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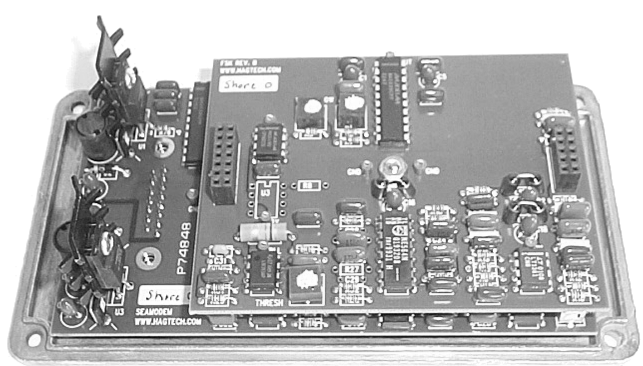
TECHNOLOGY

SeaModem

Broadband Underwater Cable Modem



Date: 02/05/03

Warnings

There are no dangerous voltages used in this product.

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1 Introduction

Description

SeaModem is a fully self-contained broadband modem for data communications over a 50-ohm bi-directional transmission line. It is configurable for different operating frequencies and has two high-speed data channels and one low-speed audio (IRIG) channel. The IRIG signal is analog (0.223V). Data channels use a differential RS-422 interface.

The small aluminum housing offers easy installation in crowded environments. The rugged assembly uses a 15-pin dsub connector for power and data, an SMA for the cable. Three LEDs show the operational status. Green indicates power, and the red LEDs light up during data reception.

Features

- High-speed broadband FSK modem
- Two data channels plus one IRIG channel
- RS-422 data I/O
- Configurable for different frequency bands
- Operational up to 20MHz

2 Installation

Connections

Power should be supplied at +/-8V nominal, but up to +/-12V is acceptable. The pinout for the dsub is given in the following table. Input impedance for the IRIG signal is 10k ohm. Output impedance is 150 ohm. IRIG channel bandwidth is about 100Hz to 3kHz.

Pin	Signal	I/O	Description	Specification
1	+8V	I	+8V supply	+4V / -0.5V
2	-8V	I	-8V supply	+4V / -0.5V
3	Tx2+	O	RS-422	
4	Rx2+	I	RS-422	
5	Tx1+	O	RS-422	
6	Rx1+	I	RS-422	
7	TxIRIG	O	IRIG	0.223Vrms (0dBm) level
8	RxIRIG	I	IRIG	
9	Gnd		+8V supply return	
10	Gnd		-8V supply return	
11	Tx2-	O	RS-422	
12	Rx2-	I	RS-422	
13	Tx1-	O	RS-422	
14	Rx1-	I	RS-422	
15	Gnd		IRIG signal ground	

The cable interface is set to 50 ohms. L-pads made from 115 and 18 ohm resistors will match it to a 43 ohm line. Transmission levels into the telephone cable are set to –8dBm.

3 Circuit Description

Frequencies

The H2O project uses a SeaModem configured with one 115kbaud data channel and one IRIG signal. The following plot shows the carrier frequencies used in transmission. The downlink uses 100kHz (on the skirt of the passband) for the AM audio carrier. The data link uses FSK modulation using the frequencies of 260kHz and 380kHz. Similarly, the uplink uses 650kHz, 810kHz, and 930kHz respectively.

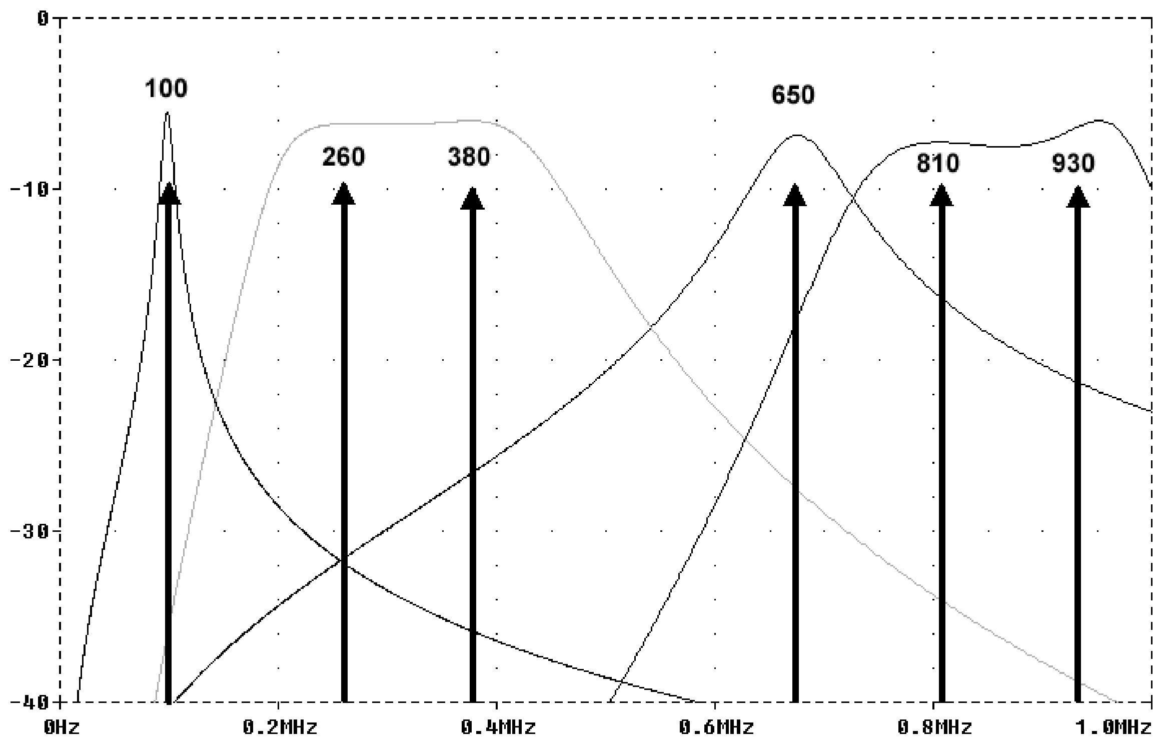


Figure 1. Carrier frequencies for H2O project.

Motherboard

The motherboard contains the I/O connectors, power filters and regulators, the line duplexer and the entire AM transmit and receive channel. U4 and U5 on the motherboard form a solid-state hybrid or duplexer. Its job is to reject transmitted signals from getting into the receiver. Separate passband filters add to this rejection. Signals to be transmitted are summed at pin 6 of U4.

The IRIG signal uses an AM carrier with about 80% modulation. The input signal (1kHz, typically) is buffered and passed through a low pass filter. This is then multiplied by a sinewave carrier and sent to the transmitter. A received signal is buffered by the duplexer and sent to a simple LC tuned filter. The output passes through a gain stage (up to a 6dBm level) and then fed to a demodulator circuit. The non-suppressed carrier provides synchronous demodulation. This is then fed to a low pass filter to remove carrier and other interfering signal components, and finally to an output buffer.

FM Daughtercard

Each FSK transceiver is fully contained on a daughtercard. There can be two stacked daughtercards. An input RS-422 signal is decoded and used to modulate a sinewave VCO. The received signal passes through two narrowband filter and gain stages. The demodulator is a PLL. A VCO attempts to track the input frequency – this is done by taking the dc output voltage from a phase detector and using it to control the input to the VCO. Loop stability and response is determined by the passive loop filter. The loop is tuned for optimum response at the chosen baud rate. The output voltage from the phase detector is fed to a low pass filter to remove carrier frequency components. This is then sent to a comparator with hysteresis and level slicing adjusted to the center of the eye pattern, which squares up the data for subsequent RS-422 transmission. The typical eye pattern at 115kbaud is shown in figure 2.

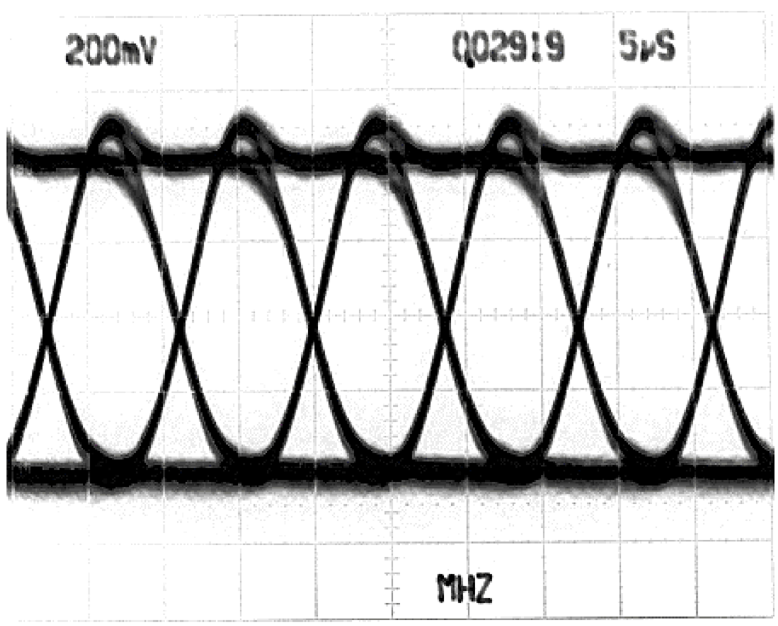
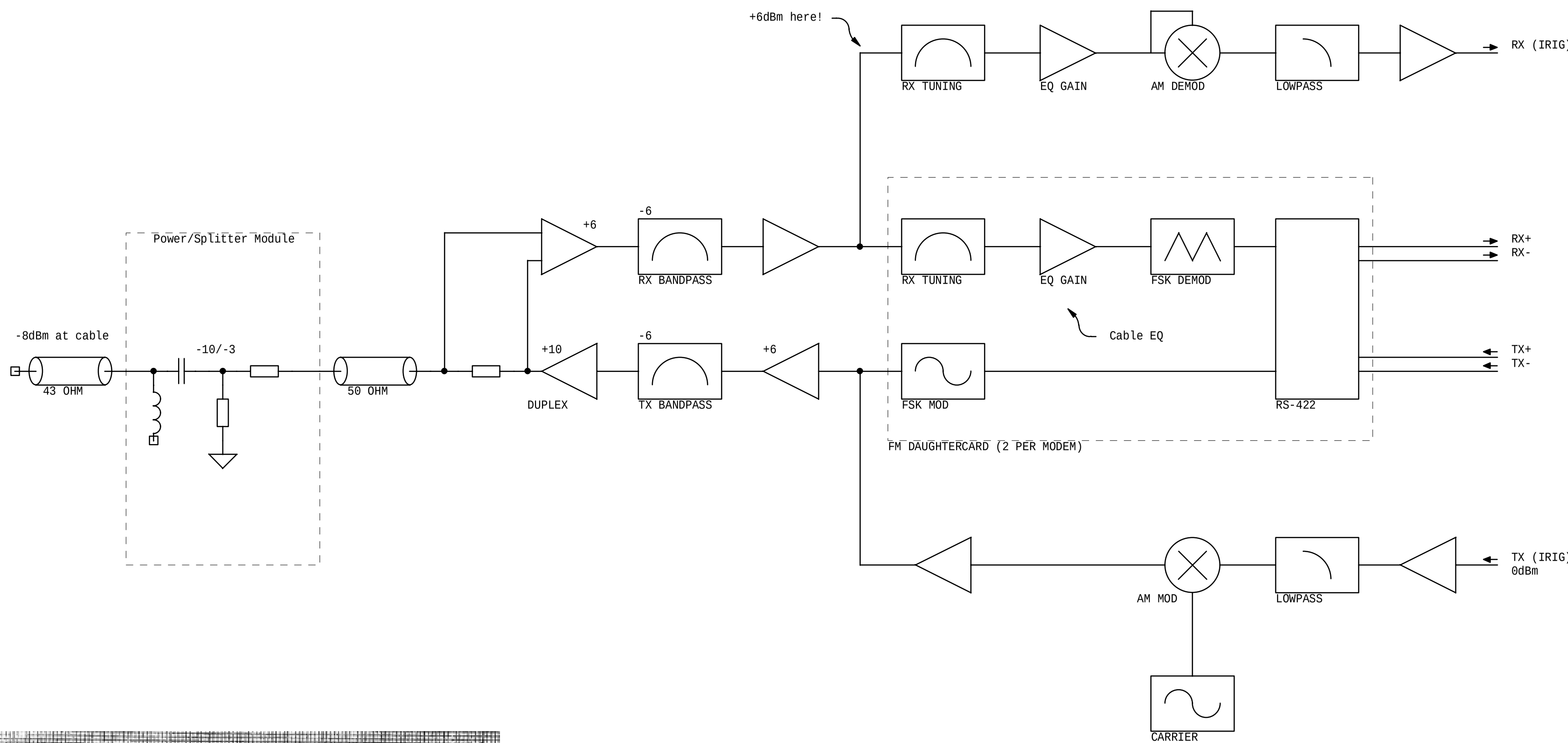
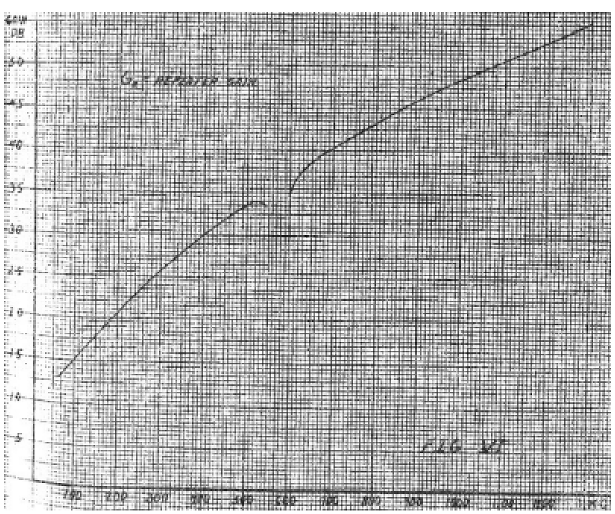


Figure 2. Receiver eye pattern at 115kb.





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Title
SeaModem: Block Diagram

Size	Document Number	Rev
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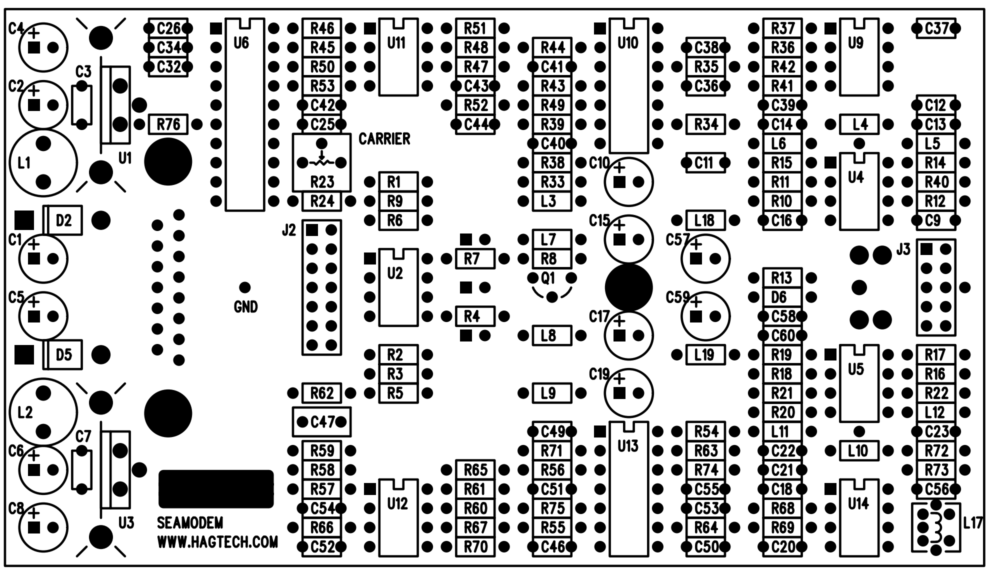
Date: Monday, December 09, 2002 | Sheet 1 of 1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C2 C3 R76 C42 C25 CARRIER R23 R24 R1 R9 R6 C10 C15 L18
L1 U1 D2 C1 J2 U2 R7 R8 L7 Q1 C57 C59 R13 D6 C58 C60 J3
C5 GND R4 L8 C17 L19 R19 R18 R21 R20 L11 U5 R17 R16 R22 L12
D5 L2 R2 R3 R5 R62 C47 L9 C19 C7 C6 C8 U3
R59 R58 R57 C54 R66 C52 U12 R65 R61 R60 R67 R70 C49 R71 R56 C51 R75 R55 C46 U13 R54 R63 R74 C55 C53 R64 C50 C22 C21 C18 R68 R69 C20 L10 U14 C23 R72 R73 C56 L17
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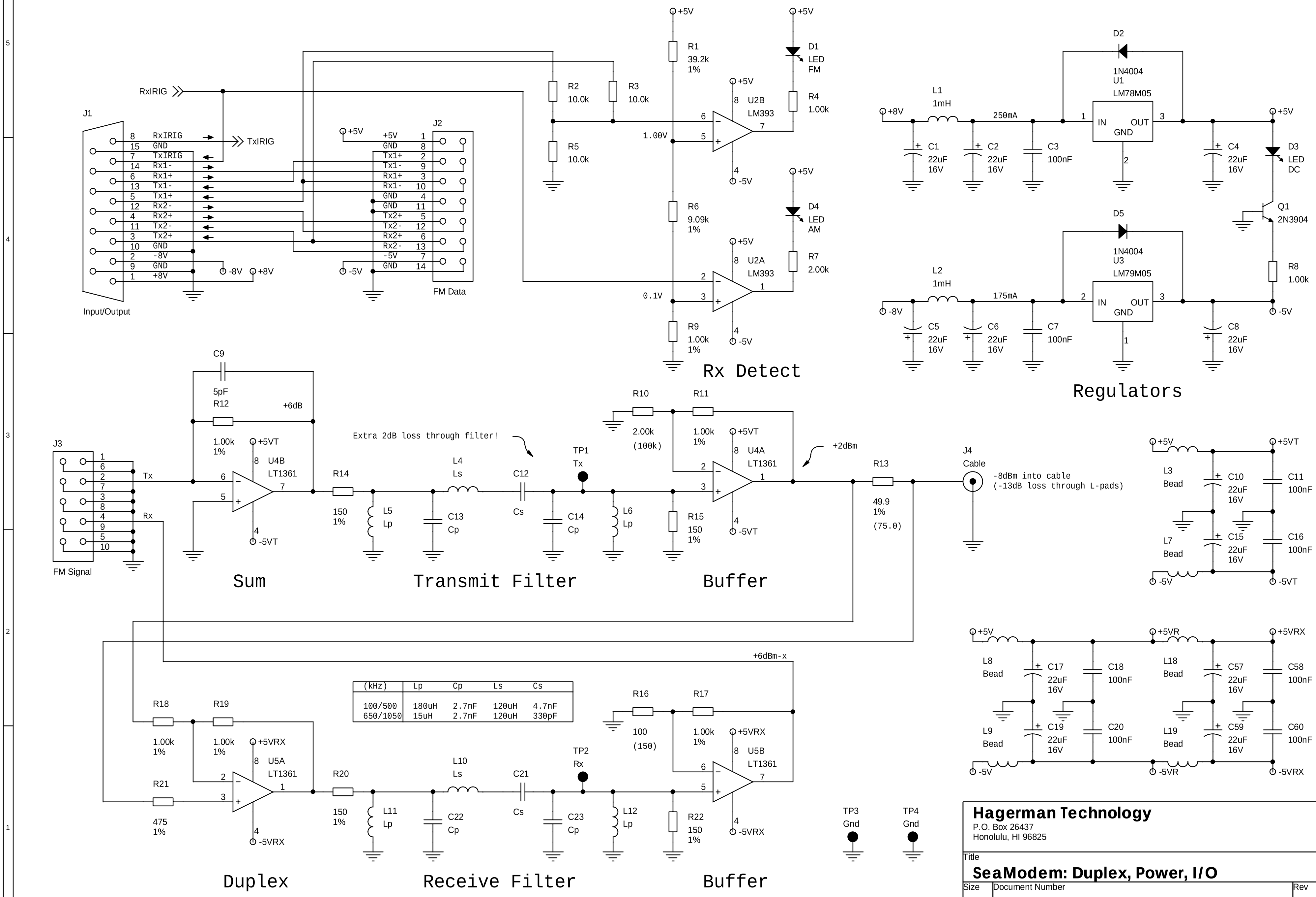

(kHz)	Lp	Cp	Ls	Cs
100/500	180uH	2.7nF	120uH	4.7nF
650/1050	15uH	2.7nF	120uH	330pF

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Title: **SeaModem: Duplex, Power, I/O**

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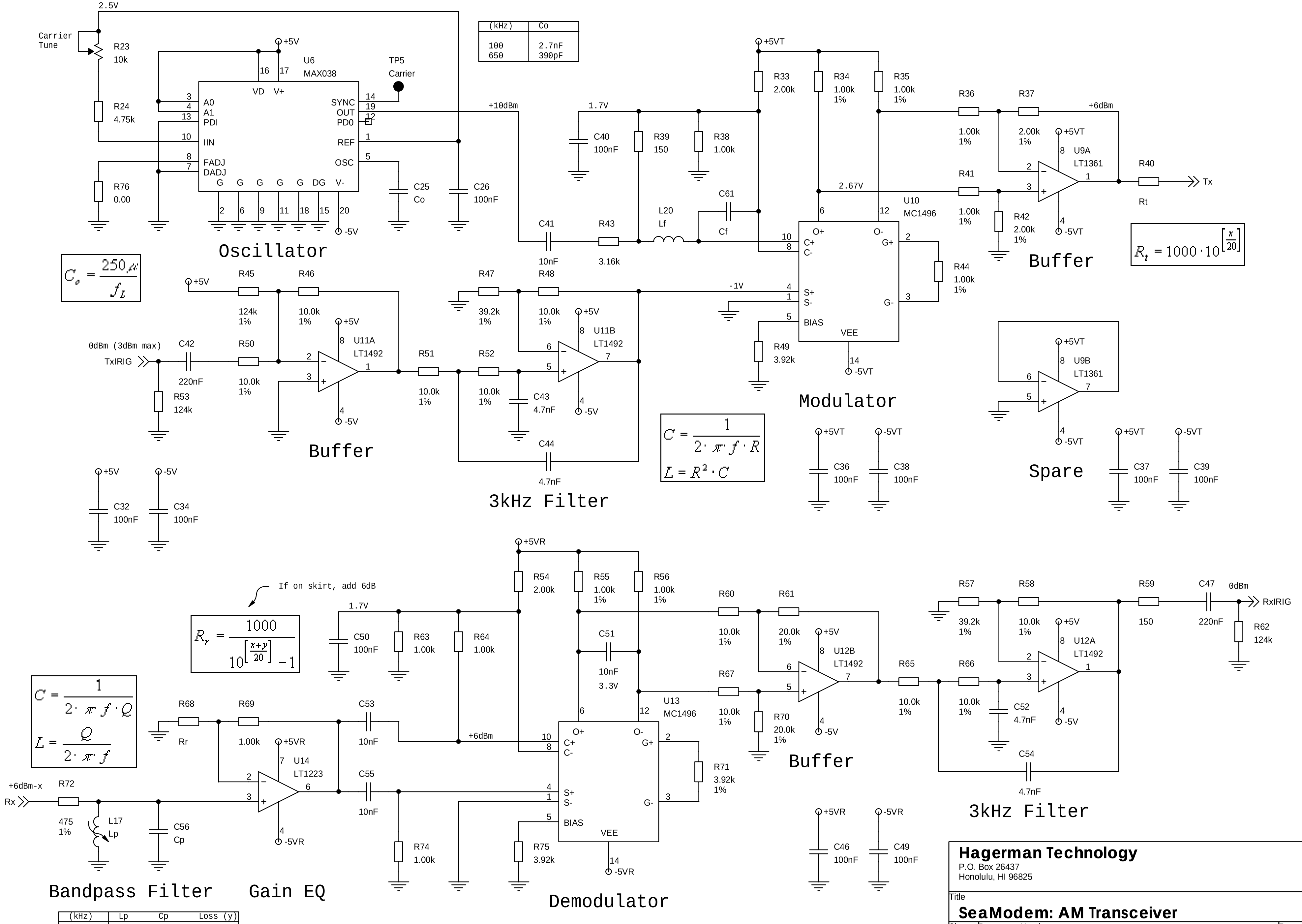
	n/a	A

Date: Wednesday, January 22, 2003 — Sheet 1 of 2



(kHz)	Co
100	2.7nF
650	390pF

$$C_o = \frac{250\mu}{f_L}$$

$$C = \frac{1}{2 \cdot \pi \cdot f \cdot R}$$

$$L = R^2 \cdot C$$

$$R_t = 1000 \cdot 10^{\left[\frac{x}{20}\right]}$$

$$R_r = \frac{1000}{10^{\left[\frac{x+y}{20}\right]} - 1}$$

$$C = \frac{1}{2 \cdot \pi \cdot f \cdot Q}$$

$$L = \frac{Q}{2 \cdot \pi \cdot f}$$

(kHz)	Lp	Cp	Loss (y)
100	47uH	56nF	9dB
650	6.8uH	8.2nF	5dB

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Title: **SeaModem: AM Transceiver**

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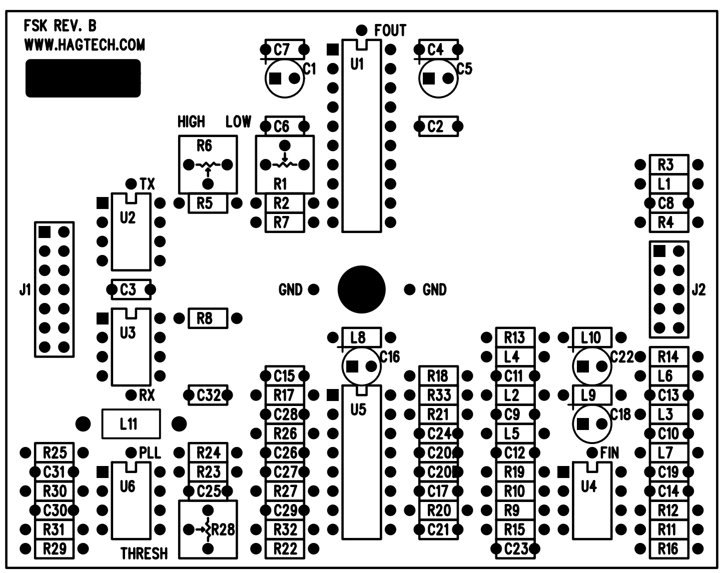
FSK REV. B
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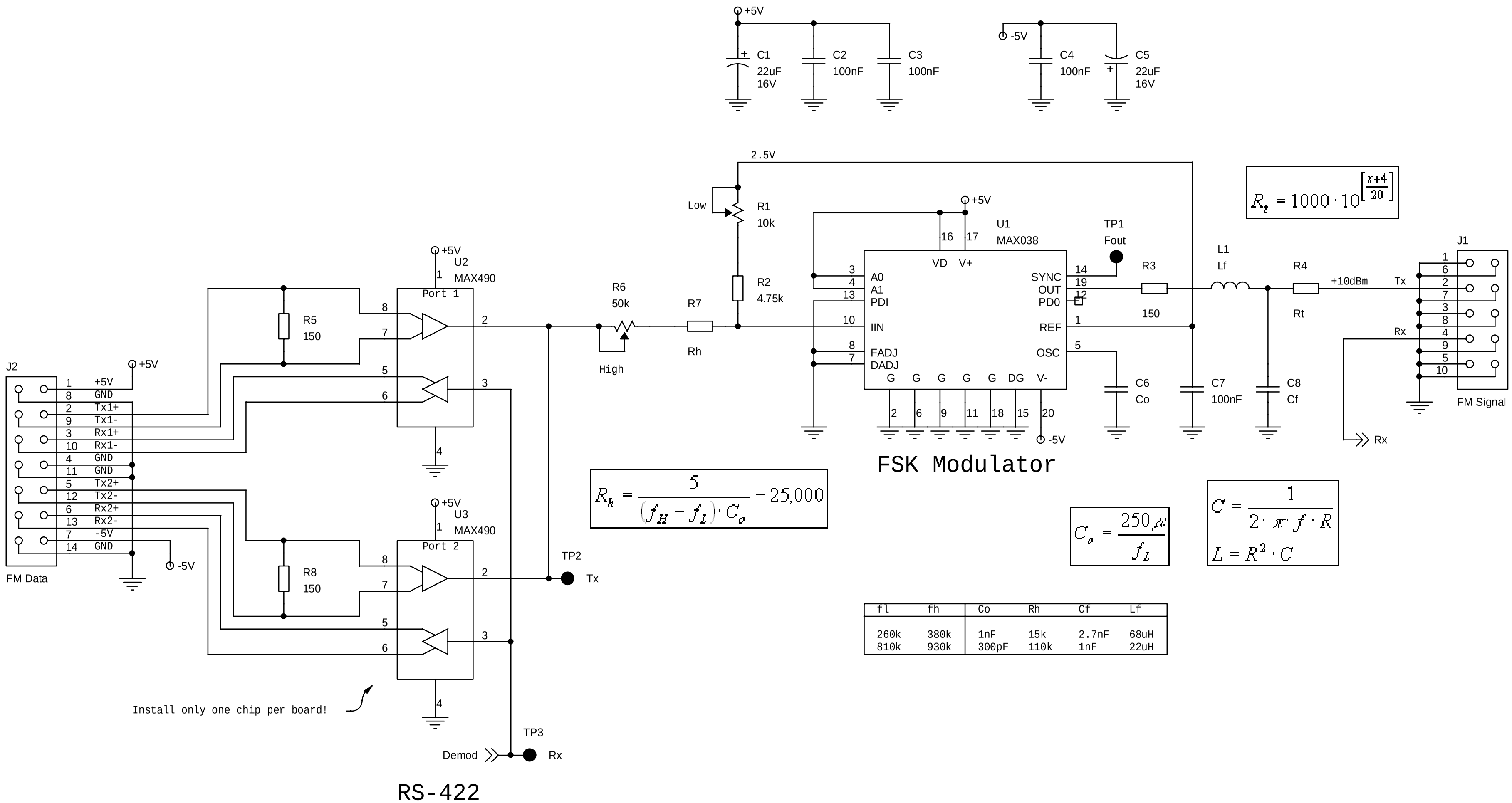
FOUT
C7
C1
U1
C4
C5
HIGH
LOW
C6
C2
R6
R1
TX
R5
R2
R7
U2
R3
L1
C8
R4
J1
J2
C3
GND
GND
U3
R8
L8
R13
L10
C16
L4
C22
R14
C15
R18
C11
L6
RX
C32
R17
R33
L2
L9
C13
U5
C28
R21
C9
C18
L3
L11
R26
C24
L5
C10
R25
PLL
R24
C26
C20
C12
FIN
L7
C31
R23
C27
C20
R19
C19
U6
U4
R30
C25
R27
C17
R10
C14
C30
C29
R20
R9
R12
R31
R28
R32
C21
R15
R11
R29
THRESH
R22
C23
R16



$$R_t = 1000 \cdot 10^{\left[\frac{x+4}{20}\right]}$$

$$R_h = \frac{5}{(f_H - f_L) \cdot C_o} - 25{,}000$$

$$C_o = \frac{250\mu}{f_L}$$

$$C = \frac{1}{2 \cdot \pi \cdot f \cdot R}$$

$$L = R^2 \cdot C$$

fl	fh	Co	Rh	Cf	Lf
260k	380k	1nF	15k	2.7nF	68uH
810k	930k	300pF	110k	1nF	22uH

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Title
SeaModem: FSK TX

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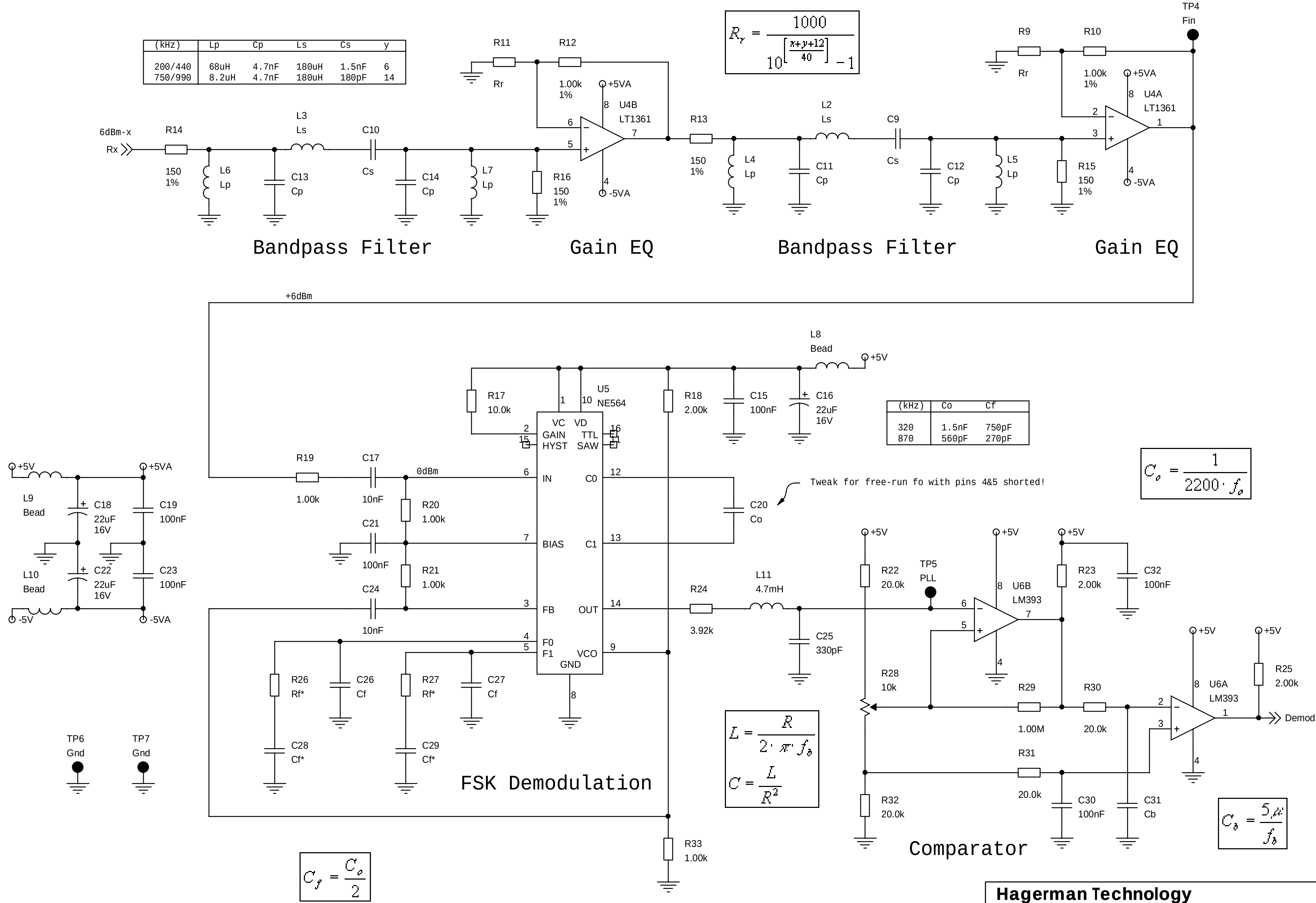

(kHz)	Lp	Cp	Ls	Cs	y
200/440	68uH	4.7nF	180uH	1.5nF	6
750/990	8.2uH	4.7nF	180uH	180pF	14

(kHz)	Co	Cf
320	1.5nF	750pF
870	560pF	270pF

$$R_r = \frac{1000}{10^{\left[\frac{x+y+12}{40}\right]} - 1}$$

$$C_o = \frac{1}{2200 \cdot f_o}$$

$$L = \frac{R}{2 \cdot \pi \cdot f_b}$$

$$C = \frac{L}{R^2}$$

$$C_f = \frac{C_o}{2}$$

$$C_b = \frac{5\mu}{f_b}$$

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Title
SeaModem: FSK RX

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