RBS-0M

Miniature Acoustic Modem

Technical Reference Manual

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1. Introduction

The RBS-0M is a miniature acoustic modem. It will transmit and receive digital data between underwater stations or an underwater location and a surface station up to 1000 meters apart. The RBS-0M modem is designed for reliable exchange of data in a variety of underwater environments, from shallow estuaries or harbors all the way to deep oceanic waters.

The following table summarizes the RBS-0M features.

RBS-0M Features

- Acoustic data exchange in shallow, confined and deep waters alike.
- Works in high multi-path and noisy environments.
- Robust data exchange format, including checksum.
- Small size and low cost.
- Low standby power consumption and energy efficient data transmission.
- Range up to 1000 meters.
- Instant-on and switch configuration for use with 'dumb devices"
- Configuration through serial commands for use with 'smart devices'.
- Compatible with all Desert Star surface stations and EM-2 series frequency hopping modems.
- Very simple to use.

The RBS-0M is a simple, effective and low-cost solution for a variety of applications that demand reliable data exchange at slow to medium speeds. Here are a few examples.

A few Applications for the RBS-0M

- Retrieval of data from underwater instruments
- Control of underwater instruments and equipment
- Control of autonomous underwater vehicles (AUV).
- An 'acoustic teletype' for communication with submarines or among submarines.
- Cost saving replacement of wired data links.
- Marine mammal telemetry.
- Acoustic diver or vehicle identification.
- Remote control of lift bags.
- Acoustic releases.
- Communication with stealthy instruments that are buried into the sea floor.

2. Unpacking

Please ensure that your shipment does contain these components.

- 1 ea. RBS-0M module
- 1 ea. LINK-D data exchange cable with DB25 to DB9 connector adapter
- 1 ea. PIG5-D 5' underwater modem cable terminated with a LINK-D compatible AMP connector
- This manual

DiveTracker™ RBS-0M 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. Modem Installation

The RBS-0M is always used in conjunction with a 'host device', i.e. an instrument, vehicle, computer or other data receiving or transmitting device. Because the RBS-0M does not have an internal battery, it must be powered by an external source.

Installation of the RBS-0M is a matter of selecting a proper place for the modem and linking it to the host device and a power source.

The sonar transducer is mounted on one end of the housing. The utility connector and a status LED occupies the other end.

The sonar transducer is the antenna of the RBS-0M. Mount it such that it is not shadowed by any obstacle. The direct path between the transducers on both ends of the acoustic data link must be free of obstructions. Use a cable clamp, a bracket or any other suitable means to secure the RBS-0M to the host device. For use as a surface station, it is possible to dangle the RBS-0M into the water suspended by its utility cable. However, make sure that the strain on the cable does not exceed a few pounds. The cable itself cannot be longer than about ten meters.

The RBS-0M features a 5-pin underwater connector through which it communicates with the host and receives power. The connector, a McArtney model MCBH5F mates to a plug of type MCIL5M. The RBS-0 is shipped with a short cable (part # PIG5-D) that is terminated with a MCIL5M connector on one end. The other end is terminated with a 9-pin AMP connector, through which it can be linked to the LINK-D data exchange cable, which is also included.

3.1. Electrical Installation For Modem Test

To test the RBS-0M, it is convenient to connect each modem to a PC or a terminal. A two-way 'acoustic teletype' system is thus created. Follow these instructions.

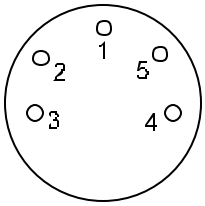
- Join the underwater cable and the data exchange cable. Connect the ends of the assembly to the modem and a personal computer or terminal respectively.

- Power the modem by applying a +8V to +16V source capable of supplying at least 2 ampere to the YELLOW lead that protrudes from the AMP connector. Connect the associated negative lead of the power supply to the BLACK lead protruding from the AMP connector.
- The modem will be active as soon as power is applied. The LED should flash once per second.

3.2. Electrical Installation For Underwater Use

The RBS-0M is normally connected to an underwater host device. For this purpose, an underwater cable is shipped with the modem. The cable is terminated on one end with a 5-pin connector, which plugs into the utility connector of the RBS-0M.

The other end of the cable is terminated with a AMP connector which is compatible with the corresponding connector on the data exchange cable (see section 3.1.). This setup is appropriate for test purposes only. For underwater use, remove the AMP connector from the underwater cable and terminate the cable instead with an underwater connector that will link the RBS-0M to your host device.



1: Ground
2: Modem Receive Data (5V TTL/CMOS Data Levels)
3: Modem Transmit Data (5V TTL/CMOS Data Levels)
4: 8V to 16V @ 2A peak power supply to Modem
5: +5V Output for powering TTL/RS232 converter box

Figure 2: Pin Assignment of the RBS-0M Utility Connector

Figure 2 shows the pin assignment of the RBS-0M utility connector. The signals are explained in detail in figure 3.

Pin #	Signal	Description
1	Ground	The ground return line.
2	Receive Data	The modem data receive line. The modem expects data at 1200 baud, 8 data bits, no parity, one stop bit. Apply 5V TTL/CMOS signals to this line, DO NOT USE RS232C data levels. A '1' is 5V, a '0' is 0V
3	Transmit Data	The modem data receive line. The modem transmits data at 1200 baud, 8 data bits, no parity, one stop bit. TTL/CMOS level signals are transmitted. A '1' is 5V, a '0' is 0V.
4	Modem Power	Apply +8V to +16V power for the modem here. Connect the negative lead of the power supply to pin 1. The power supply should be able to supply peak currents of up to 2 Ampere. **Do not exceed 16 Volt. This will damage the modem**.
5	+5V Output	+5V is available here whenever power is supplied to the modem. The RBS-0M serial data interface uses TTL level signals. This line can be used to power a TTL/RS232C level converter box when communicating with a PC or other RS232C device. The RBS-0M data cable makes use of this voltage to power the level converter which is contained in the small blue box of the data cable assembly.

Figure 3: RBS-0M Signal Utility Connector Description

Modem Data

Note that the RBS-0M uses TTL/CMOS logic data levels on pins 2 and 3. Logic data levels are used to keep power consumption to a minimum. However, these data levels are NOT compatible with RS232C ports. To interface the RBS-0M to a RS232C device, use the data exchange cable. This cable includes a level converter, which converts the data between RS232C and logic levels.

Mount the data cable on the inside of your host device, in a dry space. Use the table below to wire the data cable to the RBS-0M.

AMP Pin	RBS-0M Pin	Description
4	1	The ground return for the data.
3	2	Modem receive data.
2	3	Modem transmit data.
8	5	+5V Output of the RBS-0M. This voltage will power the level converter box.

Figure 4: Wiring Of The RS232C / CMOS Level Converting Data Cable

Modem Power

The modem requires +8V to +16V power. Receive current is only 21 mA, but in transmit mode the current can reach 2 Ampere. Make sure the battery or power supply has a sufficient maximum current capability.

The modem transmit power varies with the supply voltage. Transmit power is about 183 dB at 8V, rising to about 189 dB at 16V.

Caution!
Do not exceed +16 Volt supply voltage. Higher voltages may damage the modem.

Modem ON/OFF Switch

The RBS-0M modem is switched on whenever +8V to +16V power is applied at pin 4 of the modem connector. The LED will flash when the modem is on.

4. Modem Activation

The RBS-0M modem is active whenever power is applied to pin 4 of the utility connector and the ON/OFF signal line at pin 5 is shorted to pin 1 (ground).

The status LED shows what the modem is doing.

Blink Pattern	Meaning
LED off	RBS-0M is off.
One brief blink, once per second	RBS-0M is standing by and waiting for data or transmitting data.
Fast double blink	The station has received a sonar data. This is the pattern you should see once the station is deployed (in the water) and receiving sonar signals.
Continuos rapid blinking.	The supply voltage is less than about 9 Volt.

Figure 5: Status LED Blink Patterns

5. Modem Configuration

A set of eight switches inside the RBS-0M set the power-on configuration of the modem. The modem is factory configured for these settings:

Serial Data Port:	1200 baud, 8 data bits, no parity, one stop bit (cannot be changed)
Serial Data Port Levels:	5 Volt TTL/CMOS Compatible. '1' = 5V, '0' = 0V (cannot be changed)
Acoustic Data Receive Speed:	Speed 5 (13 bit/sec, single channel)
Acoustic Data Transmit Speed:	Speed 5 (13 bit/sec, single channel)
Receiver Sensitivity:	'High' (detection threshold 16 units)

(DIP1-DIP8 Settings: OFF OFF ON OFF ON ON ON OFF)

Figure 6: Factory Configuration Of The RBS-0M

These parameters can be changed during operation in the command mode of the modem, see section 6.3. for details. Changing the parameters by sending serial commands is preferred over changing the switch settings, because this does not require opening the modem.

However, if you are using to RBS-0M to communicate with a simple instrument that cannot send command codes, the switch settings may have to be modified. Switches may be set to your specification prior to shipping by Desert Star Systems. You can also modify the settings yourself, however this requires opening the RBS-0M and thus exposing it to hazards such as ESD and leakage. If you do need to open the RBS-0M, please contact Desert Star Systems for instructions.

Figure 7 lists the function of the 8 DIP switches.

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 (t'hold 128 units) OFF ON High Sensitivity (t'hold 16 units) ON OFF Very High Sensitivity (t'hold 8 units) ON ON Very Low Sensitivity (t'hold 128 units)
6-7	Mode of Operation	**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 7: Configuration Switch Functions

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 8: Environment Specific Configuration Switch Settings

6. Modem Operation

The RBS-0M operates as a simple acoustic 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.

Two RBS-0M (or other compatible hardware such as STM-10, STM-1, RBS-1M, RBS-2M, EM-0, EM-2) will implement a two-way acoustic data link.

After power-up, the modem sends 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.

6.1. Serial Port Data Format

Serial Data Format

The 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 serial data interface uses TTL voltage levels in order to keep power consumption to a minimum. The LINK-D data cable can be used to convert between TTL and RS232C voltage levels.

Danger!

The RBS-0M uses TTL/CMOS data levels, and not RS232C levels. A zero volt level represents a '0' bit, a 5 volt level represents a '1' bit. Do not apply RS232C signals directly to the RBS-0M, as this may result in damage to the device. (Damage will occur if your RS232C drive is powerful enough).

6.2. Acoustic Data Format

The modem 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 modem's ability to communicate 20 bits worth of information with just six pings makes it a very energy efficient transmitter.

Like most modems, the RBS-0M 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 RBS-0M 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 RBS-0M 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 modem 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 modem 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 RBS-0M 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.

6.3. 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 6.4. 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 RBS-0M modules. Use speeds S0 through S3 when communicating with a RBS-1M or another frequency hopping capable receiver.**
Rx	Set the acoustic receive data speed (see section 6.4. 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 9: Modem Control Commands

6.4. 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 10: 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 11: 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. Modem Maintenance

Your model RBS-0M requires very little maintenance. Just follow these pointers.

- Apply a thin film of silicone grease to the cable connector before mating it to the bulkhead connector.
- Never dive the RBS-0M with an open utility connector. If the modem is not connected to a cable, use the dummy plug.
- Rinse the RBS-0M in fresh water after use.

8. RBS-0M Specifications

Size:	216 mm L x 57 mm D
Weight:	454 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