Working with Analog Inputs and Outputs on the SA100 Assembly

Analog inputs and outputs on the SA100 ICs are realized as differential current signals; each input or output thus consists of two signals, a positive and a negative parts of a complete differential pair that carries information/values using current levels.

In order to provide useful interaction with standard instruments (like Signal Generators, Voltage meters, D/A converters, Oscilloscopes, etc.), these signals are converted from voltage mode (V) to current mode (I), and vice versa.

These V/I and I/V converters are built into the SA100 assemblies.

Some of the Analog Inputs and all Analog Output signals are pre-wired in a specific way to the accompanying Arduino Due board that acts as a system controller.

SA100 assembly has four (4) analog inputs that are connected to the two (2) Analog Computer ICs.

These four inputs are divided into two groups: one provides two Analog Inputs to the IC0 (SA100-0), and the other provides two Analog Inputs to IC1 (SA100-1).

Specifically, signal on pins 1, 2, 3, and 4 of CONN1 (signals IN-/IN+ 0 and 1) are connected (after V/I conversion) to IC0; pins 5, 6, 7, and 8 (signals IN-/IN+ 2 and 3) are directed to IC1.

Analog Inputs to the SA100-0 (IC0)

The group that contains signals IN-/IN+ 0 and 1 is pre-wired and pre-biased to work with the two D/A outputs from the Arduino board (D/A_0 and D/A_1 respectively, as marked on the Arduino connector).

The signals from Arduino D/A converter outputs are buffered by the unity-gain OpAmp followers and fed to the positive side of the differential-sensing voltage inputs of the V/I converters.

The corresponding negative inputs are provided with buffered bias (using a similar unity-gain OpAmp circuit) that is equal to the ½ of the Arduino's reference voltage for the D/A converters; this bias is nominally 1.65 V (3.3 V / 2).

Thus the net input to the V/I converter is nominally zero when the D/A output is equal to ½ of its full scale, or 1.65 V.

When D/A level deviates from the middle-point value, an appropriate input current is generated; for example, if one D/A voltage output is 2.65 V, the corresponding input current for one of the two inputs of the IC-0 will have a value of 2 µA (the positive side of the differential pair will have a current of +1 µA and the negative side will have a current of –1 µA).

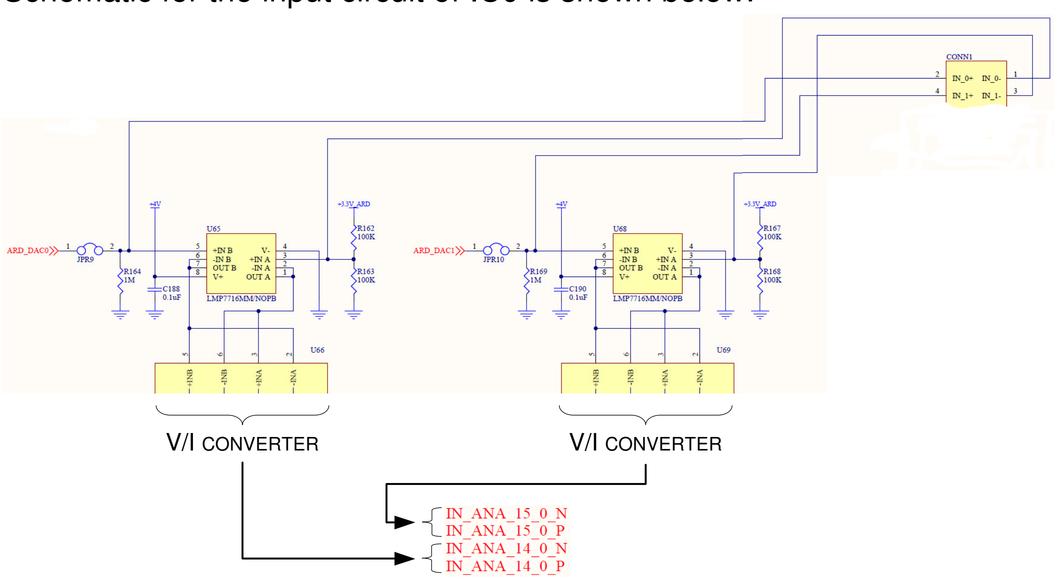
The Arduino D/A converter outputs can be monitored (for example, with an Oscilloscope) at pins 2 and 4 of CONN1, in reference to Ground potential available at any pin of CONN25.

(Please note that the Arduino D/A outputs are only capable of producing a voltage that is within 1/6 to 5/6 of the reference 3.3 V; therefore, the minimum and maximum voltages seen on pins 2 and 4 of CONN1 will be 550 mV to 2.75 V; nominal ±2 µA current inputs will be generated when D/A output is, respectively, 2.65 V and 650 mV.)

Pins 1 and 3 (in reference to GND at CONN25) produce steady potentials of 1.65 V.

Please see an illustration further in this document for the pin-out of CONN1 and CONN25, and their locations on the assembly.

Schematic for the input circuit of IC0 is shown below:

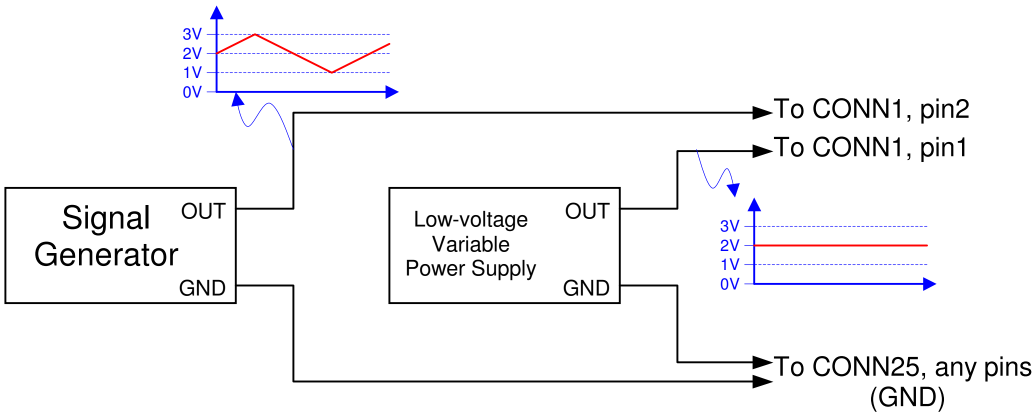


If an analog input is desired from other source (not from Ardunio D/A), then PCB shorts JPR9 and/or JPR10 can be cut open, and the (*floating*) analog signal can be applied differentially between pins 1(-) / 2(+) and 3(-) / 4(+).

(Please note that the supply voltage of the OpAmps is between GND and +4 V; any signals that are applied (in reference to GND) must be a little bit smaller than this range, or the OpAmps will saturate at the levels close to the supply rails.)

The high-value resistance (50 k) that is the equivalent of the dividers at pins 1 and 3 allows these inputs to be easily overdriven by a low-impedance source.

For example, if JPR9 is opened, the following circuit can be used (with exemplary voltage levels as shown, it will generate a full-scale positive-to-negative triangular-shaped input into IC0):

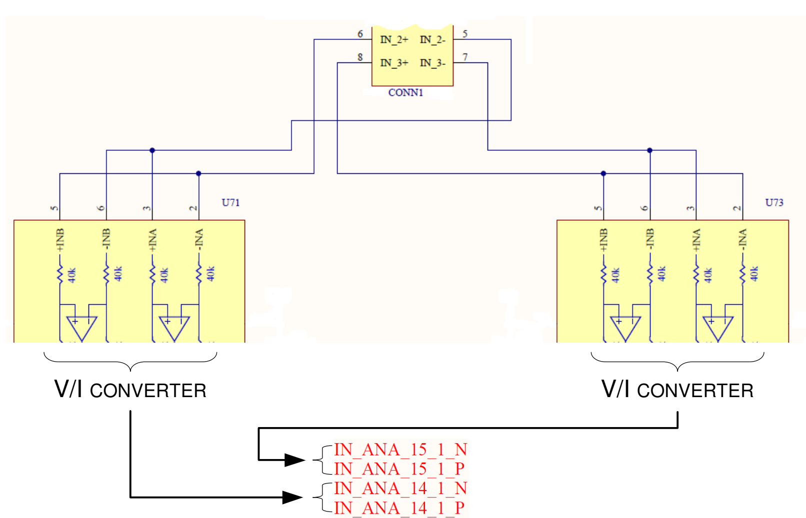


(Please note that neither of the two potentials on CONN1 are outside of the 0 to 4 V range.)

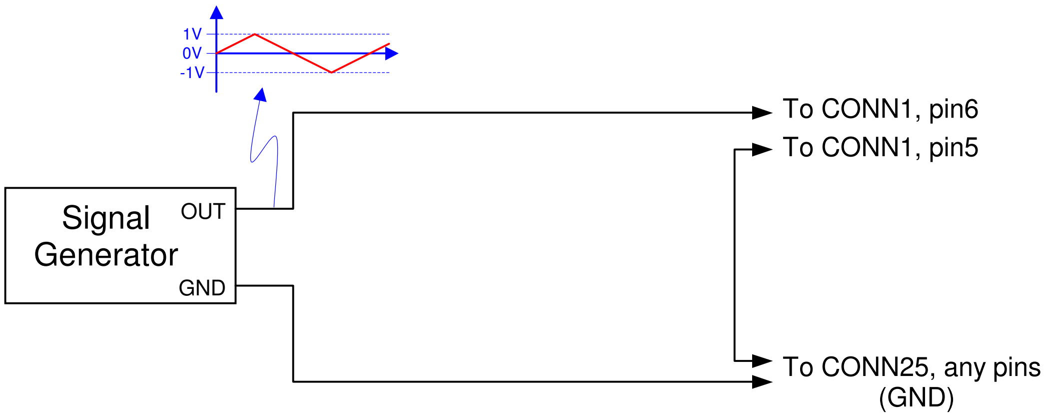
Analog Inputs to the SA100-1 (IC1)

Analog inputs on pins 5, 6, 7, and 8 (signals IN-/IN+ 2 and 3) of CONN1 are connected, after the V/I conversion, to IC1.

These analog inputs are not pre-buffered, and exhibit 20 k impedance to GND. However, unlike the inputs to IC0, they are not restricted as much for the common-mode signal range allowed. In reference to GND, each of the inputs can operate within a range of –15 V to +15 V; however, the differential voltage between the positive/negative sides of the differential pair should still be limited to ±1 V (to produce the nominal full-scale analog input signal to the SA100-1 IC).

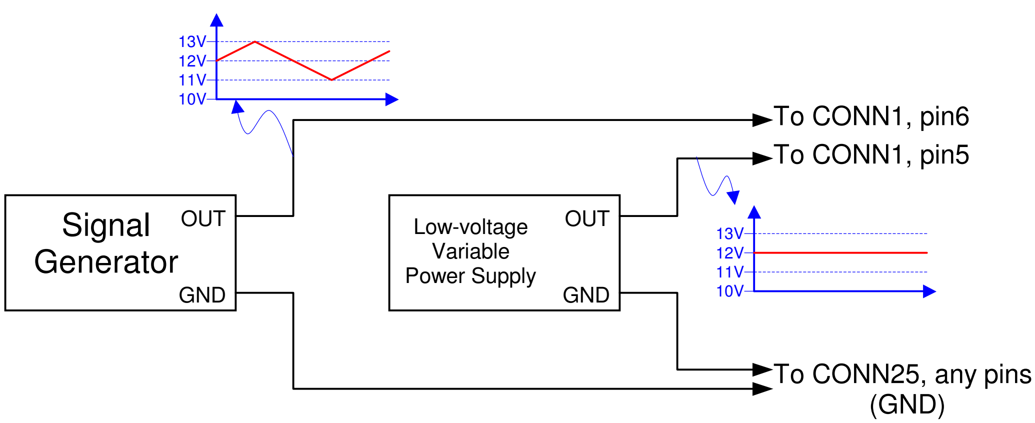


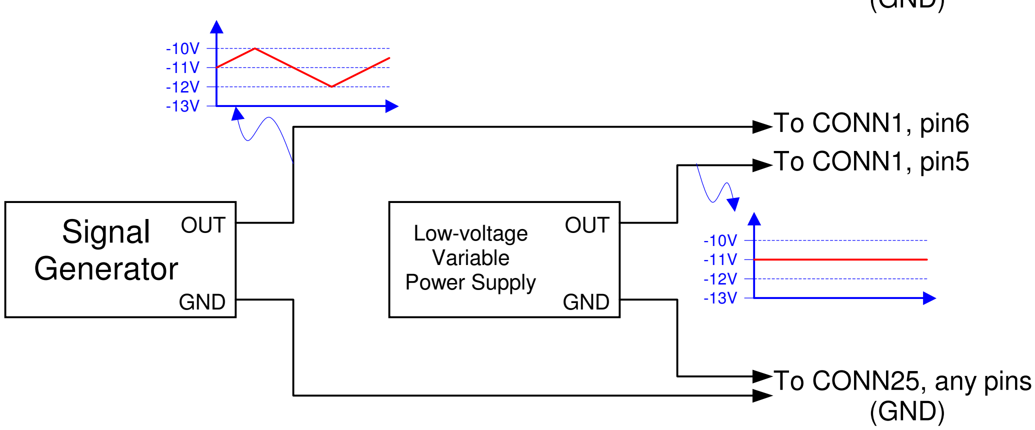
For example, the following circuit can now be used, with the Signal Generator producing a waveform that has both positive and negative levels (with exemplary voltage levels as shown, it will generate a full-scale positive-to-negative triangular-shaped input into IC1):



(Please note that the negative input of the V/I converter is simply connected to GND. The output impedance of the Signal Generator of 50 Ohms will produce -0.25 % error.)

To illustrate the common-mode capabilities of the inputs to the V/I converter of the SA100-1 part of the circuit, the following arrangements can be used (with the exemplary voltage levels as shown, they will also generate a full-scale positive-to-negative triangular-shaped input into IC1):

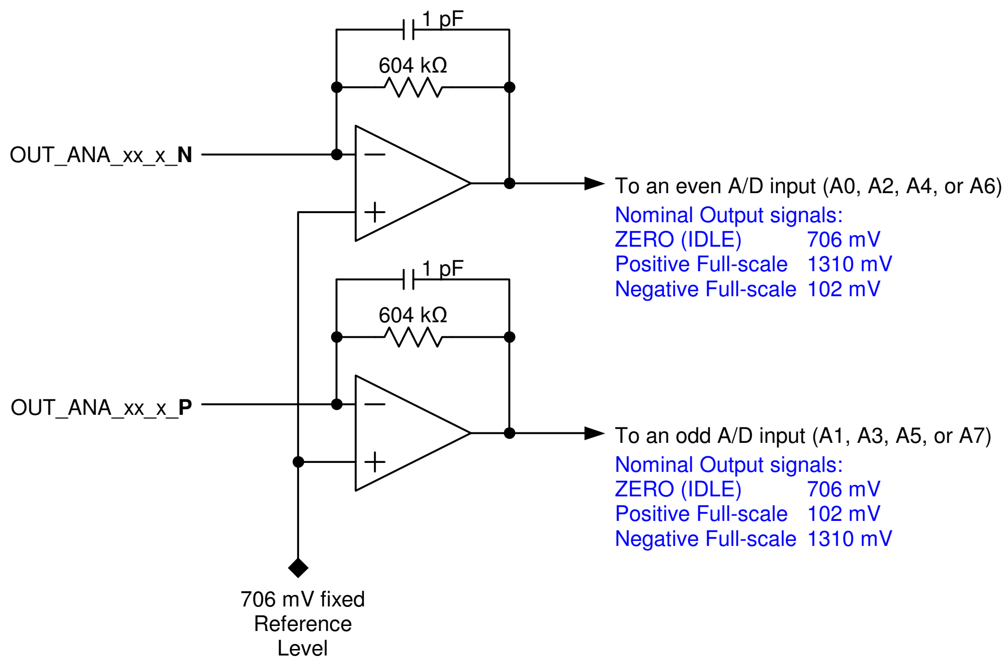




Analog Outputs

All Analog Outputs (two Analog Outputs from each of the two Analog Computer ICs) are pre-wired to the ADC inputs on the Arduino DUE controlling board (after I/V conversion).

Differential current signals pass through the I/V converters, schematically shown below (each of the four (4) outputs has this differential I/V converter circuit):



The differential output voltage between the two even/odd inputs of the ADC is, respectively, 0 mV for ZERO (Idle) state, +1208 mV for the Positive Full-scale signal, and –1208 mV for the Negative Full-scale signal.

[Output = ADC_even – ADC_odd]

Connections to the A/D inputs on the Arduino are arranged in such a way that the corresponding A/D input pairs (even/odd) can be combined to produce differential conversion result in a single A/D conversion.

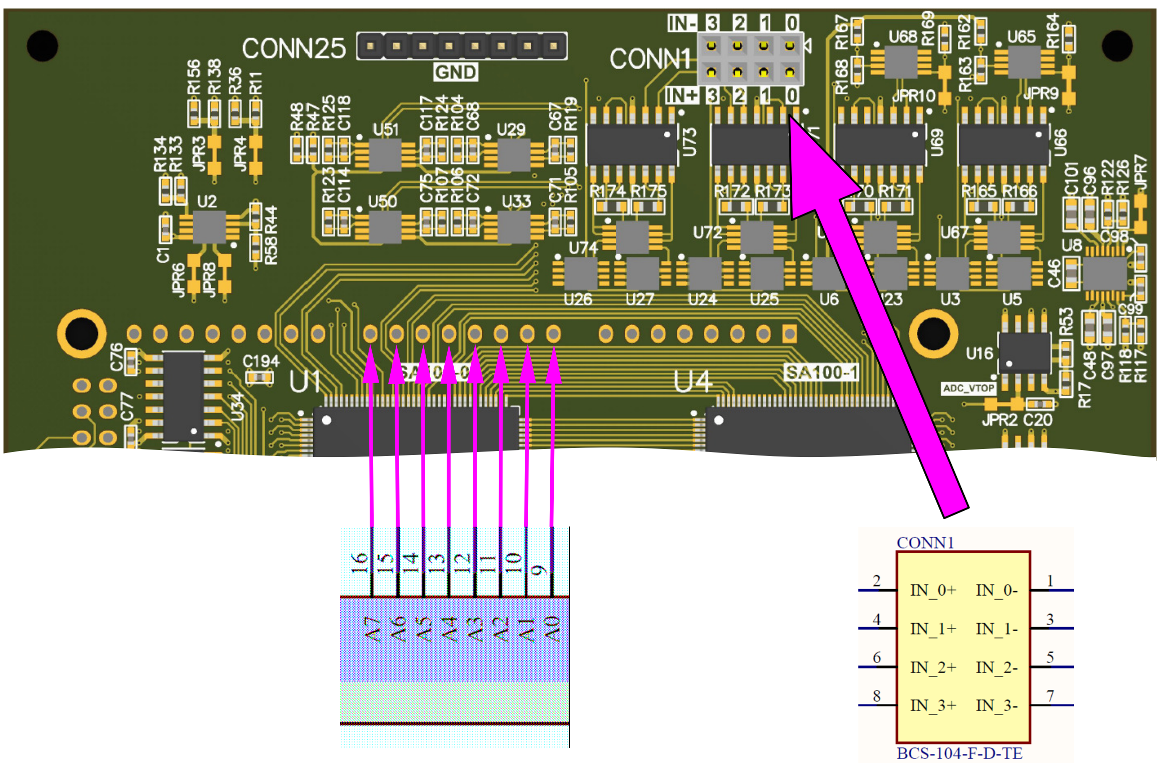
(Please note that the notation of A0, A1, etc. is specific to the particular Arduino design and accompanying software; this corresponds to the markings on the Arduino connector. However, the actual ADC channel numbers as defined by the Arduino MCU silicon manufacturer do not agree with this notation.)

Analog outputs can be probed (for example, with an Oscilloscope) or connected to the external circuits using the Arduino connector's pins as the contact/pick-up points; location of the connector is shown on the illustration further in this document.

Correspondence of the analog outputs from each of the two Analog ICs to the Arduino-notation A/D inputs is as follow:

Analog IC	Signal Name	Arduino-notation A/D input
IC0	OUT_ANA_14_0_N	A0
IC0	OUT_ANA_14_0_P	A1
IC0	OUT_ANA_15_0_N	A2
IC0	OUT_ANA_15_0_P	A3
IC1	OUT_ANA_14_1_N	A4
IC1	OUT_ANA_14_1_P	A5
IC1	OUT_ANA_15_1_N	A6
IC1	OUT_ANA_15_1_P	A7

Connectors CONN1 (Analog Inputs), CONN25 (GND) and pick-up points for Analog Outputs



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