HydroLynx Systems, Inc.

Radio Path Survey

Document No: A102715
Document Revision Date: December, 2004

Receiving and Unpacking

Carefully unpack all components and compare to the packing list. Notify HydroLynx Systems immediately concerning any discrepancy. Inspect equipment to detect any damage that may have occurred during shipment. In the event of damage, any claim for loss must be filed immediately with the carrier by the consignee. If the equipment was shipped via Parcel Post or UPS, contact HydroLynx Systems for instructions.

Returns

If equipment is to be returned to the factory for any reason, call HydroLynx between 8:00 a.m. and 4:00 p.m. Pacific Time to request a Return Authorization Number (RA#). Include with the returned equipment a description of the problem and the name, address, and daytime phone number of the sender. Carefully pack the equipment to prevent damage during the return shipment. Call HydroLynx for packing instructions in the case of delicate or sensitive items. If packing facilities are not available, take the equipment to the nearest Post Office, UPS, or other freight service and obtain assistance with packaging. Please write the RA# on the outside of the box.

Warranty

HydroLynx Systems warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from the date of shipment from the factory. HydroLynx Systems' obligations under this warranty are limited to, at HydroLynx's option: (I) replacing; or (ii) repairing; any product determined to be defective. In no case shall HydroLynx Systems' liability exceed product's original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by HydroLynx Systems, or that has been subjected to misuse, negligence, or accident. It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.

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TABLE OF CONTENTS

SECTION NO. **PAGE NO.**

1.0 INTRODUCTION

This document is provided to our customers to assist in designing a reliable system that will comply with F.C.C. regulations. Because the information required to complete the radio path survey is also required in the F.C.C. license application, HydroLynx Systems recommends a radio path survey be completed for each remote site prior to filing for F.C.C license.

1.1 RF Transmission Basics

Radio Frequency (RF) transmissions are electromagnetic energy radiated from the transmitting antenna. The parameters of an RF transmission are: **power output** measured in Watts and **frequency** measured in MHZ (megahertz, million cycles per second). At some distance away the receiving antenna picks up this energy; however, the energy level is now reduced by a factor proportional to the distance between the antennas.

1.2 FM Signal Basics

Frequency Modulation (FM) is a common method used to encode information on an RF carrier. The RF carrier frequency is increased and decreased at a rate equal to the information signal's frequency. The maximum amount of frequency increase/decrease is called **deviation** and is measured in ±kHz (plus and minus kilohertz, thousand cycles per second).

1.3 Radio Path Basics

1.3.1 System Range - Radio Horizon

The Radio Horizon, or maximum range, of a "line-of-sight" radio path is determined by the heights of the antennas. The limiting factors are the curvature of the earth and the intervening terrain. HydroLynx recommends that all radio paths be "line-of-sight" as they are the most reliable.

1.3.2 Other Factors:

Transmitter Power Output
Transmitter Feedline and Type
Transmitting Antenna Type and Gain
Receiving Antenna Type and Gain
Receiver Feedline Length and Type
Receiver Sensitivity

1.3.3 Testing

After calculating viable radio paths a field test is performed to verify the results.

2.0 RADIO PATH CALCULATIONS

This section is divided into three sub-sections: Radio Horizon, Signal Sum Calculation and Fade Margin.

2.1 Radio Horizon

The Radio Horizon is considered first since it is the maximum range for line-of-sight transmissions. The range limit due to the curvature of the earth may be approximated using the Radio Horizon Formula. To find range limits due to intervening terrain, use a Path Profile Chart and a topographic map of the region.

2.1.1 Radio Horizon Formula

Maximum Radio Horizon $\approx 1.2245 * (\sqrt{h1} + \sqrt{h2})$

The values for h1 and h2 are in feet above the base elevation of the lowest antenna. The value found for Maximum Radio Horizon is in miles.

2.1.2 Path Profile Chart

To use the Path Profile Chart, first locate the transmit and receive sites on a topographic map. Plot these site on the Path Profile Chart with regard to elevation and distance. Next, elevations of the intervening terrain are read from the topographic map and plotted vs. their distance from the transmit site. Draw a line connecting the antennas; any terrain feature above that line creates a Radio Horizon or range limit.

2.2 Signal Sum Calculation

To evaluate a system's range we first sum the signal's gains and losses to find the effective signal input to the receiver. There are many consideration when making this calculation, some of which are beyond the scope of this document to calculate exactly. The results of this calculation will be used as an indication of a viable path, which is then confirmed by a field test.

Signal Sum = (TX Power Factor + TX Antenna Gain – TX Feedline Loss – Free Space Loss – RX Feedline Loss + RX Antenna Gain)

2.2.1 Transmitter Power Factor = (log PowerOut + 3) * 10 dBm

Example: 5 watt transmitter would have a TX Power Factor = (log 5+3.00) * 10 dBm
= (0.6989+3.00) * 10 dBm
= 3.70 * 10 dBm
= 37.0 dBm

2.2.2 Antenna Gains - As specified by antenna type; refer to HydroLynx catalog.

Examples: 5050ANT +3 dB
DB224 +6 dB

2.2.3 Feedline Loss - as specified by cable type, cable length, and frequency range. Refer to HydroLynx or manufacture catalogs.

Examples: RG8 @ 18ft in VHF range: (18/100) ft * 3.1 dB = 0.56 dB
½" foam @ 200 ft in VHF range: (200/100) ft * 1.16 dB = 2.32 dB

2.2.4 Free Space Loss = 36.6 + 20(log f) + 20(log d) dB

The Free Space Loss value is not exact for all systems; only a reasonable estimation for the purpose of this calculation. The units are: f (MHZ), d (miles) and Free Space Loss (dB).

Example: System frequency (f) = 169.500 MHZ, Distance (d) = 35 Miles

Free Space Loss = 36.6 + 20(log 169.5) + 20(log 35) dB
= 36.6 + 20(2.23) + 20(1.54) dB
= 36.6 + 44.6 + 30.8 dB
= 112 dB

2.2.5 Signal Sum Example

Signal Sum = (37.0 + 3.0 – 0.6 – 112 – 2.3 + 6) dB
= –68.9 dB

2.3 Fade Margin

The Fade Margin is the difference between the Signal Sum (signal input at the receiver) and the receiver sensitivity. HydroLynx specification for receiver sensitivity is ≤ 0.5µV or –113dBm.

Fade Margin = Signal Sum – receiver sensitivity
= –68.9–(–113) dB
= 44.1 dB

HydroLynx recommends a Fade Margin greater than or equal to 18 dB. The calculated value of 44.1 dB is greater than 18 db, so this path is acceptable. However, this calculation is only an estimate and the path must be verified with a field test. After performing a few field tests it may be required to subtract a correction due to terrain, antenna heights, or other factors. It is best to start field testing the paths with the largest fade margins in case a correction eliminates paths with lower fade margins.

3.0 RADIO PATH TESTING

There are various "recommended" methods to field test radio paths. Each will give a certain level of "confidence" in the path under test. The level of "confidence" increases as the equipment used becomes more representative of the actual system equipment. HydroLynx recommends using the actual system equipment whenever possible.

3.1 Test Equipment

The minimum test equipment required is a transmitter, receiver, and some method to evaluate signal strength. Substitutions to the following list may be made as required.

Equipment Required:

5096 Data Transmitter with 5 watt transmitter
Antenna, +3dB Omni (or system's transmit antenna)
Antenna Mast (portable)
Antenna Cable (RG8 @ 18ft)
5050TS or 5050P Tipping Bucket

5051R Receiver
5062 Remote Station Tester
Antenna (same as system's)
Antenna Mast (same as system's)
Antenna Cable (same as system's)

Watt Meter
Attenuators (with adapters if necessary)
Compass (if directional antenna in use)

3.2 Test Procedure

This test is best preformed with two persons having a means of communications between them. If one person performs this test, the 5096 is programmed for a transmit interval of 60 secs on EV-2 (set-ev 2,,,60).

3.2.1 Set-up Receive Site

Plug the 5051R Sig Out cable into the 5062 Remote Station Tester Tone In jack. The 5062 displays incoming data, ID# and data value. The Attenuators will be added in line with the antenna cable so this connection must be accessible. Connect antenna to the 5051R ANT port (with no attenuators). Send test transmission from the 5096 to insure proper operation.

3.2.2 Set-up Transmit Site

Set-up antenna mast with antenna and cable at site location. Verify directional antenna azimuth if used. Connect watt meter to the 5096 antenna port. Connect antenna cable to the watt meter. Test the forward and reflected power of the 5096 and antenna system.

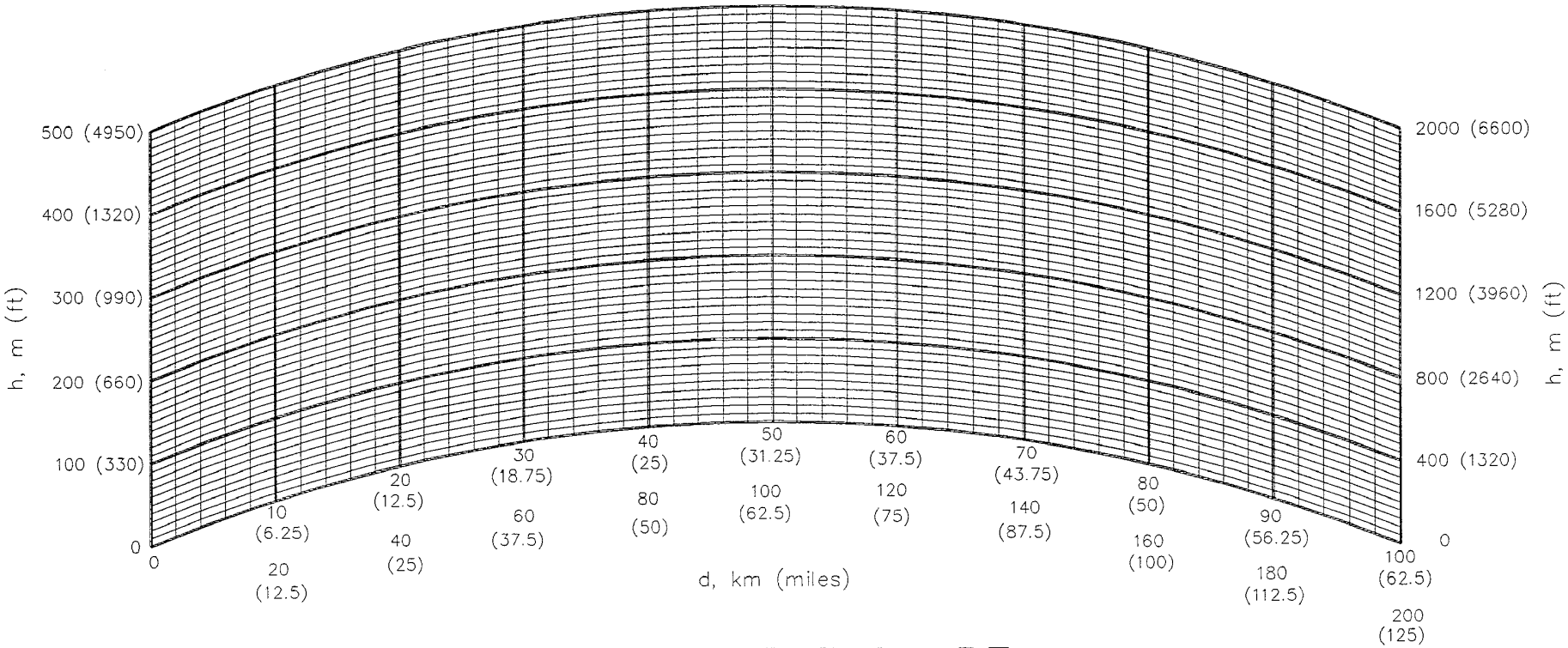
During path testing the forward and reflected power should be checked regularly to verify signal output. Connect the 5050TS or 5050P to the Precip port as data input to initiate transmissions or set-ev 2,,,60.

3.2.3 Path Testing

Initiate a number of data transmissions (typically ten) from the 5096. Verify data reception on the 5062 display. The 5062 stores the latest twenty data reports and they can be viewed by pushing the data sequence switch. Add attenuator between 5051R and the antenna. Repeat data transmissions and reception verification. Increase attenuation until reception is lost; the added attenuation is equal to the actual Fade Margin of the path. HydroLynx recommends a Fade Margin greater than or equal to 18 dB.

4.0 FORMS AND DRAWINGS

AC100891 Path Profile Chart
A101019 Radio Path Verification Checklist



PATH PROFILE CHART

FOR K = 4/3

RADIO PATH VERIFICATION CHECKLIST Document Number A101019

GAUGE #	
LOCATION:	**TEMPERATURE:** °
CLOUD COVER: **CLEAR ☐** **SCATTERED ☐** **OVERCAST ☐**	
TECHNICIAN:	**DATE:**

TRANSMITTER	
TYPE USED: **DATA ☐** **VOICE ☐**	
FREQUENCY: **Mhz**	**POWER** **watts**

ANTENNA:	
OMNI ☐	
DIRECTIONAL ☐	**BEARING:**
OTHER ☐	
ANTENNA HEIGHT: **FEET FROM GROUND LEVEL**	
DISTANCE FROM CENTRAL SITE OR REPEATER:	

PERCENTAGE OF DATA RECEIVED: **%**
RECEIVED AT: **☐ REPEATER #**
☐ CENTRAL SITE
☐ REMOTE STATION TESTER

NOTES:

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