagram	P10 Pin Assignment
5 3 1 6 4 2	1: V supply #1 2: V supply #2 3: Output - 4: Ground 5: Output+ 6: No Connect

Figure 10: Connector P10 Pin Assignment (Alternate Depth Sensor)

Sensor calibration will be necessary if you are using a sensor other than the supplied unit. Contact Desert Star Systems for calibration instructions.

DANGER!

Please be aware that working with high pressure sources is dangerous and can result in serious injury or death. For safety, ALWAYS pressurize with water, NEVER pressurize with air or other gases.

3.3.6. The Status LED

A red status LED is shipped with the EM-0 module. This LED or another convenient LED may be installed at D5. Connect the long lead of the LED (anode) to pin 1 of D5. Pin 1 is marked by a beveled corner on the silk screen. Connect the short lead of the LED to pin 2.

Resistor R40 limits the LED current. It is set at 330 Ohms. Use a smaller value resistor down to no less than 180 Ohms for a brighter LED or a larger value for dimmer operation. Be careful however to observe the max. current handling capability of the selected LED.

The LED operates under control of the CPU and emits blink patterns that indicate the state of the board.

Blink Pattern	Meaning
LED off	EM-0 is off, asleep or the battery is dead.
One brief blink, once per second	EM-0 is standing by in tracking mode. Watch for this pattern just prior to station deployment. Do not deploy unless you see this or the acoustic modem mode standby pattern (as selected).
One brief blink, once every four seconds	EM-0 is standing by in acoustic modem mode. Watch for this pattern just prior to station deployment. Do not deploy unless you see this or the tracking mode standby pattern (as selected).
Fast double blink	The station has received a sonar interrogate (tracking mode) or a sonar data word (acoustic modem mode). This is the pattern you should see once the station is deployed (in the water) and receiving sonar signals.
Continuos rapid blinking.	The battery is low. Charge or replace it.

Figure 11: Status LED Blink Patterns

3.3.7. The Sensor Amplifiers

The EM-0 module includes seven sensor data amplifiers. One amplifier is designed for resistive bridge sensors. This amplifier is normally used for depth sensing. The remaining six amplifiers accept a ground referenced positive voltage. The amplifiers are suitable for reading temperature, pressure, conductivity and other analog sensors.

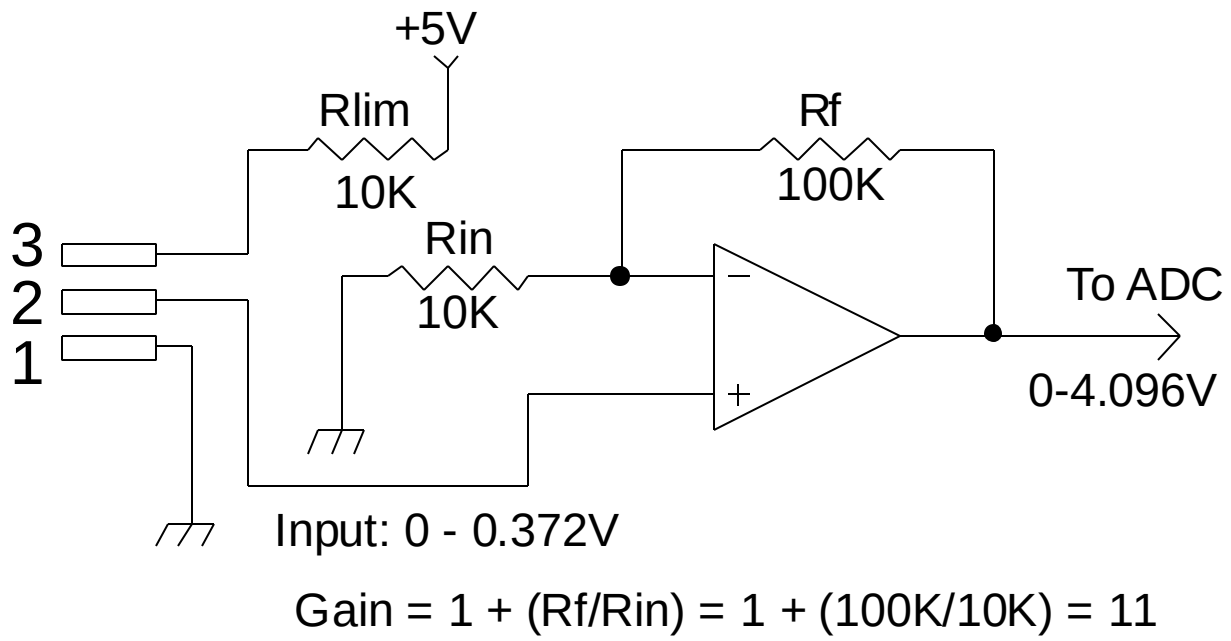

Figure 12: Wiring Diagram For The Six Single Ended Amplifiers.

Figure 12 shows the schematic for a single ended amplifier. The gain of each amplifier is resistor programmable. The amplifier output voltage is:

$$Vout = Vin \times (1 + (Rf/Rin))$$

The output of each amplifier is connected to an input of the 8-channel 8-bit A/D converter on the module. The 8-bit A/D converter accepts input signals from 0 Volt to 4.095 Volt. The A/D converter reading (ADCval) for a given input voltage (Vin) is:

$$ADCval = 256 \times Vin \times (1 + Rf/Rin)) / 4.096$$

The gain of all amplifiers is factory set to 11. This is appropriate for input signals from 0 - 0.372 Volt. To choose a different gain, change the Rf and/or Rin resistors of the amplifier. Use size 0805 surface mount resistors. The series resistance of Rin and Rf should not be below 10 Kilo Ohm to avoid excess current. Neither Rin or Rf should be larger than 1 Mega Ohm to avoid amplifier errors due to leakage currents.

The input of each amplifier is available at pin 2 of a 3-pin connector. Pin 1 is ground and a +5V power supply is available at pin 3. The +5V supply is current limited by Rlim. You may change Rlim, however total power consumption of all sensors drawn from this supply must not exceed 25 mA.

Figure 13 lists the amplifiers and resistors associated with each A/D channel. Use this table to configure the sensor amplifier section of the EM-0 module for your application.

A/D Channel	Function	Connector	Rin	Rf	Rlim
1	Depth Sensor	P10	N/A	N/A	N/A
2	Sensor Amplifier #1	P4	R2	R4	R25
3	Sensor Amplifier #2	P7	R11	R13	R30
4	Sensor Amplifier #3	P9	R19	R21	R32
5	Battery Voltage Sense	P1	N/A	N/A	N/A
6	Sensor Amplifier #4	P5	R3	R5	R26
7	Sensor Amplifier #5	P8	R12	R14	R31
8	Sensor Amplifier #6	P6	R20	R22	R27

Figure 13: A/D Converter Channel Assignment Table

The data from all channels can be logged in FLASH memory and transmitted as acoustic telemetry. Refer to section ??? for details.

3.3.8. The Special Mode Select Jumper

Jumper JP1 is used to put the MC68HC711 processor into special bootstrap mode. This mode is used to program the EPROM. It is also used by Desert Star Systems to test the EM-0 module prior to shipping using special test software. This jumper should be omitted (open) during normal operation.

4. EM-0 Activation

The EM-0 module can be activated by either shorting pins 1 and 2 of P2 or by applying a magnet near either end of the ON magnetic switch. The module is switched off by shorting pins 1 and 3 of P2 or by applying a magnet near either end of the OFF magnetic switch.

ON and OFF switching needs to be done only temporarily, as the EM-0 module will automatically latch the selected state. See section 4.3.3. for details on the ON/OFF switch wiring options.

The EM-0 module uses the MC68HC711E20 processor which includes a one time programmable PROM memory (OTPROM). The OTPROM contains the MicroTrack™ software which controls the EM-0.

As soon as the module is switched ON, MicroTrack™ will boot and the status LED will emit a blink pattern which indicates the current mode of operation of the module. The Status LED blink patterns are listed in figure 14.

Blink Pattern	Meaning
LED off	EM-0 is off, asleep or the battery is dead.
One brief blink, once per second	EM-0 is standing by in tracking mode. Watch for this pattern just prior to station deployment. Do not deploy unless you see this or the acoustic modem mode standby pattern (as selected).
One brief blink, once every four seconds	EM-0 is standing by in acoustic modem mode. Watch for this pattern just prior to station deployment. Do not deploy unless you see this or the tracking mode standby pattern (as selected).
Fast double blink	The station has received a sonar interrogate (tracking mode) or a sonar data word (acoustic modem mode). This is the pattern you should see once the station is deployed (in the water) and receiving sonar signals.
Continuous rapid blinking.	The battery is low. Charge or replace it.

Figure 14: Status LED Blink Patterns

5. EM-0 Configuration

The EM-0 module must be configured before it can be used.

- Use the DIP switches to select the power-up settings for acoustic modem mode. The EM-0 operates in acoustic modem mode when DIP switches 6 and 7 are ON, and at least one of the other DIP switches is OFF. The modem settings can also be changed through a simple set of serial commands during operation. See section 5.2. for details.

- Set all DIP switches to the ON position when operating in tracking mode and the EM-0 is mounted so that the switches are not accessible. If all DIP switches are in the ON position, the switch settings will be ignored and the EM-0 is configured by serial download only. This function is **not** available when operating the EM-0 as an acoustic modem.

- When operating in tracking mode, the EM-0 switches can be used to set the basic tracking parameters. Any switch settings will override equivalent parameters in the configuration file. Serial download must always be used for advanced functions, such as the definition of a sleep or data acquisition and telemetry schedule.

5.1. Configuration Via DIP Switch

The primary functions of the EM-0 can be defined by setting the eight position DIP switch. Other functions such as the data acquisition schedule can only be defined per serial data download. **The switch settings are ignored when all eight switches are in the ON position. In this case, the EM-0 is entirely configured via serial data download. If at least one switch is in the OFF position, any configuration defined by the switches overrides the corresponding parameter in a serial download.**

You may use figure 16 as a guide to determine switch settings. If the EM-0 is used in tracking mode, use the DiveTerm™ or DiveBase™ utilities to define a configuration file. The configuration download screen will show the appropriate switch settings (figure 15). Use these settings.

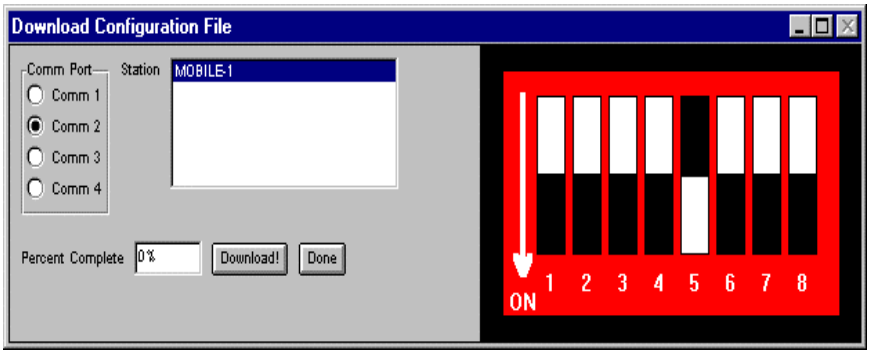

Figure 15: The Configuration Download Screen Defines Proper Switch Settings

The EM-0 Configuration Switches

- The **Transponder ID** switches select the identity of a EM-0. Select single transponder tracking mode by flipping all switches to the OFF position. In this mode, only one EM-0 can be tracked. In multi-transponder mode, up to six EM-0 can be tracked. Single transponder mode has the advantage of somewhat higher position update rates. When using multi-transponder mode, number your transponders sequentially starting with transponder #1. For example, if you are tracking two transponders, configure them as #1 and #2.

- The **Receiver Sensitivity** switches define the detection threshold for incoming signals. A lower sensitivity means greater immunity to noise and echoes but also a lesser range. Generally, lower sensitivities are used in constricted environments and noisy waters while higher sensitivities are applicable to open waters and low noise environments. The EM-0 automatic gain control automatically reduces sensitivity when noisy conditions are encountered. However, it makes sense to select a lower initial sensitivity when operating in known noisy or constricted environments.

- The **Network Type** switches define if you are tracking the EM-0 in a two or three transducer short baseline configuration or in a long baseline configuration. Acoustic modem mode is selected by setting both switches to the ON position.

- In Tracking And Data Acquisition Mode, the **Transmit Speed** switch selects the speed of the depth telemetry and how fast the transponder replies to an interrogate. High speed is applicable in most cases, but work in pools often requires the low speed setting. In acoustic modem mode, this switch selects if the same speed or different speeds are to be used for transmit and receive. Use the OFF position (same speed) if communication is between two EM-0 modules. Use the ON position to select a higher transmit speed when communicating with the more capable EM-2 module.

- The Modem Speed switches set the speed of digital communication in acoustic modem mode. Figure 16B relates the switch settings to speeds. Higher speeds can be used in low-echo environments such as deep ocean waters. Lower speeds must be used in high echo environments such as shallow waters, tanks, reefs, kelp forests etc. Depending on the setting of the Transmit Speed switch, the EM-0 will either use the same or different speeds for receive and transmit. The EM-0 may use higher transmit speeds when it communicates with the more capable EM-2 module, a STM-1 surface station or a RBS-1M modem.

Each configuration switch can either be in the ON or the OFF position. Some switches have a different meaning depending on whether tracking or acoustic modem mode is selected. The following tables detail the switch settings.

Switch Number	Switch Function	Switch Settings			
1-3	Transponder ID	**S1**	**S2**	**S3**	
		OFF	**OFF**	**OFF**	**Single Transponder Mode**
		OFF	OFF	ON	Transponder #1
		OFF	ON	OFF	Transponder #2
		OFF	ON	ON	Transponder #3
		ON	OFF	OFF	Transponder #4
		ON	OFF	ON	Transponder #5
		ON	ON	OFF	Transponder #6
		ON	ON	ON	Ignore All Eight Switches
4-5	Receiver Sensitivity	**S4**	**S5**		
		OFF	**OFF**		**Low Sensitivity**
		OFF	ON		High Sensitivity
		ON	OFF		Very High Sensitivity
		ON	ON		Very Low Sensitivity
6-7	Network Type & Transponder Mode	**S6**	**S7**		
		OFF	**OFF**		**3 Surface Transducer SBL**
		OFF	ON		2 Surface Transducer SBL
		ON	OFF		Long Baseline
		ON	ON		not valid
8	Transmit Speed	**S8**			
		OFF			**High Transmit Speed**
		ON			Low Transmit Speed

note: factory switch settings for EM-0 are bold

Figure 16A: EM-0 Configuration Switch Functions, Tracking & Data Acquisition Mode

Switch Number	Switch Function	Switch Settings
1-3	Modem Speed (speed code) note: TX&RX: transmit & receive speed if S8 = OFF TX: transmit speed if S8 = ON RX: receive speed if S8 = ON Speed Codes: 0: 9 (15) bit/sec, frq hopping 1: 24 (38) bit/sec, frq hopping 2: 48 (77) bit/sec, frq hopping 3: 96 (154) bit/sec, frq hop. 4: 3 (5) bit/sec, single-ch. 5: 8 (13) bit/sec, single-ch. 6: 23 (38) bit/sec, single-ch.	**S1 S2 S3 TX&RX TX RX** OFF OFF OFF 4 0 4 OFF OFF ON 5 1 4 OFF ON OFF 6 1 5 OFF ON ON not valid 2 5 ON OFF OFF not valid 3 5 ON OFF ON not valid 2 6 ON ON OFF not valid 3 6 ON ON ON not valid not valid not valid
4-5	Receiver Sensitivity	**S4 S5** OFF OFF Low Sensitivity OFF ON High Sensitivity ON OFF Very High Sensitivity ON ON Very Low Sensitivity
6-7	Network Type & Transponder Mode	**S6 S7** OFF OFF not valid OFF ON not valid ON OFF not valid ON ON Acoustic Modem Mode
8	Transmit Speed	**S8** OFF Same Transmit & Receive Speed ON Different Transmit & Receive Speed

Notes:
1. Data speeds are user data throughput. The raw bit transmission speed is given in parenthesis.

Figure 16B: EM-0 Configuration Switch Functions, Acoustic Modem Mode

The following table suggests receiver sensitivity and transmit speed settings for various environments. The list is a good starting point, however some experimentation may reveal more appropriate settings.

Environment	Receiver Sensitivity	Transmit Speed
Small Pools & Tanks	Very Low	Low
Large Pools & Tanks	Very Low - Low	Low
Noisy Harbors, Surf Zones	Very Low - High	High
Open Ocean	High - Very High	High
Restricted, Quiet Waters	High - Very High	High
Open, Quiet Waters (Lakes)	Very High	High

Figure 17: Environment Specific Configuration Switch Settings

5.2. Configuration Via Serial Download

The EM-0 may be configured by defining and downloading a configuration file using either the DiveBase™ surface station software or the DiveTerm™ utility. Configuration via serial download is only available when operating in Tracking and Data Acquisition Mode. Always use the DIP switch to configure an EM-0 module operating in acoustic modem mode.

Any switch settings override equivalent parameters in a serial download. To ignore switch settings entirely, set all eight witches to the ON position. This is useful in applications where the configuration switches are not easily accessible.

Figure 18 shows a configuration form as generated by DiveTerm™ and DiveBase™ running on a Windows 95 or Windows NT computer. The configuration of the EM-0 module and the entire tracking system is determined by filling in a set of these forms. To download a completed configuration file, connect the EM-0 to a COM port of the PC using the LINK-EM0 data cable. Press the Download button on the last configuration screen to start the configuration file download process. Refer to the DiveBase™ or Diveterm™ manual for details on configuration and serial downloading.

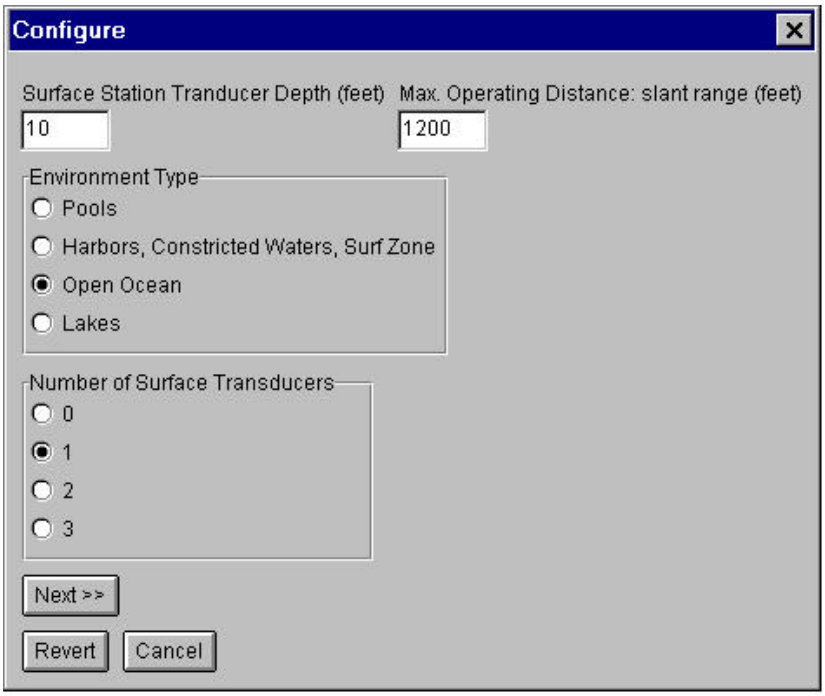

Figure 18: A Sample Configuration Form As Generated By DiveBase™ And DiveTerm™

6. Operating The EM-0

The EM-0 module can operate in two distinct modes.

- In **Tracking And Data Acquisition Mode**, the position of the module can be tracked using a surface station such as our models STM-10 and STM-1. This mode is useful for tracking tagged animals, instruments and underwater vehicles. When operating in this mode, the EM-0 can also acquire data from sensors hooked up to it's seven analog input channels (see section 4.3.7.). The acquired data can be stored in the on-board FLASH memory for post-mission retrieval. It can also be transmitted to the surface station as acoustic telemetry. Finally, the tracking mode supports the secured acoustic exchange of 8-bit status and command words between the EM-0 and a surface station. The data acquisition and telemetry capabilities are valuable for a variety of underwater instrumentation jobs.

- The EM-0 can operate as an **Acoustic Modem**. In this mode, any data received by the EM-0 via its serial data interface is transmitted via sonar. Any data received via the sonar link is transmitted by the EM-0 through its serial data interface. The acoustic modem mode can be used to exchange digital data streams between pairs or groups of underwater and surface devices. Applications include wireless communication with underwater vehicles and instruments, communication between an underwater master buoy and several nearby slave instruments or the implementation of a simple underwater 'teletype' to support written communication between a submarine and the surface crew. In acoustic modem mode, the EM-0 operates similar to a telephone modem.

6.1. Tracking & Data Acquisition Mode

The tracking and data acquisition mode is selected whenever switch 6 of switch 7 of the eight position DIP switch are in the OFF position or all eight switches are in the ON position.

The mode offers these capabilities:

- Tracking of the EM-0 module using a STM-1 or other Desert Star Systems surface station.
- Acquisition and storage of sensor data (data loggers).
- Acoustic transmission of sensor data to the surface station. Graphic display of sensor data.
- Exchange of secured 8-bit command and status words between the EM-0 and the surface station.

This mode is suitable for applications ranging from animal and vehicle tracking to instrument recovery, remote sensing and remote control.

In all these applications (except plain data logging), the EM-0 interacts with and is controlled by the surface station with which it communicates via sonar. The surface station runs the DiveBase™ software.

Figure 19 shows the DiveBase™ screen. The large window in the left half of the screen shows the location of the EM-0. The message window is in the background on the right. Status messages from the EM-0 are displayed here. An x-t sensor graph window is seen on top of the message window. This graph indicates the depth of the EM-0. Other graph windows can be defined to show the current output of specific sensors. The DiveBase™ manual describes how to track, acquire sensor data and otherwise interact with transponders such as the EM-0.

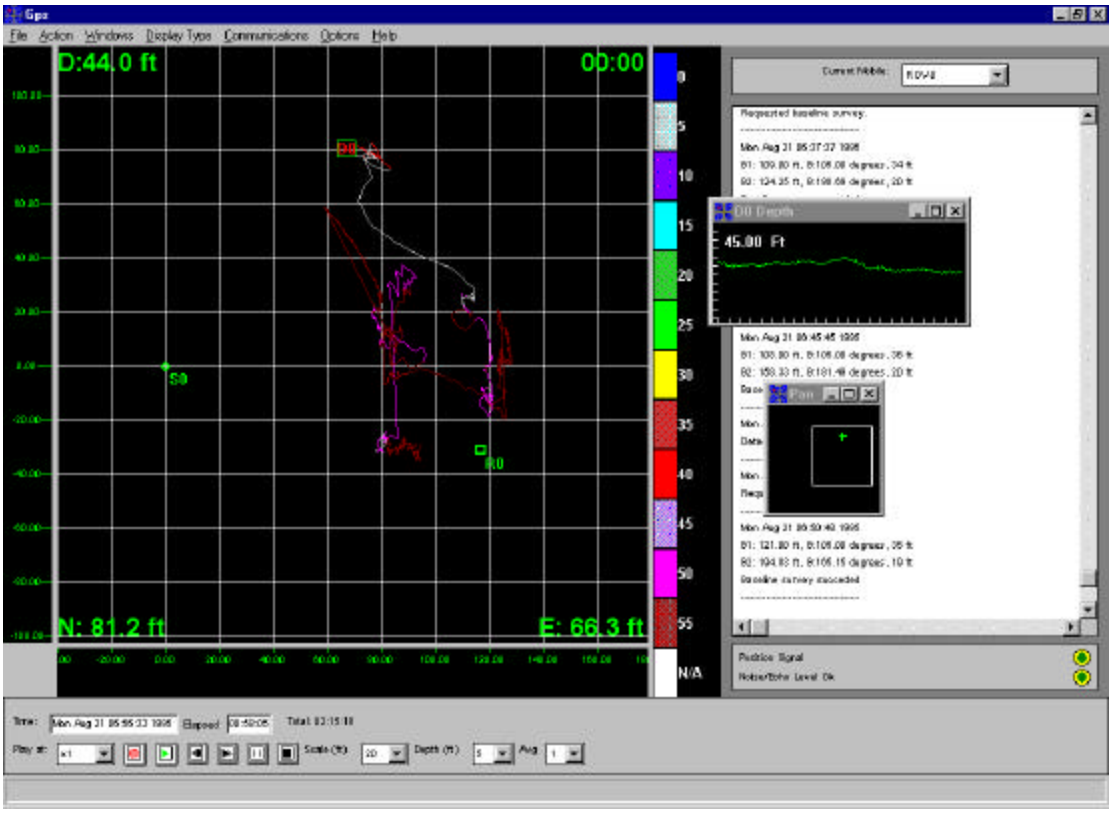

Figure 19: The DiveBase™ Tracking Window, A x-t Sensor Data Graph And A Message Window

The EM-0 module may be used to log sensor data in FLASH memory. After recovery of the module, this data can be retrieved. Use the configuration functions of DiveBase™ or DiveTerm™ to define a data acquisition schedule. To retrieve data from the module, use the **Tape Download** function of DiveTerm™. Retrieved data is stored in binary format. Use the Convert utility to convert retrieved data into ASCII format for import into data bases and analysis programs.

6.2. Acoustic Modem Mode

Acoustic modem mode is selected by setting switches 6 and 7 of the eight position DIP switch in the ON position. In addition, at least one of the remaining switches must be in the OFF position for this mode to be enabled.

In acoustic modem mode, the EM-0 operates as a simple modem:

- Any data received via the serial data interface is transmitted via sonar.
- Any data received via sonar is transmitted via the serial data interface.

Using two EM-0 modules (or other compatible hardware such as STM-0, STM-1 and EM-2), a two-way acoustic data link can be implemented.

Prior to operating the EM-0, set the DIP switches to suit your situation. Refer to section 4.1. for details. The switches define the power-up parameters of the EM-0 only. You can change the data transmit and receive speeds and the receiver sensitivity at any time by sending command codes through the serial data link.

After power-up, the EM-0 will send an identifier string through the serial data port. The data string identifies the software version and the mode of operation. For modems with the MicroTransponder software V1.20, it will read:

MTV1.20: Modem

The modem is ready for operation immediately after the transmission of this string. The following sections explain modem operation.

6.2.1. Serial Port Data Format

Serial Data Format

When in acoustic modem mode, the EM-0 serial data interface operates at 1200 baud, 8 data bits, no parity bit, 1 stop bit. The 1200 baud speed is fast enough to keep up with the fastest sonar data transmission yet slow enough to be supported by just about any device.

Serial Data Levels

The EM-0 serial data interface uses TTL voltage levels in order to keep power consumption to a minimum. The LINK-EM0 data cable converts between TTL and RS232C voltage levels.

Danger!

The EM-0 module uses TTL/CMOS data levels, and not RS232 levels. A zero volt level represents a '0' bit, a 5 volt level represents a '1' bit. Do not apply RS232 signals directly to the EM-0, as this may result in damage to the board. (Damage will occur if your RS232 drive is powerful enough).

6.2.2. Acoustic Data Format

The EM-0 transmits and receives acoustic data words consisting of one synchronization ping, four data pings and one checksum ping. Each data ping is position coded and represents 4 bits of information, for a total of 16 bits. The checksum is used by the receiver to verify the integrity of each word. The EM-0 ability to communicate 20 bits worth of information with just six pings makes it a very energy efficient transmitter.

Like most modems, the EM-0 receives and transmits 8-bit data words via its serial data interface. During transmit, it will pack two 8-bit serial data words into a 16-bit acoustic data word which is transmitted**. No data is transmitted until at least two bytes have been received via the serial data interface.** To ensure that the last byte of your data sentences is transmitted, append an idle character (NULL, SPACE, etc.) to each data sentence.

Each received data word is unpacked into two 8-bit words which are transmitted via the serial data interface.

If the EM-0 detects a bad checksum on an incoming acoustic data word, it will transmit '##' via the serial data link. This *bad data* indicator is useful to guide the adjustment adjust modem sensitivity and speed.

Acoustic Transmit/Receive Switching

The EM-0 implements a half-duplex acoustic modem. Data is either transmitted or received at any one time. Data can not be received and transmitted via the acoustic link at the same time. By default, the EM-0 is in receive mode. It switches automatically to transmit mode as soon as at least two data bytes are in its serial input data buffer. The EM-0 will remain in transmit mode until less than two bytes remain in its serial input data buffer. It is up to you, the user, to coordinate data transmission and reception**. If the modems at both end of an acoustic link transmit data at the same time, all data will be lost.**

The EM-0 can be used to exchange data in multi-station networks. The data transmitted by any station will be received by all other stations. It is up to the user to coordinate transmissions in such networks.

6.2.3. Modem Control

The modem has a data mode and a control mode.

- **Data Mode** is used to transmit and receive data.
- **Control Mode** is available to change modem operation parameters.

The modem will be in data mode after power up. To switch to control mode send '###'. The modem will acknowledge control mode by sending '<CM>'. To return to data mode, send 'D'. The modem will acknowledge data mode by sending '<DM>'. The table below lists the modem control commands.

Command	Function
###	Switch to control mode. The modem transmits '<CM>' to indicate control mode. **This command is available in data mode only. All other commands are available in control mode only.**
D	Return to data mode. The modem transmits '<DM>' to indicate data mode.
Sx	Set the acoustic transmit data speed (see section 6.2.4. for details): S0: 9 (15) bit/sec, frequency hopping S1: 24 (38) bit/sec, frequency hopping S2: 48 (77) bit/sec, frequency hopping S3: 96 (154) bit/sec, frequency channel S4: 3 (5) bit/sec, single-channel S5: 8 (13) bit/sec, single-channel S6: 23 (38) bit/sec, single channel **Note: Use speeds S4 through S6 only for communication between two EM-0 modules. Use speeds S0 through S3 when communicating with a EM-2 module or another frequency hopping capable receiver.**
Rx	Set the acoustic receive data speed (see section 6.2.4. for details): R4: 3 (5) bit/sec, single-channel R5: 8 (13) bit/sec, single-channel R6: 23 (38) bit/sec, single channel
Txx	Set the receiver detection threshold. The minimum possible threshold is T01. The modem is at its maximum sensitivity of 85 dB. The maximum threshold is T99, equivalent to a sensitivity of about 125 dB.

Notes:

2. Data speeds are user data throughput. The raw bit transmission speed is given in parenthesis.

Figure 20: Modem Control Commands

6.2.4. How To Set Modem Speed And Sensitivity

The acoustic data transfer speed and the receiver sensitivity of the modem can be controlled through the DIP switches and command codes. Proper settings are required to obtain reliable data exchange.

Modem Receiver Sensitivity

The sensitivity of the receiver modem is adjusted by setting the detection threshold. A low detection threshold makes the modem very sensitive. This increases the maximum data exchange range, but at the same time makes the modem more susceptible to noise. A high detection threshold means greater immunity to noise but a shorter transmit range. In theory, a doubling of the threshold setting will cut the maximum range in half. In reality this effect may be more or less pronounced, depending on the acoustic environment.

The following table gives a rough guide of recommended settings for various environments.

Environment	Threshold Range	Comment
Lakes	4 - 12	Lakes tend to be very quiet waters due to lack of biological activity. Use a high sensitivity unless boat traffic calls for a reduced sensitivity.
Pools & Tanks	8 - 99	Pools and tanks are often quiet, though they will at times pick up noise from nearby machinery. However, the small size of most pools and tanks normally does not require a high sensitivity, and better reliability may be achieved by reducing the sensitivity. The very strong and persistent echoes found in pools may also require a reduced sensitivity. On the other hand, pools and tanks tend to 'smear' the leading edge of sonar pulses. Especially when attempting to user higher data exchange speeds, you may have to reduce the detection threshold to fight this effect. In general, experimentation is called for to adjust a system for a given pool or tank.
Shallow Reefs	16 - 50	Shallow reefs, both in tropical and temperate seas often harbor a lot of biological noise making activity. The noise of the snapping shrimp for example is extremely common - a crackling noise well known by most divers. We sometimes operate at settings of as little as 12 here, but we have also seen noise as high as 48 units.
Deep Water	4 - 12	Deep oceanic waters tend to be quiet in the EM-0 frequency range. Your modem can probably be rather sensitive and cover very long distances.
Harbors	8 - 99	There can be much man induced noise in harbors, but at other times harbors a quiet. Do some experimentation.
Hydraulic Equip.	30 - 99+	Hydraulic equipment, including hydraulic ROV are very noisy. Hydraulics create a 'whine' that extends from a few hertz all the way to 100 kHz and beyond. Consequently, sensitivity must be reduced. In fact, it is quite possible that a sensitivity beyond the maximum of 99 is required (we have operated as high as a 270 unit equivalent). In this case, contact Desert Star Systems to modify your EM-0 for reduced sensitivity.

Figure 21: Modem Sensitivity Selection Guide

In general, finding the proper threshold setting to obtain the required range yet not be affected by ambient noise will require some experimentation. After the useable range is found, you may set the sensitivity

'permanently' or your software may implement a mechanism that controls the sensitivity to track changing noise levels.

One good method to experiment is to connect the EM-0 modules to a PC running a terminal emulation program. HyperTerm is one such application that is shipped with Microsoft Windows. Deploy the EM-0 modules at the designated site. Then, follow this procedure:

- Use one EM-0 to listen. Reduce the detection threshold until you see '##' symbols appearing on the screen. These bad data symbols indicate that the EM-0 is picking up noise (the other EM-0 is not transmitting!). Now, increase the detection threshold until the '##' symbols no longer appear. You have found the minimum useful detection threshold. Be careful, however: If the detection threshold is way too low, you may not see any '##' symbols because the noise is constantly beyond the detection threshold.

- Now, start typing on the terminal that is connected to the second EM-0. Whatever you type should appear on the screen of the receiving EM-0. If that is not the case, you may be out of range or the data exchange speed may be too high (in pools and other environments with long echoes). Once a data path is established, increase the receiver detection threshold until the data either becomes erroneous ('##' symbols) or no data is received at all. You have now found the maximum limit of the useful detection threshold range for this environment.

Be also aware that the EM-0 mounting location can strongly affect signal strength and thus the maximum possible operating range. For greatest range, keep the data path free of obstructions and stay at least six feet away from the water surface, the sea floor or the walls of pools and tanks.

Acoustic Data Transmission Speed

Communication between acoustic modems requires that all modems use the same communication speed (S0..S6). The EM-0 can transmit at four different speeds in frequency hopping mode and at three different speeds in single channel mode. Because the EM-0 receiver is a single channel design, you must use the single channel mode (speeds S4, S5 and S6) when communicating among EM-0 modules. The frequency hopping channels are available only when an EM-0 talks to an EM-2 or another frequency hopping capable receiver.

High data exchange speeds are desirable because data is exchanged faster, but the data transfer at higher speeds is also less reliable. The limiting factor is normally the duration of the echoes in the operating environment. The longer the echo lasts, the longer the modem has to wait before it can use a transmit frequency again. Thus, pools require very slow data speeds, while data exchange can be much faster in wide open waters. In general, the chosen data exchange speed should not exceed the minimum requirement of your application as this will unnecessarily reduce data exchange reliability.

The following table is a guideline to speed selection for some typical environments.

Environment	Maximum Speed	Comment
Lakes	Single Channel: S5-S6 Freq. Hopping: S2-S3	A 'typical lake', i.e. a muddy, gently sloping depression in the ground will have few echo surfaces. Echoes will not last long and thus higher speeds can be used.
Pools & Tanks	Single Channel: S4 Freq. Hopping: S0	Pools and tanks exhibit very persistent echoes. Only minimum operating speeds are possible.
Shallow Reefs	Single Channel: S5 Freq. Hopping: S1-S2	Sound tends to bounce of the hard rocky bottom and the sea surface, creating moderate echoes and thus requiring moderate speed.
Deep Water	Single Channel: S6 Freq. Hopping: S2-S3	There are few echoes in deep waters, so higher speeds are possible.
Harbors	Single Channel: S4-S5 Freq. Hopping: S0-S2	The smooth, hard surfaces of ships and docks efficiently reflect sonar signals. Echoes are of moderate to strong persistence.

Figure 22: Modem Speed Selection Guide

To test for the maximum possible speed, establish a link between two modems. Start operating at a slow speed, then increase the speed until data exchange becomes unreliable. You may be able to operate at a somewhat higher speed if you reduce the modem sensitivity. However, because echo strength can vary greatly from ping to ping, trying to squeeze the last bit of speed by this means may result in a data link with varying reliability.

If you cannot achieve the desired data exchange speed with a set of EM-0 modems, consider using a model EM-2 at the receiving end of the speed demanding link. The EM-2 modem includes a frequency hopping receiver, which boosts the maximum possible data rate by a factor of three in echo limited environments.

7. Module Maintenance

Your model EM-0 DiveTracker requires very little maintenance. Just follow these pointers.

- Inspect all connectors for loose wires and corroded contacts on a regular basis.
- Check all mounting screws periodically for tightness.
- If the module does get exposed to water, rinse it thoroughly in fresh water, shake it dry and inspect for any corrosion.

8. Model EM-0 Specifications

Size:	98 mm L x 41 mm D electronics module (109 mm x 41 mm including transformer)
Weight:	82 g
Operating temperature:	0-70 degrees Celsius
Data I/O:	TTL serial data link
Status Indicator:	Status LED
Sensors:	Depth sensor, 300 m +/- 3 m (100 m +/- 1 m optional) or other customer supplied resistive bridge sensor
	Six 8-bit A/D channels with programmable gain amplifiers
	Asynchronous serial interface available on CPU board for external 'smart' sensors
Microprocessor:	MC68HC711, 2 MHz
Memory:	Firmware stored in 20 Kbyte EPROM
	512 byte of RAM
Data Logging:	512 Kbyte of serial FLASH memory available for sensor data logging
Sonar transceiver:	TX power 183 dB @ 8V - 189 dB @ 16V
	4-channel frequency hopping transmitter, 33.8 kHz- 42 kHz standard, 65 kHz - 75 kHz optional
	RX sensitivity <= 95 dB re. 1 μPa
	4th order continuos time bandpass filter
	Single channel receiver, 33.8 kHz
Sonar transducers:	33 kHz - 42 kHz omni-directional transducer standard
Sonar range:	100 - 1000 meters communication range, depending on sea conditions
Sonar modulation:	Frequency hopping transmitter, pulse position modulated
	Single channel receiver, pulse position modulated
Sonar bitrate:	3-23 bits/sec actual user data (5 - 35 bits/sec raw) receive
	3-96 bits/sec actual user data (5 - 150 bits/sec raw) transmit
Sonar data format:	16-bit data + 4 bit checksum per word
Sonar Navigation:	Compatible with Desert Star Systems LBL, SBL and USBL tracking systems
	Navigation range is 100-1000 meters, depending on sea conditions.
	Distance measurements repeatability +/- 0.15 m
Power consumption:	9V to 16V supply voltage
	0 mA in sleep mode
	26 mA in sonar receive mode
	Up to 2 Ampere peak in high-power sonar transmit mode
Data transmit power:	30 mAh per 1000 user data bytes with 16V supply voltage (189 dB transmit power)
	15 mAh per 1000 user data bytes with 8V supply voltage (183 dB transmit power)

Note: all specifications are subject to change without notice

9. Model EM-0M Specifications

Size:	98 mm L x 41 mm D electronics module (109 mm x 41 mm including transformer)
Weight:	82 g
Operating temperature:	0-70 degrees Celsius
Data I/O:	TTL serial data link
Status Indicator:	Status LED
Microprocessor:	MC68HC711, 2 MHz
Memory:	Firmware stored in 20 Kbyte EPROM
	512 byte of RAM
Sonar transceiver:	TX power 183 dB @ 8V - 189 dB @ 16V
	4-channel frequency hopping transmitter, 33.8 kHz- 42 kHz standard, 65 kHz - 75 kHz optional
	RX sensitivity <= 95 dB re. 1 μPa
	4th order continuos time bandpass filter
	Single channel receiver, 33.8 kHz
Sonar transducers:	33 kHz - 42 kHz omni-directional transducer standard
Sonar range:	100 - 1000 meters communication range, depending on sea conditions
Sonar modulation:	Frequency hopping transmitter, pulse position modulated
	Single channel receiver, pulse position modulated
Sonar bitrate:	3-23 bits/sec actual user data (5 - 35 bits/sec raw) receive
	3-96 bits/sec actual user data (5 - 150 bits/sec raw) transmit
Sonar data format:	16-bit data + 4 bit checksum per word
Sonar Navigation:	Compatible with Desert Star Systems LBL, SBL and USBL tracking systems
	Navigation range is 100-1000 meters, depending on sea conditions.
	Distance measurements repeatability +/- 0.15 m
Power consumption:	9V to 16V supply voltage
	0 mA in sleep mode
	21 mA in sonar receive mode
	Up to 2 Ampere peak in high-power sonar transmit mode
Data transmit power:	30 mAh per 1000 user data bytes with 16V supply voltage (189 dB transmit power)
	15 mAh per 1000 user data bytes with 8V supply voltage (183 dB transmit power)

Note: all specifications are subject to change without notice