ADC-1
Analog to Digital Converter Module

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(For METCON-1 and METCON-2)

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1. INTRODUCTION

This paper outlines an ADC (Analog to Digital Converter) module for use with the METCON telemetry and control system. This module is connected to METCON through a short seven conductor ribbon cable. The firmware within METCON polls the ADC module through this cable to read the values at the inputs to the ADC0838 (IC1[1]), the Analog to Digital Converter integrated circuit.

2. VOLTAGE INPUTS

This module measures up to eight external differential voltages in the range of either 0.00 to +2.55 volts or -1.27 to +1.27 volts by means of a balanced input circuit of about 100K ohms. The common mode input range extends from at least -1.00 to +2.50 volts.

3. CIRCUIT DESCRIPTION.

VR2 is a temperature stable voltage reference for setting the full scale value for IC1. The reference voltage chosen for the ADC module is 2.550 volts. Because of that choice, each bit equals 10 mV and thus the value of the eight bit word from IC1 reads directly in hundredths of a volt. The basic reference voltage of VR2 is 1.240 volts but it is scaled to 2.550 volts by means of R2, R3, and R4. R3 provides for about 5% variation of the reference voltage so that the reference voltage can be "netted" exactly to 2.550 volts.

The offset voltage, labled ACOM, is typically about 1 volt. A value greater than zero is used to ensure that it's within the range of possible op-amp outputs.

[1] See the National Semiconductor *Data Acquisition Linear Devices Databook* for an excellent discussion of how the ADC0838 operates.

Each op-amp differential circuit can be biased to either ACOM or A128 (1.28 volts above ACOM). When the jumper is installed in the ACOM position the range of useful differential inputs is 0.00 to 2.55 volts. With ACOM selected, a 0.00 differential voltage will cause the voltage at the output of the op-amp to be 0+ACOM volts and the A/D converter will output a value equal to 0. A differential voltage of 1.28 volts will cause an op-amp output to be 1.28+ACOM volts and the A/D converter will output a value of of 128. A differential voltage of 2.55 volts will cause an op-amp output to be 2.55+ACOM volts and the A/D converter will output a value of of 2.55

When the jumper is installed in the A128 position the range of useful differential inputs is -1.28 volts to +1.27 volts. With A128 selected, a 0.00 differential voltage will cause the voltage at the output of the op-amp to be 0+A128 volts (1.28 volts above ACOM) and the A/D converter will output a value equal to 128. A differential voltage of -1.28 volts will cause an op-amp output to be -1.28+A128 volts (0.00 volts above ACOM) and the A/D converter will output a value of of 0. A differential voltage of +1.27 volts will cause an op-amp output to be +1.27+A128 volts (2.55 volts above ACOM) and the A/D converter will output a value of of 255.

So, when ACOM is selected the differential voltages must be positive to get a useful output and the output is read directly in units of 10 mV. When A128 is selected, the differential voltages may be positive or negative for useful output. The A/D output is added to -128 and this signed result will be the measured voltage in units of 10 mV.

There are eight analog inputs to the ADC module. Only one channel, channel 0, will be discussed for this circuit description. All other channels operate the same way.

The input signal is applied to J1-1 (negative) and J1-2 (positive). IC2c and associated resistors provide a differential input. C5 is used to limit RFI and should only be installed if there is a confirmed RFI problem. The value of C5 is chosen as needed to combat specific RFI problems.

4. ADC ERRORS

The ADC0838 does a pretty good job of accurately converting voltage to a bit pattern that the microcomputer can read. The errors are less than 1/2 lsb (i.e., less then 5 mV) so the ADC0838 itself won't cause much of a problem.

In some applications, you can connect the ADC0838 directly to the device that you want to measure. One caution when doing so is that the ADC should be connected to a low impedance point (assuming your device to measured has a low impedance output). The problem is that the ADC0838 pushes and pulls small amounts of current into and out of its ADC input pins during the conversion process. If the device to be measured presents a large impedance to the ADC0838 these small currents will flow into (or out of) that large impedance and that will create a voltage drop (or rise). That voltage is in series with the voltage of the device you are trying to measure and will introduce errors. The way to work around that is to use an op-amp (prehaps in a differential configuration to remove common mode noise) to buffer the signal and present a low impedance input to the ADC0838. That's what we did with the METCON ADC Module. However, that has problems too.

The differential amplifiers have two major sources of errors. First, there's the tolerance of the resistors used. Second, there's the voltage and current offsets introducted by the op-amps themselves. Ideally, the resistors used for each op-amp would matched for best tolerance reduction. It doesn't really matter if the resistors are 90K, 100K or 110K. What does matter is that they be closely matched. Even 1% resistors can lead to errors of several tens of millivolts. This is much worse than the ADC chip is capable of resolving so you WILL see errors caused by resistor tolerance mismatches. For better accuracy, use a resistor network that contains matched resistors. Also, use better op-amps that have lower voltage and current offsets.

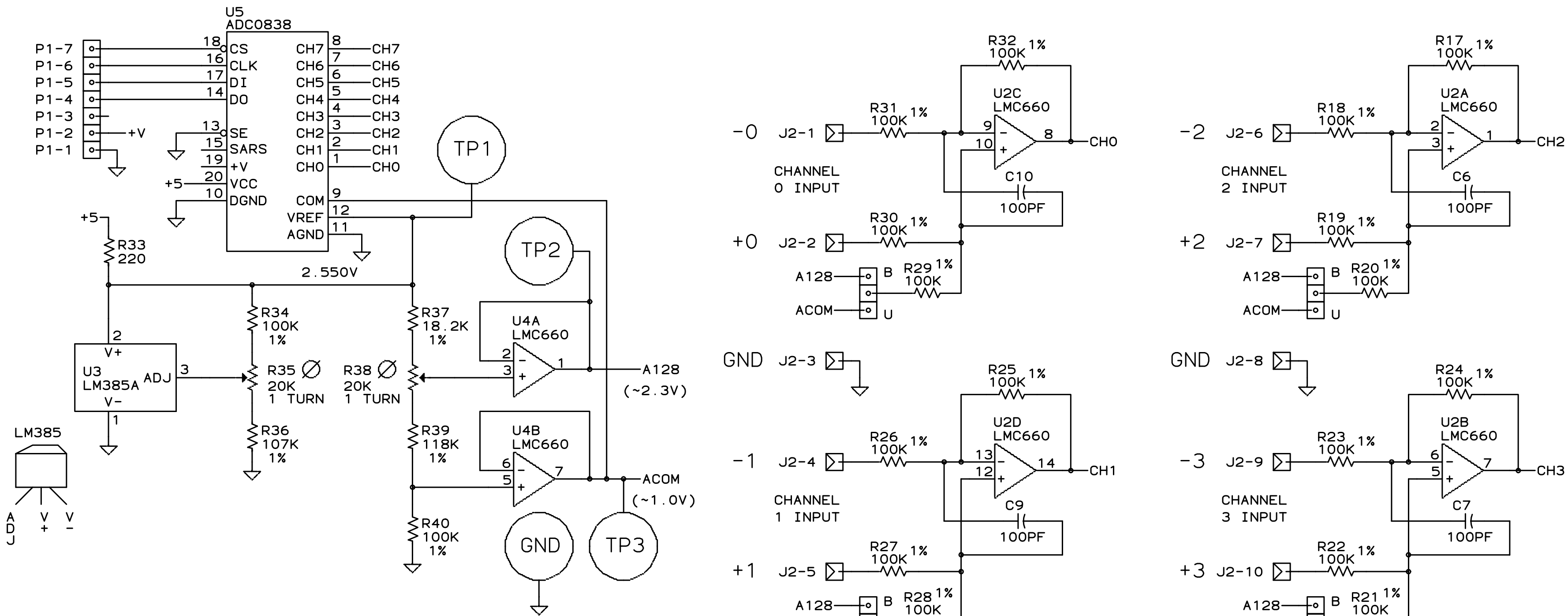
5. CALIBRATION

Connect a digital voltmeter to TP1 (positive) and GND (negative). Adjust R3 so that the voltmeter reads 2.550 volts.

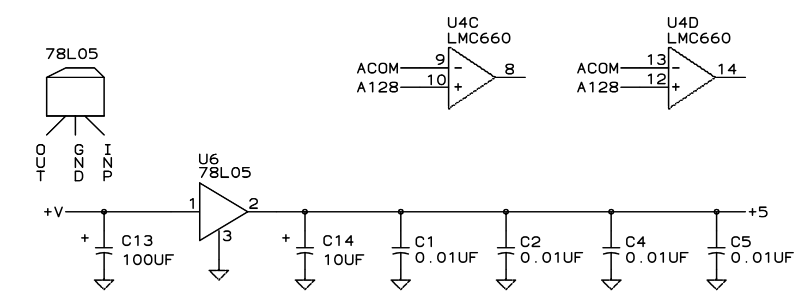
Connect a digital voltmeter to TP2 (positive) and TP3 (negative). Adjust R6 so that the voltmeter reads 1.280 volts.

Disconnect the voltmeter from the ADC module. This completes the calibration.

———ooOoo———



ABSOLUTE ALLOWABLE LIMITS FOR PROPER OPERATION	
UNIPOLAR INPUT (ACOM) CONFIG	BIPOLAR INPUT (A128) CONFIG
-1V <= INP+ <= +4V	-2.5 <= INP+ <= +2.5V
-3.55V <= INP- <= +4V	-3.8V <= INP- <= +2.5V
INP- <= INP+ <= (INP- + 2.55V)	(INP- - 1.28V) <= INP+ <= (INP- + 1.27V)



NOTES:

1) OP AMP POWER CONNECTED AS FOLLOWS:
   PIN-4 TO +5 PIN-11 TO GND
2) ADJUST R35 SO THAT TP1 = 2.550 VDC
3) ADJUST R38 SO THAT TP2-TP3 = 1.28 VDC
4) INSTALL SHORT ON ACOM FOR 0 TO +2.55 VDC INPUTS
5) INSTALL SHORT ON A128 FOR -1.28 TO +1.27 VDC INPUTS
6) C1, C2, C4, C5, C6, C9 & C10 INSTALLED ONLY IF
   NEEDED FOR RFI SUPPRESSION

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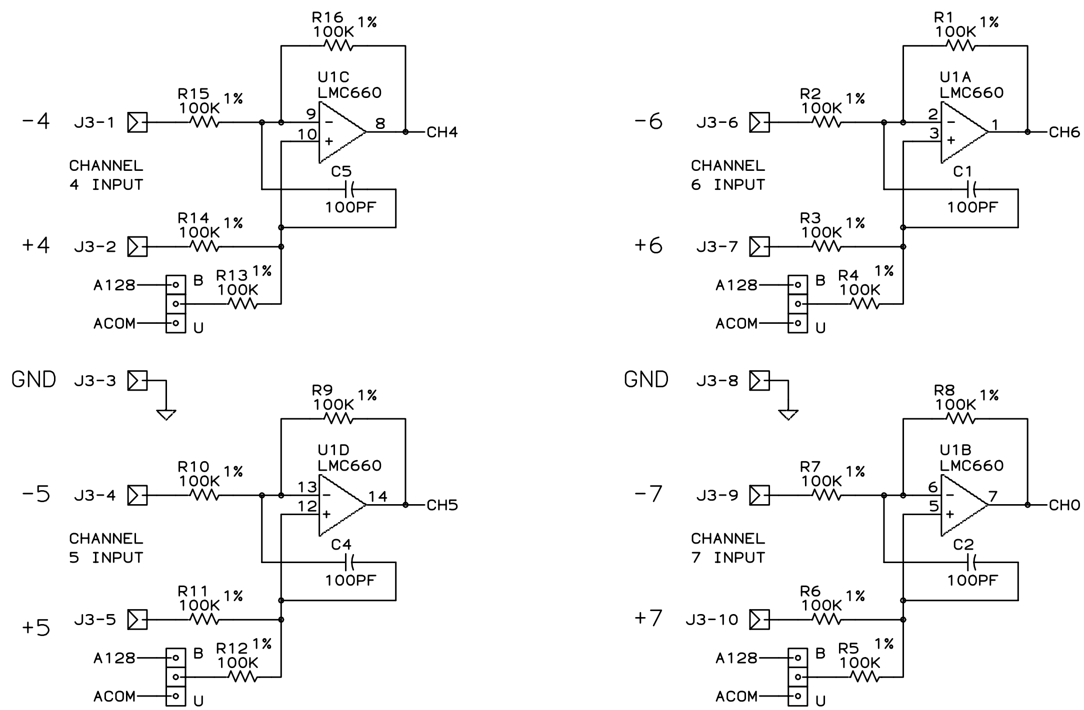
METCON A/D CONVERTER

FILE: MCADC	ENGR: PBN	REV 0
ORIG: 901101	LST MOD: 940219	SHT: 1 OF 2



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