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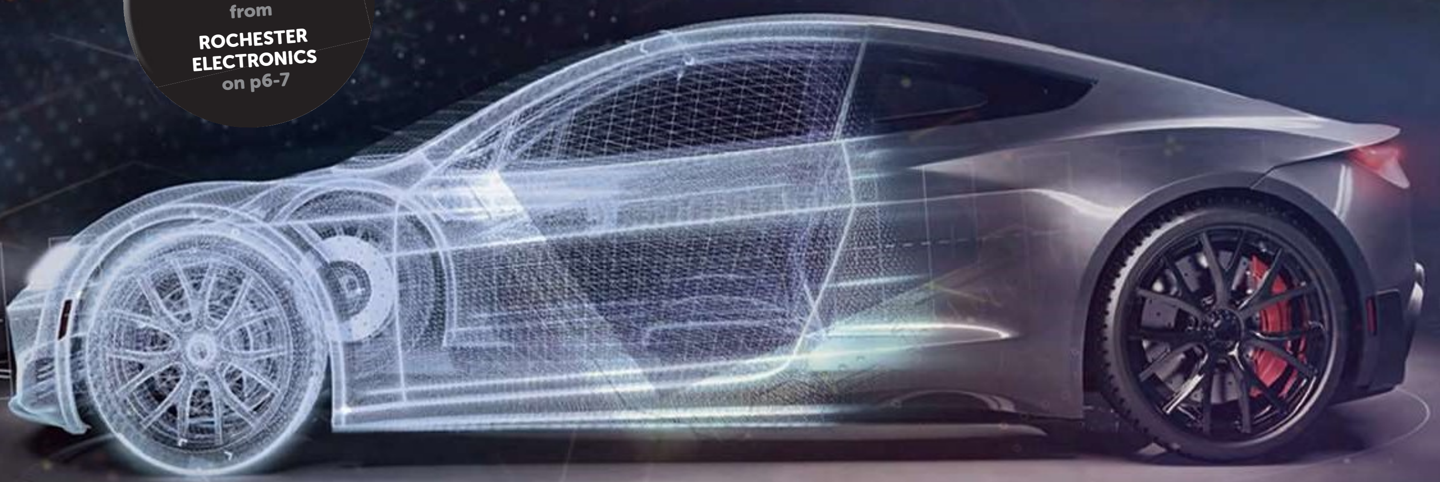

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Optically-isolated analogue output modules for a 0-5V to –5V - +5V signal converter

By Professor Murat Uzam, Department of Electrical and Electronics Engineering, Yozgat Bozok University, Turkey

This month we will discuss the third and fourth optically-isolated analogue output modules for a 0-5V to −5V - +5V signal converter, which provide voltages from −5V to +5V. Module 1, shown in Figure 1, requires four DC power supplies: isolated +12V, +5.00V, −12V and +12V, whereas Module 2, shown in Figure 2, requires three DC supplies: isolated +12V, −12V and +12V.

Module 1

Module 1's circuit contains the Positive Unipolar Photovoltaic Isolation Amplifier 3 (PUPIA3 – explained previously), with a HCNR201 high-linearity analogue optocoupler providing photovoltaic isolation. The circuit's input stages to the left of HCNR201 are isolated from its output stages to its right.

Due to limited current drive capability, the buffer amplifier (a voltage follower) LM358P-1A is used on the DAC output.

LM358P-1A's output is connected to the input of the PUPIA3, which consists of:

1. Input: R1, R2, LM358P-1B;
2. HCNR201;
3. Output: P1, R3, C3, LM358P-2A.

Providing $0.00V \leq V_{IN} \leq 5.00V$, PUPIA3's output voltage will range between 0.00V and 5.00V. This output is connected to the non-inverting input terminal of LM358P-3A. Jumper S1 (shown here as a switch for clarity) is used to choose either the isolated 0-5V analogue output, when S1 is open, or when closed, the 0-5V to −5V - +5V isolated analogue output.

With S1 open, the circuit works as explained in the optically-isolated 0-5V analogue output design. Here we will only consider the 0-5V to −5V - +5V signal converter – optically-isolated analogue output operation mode, i.e., with S1 closed.

This design is used to level shift the unipolar 0-5V input to a bipolar −5V to +5V output. When $0.00V \leq V_{IN} \leq 5.00V$, LM358P-3A, with its bipolar supply voltages, acts with the transfer function of:

$$V_{OUT} = \left(1 + \frac{R4 + P2}{R5}\right) V_{IN} - 5$$

After adjusting P2's value, we obtain R4 + P2 = R5, then:

$$V_{OUT} = 2V_{IN} - 5$$

A buffer amplifier (voltage follower) LM358P-3B is used on the output of LM358P-3A. Dual series Schottky barrier diodes D1 and D2 divert any overcurrent from V_{OUT} to the positive or negative power supply. A ferrite bead in series

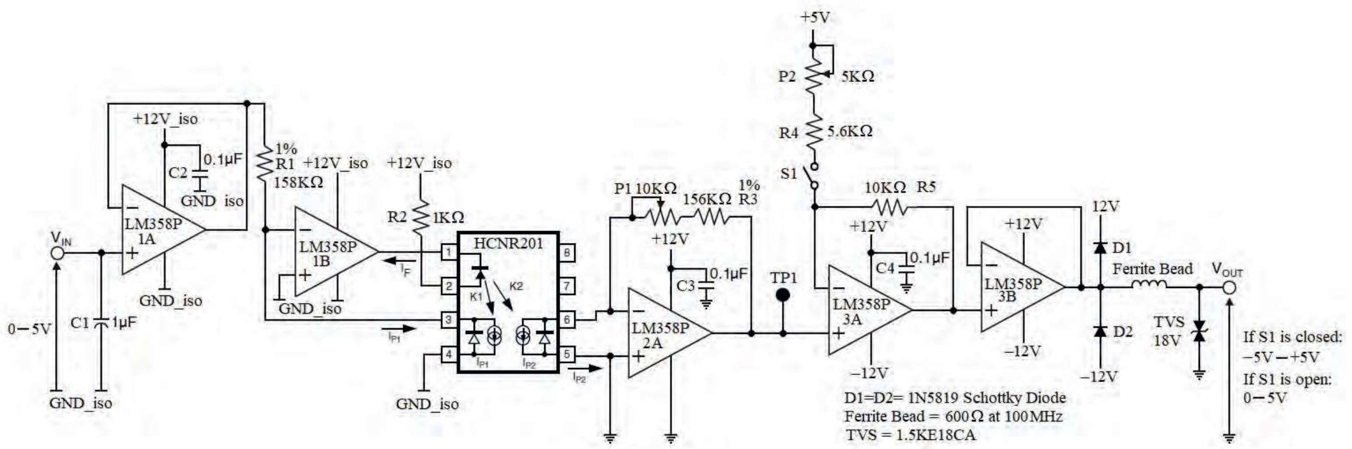

Figure 1: Optically-isolated 0-5V to –5V - +5V signal converter – Module 1

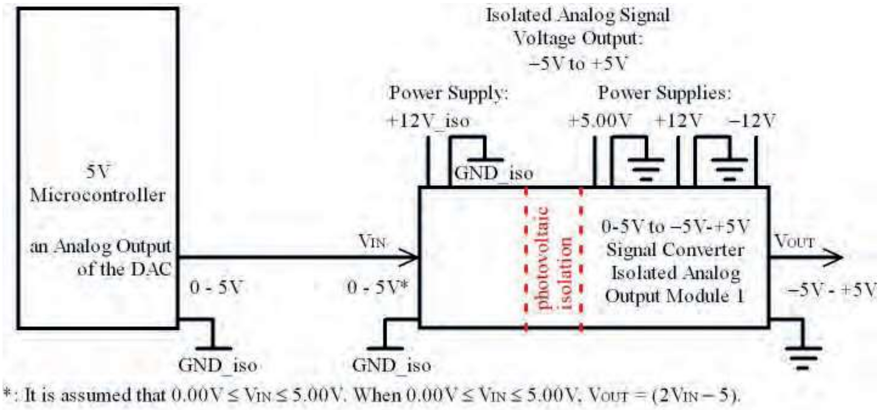

Figure 2 : Module 1 connections

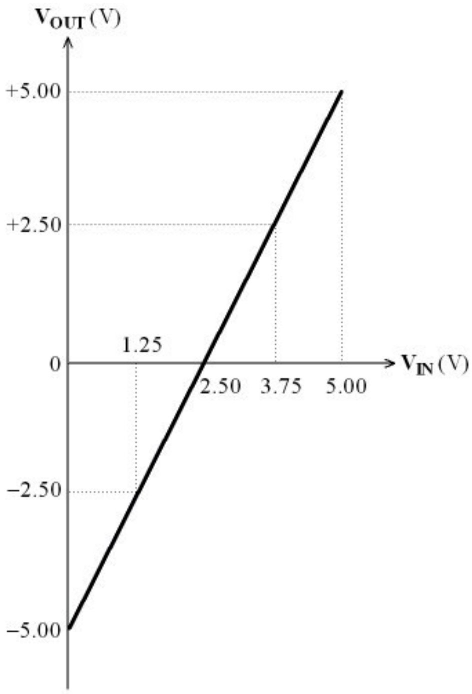

Figure 3: V_{OUT} vs. V_{IN} for Modules 1 and 2

VIN(V)	VOUT(V)
5.00	+5.00
..	..
4.50	+4.00
..	..
4.00	+3.00
..	..
3.75	+2.50
..	..
3.50	+2.00
..	..
3.00	+1.00
..	..
2.50	0.00
..	..
2.00	−1.00
..	..
1.50	−2.00
..	..
1.25	−2.50
..	..
1.00	−3.00
..	..
0.50	−4.00
..	..
0.00	−5.00

Table 1: Example input and output voltages for Modules 1 and 2, assuming $0.00V \le V_{IN} \le 5.00V$

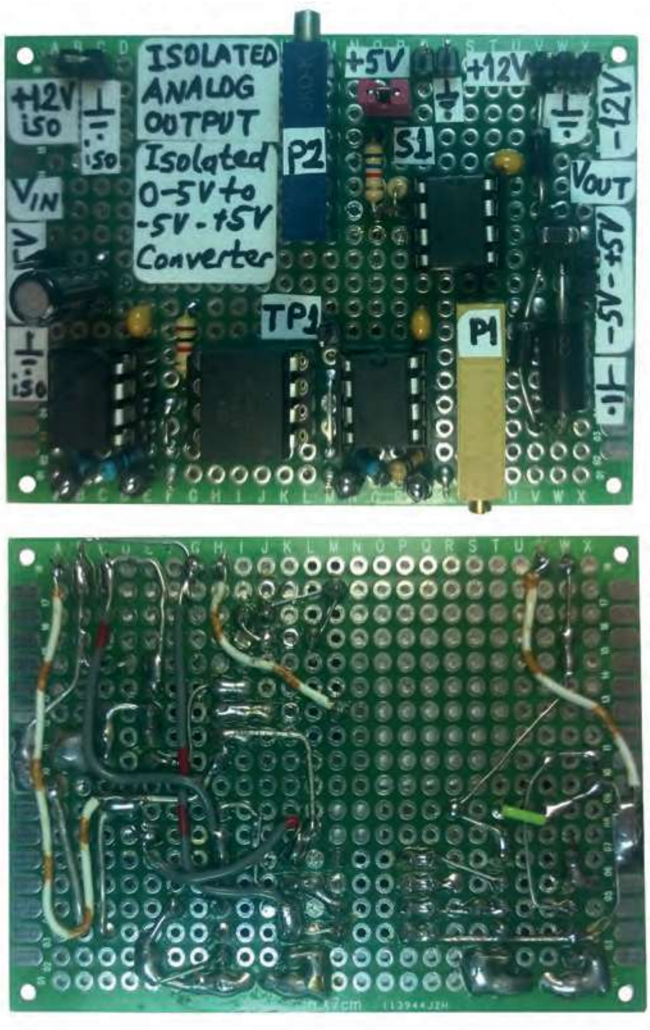

Figure 4: Module 1 prototype circuit board

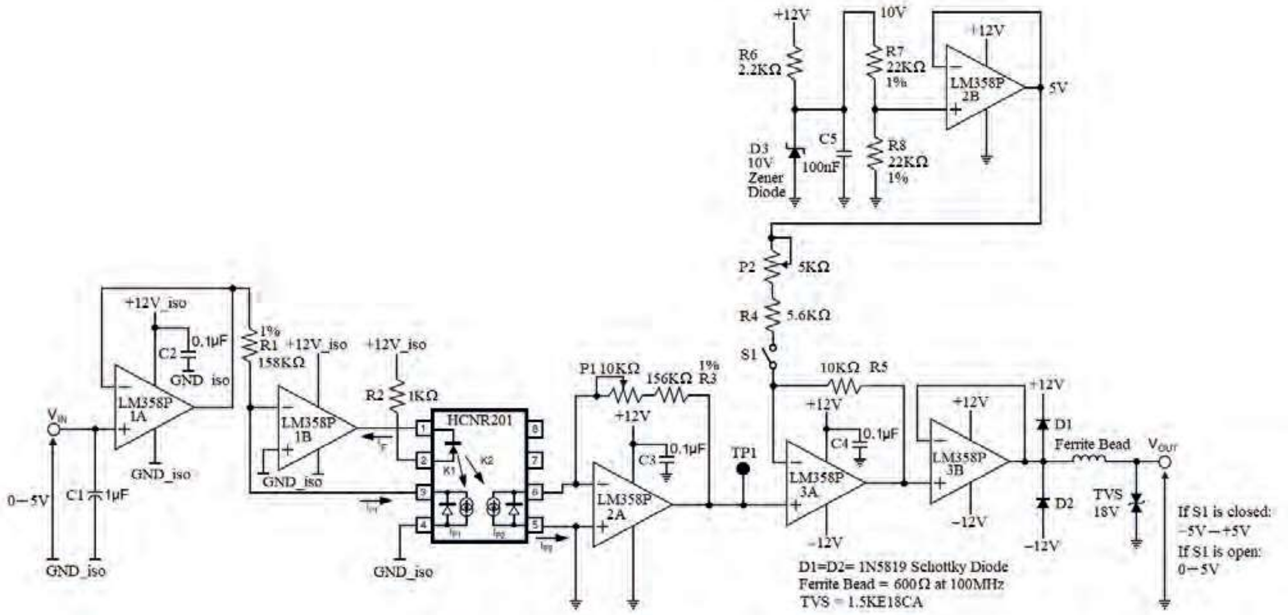

Figure 5: Module 2 circuit

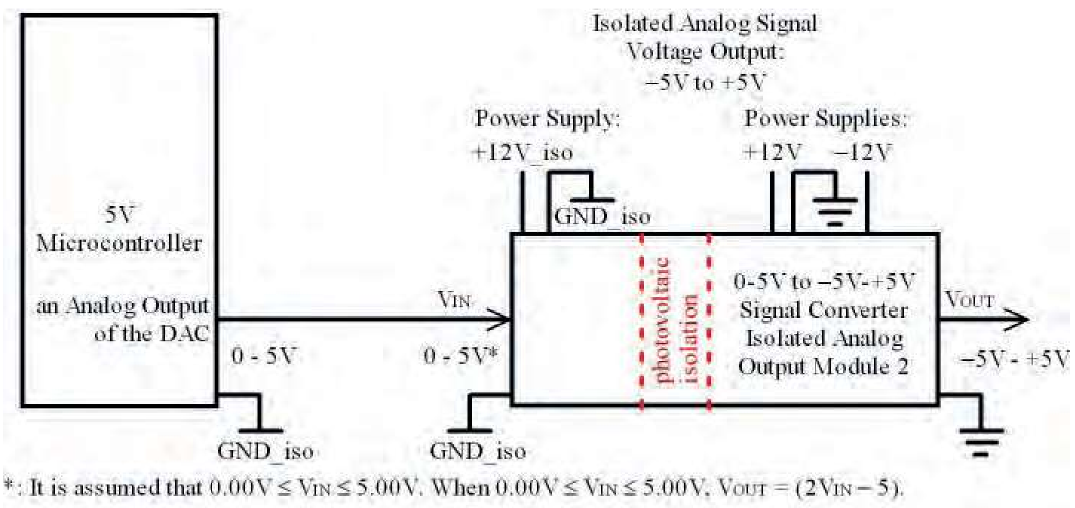

Figure 6: Module 2 connections

with the output path adds isolation and decoupling from high-frequency transient noises. A transient voltage suppressor (TVS) is used to filter out any transients entering from V_{OUT}.

In this design, the circuit's input is powered by +12V, whereas its output is powered by +5.00V, +12V and −12V, isolated from the +12V at the input. The circuit can supply up to 20mA.

We have assumed that V_{IN} comes from the DAC output of a 5V microcontroller with $0.00V \le V_{IN} \le 5.00V$. When $0.00V \le V_{IN} \le 5.00V$, $V_{OUT} = 2V_{IN} - 5$. The input voltage range V_{IN} = 0.00-5.00V, hence V_{OUT} = −5.00V to +5.00V; see Figure 3.

Table 1 shows examples for input and output voltages for the two modules, with the prototype circuit boards shown in Figures 4 and 7.

To calibrate with S1 open: Set V_{IN} to +5.00V, and by adjusting P1 make V_{OUT} = +5.00V.

With S1 closed, the calibration steps are:

1. Set V_{IN} to +5.00V and then by adjusting P1 make V_{TP1} = +5.00V.
2. By adjusting P2, make sure that when V_{IN} = 0.00V, V_{OUT} = −5.00V and, also, when V_{IN} = +5.00V, V_{OUT} = +5.00V.

Module 2

Figures 5, 6 and 7 show the optically-isolated analogue output Module 2, with its connections to the DAC output of a 5V microcontroller. As with Module 1, the circuit is also PUPIA3 based, with a high-linearity analogue optocoupler (HCNR201) providing photovoltaic isolation.

Module 2 operates exactly the same way as Module 1, and it contains all the same components as Module 1, but with R6, D3 (10V Zener diode) and C5

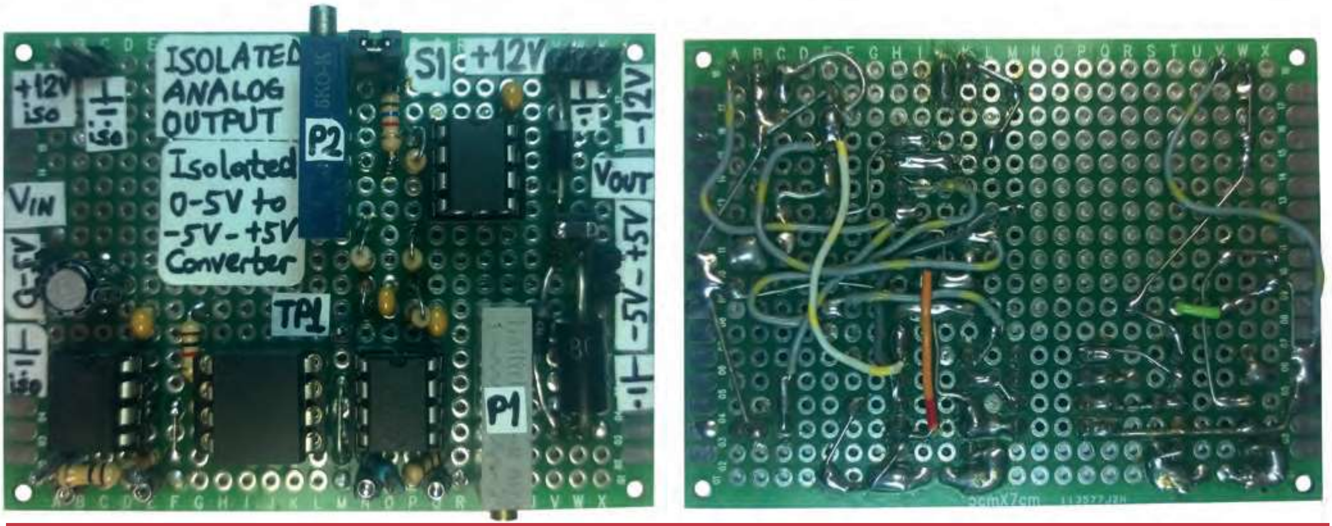

Figure 4: Module 2 prototype circuit board

to provide a 10.00V reference voltage from a +12V power supply. This 10.00V reference is then divided by resistors R7 and R8 to obtain +5.00V, which is connected to the non-inverting input of the buffer amplifier LM358P-2B, with an output fixed at +5.00V and capable of sourcing up to 20mA.

Unlike Module 1, in this design the circuit's output is powered by only +12V and −12V that are isolated from the +12V applied to the circuit's input.

For proper operation, make sure that R7 = R8.

To calibrate the circuit when S1 is open, set V_{IN} to +5.00V and by adjusting P1 make V_{OUT} = +5.00V. When S1 is closed:

1. Set V_{IN} to +5.00V and by adjusting P1 make V_{TP1} = +5.00V.
2. By adjusting P2, make sure that when V_{IN} = 0.00V, V_{OUT} = −5.00V and, also, when V_{IN} = +5.00V, V_{OUT} = +5.00V. EW