0-5V or 4-20mA to 0-5V signal converter-analogue input modules

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Here we focus on a project involving thirteen analogue input modules and seven analogue output modules for 5V microcontroller ADC/DAC channels. In this part, we'll cover the twelfth and thirteenth analogue input modules, i.e. modules 1 and 2 for a 0-5V or 4-20mA to 0-5V signal converter.

Module 1 handles either DC input voltages from 0V to +12V or DC input currents from 0mA to 48mA, and requires two DC power supplies: +6.26V and +12V. Module 2 handles the same DC input voltages and currents but requires only one power supply, +12V DC.

This article concludes our study of analogue modules; in the next installment we'll focus on seven analogue output modules.

Analogue Input Module 1

Figure 1 shows module 1 of the 0-5V or 4-20mA to 0-5V signal converter, with its connections to the microcontroller shown in Figure 2.

In voltage mode, the input voltage range V_{IN} is 0-12V; in current mode, the input current I_{IN} is 0-48mA. In voltage mode (S1 open), when $0.00V \le V_{IN} \le 5.00V$, $V_{OUT} = V_{IN}$. When $5.01V \le V_{IN} \le 12V$, V_{OUT} is a value from 5.01V to 5.07V, thanks to the op-amp (LM358P-A) used here.

In current mode (S1 closed), when $0mA \le I_{IN} \le 20mA$, $V_{OUT} = (I_{IN} \times 250)V$. When $20mA < I_{IN} \le 48mA$, V_{OUT} will be anywhere from 5.01V to 5.07V, because of LM358P-A.

The relationship between V_{OUT}, V_{IN} and I_{IN} is shown in Figure 3. Voltages to 12V and currents to 48mA are handled without damage to the circuit, and are output as values from 5.01V to 5.07V.

Since voltage and current can suffer electric surge or electrostatic discharge on the external terminal connections, the TVS (transient voltage suppressor) in the circuit provides effective protection. Diode D1 protects the circuit from accidental reverse polarity of V_{IN} or I_{IN}. Precision current-sensing resistor R1 can be switched on or off, and jumper S1 (shown as a switch for clarity) does the switching between current and voltage. When S1 is open, the input can receive 0-5V; when closed, it receives 4-20mA.

A ferrite bead in series with the input path adds isolation and decoupling from high-frequency transient noises, and external Schottky diodes protect the op-amp. Even when internal ESD protection diodes are provided, external diodes can help lower noise and offset errors. Dual series Schottky barrier diodes D2 and D3 divert any overcurrent to power supply or ground. LM358P-A, with a +6.26V supply voltage, acts as a voltage limiter and is connected as a buffer amplifier (voltage follower). V_{OUT} appears from the output of the LM358P-A.

Table 1 shows example input and output voltages and currents for this module; the circuit board is shown in Figure 4.

Analogue Input Module 2

Figure 5 shows analogue input module 2 for a 0-5V and 4-20mA to 0-5V signal converter for the ADC input of a 5V microcontroller; its connections to the MCU are shown in Figure 6. Here, too, we've assumed that when voltage mode is selected, V_{IN} = 0-12V, and in current mode, the input current I_{IN} = 0-48mA.

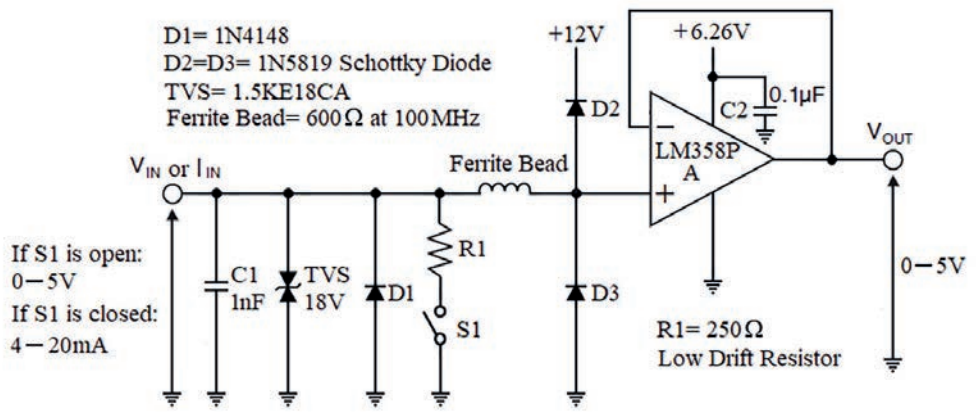

Figure 1: Diagram of analogue input module 1 for a 0-5V and 4-20mA to 0-5V signal converter

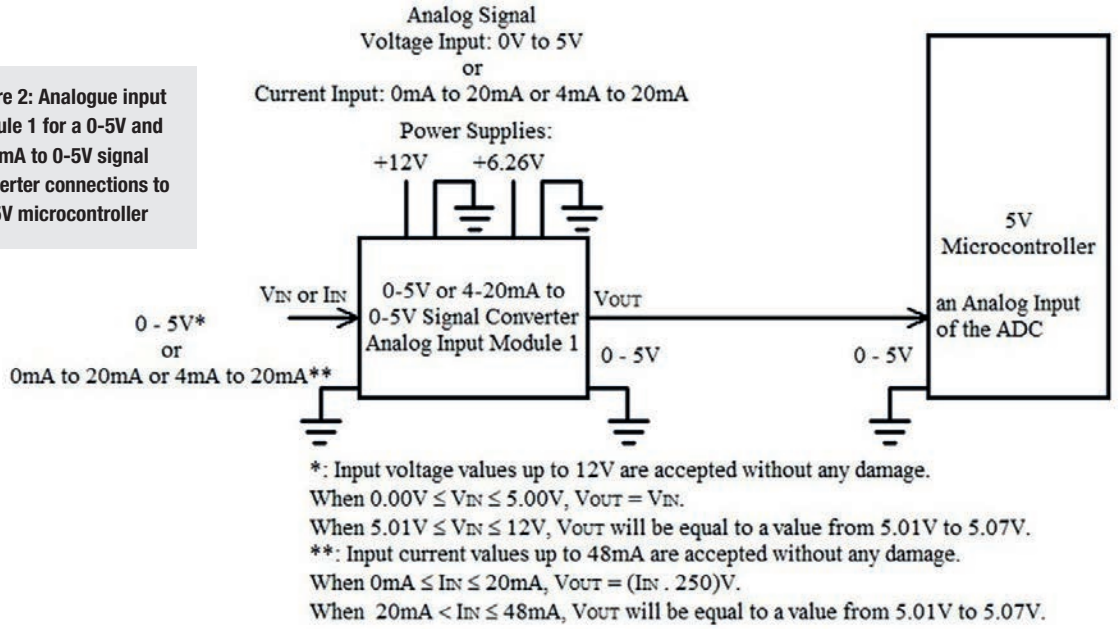

Figure 2: Analogue input module 1 for a 0-5V and 4-20mA to 0-5V signal converter connections to the 5V microcontroller

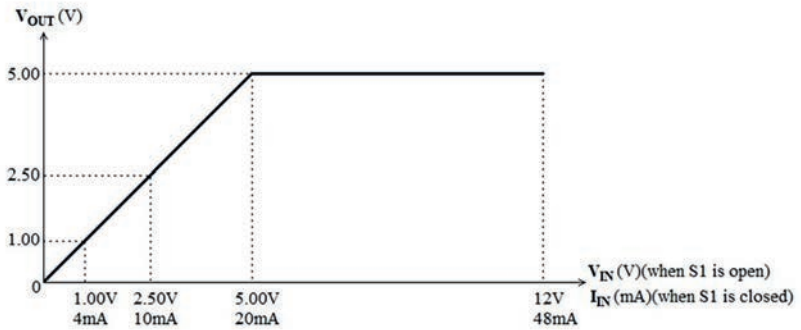

Figure 3: V_{OUT} vs V_{IN} or I_{IN} of analogue input module 1 for a 0-5V and 4-20mA to 0-5V signal converter

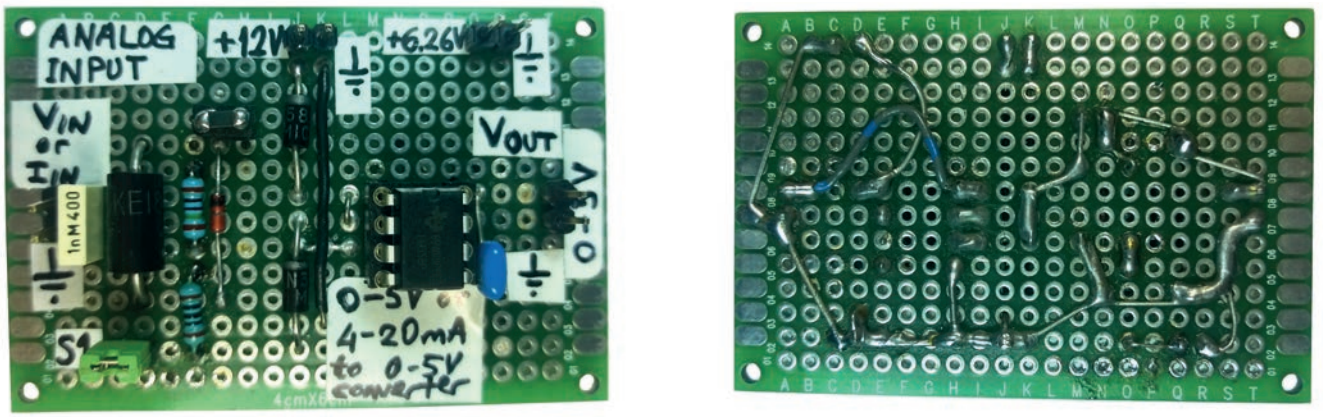

Figure 4: Circuit board (top and bottom) of analogue input module 1 for a 0-5V and 4-20mA to 0-5V signal converter

VIN(V)	IIN(mA)	VOUT(V)
12.00	48	5.0X
..	..	5.0X
10.00	40	5.0X
..	..	5.0X
5.00	20	5.00
..	..	..
4.75	19	4.75
..	..	..
4.50	18	4.50
..	..	..
4.25	17	4.25
..	..	..
4.00	16	4.00
..	..	..
3.75	15	3.75
..	..	..
3.50	14	3.50
..	..	..
3.25	13	3.25
..	..	..
3.00	12	3.00
..	..	..
2.75	11	2.75
..	..	..
2.50	10	2.50
..	..	..
2.25	9	2.25
..	..	..
2.00	8	2.00
..	..	..
1.50	6	1.50
..	..	..
1.25	5	1.25
..	..	..
1.00	4	1.00
..	..	..
0.75	3	0.75
..	..	..
0.50	2	0.50
..	..	..
0.25	1	0.25
..	..	..
0.00	0.00	0.00

Table 1: Example input and output voltages and currents for analogue input module 1 for a 0-5V and 4-20mA to 0-5V signal converter.

5.0X: a value from 5.01V to 5.07V, due to the electrical characteristics of the op-amp

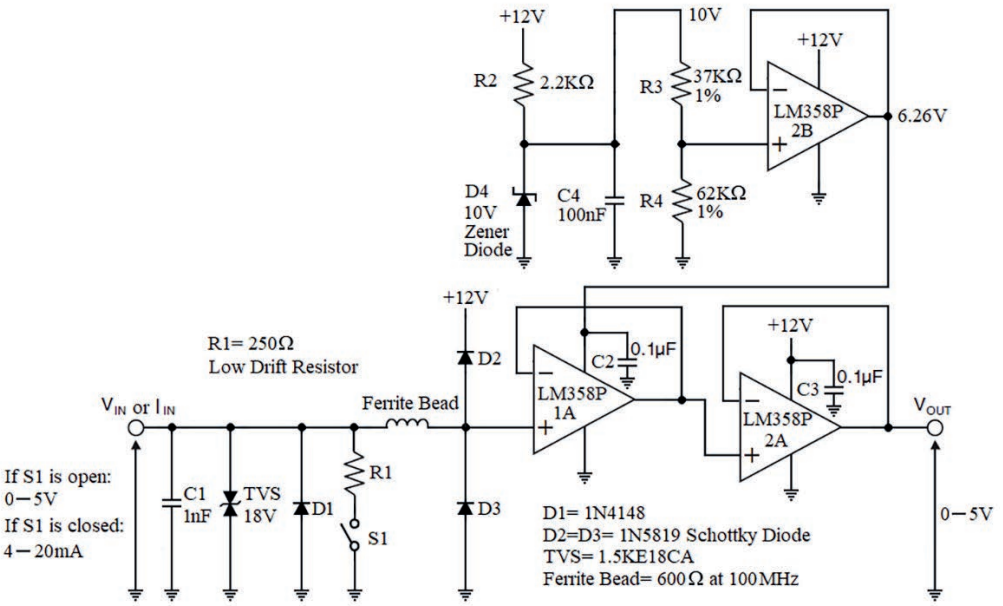

Figure 5: Diagram of analogue input module 2 for a 0-5V or 4-20mA to 0-5V signal converter for the ADC input of a 5V microcontroller

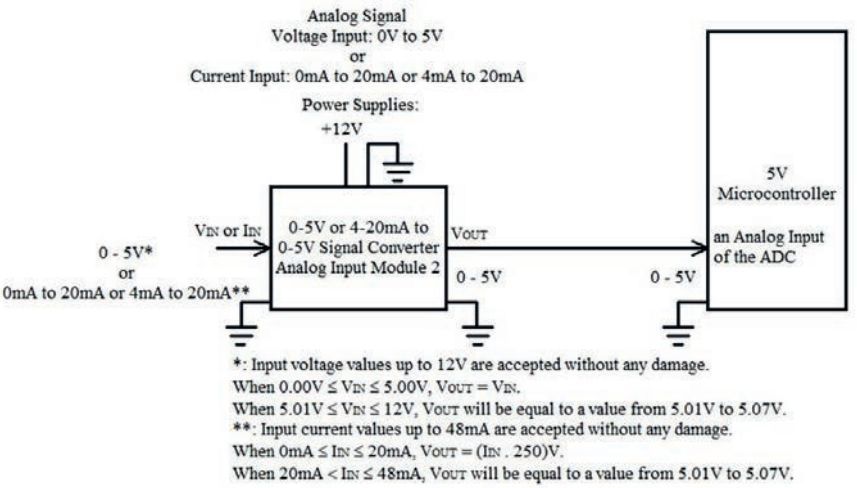

Figure 6: Connections to the MCU of the analogue input module 2 for a 0-5V or 4-20mA to 0-5V signal converter

In voltage mode (S1 open), when 0.00V ≤ V_{IN} ≤ 5.00V, V_{OUT} = V_{IN}. When 5.01V ≤ V_{IN} ≤ 12V, V_{OUT} will be a value from 5.01V to 5.07V, due to the op-amp in the circuit. In current mode (S1 closed), when 0mA ≤ I_{IN} ≤ 20mA, V_{OUT} = (I_{IN} x 250)V. When 20mA < I_{IN} ≤ 48mA, V_{OUT} will be a value from 5.01V to 5.07V, due to the LM358P-1A op-amp. The relationship between V_{OUT}, V_{IN} and I_{IN} is shown in Figure 3.

The bottom part of Figure 5 is identical to that of the first analogue input module, except for the buffer amplifier LM358P-2A from where the output voltage V_{OUT} is obtained.

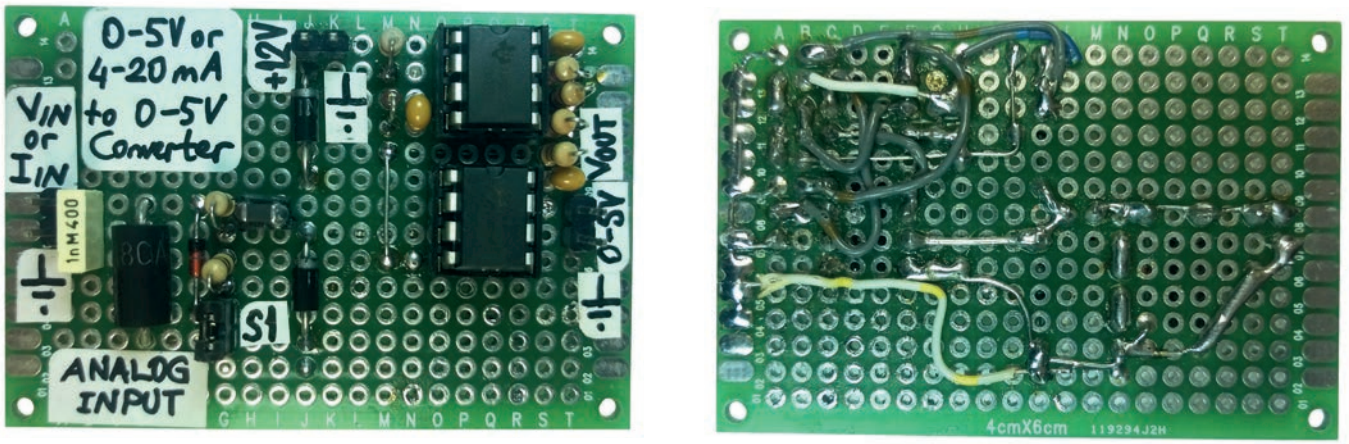

Figure 7: Circuit board of analogue input module 2 for a 0-5V or 4-20mA to 0-5V signal converter

The top part is used to get the +6.26V reference voltage. Resistor R2, diode D4 (10V Zener) and capacitor C4 provide a 10.00V reference voltage from a +12V power supply.

Dividing this voltage with resistors R3 and R4 produces a +6.26V reference voltage. This +6.26V is then connected to the non-inverting input of the buffer amplifier LM358P-2B, whose output is fixed as a +6.26V reference voltage, capable of sourcing to 20mA.

Table 1 shows example input and output voltages and currents for this module; the circuit board is shown in Figure 7.

For proper operation ensure that R4/(R3+R4) = 62.62%. EW