4-LEAD ELECTROCHEMICAL SENSOR EXAMPLE

Many electrochemical sensors come in 4-lead packages that have a counter, a reference, and two sensing electrodes. The ADuCM355 supports biasing and measuring of these sensor types.

The M355_ECSns_DualWE example project configures the low power, potentiostat CH0 channel to bias the sensor. The current flowing to and from the SE0 pin is measured via the low power TIA Channel 0 (TIA0). The current flowing from the SE1 electrode is measured via the low power TIA Channel 1 (TIA1).

The TIA amplifiers convert the current to a voltage that is measured via the analog-to-digital converter (ADC), and the source code calculates the current flowing in each electrode.

The M355_ECSns_DualWE code example project is located in the examples folder.

Figure 30 shows the configurable parameters located in the AD5940Main.c file. Modify the value of the correct LpTiaRtiaSel parameter for each channel based on the maximum expected current.

Figure 31 shows the connection details between the 4-lead sensor and the ADuCM355.

```
/* Configure CH0 Parameters */
pAmpCfg->SensorCh0.LpTiaRf = LPTIARF_1M;
pAmpCfg->SensorCh0.LpTiaRl = LPTIARLOAD_10R;
pAmpCfg->SensorCh0.LptiaRtiaSel = LPTIARTIA_10K;
pAmpCfg->SensorCh0.Vzero = 1110;
pAmpCfg->SensorCh0.SensorBias = 0;

/* Configure CH1 measurement parameters */
pAmpCfg->SensorCh1.LpTiaRf = LPTIARF_1M;
pAmpCfg->SensorCh1.LpTiaRl = LPTIARLOAD_10R;
pAmpCfg->SensorCh1.LptiaRtiaSel = LPTIARTIA_96K;
```

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Figure 30. Dual Working Electrode Configuration

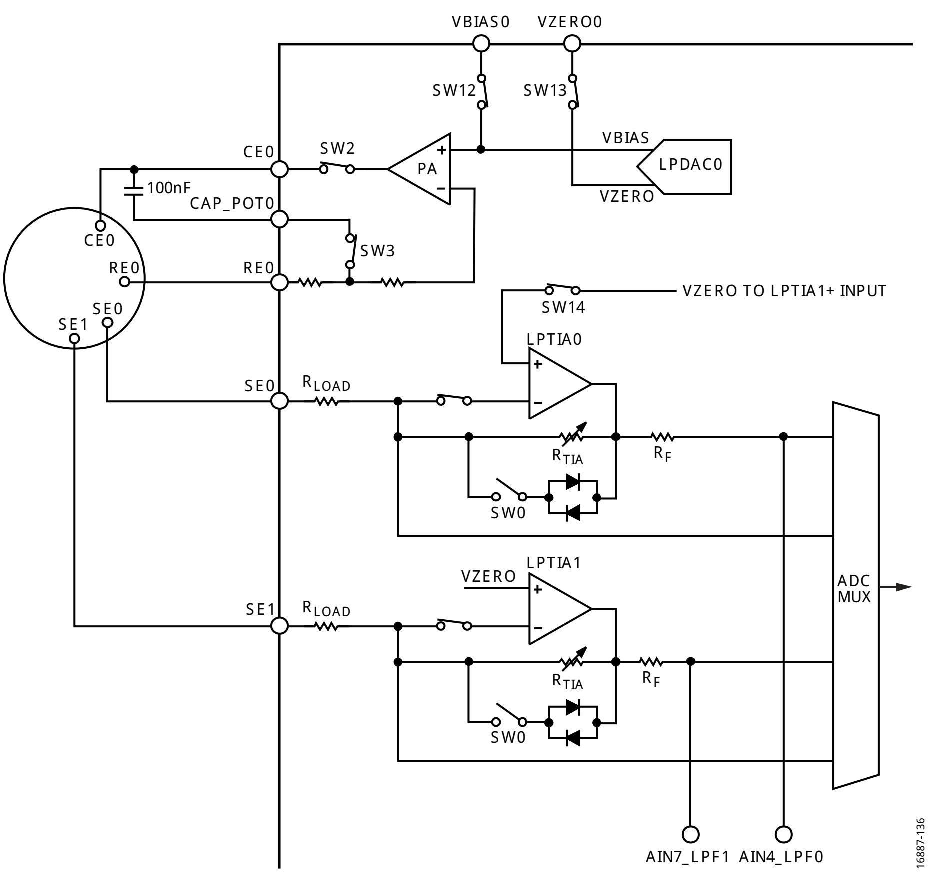

Figure 31. Circuit Setup for 4-Lead, Dual Gas Detection Sensor

ADUCM355 SYSTEM CALIBRATION

Because of the complexity of the ADuCM355 and the large number of voltage and current measurement channels on the device, many calibration routines are implemented to ensure a high level of measurement accuracy. This section describes the main calibration functions with links to further online information.

HIGH SPEED TIA GAIN RESISTOR CALIBRATION

The high speed TIA has three different programmable gain resistor options.

Adjust the gain resistors to convert the current from the SE0, SE1, and DE0 inputs or from the DE1 input to a differential voltage across the R_{TIA2} resistor, R_{TIA2_03} resistor, or R_{TIA2_05} resistor.

The R_{TIA2}, R_{TIA2_03}, and R_{TIA2_05} resistors have an initial accuracy range and vary with temperature, as specified in the ADuCM355 data sheet where R_{TIA2} is the HPTIA R_{TIA} gain resistor on the SE0 and SE1 inputs, and R_{TIA_02} and R_{TIA_05} correspond to the HPTIA R_{TIA} gain on the DE0 and DE1 inputs.

If the high speed TIA is uncalibrated for the selected gain resistor and the ADC programmable gain amplifier (PGA) setting, an error is present when measuring an absolute input current.

To generate a precision calibration current, use the high speed DAC to create a differential voltage across an external precision R_{CAL} resistor that is connected to the ADuCM355 RCAL0 pin and RCAL1 pin. The precision calibration current can be routed through any of the three high speed TIA gain resistors.

Because the calibration current value is known and the ADC can measure the voltage drop across the R_{TIA2}, R_{TIA2_03}, and R_{TIA2_05} resistors, the exact R_{TIA} resistor value can be determined.

Figure 33 to Figure 35 show the setup and switch settings that connect the high speed DAC output to the external R_{CAL} resistor so that the current flows into the high speed TIA and R_{TIA2}, R_{TIA2_03}, and R_{TIA2_05} gain resistors, respectively.

The AD5940.c file has a function that calibrates each gain resistor for the HSTIA. For further details on how to use this function, visit https://wiki.analog.com/resources/eval/user-guides/eval-ad5940/calibration_routines/hstia_cal?doc=EVAL-ADuCM355QSPZ-UG-1308.PDF.

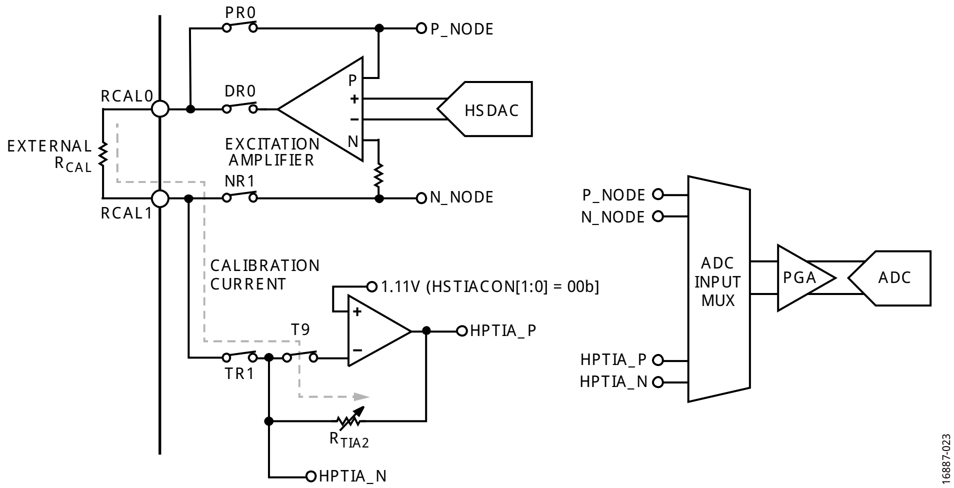

Figure 33. High Speed DAC, High Speed TIA, and Switch Matrix Settings for R_{TIA2} Calibration

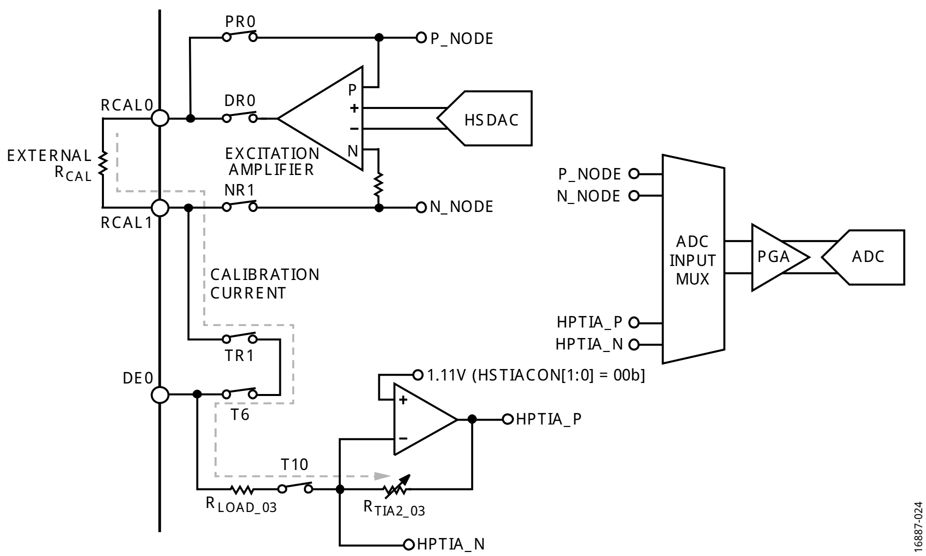

Figure 34. High Speed DAC, High Speed TIA, and Switch Matrix Settings for R_{TIA2_03} Calibration

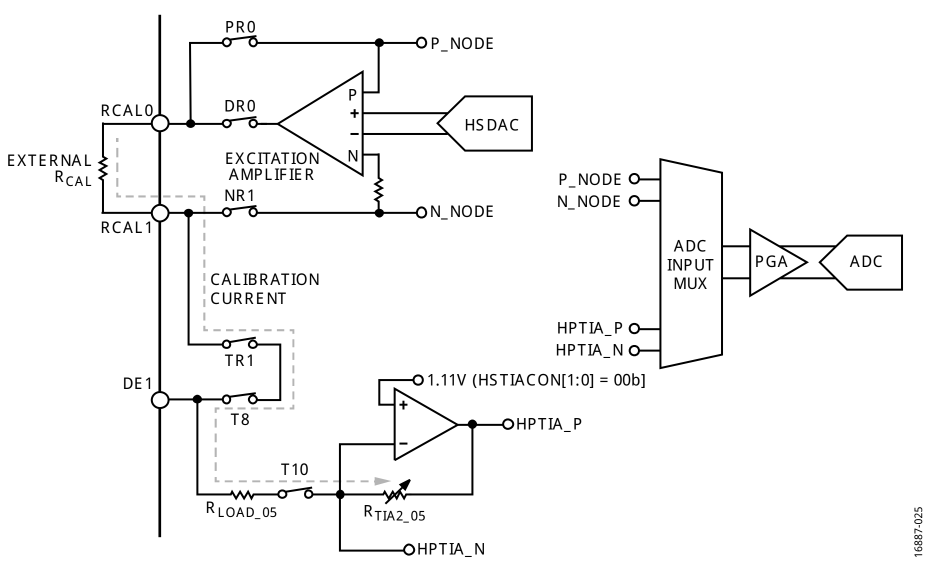

Figure 35. High Speed DAC, High Speed TIA, and Switch Matrix Settings for R_{TIA2_05} Calibration

LOW POWER TIA0/TIA1 GAIN RESISTOR CALIBRATION

The ADuCM355 contains two independent, low power TIA channels.

Each TIA has an independent, programmable gain resistor to scale the input current from the SE0 pin and the SE1 pin to a voltage that the ADC can measure.

Figure 36 shows the gain resistor for the low power TIA0. A similar diagram is valid to use for the low power TIA1.

Similar to the example described in the High Speed TIA Gain Resistor Calibration section, adjust the gain resistor to convert the current from the SE0 input pin and the SE1 input pin to a differential voltage across the R_{TIA} resistors.

These resistors have an initial accuracy range and vary with temperature, as specified in the ADuCM355 data sheet.

When these resistors are uncalibrated, an error is present when measuring an absolute input current.

To generate a precision calibration current, use the low power DAC to create a differential voltage across an external precision R_{CAL} resistor that is connected to the ADuCM355 RCAL0 pin and RCAL1 pin. The precision calibration current is routed through either the low power TIA0 gain resistor or the low power TIA1 gain resistor.

Because the calibration current value is known and the ADC can measure the voltage drop across each R_{TIA} resistor, the exact R_{TIA} resistor value can be determined.

Figure 37 and Figure 38 show the setup and switch settings used to connect the low power DAC outputs to the external R_{CAL} resistor so that the current flows into the LPTIAx gain resistors, LPRTIAx.

Several example projects in the ADuCM355 SDK implement a function to calibrate the gain resistor. For further details on how to use this function, visit https://wiki.analog.com/resources/eval/user-guides/eval-ad5940/calibration_routines/lptia_cal?doc=EVAL-ADuCM355QSPZ-UG-1308.PDF.

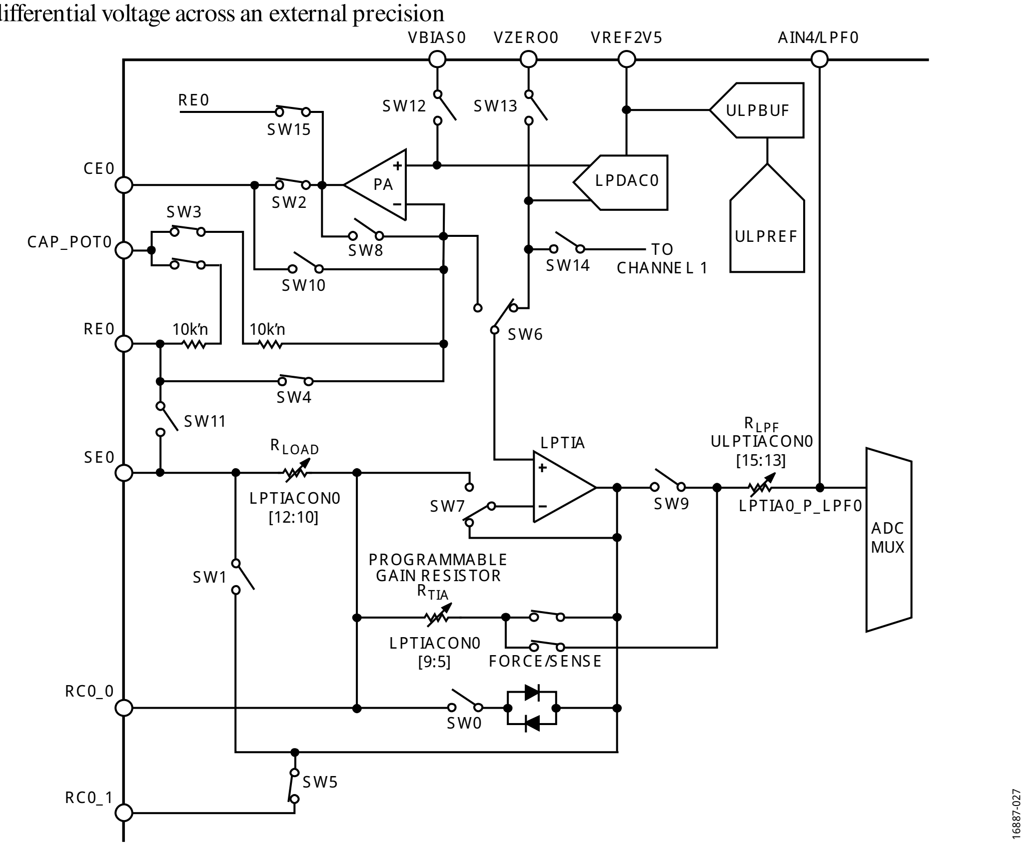

Figure 36. LPTIA0 Gain Calibration Resistor

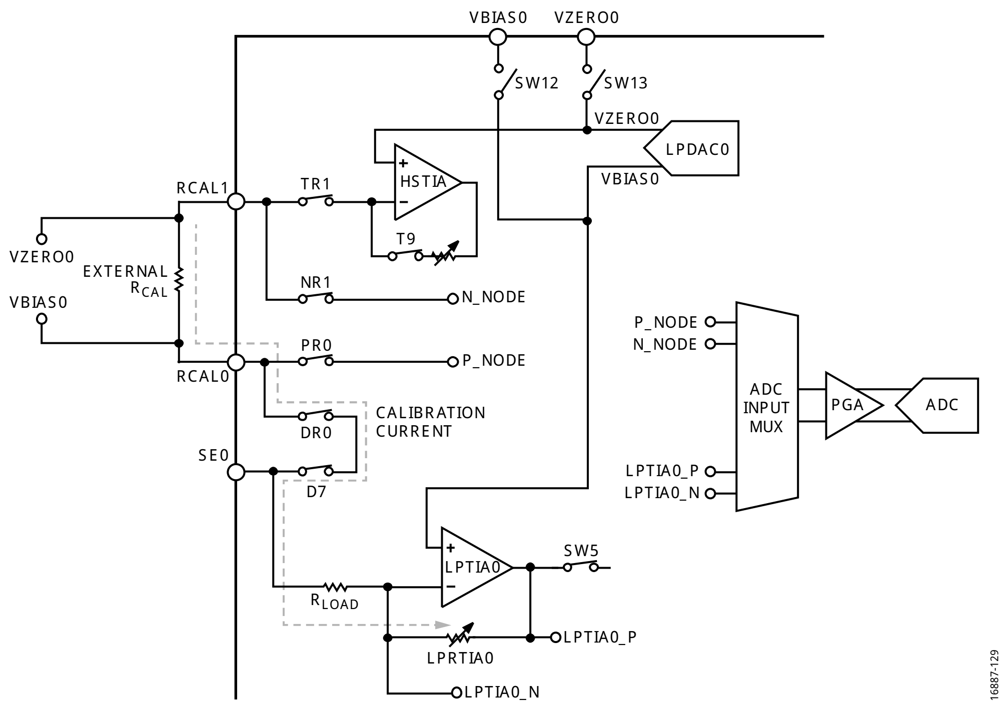

Figure 37. High Speed TIA, Low Power TIA0, and Switch Matrix Settings for LPRTIA0 Resistor Calibration

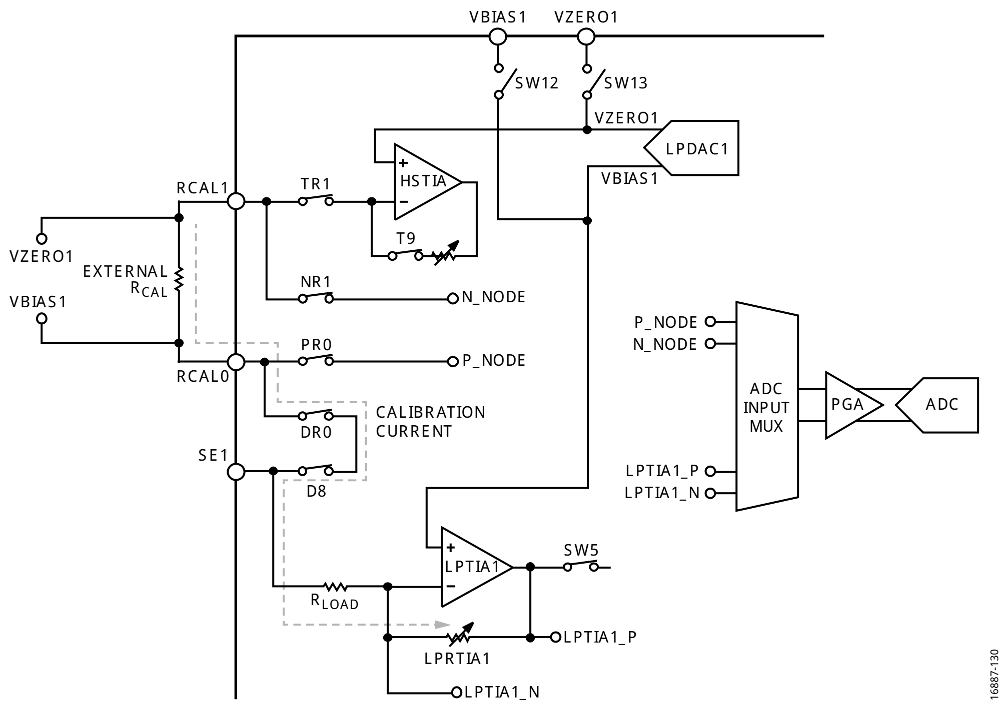

Figure 38. High Speed TIA, Low Power TIA0, and Switch Matrix Settings for LPRTIA1 Resistor Calibration

ORDERING INFORMATION

To view the complete EVAL-ADuCM355QSPZ schematic, visit https://www.analog.com/media/en/technical-documentation/evaluation-documentation/EVAL-ADuCM355-RevBSchematic.pdf.

To view the PCB layout, visit https://www.analog.com/media/en/technical-documentation/evaluation-documentation/EVAL-ADuCM355-EvalBrd_Layout.pdf.

BILL OF MATERIALS

Table 2.

Name	Value	Part Description	Manufacturer	Part No.
AVDD, DVDD	25.195.0253.0	Connector PCB terminal block 3.5 mm	Wieland Electric GMBH	25.195.0253.0
C1, C2, C14, C34, C35, C36	0.1 µF	Ceramic capacitor, X7R	Wurth Elektronik	8.85012E+11
C9 to C12, C17 to C21, C28, C29	0.1 µF	Ceramic capacitor, X5R, ultrabroadband	American Technical Ceramics	545L104KT10C
C13	220 pF	Ceramic capacitor, X7R	Kemet	C0402C221J5RACTU
C23, C25 to C27, C30, C31	0.47 µF	Ceramic capacitor, X5R, 0402	Taiyo Yuden	LMK105BJ474KV-F
C24	4.7 µF	Ceramic capacitor, X6S, general-purpose	Murata	GRM185C81A475KE11D
C32, C33	7 pF	Ceramic capacitor NP0 (C0G), high frequency, high-Q	Murata	GJM1555C1H7R0CB01D
C37 to C41, C47, C49, C53 to C55	0.1 µF	Ceramic chip capacitor, X8R	TDK	C1608X8R1E104K080AA
C42, C46, C48, C52, C57	10 µF	Tanceram® chip capacitor, X5R, low equivalent series resistance (ESR)	Johanson Dielectrics	250R18X106KV4E
C43 to C45	1 µF	Ceramic capacitor, Y5V	Yageo	CC0603ZRY5V6BB105
CH0, CH1	CO-A4	4-lead electrochemical sensor socket	Alphasense	CO-A4
C_LPF0, C_LPF1	4.7 µF	Ceramic capacitor, 0805, X5R	Taiyo Yuden	EMK212BJ475KG-T
DS1	SML-310MTT86	LED, green surface mount	ROHM	SML-310MTT86
DS2	LNJ926W8CRA	LED, blue surface mount	Panasonic	LNJ926W8CRA
E1, E2	80 Ω at 100 MHz	Ferrite bead, 0.1 Ω maximum dc resistance, 1 A	Murata Manufacturing	BLM41PF800SN1L
E3, E4	60 Ω at 100 MHz	Inductor chip ferrite, 0.02 Ω dc resistance, 3.5 A	Murata	BLM21PG600SN1D
JP4, JP5, JP7 to JP20	0	Resistance jumper	Panasonic	ERJ-6GEY0R00V
JP25 to JP36, JP38 to JP46	M20-9990245	Connector PCB, straight male jumper, 2-position, M020779	Harwin	M20-9990245
JP6	0	Use existing E004447	Panasonic	ERJ-3GSYJ0.0
P1	TSW-110-08-G-S	Connector PCB, straight header 10-position	Samtec	TSW-110-08-G-S
P14, P26	TSW-101-07-G-D	Connector PCB, dual straight header, 2-position	Samtec	TSW-101-07-G-D
P2	TSW-120-07-S-S	Connector PCB, 20-position, unshrouded male header, 0.64 mm square post, 2.5 4 mm pitch, 5.84 mm post height, 2.54 mm solder tail	Samtec	TSW-120-07-S-S
P27	TSW-104-25-F-D-RA	Connector PCB header, 2.54 mm square post, dual row, right angle	Samtec	TSW-104-25-F-D-RA
P3	2520-6002-UB	Connector PCB header, straight male, 20-position	3M	2520-6002UB
P4	47346-0001	Connector PCB microUSB receptacle	Molex	47346-0001
P5	IPS1-109-01-L-D	Connector PCB, 18-position, female header, shrouded dual row, straight, 2.54 mm solder tail, 2.54 mm pitch	Samtec	IPS1-109-01-L-D
Q1, Q2	MMBFJ177	Precision channel junction field effect transistor (JFET) switch	Fairchild Semiconductor	MMBFJ177
R1, R2	150 kΩ	Precision thick film chip resistor, R0603	Panasonic	ERJ-3EKF1503V
R10, R17	560 Ω	Thick film chip resistor	Multicomp (SPC)	MC0063W06031560R
R14	0 Ω	Thick film chip resistor	Multicomp (SPC)	MC00625W040210R