The **Model 2015SPI-3N** carbon dioxide (CO_2) sensor has an on board flow through gas cell and a Digital Signal Processor. The gas calibration is done with zero gas (0.0% CO_2) to record maximum peak to peak out of the detector at three temperatures 5°C, 25°C, 45°C. From these three data points the ZERO temperature coefficient (**ZTC**) will be calculated as volts change per °C for this serial numbered sensor and stored in the EEPROM U7. With **5%** **CO_2** in the gas cell, peak to peak readings (TP4 via U4) will be recorded at 5°C, 25°C, 45°C. From these three data points the SPAN temperature coefficient (**STC**) will be calculated. The response curve coefficients C0 thru C7 are determined from the sensors response to 20% and 5% CO_2 when compared to a family of responses. If there is no family curve that gives the accuracy required by the spec use gas flow blender to get new coefficients. Refer to **Application Note A66** that decribes the use of the **RS-232 Test Board** for calibration and troubleshooting. Refer to **Application Note A59** and **A61** for more detail about the SPI digital interface. If jumper **JP1** (JP2 on older units made in 1999) is installed during a power on reset or when the RESET switch is pressed, microprocessor U5 will go into **SLAVE mode** looking for commands from the customer's microprocessor in **MASTER mode**. If you are using the **RS-232 Test Board** to calibrate or troubleshoot this sensor, you should remove **JP1** to put the sensor in **Master** and the Test Board in **Slave mode**.

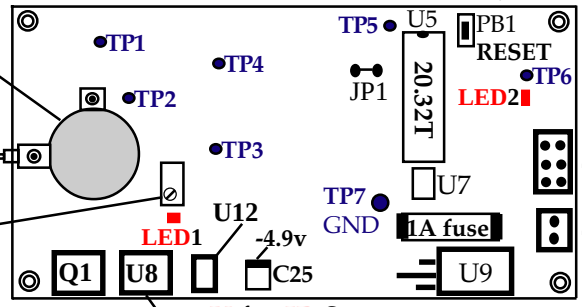
Other applicable models

2015SPI-XX (with analog out)
2015SPI-1-N 2% CO_2
2015SPI-CO-N 100% CO
2015SPI-4-N 100% CH_4

on board Flow thru CO_2 **gas cell**

gas **inlet** with flow valve. Flow limits 0.3 LPM to 1.0 LPM

Peak to Peak adjust R31 Do Not Adj after ZTC is calculated.

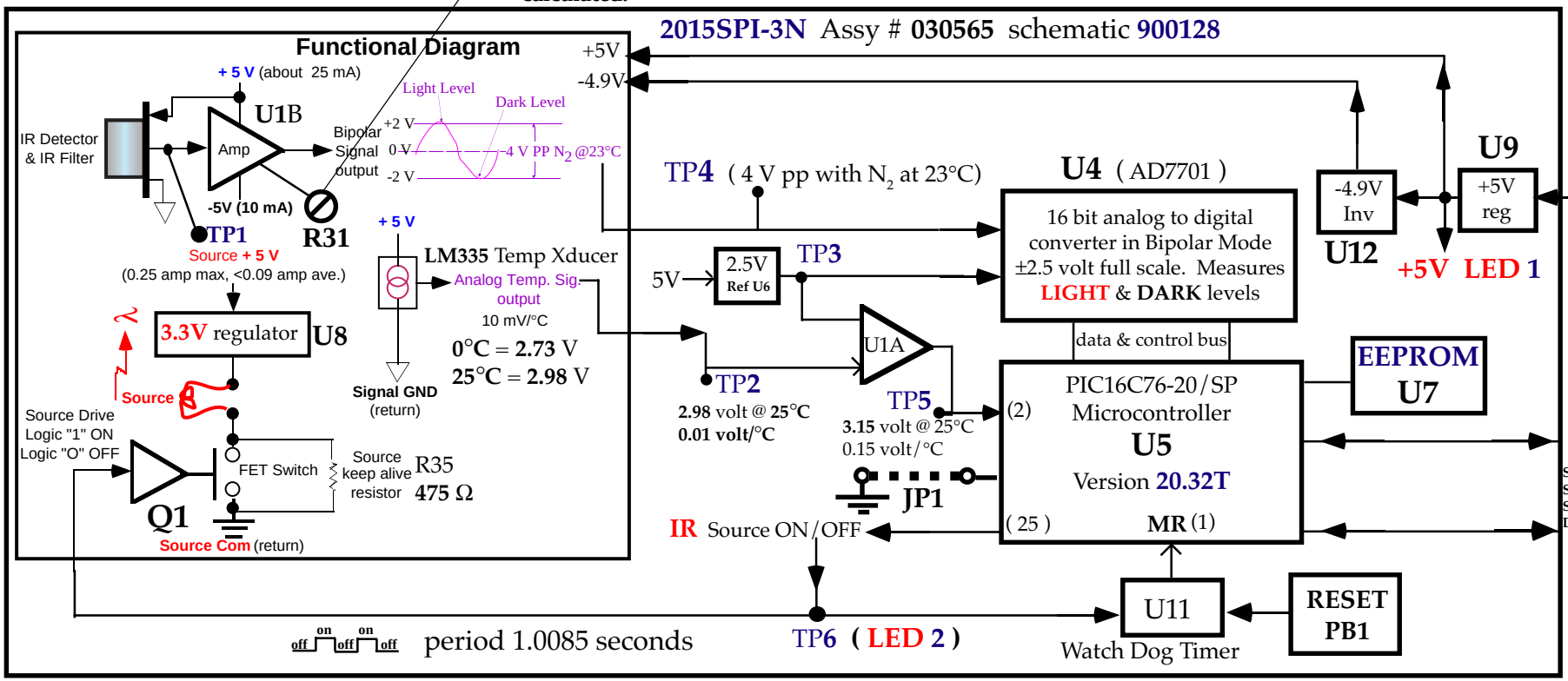


J1 Digital In/Out

J2 +12 VDC power

Power supply checks

+12 VDC input, 8 to 16 V
Fuse F1 (1 amp) polarity protect D1
LED 1 lights from **+5V** (**U9**)
+**4.75** to **5.25** volt limits
-4.6 to **-5.1V** comes from **U12**
LED 2 flashes from **IR** source ON/OFF signal **TP6**



The **Version** on the **PIC** chip **U5**, such as **20.32T**, indicates the type of **temperature transducer** on the **2015SPI-3N** PCB (schematic **900128**) an **LM335** . Versions without a **T**, i.e. **20.32** are used on the **2015SPI-3** PCB (920120) with the switches (see schematic 910120). These use a **TMP-36** temp Xducer. The **LM335** is shown in the block diagram on page 1. 2015SPI-3 boards assembled without stuffing the switches were made in late 1999 have the **TMP-36**. It has an output of **0.750 volt** at **25°C** and it increase 0.01 volt per °C increase in temperature like the **LM335**. The difference is that the **LM335** has an output of **2.98 volt** at **25°C**. The older PC board is still used on all 2015SPI units with switches. Op Amp U1-A1 has a different gain for the **TMP-36** so that its' output is about 2.26 volt at 25°C (gain = 2.259/0.75 = **3.012**) at TP1. The **LM335** requires subtracting 2.5 volts from its output of 2.98 vots at 25°C before it is increased by the gain of 6.06. The tolerances of the gain resistors and the 2.50 reference voltage along with the tolerance of the **LM335** itself may result in some significant temperature errors from actual ambient temperature. This absolute temperature error is not important since the temperature compensation is relative to the stored gas calibration temperature. The **slope** of the temperature sensor per °C is the important parameter. If the **ZTC** (**Z**ero **T**emp**C**o) and **STC** (**S**pan **T**emp**C**o) are calculated using a separate temperature chamber thermometer, the tolerances will effect the accuracy of the temperature compensation. If the **ZTC** and **STC** is calculated using the temperature measured from each individual sensor the accuracy of the compensation will be improved significantly because the slope tolerances will be calibrated out.

LM335

The tolerances shown below for TP5 do NOT include the LM335 tolerances.
They are just due to the 2.5 V ref IC & the op amp gain tolerances.

°K	°C	TP2	TP5	TP5 MAX	TP5 MIN
253	-20	2.530	0.182	0.365	0.006
258	-15	2.580	0.485	0.674	0.303
263	-10	2.630	0.788	0.983	0.600
268	-5	2.680	1.091	1.292	0.897
273	**0**	**2.730**	**1.394**	**1.601**	**1.194**
278	5	2.780	1.697	1.910	1.491
283	10	2.830	2.000	2.219	1.788
288	15	2.880	2.303	2.528	2.085
293	20	2.930	2.606	2.837	2.382
298	**25**	**2.980**	**2.909**	**3.147**	**2.679**
300	27	3.000	3.030	3.270	2.797
302	29	3.020	3.152	3.394	2.916
303	30	3.030	3.212	3.456	2.976
306	33	3.060	3.394	3.641	3.154
308	35	3.080	3.515	3.765	3.273
313	40	3.130	3.818	4.074	3.570
317	44	3.170	4.061	4.321	3.807
318	45	3.180	4.121	4.383	3.867
322	49	3.220	4.364	4.630	4.104
323	**50**	**3.230**	**4.424**	**4.692**	**4.164**
328	55	3.280	4.727	5.001	4.460

LM335 uncalibrated temperature error = 4°C typ, 9°C max
TP5=(TP2-2.5)6.0606 **Schematic 900128**

LM4040-2.5 voltag		±0.029 volt tolerance on 2.5 v ref	
Max	Min	2.529	2.471
2.55	2.45	Max	Min

tol +2% tol -2% **LM4040CIM3-2.5**

Analog Devices **TMP-36** Temp. Xducer
(Accuracy spec **25±2°C** = 0.750 volt)
used on 2015SPI pcb with switches

°K	°C	TP2	TP1	TP1 MAX	TP1 MIN
253	-20	0.300	0.904	0.922	0.886
258	-15	0.350	1.054	1.075	1.033
263	-10	0.400	1.205	1.229	1.181
268	-5	0.450	1.355	1.383	1.328
273	**0**	**0.500**	**1.506**	**1.536**	**1.476**
278	5	0.550	1.657	1.690	1.623
283	10	0.600	1.807	1.843	1.771
288	15	0.650	1.958	1.997	1.919
293	20	0.700	2.108	2.151	2.066
298	**25**	**0.750**	**2.259**	**2.304**	**2.214**
300	27	0.770	2.319	2.366	2.273
302	29	0.790	2.380	2.427	2.332
303	30	0.800	2.410	2.458	2.361
306	33	0.830	2.500	2.550	2.450
308	35	0.850	2.560	2.611	2.509
313	40	0.900	2.711	2.765	2.657
317	44	0.940	2.831	2.888	2.775
318	45	0.950	2.861	2.919	2.804
322	49	0.990	2.982	3.042	2.922
323	**50**	**1.000**	**3.012**	**3.072**	**2.952**
328	55	1.050	3.163	3.226	3.099

TMP 36 accuracy 25±2°C = 0.750 V, slope 9.8 to 10.2 mV/°C
TP1= TP2 * 1000/332 = 3.0120481 * TP2 **schematic 910120**