

STM-0M

Acoustic Modem Surface Station

Technical Reference Manual



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1. INTRODUCTION	3
<hr/>	
2. UNPACKING THE SURFACE STATION	3
<hr/>	
3. SURFACE STATION INSTALLATION AND ACTIVATION	3
<hr/>	
3.1. INSTALLING THE STM-10	ERROR! BOOKMARK NOT DEFINED.
3.2. INSTALLING THE STM-1	ERROR! BOOKMARK NOT DEFINED.
3.3. SURFACE STATION SONAR TRANSDUCER INSTALLATION	4
3.4. SURFACE STATION ACTIVATION AND OPERATION	5
3.5. INSTALLING AND CONFIGURING SURFACE STATION SOFTWARE	ERROR! BOOKMARK NOT DEFINED.
<hr/>	
4. CONNECTORS, INDICATORS AND CONTROLS	10
<hr/>	
4.1. STM-10 CONNECTORS, INDICATORS AND CONTROLS	ERROR! BOOKMARK NOT DEFINED.
4.2. STM-1 CONNECTORS, INDICATORS AND CONTROLS	ERROR! BOOKMARK NOT DEFINED.
<hr/>	
5. MAINTAINING THE SURFACE STATION	12
<hr/>	
6. MODEL STM-10 SPECIFICATIONS	ERROR! BOOKMARK NOT DEFINED.
<hr/>	
7. MODEL STM-1 SPECIFICATIONS	12
<hr/>	

1. Introduction

The STM-0M is an acoustic modem, designed for use as a surface station. The STM-0M can communicate with the ADM-0 housed acoustic modem, the EM-0M modem module and other STM-0M surface stations.



Figure 1: The STM-0M Acoustic Modem 'Surface Station'

2. Unpacking The Surface Station

Please ensure that your STM-0M shipment contains these components.

- | STM-0M Component List |
|--|
| <ul style="list-style-type: none">• 1 ea. model STM-0M surface station• 1 ea. ACDC-U universal switching power supply• 1 ea. LINK-S data exchange cable• 1 ea. TDCR-S50-40 sonar transducer• This manual |

The STM-0M is NOT shipped with any software. The only software needed is a terminal program (such as HyperTerm on a PC), or an application that controls your modem.

Please contact Desert Star Systems immediately if you are missing any components.

3. Surface Station Installation And Activation

The STM-0M may be installed in a drive bay of the surface station PC, it may be panel mounted in a rack or instrument panel, or it may be used as a desktop unit.

To install the STM-0M in a drive bay...

1. Slide the STM-0M into an empty half-height 5" drive bay on your PC.
2. Connect a spare 4-pin power plug of your PC into the power jack on the back panel of the STM-1 housing. Use the supplied Y-splitter if there are no free power plugs in your PC.
3. Locate the 10-pin COM1 jack on the motherboard of your PC. Disconnect the cable which is connected to it. Plug the supplied ribbon cable into the COM1 jack on the PC motherboard and into the 10-pin jack on the back panel of the STM-0M housing.
4. Follow the instructions below to install the sonar transducers.

To mount the STM-0M externally...

1. Place the STM-0M close to the PC.
2. Connect the ACDC-U power supply to the 4-pin power jack on the back panel of the STM-1 and to a suitable 110 VAC or 220 VAC power outlet.
3. Connect the DB9 connector on the station's back panel to the COM1 connector on your PC. Use the LINK-S data link cable.
4. Follow the instructions below to install the sonar transducers.

3.1. Surface Station Sonar Transducer Installation

The STM-0M surface station connects to a single cabled sonar transducer. The transducer serves as the antenna for communication. Proper mounting of the transducer is essential. If transducer is blocked by obstacles, communication may be limited in range or may not be available.



Figure 2: A Sonar Transducer is lowered over the side of the Surface Vessel

The most common method of mounting the surface station sonar transducer is shown in figure 5. The cabled transducer is attached to a load carrying (strain relief) line and weighted down with a lead weight of about 5 kg (10 pounds). The line is attached to the top U-bolt of the transducer cage, the weight to the bottom U-bolt. The transducer is then lowered over the side of the vessel. This mounting method is fast and does not require any special engineering. The weighted transducer is kept in the proper 'cable up /

transducer head down' orientation by the weight. The approach lends itself to anchored operations as well as live boat operations as long as the weight and line strength is dimensioned properly to keep the transducer down even at the highest conceivable vessel speed. Of course, caution must be taken to prevent the transducer from getting caught up in the ship's propeller. Depending on circumstances, other mounting techniques such as pole mounting may be employed.

To maximize performance, please consider these guidelines:

- Many objects reflect sonar energy, especially if they contain air such as a ship's hull, air tank or even kelp. A 'shadow' is thus created behind the body. A transducer located in that shadow may not pick up sonar energy. It is important to ensure that transducers are placed such that no path blockage will occur. The system can tolerate temporary shadowing, but a permanent blockage will result in loss of navigation and communication capabilities.
- There are many natural and man-made noise sources under water. All stations in a network must be able to 'hear' the other stations. This implies that the signal of the other stations must be 'louder' than the background noise. Thus, it is important to keep sonar transducers away from any interfering noise sources. Most problematic is high-frequency noise such as is generated by a boat's propeller churning in the water, gas or fluids 'hissing' through a pipe, the banging of hammers and other tools etc. The system can tolerate momentary, sporadic noise. However a persistent noise source will raise a 'curtain' that the system may not be able to penetrate.
- Practical limitations may not allow you to obtain an ideal setting for transducer mounting. However you should attempt to minimize the interfering factors.

How to Maximize Sonar Transducer Performance

3.4. Surface Station Activation And Operation

For operation, the STM-0M must

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:

1. 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 off 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.

4. Connectors, Indicators And Controls

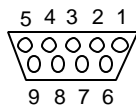
The STM-0M features a RESET push-button switch. Press this button to restart the STM-0M.

Serial Data Connectors

There are two RS232C serial data connectors located on the back panel of the surface STM-0M. Plug the supplied LINK-S cable into the DB9 connector on the surface station and a COM connector on your PC if you are using the surface station as an external device.

The ribbon cable jack should be used if you mount the surface station in the drive bay of a PC. Use the supplied ribbon cable to link this jack to the COM1 jack on the motherboard or serial IO card of your PC. Make sure that pin 1 on both cable connectors is aligned with pin 1 of the surface station and the motherboard jack respectively.

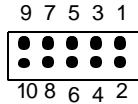
The wiring of the DB9 connector and the ribbon cable jack is identified in the following tables.



- 1: Not Connected
- 2: TXD (Transmit Data), Output
- 3: RXD (Receive Data), Input
- 4: DSR (Data Set Ready), Input
- 5: Signal Ground
- 6: DTR (Data Terminal Ready), Output
- 7: CTS (Clear To Send), Input

- 8: RTS (Request To Send), Output
- 9: Not Connected

Figure 18: DB9 Serial Data Exchange Connector Pin Assignment



- 1: Not Connected
- 2: TXD (Transmit Data), Output
- 3: RXD (Receive Data), Input
- 4: DSR (Data Set Ready), Input
- 5: Signal Ground
- 6: DTR (Data Terminal Ready), Output
- 7: CTS (Clear To Send), Input
- 8: RTS (Request To Send), Output
- 9: Not Connected

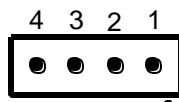
Figure 19: Ribbon Cable Connector Pin Assignment

ADVISE:
 Some motherboards and serial I/O cards have the connectors wired in a non-standard way. Make sure that the connector is wired in the same way as the Ribbon Cable, If it is not you will have to purchase a new serial I/O card that is wired correctly or connect the STM-1 to the external serial port using the DB9 connector

Power Connector

A 4-pin 'disk drive power connector' (model 3M 53109-0410 jack; model 3M 70156 plug) is used to supply power to the station. The power connector is directly compatible with personal computer cabling. When the station is installed in a PC drive bay, simply connect a spare power connector to the jack on the back panel. The station may also be powered by the external ACDC-U power supply or you may connect a 9V to 16V DC power source.

The station's power requirement is 120 mA in receive mode and up to 2 Ampere in transmit mode.

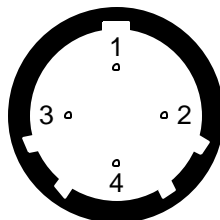


- 1: Ground
- 2: +9V to +12V @ 2 Ampere
- 3: No Connect
- 4: No Connect

Figure 20: Power Connector Pin Assignment

SONAR #1, SONAR #2, SONAR #3

Only connector SONAR #1 is used on the STM-0M. Plug the sonar transducer into this connector.



- 1: Ground
- 2: External Sonar Transducer
- 3: No Connect
- 4: No Connect

Figure 11: SONAR #1, SONAR #2, SONAR #3 Connectors

5. Maintaining The Surface Station

Models STM-0M requires virtually no maintenance. Make sure the connectors remain free of debris and use a dry or somewhat damp cloth to remove dust.

Please be aware the STM-0M module is not waterproof or even water resistant. Make sure it is operated in a dry area. Make sure all connectors are dry before connecting them to the station.

If the station should come in contact with significant quantities of salt water, you may have a slight chance of rescuing it by instantly removing it from the power source, rinsing it thoroughly with fresh water and shaking it dry.

6. Model STM-0M Specifications

Size:	216 mm x 146 mm x 38 mm (8.5" x 5.75" x 1.5") overall Compatible with standard half-height 5" drive bays on personal computers May be installed in a drive bay or may be desk-top mounted
Weight:	1100 gram (40 oz)
Operating temperature:	0-50 degrees Celsius
Data I/O:	Controlled via IBM compatible PC through serial data link
Status Indicator:	Status LED on front panel
Microprocessor:	MC68HC11, 1 MHz
Sonar transceiver:	100 Watt RMS output in transmit mode RX sensitivity 7 microvolt RMS @ 6 dB S/N 4th order continuous time bandpass filter
Sonar transducers:	One external transducer. 34-41 kHz standard. Other frequencies available on request
Sonar range:	100-1000 meters communication range, depending on sea conditions
Sonar modulation:	Single frequency pulse position coding.
Sonar bitrate:	15 - 150 bits/sec
Sonar Navigation:	Long baseline and short baseline principle supplemented by sensor derived depth information yields 3D position
Power consumption:	9V to 16V supply voltage May be powered by PC or external (ACDC-U) power supply 0.01 mA in sleep mode 20 mA in sonar receive mode Up to 1 Ampere in high-power sonar transmit mode

Note: all specifications are subject to change without notice