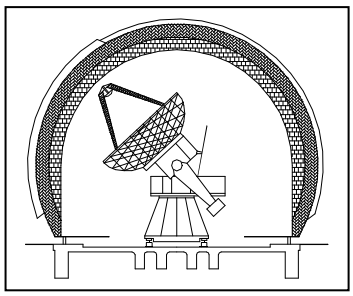


CALIFORNIA INSTITUTE
OF TECHNOLOGY

PASADENA, CALIFORNIA

David A. Miller, Engineer (626)395-3668
July 28, 2010

Notes on Micro Lambda Wireless YIG Filter Part Number MLFP-41840RS

INTRODUCTION:

In the long climb of switching from Gunn-based local oscillator chains to solid-state chains, for pumping SIS mixers, it was recently discovered that the commercial tunable synthesizer, which would provide the primary input frequency, generated spurious frequency noise at levels which could be easily detected in the IF band of the sensitive SIS receiver. This problem was also exacerbated with the move to larger IF bandwidths, i.e., from 1-2 GHz to 4-8 GHz. It has been demonstrated that by filtering the output of the synthesizer, these spurious signals can be reduced to the level whereby they are eliminated from the IF passband. These notes explain the implementation of this YIG filter at the output of the commercial synthesizer (in this case, an Anritsu MG3694B, 2-40 GHz).

YIG FILTER:

Cost constraints and performance guided the selection of the tunable YIG filter to Micro Lambda Wireless, Inc. Their model MLFP-41840 is adjustable from 18 to 40 GHz, with a typical 3-dB bandwidth of approximately 80 MHz at the passband frequency. The filter can be configured:

- As stand alone (where the user designs and implements the power and control electronics)
- With an analog power and control electronics board
- With an analog power and direct digital control (12-bit parallel) electronics board
- With an analog power and serial digital control (SPI; 16-bit) electronics board

The configuration using the SPI interface was chosen, to reduce the number of digital lines needed to control the filter, and for the availability of finer frequency tuning, if needed. Specification sheets for the YIG filter and electronics are attached at the end of this note, along with a photograph of a prototype LO Drive box with the YIG filter, electronics, and computer control board integrated. The following are details of the testing and operation of this particular YIG filter module and SPI electronics board.

a) Power Supplies, Thermal, Mechanical

The YIG filter and electronics board require +24VDC @ 1.2A (max.) for tuning and analog electronics, +24 VDC @ .75A for the heater, and -15VDC @ 0.1A for the analog electronics. The heater voltage supply is not common to the analog supplies, so it can be floated in respect to ground potential. Obviously, with the listed voltage supplies required to power the filter, the heat generated is significant, and its removal is a major concern. In operation, the baseplate for the electronics board gets too hot to touch. During testing of the YIG filter with a network analyzer, it was seen that the tuning of the YIG is very sensitive to temperature fluctuations; with the module sitting on

the benchtop and blowing on it, the center frequency of the passband would change several tens of megahertz. When installing the YIG in a prototype LO Drive box, the filter module was enclosed on three surfaces (top, side, bottom) with ½" aluminum, to which the electronics board was also attached. On top of this structure a +24VDC fan was attached for cooling. Testing with the filter and electronics board in this configuration showed better stability of the passband center frequency once the structure reached stable operating temperature. With at least one hour "on" before testing, the sensitivity was a few megahertz for ambient temperature fluctuations.

b) SPI Interface

National Instruments offers a USB/SPI translation card, USB-8451, which makes interfacing and control with a computer quite easy. Drivers are available to install and use from LabView. The SPI interface consists of:

- SCLK – serial clock; output from master
- MOSI – master output, slave input
- MISO – master input, slave output
- CS – chip select; output from master

For controlling the YIG, only SCLK, MOSI, and CS are used. The SPI control is 16 bits, grouped into two 8-bit words, with each word ranging in value from 000 to 255. During testing, the passband center frequency was measured at several settings of the YIG, then these points were plotted and fitted to a first-order polynomial to generate a tuning function. In the range of 26-40 GHz, the tuning function is,

$$Y = 7.27596E\text{-}12 + 74.22*X$$

Where X = integer from 0-560. This tuning range has a step-size of 25 MHz. For purposes of operation in a fully-developed system, the step-size of the tuning of the passband center frequency can be reduced by either interpolation of this function, development of finer step-size function, and/or remapping of the tuning function to the frequency of the synthesizer. Generation of the tuning control words is as follows:

$$MSB = 93 + int[(74.22*X)/255]$$
$$LSB = round[rmod(74.22*X,255), 0]$$

Where "int" = returns only the integer part of the calculation; "rmod" = returns the remainder of the division calculation; "round" = return the number with zero decimal-place values. This tuning code generation was implemented in a LabView program, which was developed for controlling the tuning of the YIG and synthesizer concurrently.

CONCLUSION:

Implementing a tunable YIG filter at the output of a commercial synthesizer is a viable solution to the removal of spurious frequency noise signals which would impede the performance of SIS receiver systems with broadband IF bandwidths. Care taken in the design, installation, and operation of the YIG filter should result in stable performance. Comparisons of Gunn-based local oscillator chains versus solid-state LO chains for pumping SIS mixers reveal remarkably similar results in receiver noise temperatures and IF passband quality. The supply requirements to operate the YIG filter and electronics result in large, bulky analog power supplies, and this is being addressed by investigating smaller, lighter, and more efficient switching power supplies for powering the LO Drive electronics.

MICRO LAMBDA WIRELESS, INC.

MILLIMETER WAVE
YIG BANDPASS FILTERS
3-50 GHz

FEATURES

- 3-50 GHz Frequency Coverage
- Excellent Linearity
- K-Type Connectors
- Low Insertion Loss

DESCRIPTION

The MICRO LAMBDA Millimeter Wave line of 4-stage YIG bandpass filters provide high selectivity and offer excellent image rejection. Standard frequency bands include 3-50 GHz and 7-40 GHz and 18-40 GHz frequency coverage. These filters provide excellent linearity, low frequency drift and very flat 3 dB bandwidth response over the frequency range. These filters are suited for spectrum analyzers, down-converters and a variety of microwave test equipment applications.

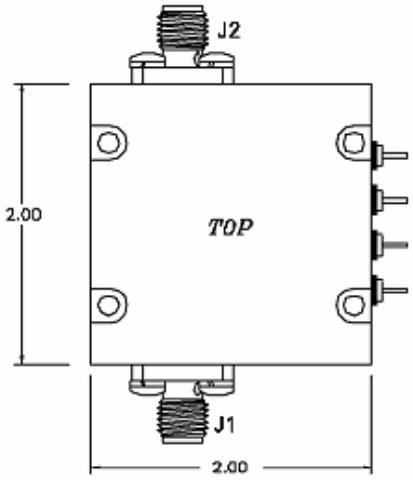
ELECTRICAL AND PERFORMANCE SPECIFICATIONS

Guaranteed Specifications at 0° to +65° C Case Temperature

Model No.	MLFP-43040	MLFP-43044	MLFP-43050	MLFP-47040	MLFP-41840
Frequency Range, Min. (Note 2)	3-40 GHz	3-44 GHz	3-50 GHz	7-40 GHz	18-40 GHz
No. of Stages	4	4	4	4	4
3dB Bandwidth, Min. (Note 1)	30 MHz +(f/GHz)	30 MHz +(f/GHz)	30 MHz +(f/GHz)	35 MHz +(f/GHz)	50 MHz +(f/GHz)
Insertion Loss, Max.	6 dB	6 dB	6 dB	5 dB	5 dB
Passband Spurs & Ripple, Max.	2.5 dB	2.5 dB	2.5 dB	2.5 dB	2.5 dB
Passband VSWR, Max.	2:1	2:1	2:1	2:1	2:1
Selectivity, Typ.	24 dB/Octave	24 dB/Octave	24 dB/Octave	24 dB/Octave	24 dB/Octave
Off Resonance Isolation, Min.	80 dB	80 dB	60 db	80 db	80 db
Off Resonance Spurious, Min.	60 dB	60 dB	40 db	60 db	60 db
Limiting Level, Min.	+10 dBm	+10 dBm	+10 dBm	+10 dBm	+10 dBm
Tuning Coil Characteristics					
Tuning Sensitivity, Typ.	30 MHz/mA	30 MHz/mA	25 MHz/mA	30 MHz/mA	30 MHz/mA
Linearity, Max.	+/- 35 MHz	+/- 35 MHz	+/- 35 MHz	+/- 30 MHz	+/- 25 MHz
Hysteresis, Typ.	50 MHz	50 MHz	60 MHz	45 MHz	30 MHz
Temperature Drift, Max.	(3 dB BW)/2	(3 dB BW)/2	(3 dB BW)/2	(3 dB BW)/2	(3 dB BW)/2
Coil Resistance, Typ.	6 Ohms	6 Ohms	4 Ohms	6 Ohms	6 Ohms
Coil Inductance, Typ.	200 mH	200 mH	100 mH	200 mH	200 mH
Heater Voltage	20-30 Vdc	20-30 Vdc	20-30 Vdc	20-30 Vdc	20-30 Vdc
Heater Current-Surge, Max. @ 25 deg. C.	750 mA	750 mA	750 mA	750 mA	750 mA
Steady State @ 25 deg. C.	150 mA	150 mA	150 mA	150 mA	150 mA
Case Style	21-056	21-056	21-056	21-056	21-056

Note: 1) Modified 3 dB Bandwidths Available.
2) Other Frequency Ranges Available.

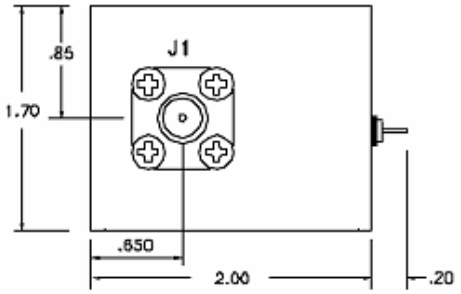
Micro Lambda Wireless, Inc. - 46515 Landing Parkway, Fremont California 94538 * Phone (510) 770-9221 * Fax (510) 770-9213

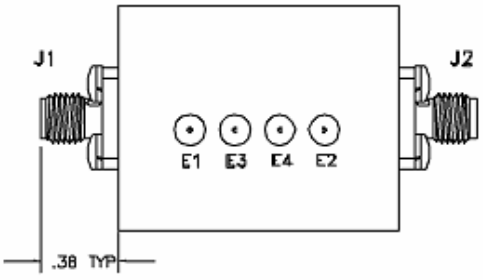


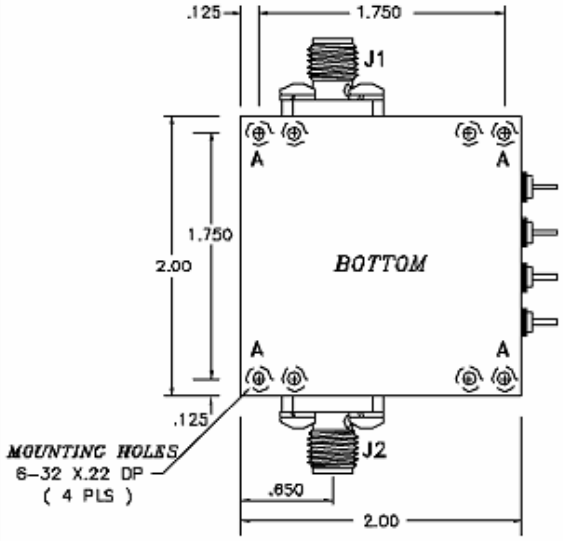
CONN	FUNCTIONS
J1	RF IN (K-CONN; FEM.)
J2	RF OUT (K-CONN; FEM.)
E1	+ COIL
E2	– COIL
E3	HEATER
E4	HEATER

* POSITION OF E1 & E2 SELECTED AT FACTORY FOR COIL POLARITY

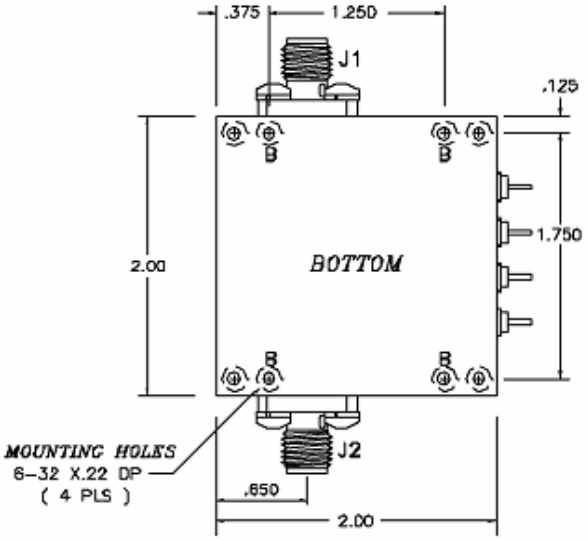
WEIGHT : 16 Oz. MAX







MOUNTING HOLES LOCATION: OPTION A



MOUNTING HOLES LOCATION: OPTION B

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE ARE : FRACTIONS DECIMALS ANGLES .xx ±.010 .xxx ±.005	CONTRACT NO.	MICRO LAMBDA, INC.	
MATERIAL CARPENTER 49	APPROVALS / DRAWN N.NGUYEN	DATE 2/15/00	MMW FILTER (2.0" X 2.0" X 1.7")
FINISH	CHECKED		
DO NOT SCALE DRAWING	ISSUED		SIZE / CAGE No. DRN63 / DWG. NO. 21 – 056 / REV.

MICRO LAMBDA WIRELESS, INC.

YIG DEVICE (RS SERIES) DRIVERS
SERIAL REMOTE SERIES
FOR ELECTROMAGNETIC DEVICES
.5-50 GHz

FEATURES

- All Electromagnetic Oscillators and Filters
- MLOM, MLOB & MLOS Series Oscillators
- MLFM, MLFD, MLFP & MLFR Series Filters
- Compensation for Temperature Drift
- Voltage Regulators for Improved Stability
- 16 Bit Tuning Resolution
- Remote Device/Driver Location

DESCRIPTION

All Micro Lambda Electromagnetic YIG Devices are available with remotely located serial driver circuits. These drivers eliminate the need for customers to design or develop their own circuits and sophisticated test and alignment procedures. These remote drivers can be aligned at Micro Lambda's factory to ensure peak performance. Alignment and compensation with the particular YIG Device can be maximized down to the component level.

All drivers in this series provide input voltage regulators, reverse voltage/dataline protection and compensation circuits to improve frequency drift. All voltages required by the YIG Device, except the heater inputs are supplied by the voltage regulators.

COMMERCIAL SERIAL DRIVERS	.5-50 GHz YIG DEVICE, SERIAL SERIES
DRIVER INPUT & RESPONSE	SPECIFICATION (0 to + 65 deg. C)
Tuning Command	Start Word (all 0's) = Lowest Frequency Stop Word (all 1's) = Highest Frequency
Tuning Resolution	16 BIT Positive Logic (Fmax-Fmin)/65,535 Resolution
Frequency Accuracy (Note 1) (excluding hysteresis)	YIG Device Accuracy +2 MHz
Tuning Speed	5 mSec for 1 GHz step to within +/-10 MHz.
Main Driver Inputs	
Supply Voltage & Current (Note 2)	
+15 V +/- .5 V	Device Tuning Current + 100 mA, Max.
-15 V +/- .5 V	100 mA, (Plus Oscillator –5 Vdc Current if any) Max.
Supply Voltage Pushing	+/- .2%MHz Max. @ .5Vdc (2-3000 kHz)
Supply Voltage Ripple	10 mV Ripple Pk-Pk from 2 kHz to 3 MHz
Ground	Chassis Ground
YIG Heater Voltage & Current (Note 3)	1000 mA surge for 2 seconds, 150 mA steady state
+24 Vdc ±4 Vdc	Polarity independent : ±12 Vdc or ±15 Vdc acceptable
Digital Interface	The MLWI digital driver interface is a standard 3-wire connection compatable with SPI/QSPI/MICROWIRE interfaces. The chip-select input (CSELECTn) frames the serial data loading at the data input pin (DATA). Immediately following CSELECTn's high-to-low transition, the data is shifted synchronously and latched into the input register on the rising edge of the serial-clock input (CLOCK). After 16 data bits have been loaded into the serial input register, it transfers its contents to the DAC latch on CSELECTn's low-to-high transition (Figure 2). Note that if CSELECTn does not remain low during the entire 16 CLOCK cycles, data will be corrupted. In this case, reload the DAC latch with a new 16-bit word.
Power-On Reset	The MLWI digital driver has a power-on reset circuit to set the DAC's output to OV(F-min) in unipolar mode when VDD is first applied. This ensures that unwanted DAC output voltages will not occur immediately following a system power-up, such as after power loss.

Note 1: Accuracy Includes Temperature Drift & Linearity.
2. Some YIG Devices require higher voltages - Check with factory.
3. See particular YIG Device specification for heater current requirements.

Micro Lambda Wireless, Inc. - 46515 Landing Parkway, Fremont California 94538 * Phone (510) 770-9221 * Fax (510) 770-9213

Serial Interface Timing Diagrams

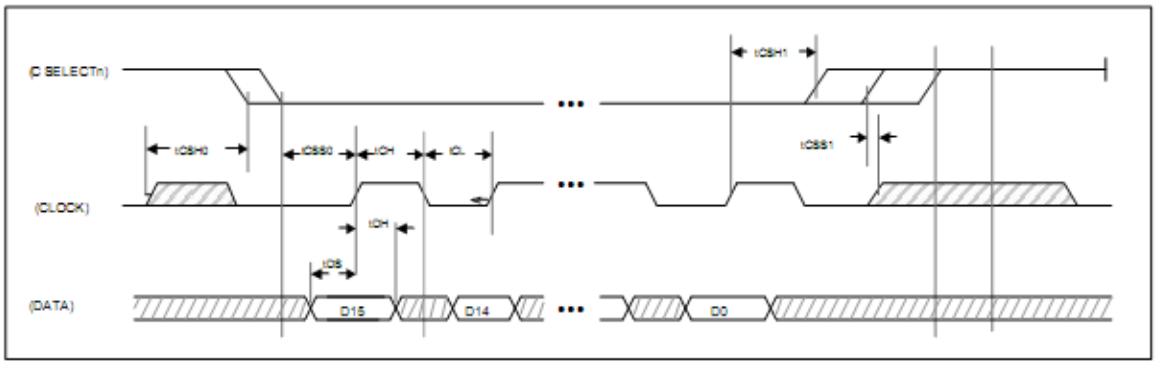


Figure 1. Timing Diagram

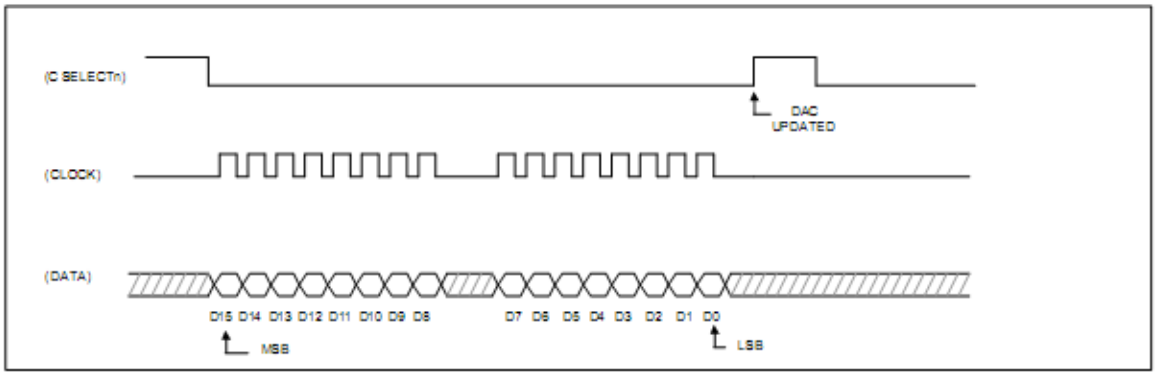
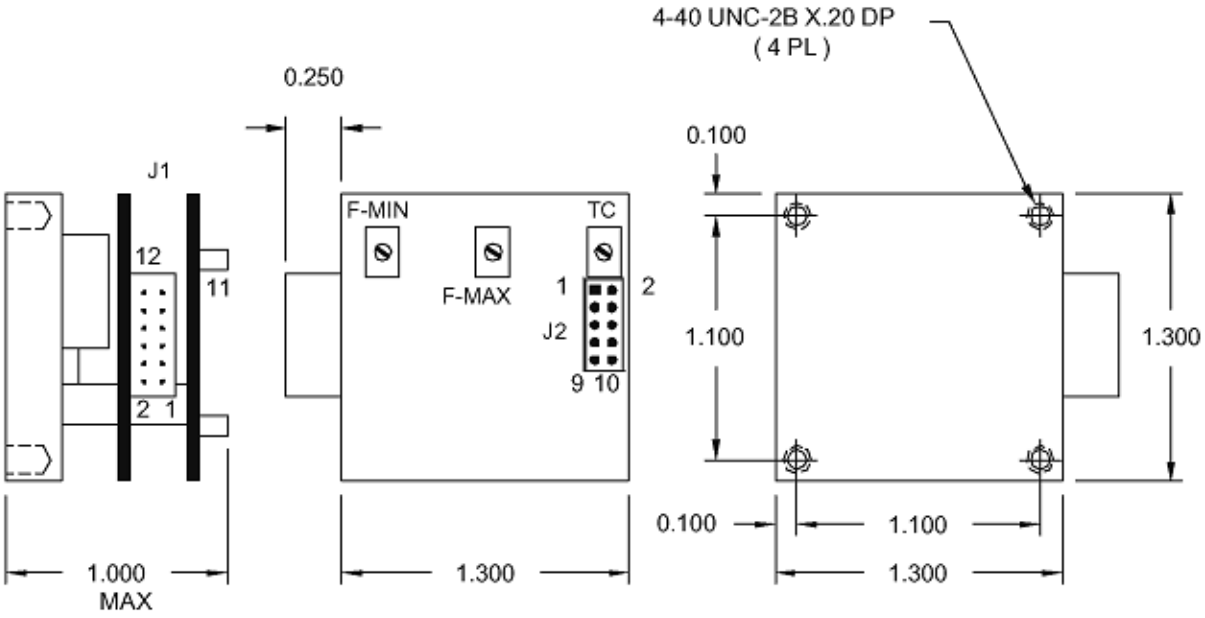


Figure 2. 3-Wire Interface Timing Diagram

TIMING CHARACTERISTICS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CLOCK Frequency	fCLK				10	MHz
CLOCK Pulse Width High	tCH		45			ns
CLOCK Pulse Width Low	tCL		45			ns
CSn Low to CLOCK High Setup	tCSS0		45			ns
CSn High to CLOCK High Setup	tCSS1		45			ns
CLOCK High to CSn Low Hold	tCSH0		30			ns
CLOCK High to CSn High Hold	tCSH1		45			ns
DATA to CLOCK High Setup	tDS		40			ns
DATA to CLOCK High Hold	tDH		0			ns
VDD High to CSn Low (power-up delay)				20		µs



WEIGHT: 6 Oz

BOTTOM BOARD (DAC BOARD)
J1 (2MM DUAL ROW TERMINAL STRIP)

DIGIKEY PART # : H2065-ND

MATING WITH # : H2141-ND

PIN	*FUNCTIONS*	
1	CLOCK	
2	DATA	
3	CSELECTn	
4	GROUND	
5	-V SUPPLY	
6	+V SUPPLY	
7	HEATER 1	
8	HEATER 2	
9	FM +	(*)
10	FM -	(*)
11	N/C	
12	N/C	

TOP BOARD (DRIVER BOARD)
J2-OUTPUT CONNECTION TO YIG

PIN	*FUNCTIONS*	
1	TUNE COIL +	
2	TUNE COIL -	
3	FM +	(*)
4	FM -	(*)
5	OSC. VCC(+15V)	(*)
6	- 5V	(*)
7	HEATER +	
8	HEATER -	
9	GND	(*)
10	+5V (OPTIONAL)	(*)

NOTES:

1- (*) : NOT USED FOR FILTER

2- RECOMMENDED WIRE SIZE = 20-22 GAUGE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE ARE : FRACTIONS ± DECIMALS .XX ± .030 .XXX ± .010 ANGLES ±	CONTRACT NO.	MICRO LAMBDA WIRELESS, INC.	
MATERIAL	APPROVALS / DATE		
	DRAWN N.NGUYEN 4/11/02	1.8" 16 BIT SERIAL REMOTE DIGITAL DRIVER (1.8 X 1.8 X 1.0")	
FINISH	CHECKED		
DO NOT SCALE DRAWING	ISSUED	SIZE	CAGE NO. 0RN63 / DWG NO. 51 - 011 / REV. A

Single Channel LO Drive Prototype Box