M² CIRCUITS

LOW LEVEL PREAMPLIFIER

INTRODUCTION

The Low Level Preamplifier (LLP) is a differential amplifier designed to amplify small signals from high impedance sources and provide a single ended output. The high input impedance allows for light loading of many signal sources, and six calibrated gain steps allow for the accurate measurement of the input signal.

SPECIFICATIONS

Input Characteristics

The input of the LLP is AC coupled and has a differential impedance of 2 megohms, paralled by 11pF. The single-ended impedance (+ or - input to ground) is 1 megohm, paralled by 22pF.

Output Characteristics

The single ended output is AC coupled and has an impedance of 47 ohms. The maximum output level is +20dBu.

Bandwidth

The bandwidth will vary depending on the gain range selected. Values are noted where the output level falls by 3dB. Typical readings are as follows:

x10.....2Hz-1.7MHz

x20.....2Hz-740kHz

x50.....2Hz-740kHz

x100.....2Hz-700kHz

x200.....2Hz-640kHz

x500.....2Hz-530kHz

Common Mode Rejection Ratio (CMRR)

The CMRR of the LLP is 5000:1, or approximately 74dB. This value is consistent for the lower gain ranges of x10 to x50, but will become better on the higher ranges of x100 to x500. On the x500 range the CMRR measured is 6000:1, approximately 76dB.

Audio-Band Distortion

The Total Harmonic Distortion (THD) will vary depending on the gain range selected. The following readings were taken at a frequency of 1kHz with a range of 20Hz to 20kHz:

x10.....0.00055%

x20.....0.00041%

x50.....0.00068%

x100.....0.00413%

x200.....0.00407%

x500.....0.00429%

Noise Performance

The noise floor on the highest range (x500) of the LLP is -80dBu or better, with typical values of -100dBu on the lower ranges (x10, x20).

Gain Accuracy

The LLP has six calibrated gain steps from 10 to 500 in a 1-2-5 sequence. The accuracy of these steps is within 2.5% of the stated value.

Power Requirements

The LLP is designed to use a 30VDC supply from an external power source. It is possible to run the LLP at a lower supply voltage with the effect of reduced output swing. The power consumption is 540mW.

THEORY OF OPERATION

The Low Level Preamplifier (LLP) can be broken down into two main sections: the signal proccessing circuit, and the virtual earth generator. If desired, one may omit the virtual earth generator entirely if a bipolar supply is available. The inclusion of the virtual earth allows for a wide range of external supply options. In some applications it may neeed to be run off of a single ended "wall-wart." Such is the case when using the enclosure that the PCB was designed to fit (see assembly notes on page 3 for details).

SIGNAL PROCCESSING

The signal processing circuit may be further divided into two sub-circuits: the input amplifier, and the output amplifier. In order to meet the large bandwitdh specification the amount of gain needs to be spread out between two stages; this ensures that an expensive, specialty operational amplifier not be required. However, the devices selected have respectable specifications and cost more than the average op-amp.

The input amplifier uses a dual J-FET input, low noise, 10MHz, TLE2082 op-amp from Texas Instruments. This op-amp replaces the more common TL072 with better noise and bandwidth specifications. If the preamplifier is to be used only in audio a TL072 may be substituted for a reduced bandwidth at higher gains. The input amplifier also contains the input filtering and input protection. L1, L2, C3, and C4 make up the input filter that rejects unwanted signals above 2MHz. The input coupling capacitors C1 and C2, in combination with the termination resistors R7 and R8, account for the low-frequency rolloff of 2Hz. Bridge rectifier BR1 is placed between the inverting and non-inverting inputs of the opamp to protect against input overvoltage and transients which could cause damage to the J-FET inputs. BR1 is reversed biased by the supply rails so that under normal conditions it will not conduct. Should the input voltage exceed that of the supply rails the diodes will conduct, shunting to the power rails. R11 and R12 prevent excess current flow through BR1 in a fault condition. The amplifier itself is a fixed, x10, differential stage made from U1A and U1B. The gain set by R13 and variable resistor R15 in parallel. R13 significantly reduces the adjustment range of R15 so that a very fine adjutment of the x10 gain can be made.

The output amplifier consists of an INA217 Instrumention Amplifier from Texas Instruments. This inst-amp contains a differential gain stage and differential to single ended amplifier. The laser-trimmed internal feedback resistors allow for excellent CMRR, and requires minimal external components. The gain of the INA217 is set via the six position gain selector switch that selects the resistor value between pins 1 and 8. The gain of the stage can be found using $A_V = 1 + (10\ 000/R_G)$, where A_V is the voltage gain and R_G is the gain setting resistor. The gain is multiplied by the input stage to reach the final value. The accuracy of the first four ranges therfore rely on the x10 CAL adjustment in the input amplifier. The two highest ranges are also affected by the x10 CAL, however, the x200 and x500 have their own individual fine adjustments, R10 and R9 respectively. C12 ensures that no DC offset is allowed to make it to the output terminal, with R21 acting as a discharge path and R22 limiting the maximum output current.

VIRTUAL EARTH GENERATOR

The virtual earth generator, or "rail-splitter," as it is commonly known, provides a 0V reference when using a single-ended power supply. U3 (NE5534) takes the reference voltage of half of the supply voltage (provided by R18, R19, and R20) to create a low impedance output at that voltage. When used with a 30V supply, U3's output is 15V. This can be adjusted by R20, which makes up for any tolerance errors between R18 and R19. This output becomes the 0V common for the entire preamplifier, and because the external supply is floating (ie. not referenced to earth), the circuit sees +15V and -15V with respect to the 0V reference. All measurements should be made from the 0V REF, as this is the circuit ground.

OPERATING INSTRUCTIONS

The Low Level Preamplifier is a very straight forward device to use. Using an external power supply, connect it to the preamplifier using a 2.1mm barrel jack (centre positive). Connect the output to the measurement equipment you plan on using, and connect your signal source to the input. Be sure to start on the lowest gain setting if the source's amplitude is not known. Using the range switch to adjust the output until the desired level is reached. The measurment taken must be then multiplied by the gain setting on the preamplifier.

CALIBRATION PROCEDURE

The following procedure must be completed in the order presented, as certain adjustments rely on previous steps to be completed

EQUIPMENT REQUIRED

- AC RMS millivolt meter
- Signal generator
- DC voltmeter

PROCEDURE

1. Apply power to the preamp using a 30VDC supply (centre positive). Using a DC voltmeter, measure the voltage present between TP1 and TP2. Adjust REF CAL (R20) to obtain 15V.
2. Connect the AC millivolt meter to the output of the preamp. Set the gain switch to the x10 posistion. Connect the signal generator to the input of the preamp and set it to output a 1kHz sinewave at -20dBu (77.5mV). Using the x10 CAL (R15) adjust the output so the meter reads 0dBu (0.775V).
3. Move the gain range switch up the steps to the x100 setting, observing the output on the millivolt meter for the correct readings. The x20 (26dB), x50 (34dB), and x100 (40dB) ranges should be within 2.5% of the range setting. If an error greater than 2.5% is found on a particular range, the resistor may be out of tolerance and should be replaced.
4. Set the output of the signal generator to -40dBu (7.75mV). Change to the x200 range and adjust the x200 CAL (R10) for a reading of +6dBu (1.55V).
5. Change to the x500 range and adjust the x500 CAL (R9) for a reading of +14dBu (3.88V).

At this point, the Low Level Preamplifier is now calibrated and ready to be used. The preamplifier should not need to be adjusted frequently unless a critical component is changed. However, occasional checks of its accuracy should be made - especially before critical measurements.

ASSEMBLY NOTES

The Low Level Preamplifier (LLP) was designed to meet respectable specifications while attempting to keep the overall cost relativly low. The specifications listed are for a unit constructed to the schematic values and tolerances. Should one want to further improve the performance, higher tolerance parts may be used. A Bill of Materials (BOM) has been provided, but does not contain specific part numbers. That being said, it should not be difficult to source the values listed.

The dimensions of the PCB are 75mm x 75mm. The board was designed to fit into a Hammond Manufacturing extruded aluminium enlosure, model number 1455K1201. More information may be found at www.hammondmfg.com.