Si890x Digital Isolator-Based, 10-Bit Isolated Monitoring ADC User's Guide

1. Introduction

The Si890x are isolated ADCs suitable for low-frequency analog data acquisition applications. These devices integrate an isolated 10-bit SAR ADC with I^2C, UART, or SPI serial communication ports. Isolation ratings of 2.5 or 5 kV are available. See the Si8900 data sheet for details.

2. Kit Contents

The Si890xPWR-EVB Evaluation kit contains the following items:

- Si890xPWR-EVB evaluation module containing:
  - High voltage 110 V/220 V ac line current and voltage measurement circuit with 3.3 Vpp analog output signals
  - Si8900 Isolated 10-bit ADC with UART serial port
  - Si8901 Isolated 10-bit ADC with I^2C serial port
  - Si8902 Isolated 10-bit ADC with SPI serial port
  - C8051F007 mixed-signal MCU master controller
  - AC line-side bias supply

2.1. Hardware Overview

The Si890xPWR-EVB (Figure 1) demonstrates 50/60 Hz ac line voltage and current measurements. This EVB is housed in a plastic case with recessed connectors to protect against user electrical shock. The Si890x accepts a 110 or 220 Vac input and supports load currents up to 10 A (max). The on-board line side circuit interface measures ac voltage and current, which is then digitized by the Si890x on-chip 10-bit ADC. The resulting converted data is then transmitted through the output side isolated serial port to the on-board master processor (C8051F007 MCU). The C8051F007 converts the serial data back to analog format where it is available to the user at the low-voltage side of the evaluation module.

Key features for this EVB include the following:

- EVB module measures ac line voltage (110 Vac or 220 Vac at 50/60 Hz) and ac line current (10 A max)
- 10-bit ADC with three input channels and selectable, isolated serial ports: UART (Si8900) or I^2C (Si8901) or SPI (Si8902)
- High common mode transient immunity (CMTI): 35 kV/µs (min), 50 kV/µs (typ)
- Industrial temperature operating range (–40 to +85 °C)
- 60-year isolation barrier life at rated working voltage
- Safety certified (pending)
  - CSA component notice 5A approval
  - IEC 60950, 61010, 60601
  - VDE/IEC 60747-5-2
  - UL1577 recognized: (Up to 5 kVrms for 1 minute)

Danger! High Voltage: Read instructions carefully. Do not operate this evaluation board unless it is housed in its plastic case and secured by the four screws.

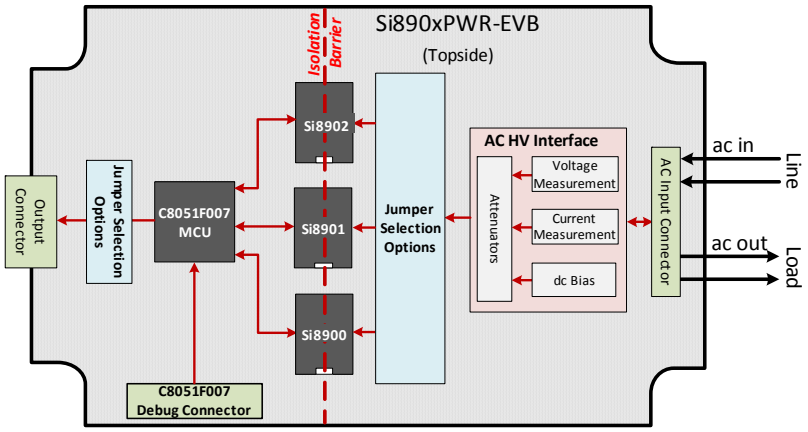


Figure 1. Si890xPWR-EVB Block Diagram

Figure 2. Si890xPWR-EVB Circuit Board and Plastic Housing

Figure 2 shows photographs of the EVB circuit board and plastic housing. Note the location of the Si8900, Si8901, and Si8902 ICs, which are centered between the two isolated ground planes. The ac input barrier strip (TB-1, bottom side of board) is recessed to provide an extra margin of space between the housing exterior and the ac line connection.

Safety Warning: The board MUST remain in the plastic enclosure whenever the ac line voltage is connected to the Si890x input terminals.

3. Required Equipment

- One dc regulated power supply capable of generating 2.7 V to 3.6 Vdc at 200 mA.
- Small hand tools: soldering iron, wire cutters, needle-nose pliers, wire stripper, screwdrivers.
- Minimum two-channel oscilloscope.
- 22-gauge stranded wire for low-voltage signal connector P1.
- A suitable ac load (e.g., power resistor, lamp with or without dimmer, max current of 10 A).
- AC line cord wire (**Note**: wire gauge depends on the amount of current to be measured).
- Optional line-side external dc supply input. Use only if the EVB is connected to a low-voltage (5 V or less) line-side device instead of the ac line).

4. EVB Factory Jumper Configuration

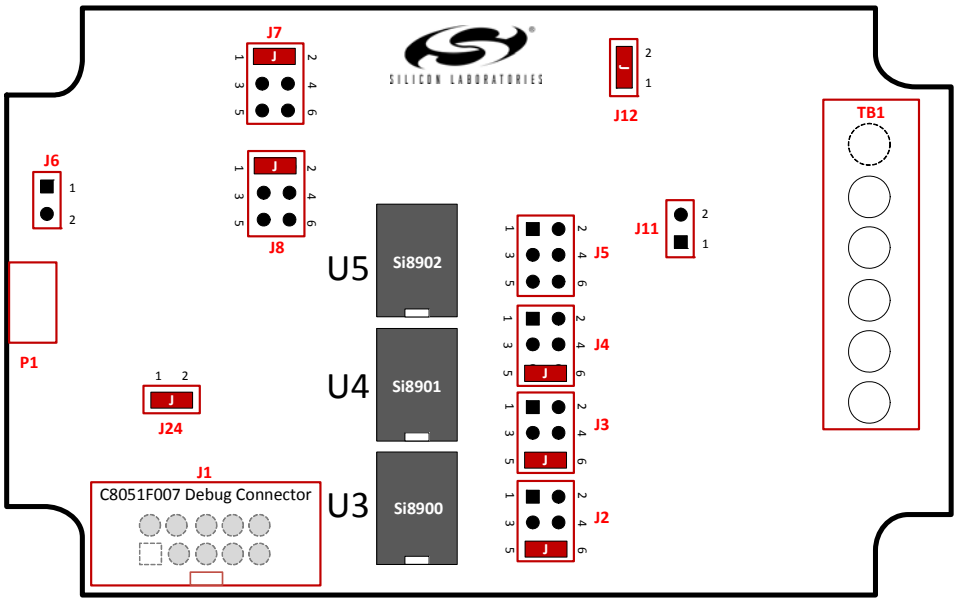


Figure 3. EVB Default (Factory) Jumper Settings

Table 1. Factor Jumper Settings

Item	Function	Settings	Comments
J1	Master MCU debug connector	None	User can optionally modify Master MCU firmware*
J2	ADC channel 1 analog input	5-6	Si8900 ADC channel AIN1 measures ac line voltage
J3	3.3 V bias voltage	5-6	3.3 V bias voltage connected to Si8900
J4	ADC channel 0 analog input	5-6	Si8900 ADC channel AIN0 measures ac line voltage
J5	ADC channel 2 analog input	No Jumper	Not Used
J6	Master MCU RESET input	No Jumper	Adding a jumper disables master MCU, customer master uses serial ports
J7	Output connector P1 pin D0 assignments	1-2	Si8900 UART Rx input assigned to P1 pin D0
J8	Output connector P1 pin D1 assignments	1-2	Si8900 UART Tx output assigned to P1 pin D1
J11	110 Vac or 220 Vac line voltage select	No Jumper	110 Vac line voltage selected
J12	3.3 V bias voltage	1-2	3.3 V bias voltage generated from ac line (no jumper = VDD coming from TB-1, pin 4)
J24	For future use	1-2	For future use
***Note:** Requires C8051F005 MCU Development Kit			

Table 2. User Jumper Options

Item	Pins 1–2	Pins 3–4	Pins 5–6
J2	Connects ac current signal to U3, AIN1	Connects ac current signal to U5, AIN1	Connects ac current signal to U4, AIN1
J3	Connects 3.3 V bias to U5, VDDA	Connects 3.3 V bias to U3, VDDA	Connects 3.3 V bias to U4, VDDA
J4	Connects ac line voltage signal to U5, AIN0	Connects ac line voltage signal to U3, AIN0	Connects ac line voltage signal to U4, AIN0
J5	Connects external AIN2 to U5, AIN2	Connects external AIN2 to U3, AIN2	Connects external AIN2 to U4, AIN2
J6	Holds master MCU in reset	N/A	N/A
J7	Connects UART Rx to D0 output header	Connects I^2C port SCL to D0 output header	Connects SPI port SD0 to D0 output header
J8	Connects UART Tx to D1 output header	Connects I^2C port SDA to D1 output header	Connects SPI port SCLK to D1 output header
J11	Jumper when using 220 Vac input (no jumper for 110 V)	N/A	N/A
J12	Jumper if using on-board VDDA supply (no jumper for external 3.3 V bias)	N/A	N/A

5. Hardware Setup and Demo

Safety Warning: Remove power from the board before proceeding!

Setting-up the Si890xPWR-EVB evaluation module requires configuring the jumper options, then connecting the input and output cables with the ac line disconnected and the external dc power supply off. EVB setup and configuration is as follows:

1. Remove the four screws from the bottom of the EVB plastic enclosure and remove the top cover.
2. The default factory EVB settings enable the Si8900 (UART). Verify the factory jumper option settings using Table 1 (use Figure 3 to locate the configuration headers). If so desired, the Si8901 or Si8902 can be selected instead of the Si8900 by following the instructions in Paragraph 3. Otherwise, skip to paragraph 4.
3. Configuring an Isolated ADC:

   a.Choose the isolated ADC to be enabled (Note that only one ADC can be in service at a time).

   b.Headers J2, J3 and J4 route the ac line-side VDD, AIN0, and AIN1 corresponding pins of the desired Si890x device (Input AIN0 typically measures line input voltage, and AIN1 typically measures ac line current). For example, if the Si8902 is the device to be used, insert shorting jumpers between pins 1 and 2 on headers J2, J3, and J4 as shown in the “Selecting Si8902” drawing of Figure 4. Configurations for selecting the Si8900 and Si8901 are also shown in Figure 4.

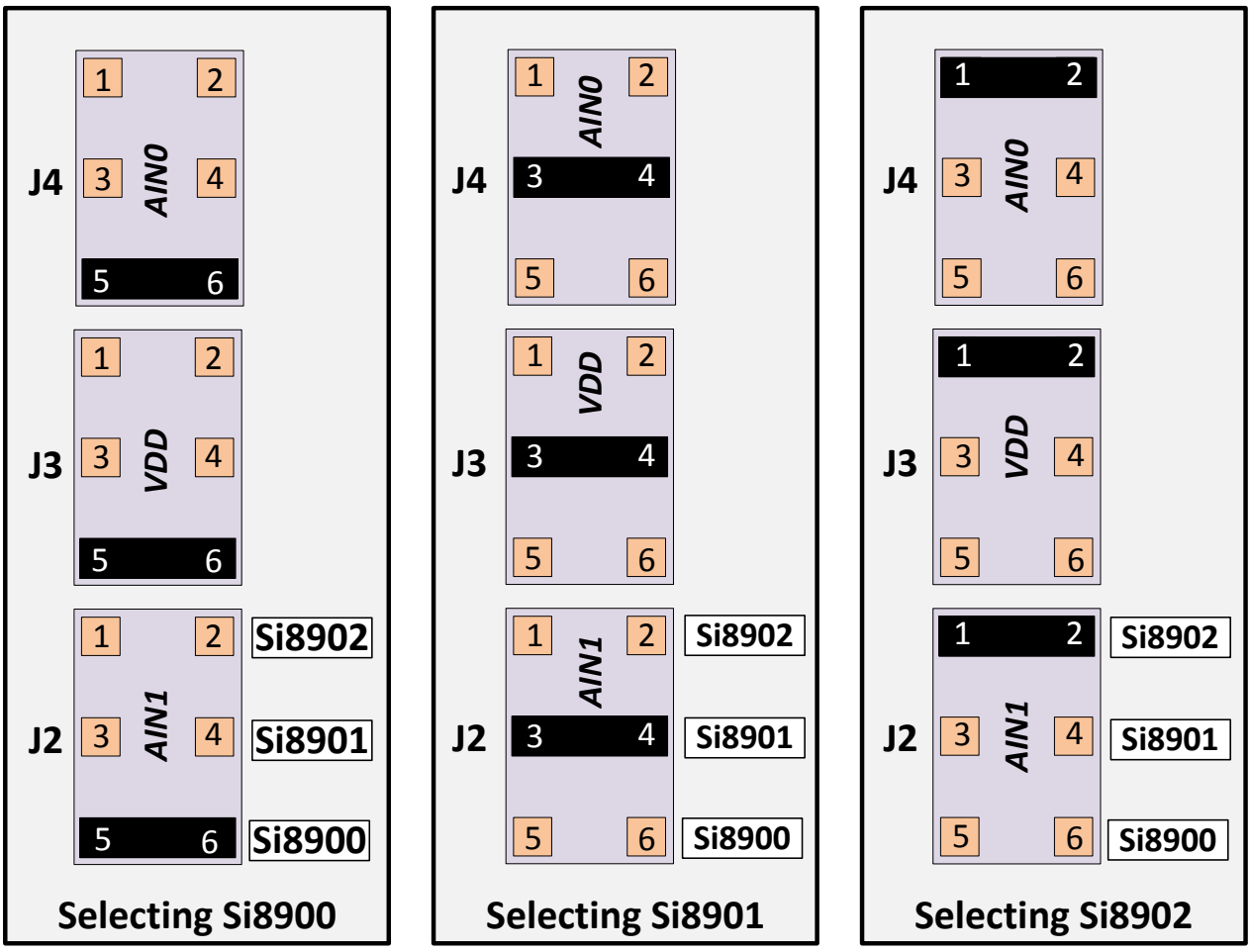


Figure 4. Si890x Input Configuration Jumpers

c.The serial port pins for the selected Si890x device are routed to output connector P1 by configuring headers J7 and J8 as shown in Figure 5.
1. If using the Si8900, install shorting jumpers on pins 1 and 2 on both J7 and J8.
2. If using the Si8901, install shorting jumpers on pins 5 and 6 on both J7 and J8.
3. If using the Si8902, install shorting jumpers on pins 3 and 4 on both J7 and J8.

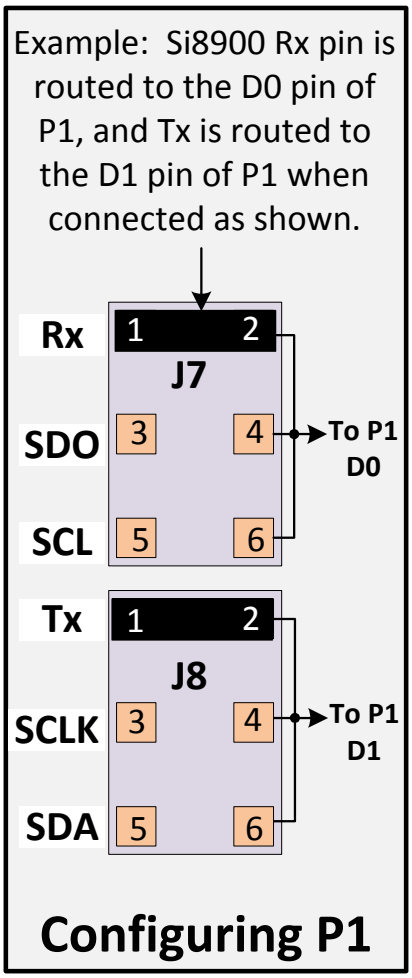


Figure 5. Configuring Output Connector P1

4. Locate the six-screw ac line terminal block (TB1) on the right side of the circuit board. With the ac line disconnected from the outlet, loosen the screws on TB1 corresponding to AC_H and GNDA, as shown in Figure 6. Strip 1/4 inch of insulation from the “hot side” of the ac wire and insert the wire through the enclosure opening and into the AC_H terminal block opening. Be sure there is no bare wire exposed. Tighten the screw on the terminal block to secure the AC_H wire. Repeat this procedure for the GNDA wire connection to TB1.
5. Locate the ac output (load) terminals AC_OUT and AC_H on TB1 as shown in Figure 6. With the ac line disconnected from the outlet, loosen the screws on TB1 corresponding to AC_OUT and AC_H, as shown in Figure 3. Strip 1/4 inch of insulation from the “hot side” of the ac wire and insert the wire through the enclosure opening and into the AC_H terminal block opening. Be sure there is no bare wire exposed. Tighten the screw on the terminal block to secure the AC_H wire. Repeat this procedure for the AC_OUT wire connection to TB1.

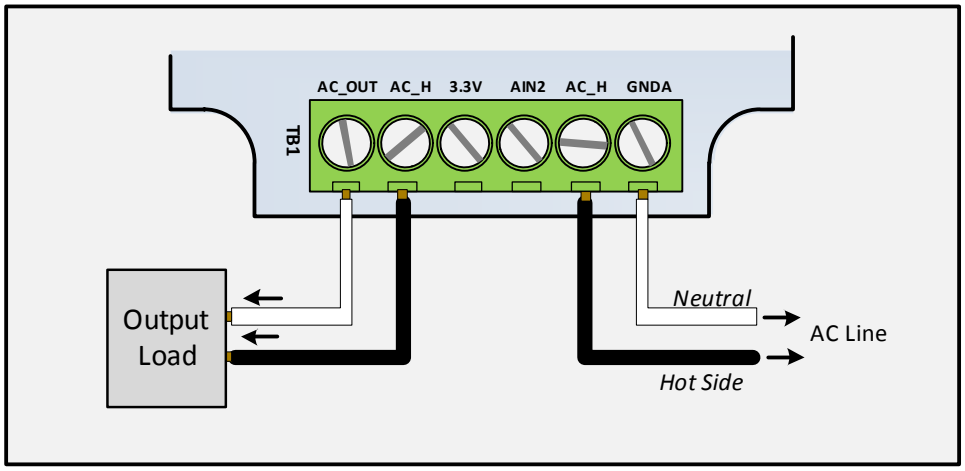


Figure 6. AC Line and Load Connections to Barrier Strip TB1 (Top of Board View)

6. Connect the loose ends of the AC_OUT and AC_H wires from TB1 to the load (e.g. power resistor, lamp, etc.).
7. Replace the top cover of the enclosure and secure with four screws. Examine the ac line side of the enclosure and verify that the ac lines external to the enclosure have no bare wire exposed.
8. Locate the male connector that mates to output side connector P1 (see Figure 5) and test fit to connector to P1. Remove the connector from P1. Cut nine equal lengths of AWG28 wire, each one eight inches long. Strip 1/4 inch of insulation from each end of all eight wires. Solder one end of each wire to each wire to the male connector. When soldering is complete, plug the male connector into P1.
9. Obtain an external adjustable power supply (bench or lab supply), but do not connect it to the Si890x EVB yet. With no load attached, turn the power supply on and set the output to 3.3 V. Turn the power supply off and discharge its outputs by shorting the positive and negative terminals together.
10. Connect the dc supply outputs to the VDDB and GNDB input pins of P1, as shown in Figure 7.
11. Turn the oscilloscope on and connect oscilloscope probes to the DAC0 and DAC1 output pins of P1, as shown in Figure 7.

PIN#	FUNCTION
1	VDDB
2	GNDB
3	D0
4	D1
5	SDI
6	/EN
7	DAC0
8	DAC1
9	Not Used

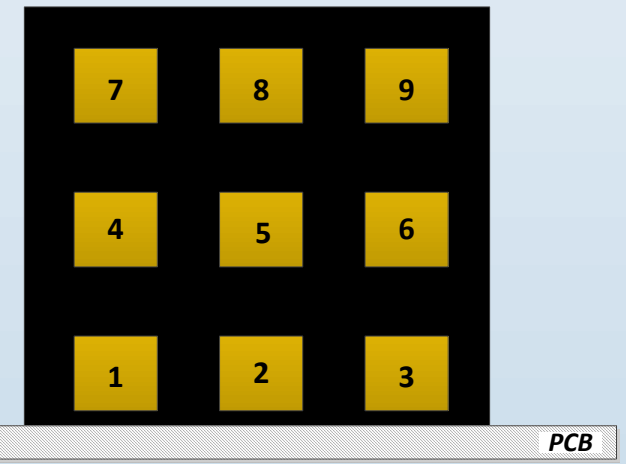


Figure 7. Low Voltage Connections to Output Connector P1

12. Turn on the oscilloscope and plug the ac input lines into a source of 110/220 Vac, then turn on the external dc power supply. With the load engaged, the voltage (blue) and current (yellow) waveforms will appear on the oscilloscope as shown in Figure 8. Vary the load to observe the changes in current.
13. To power the EVB down, first unplug the ac line connection then turn the external dc power supply off.

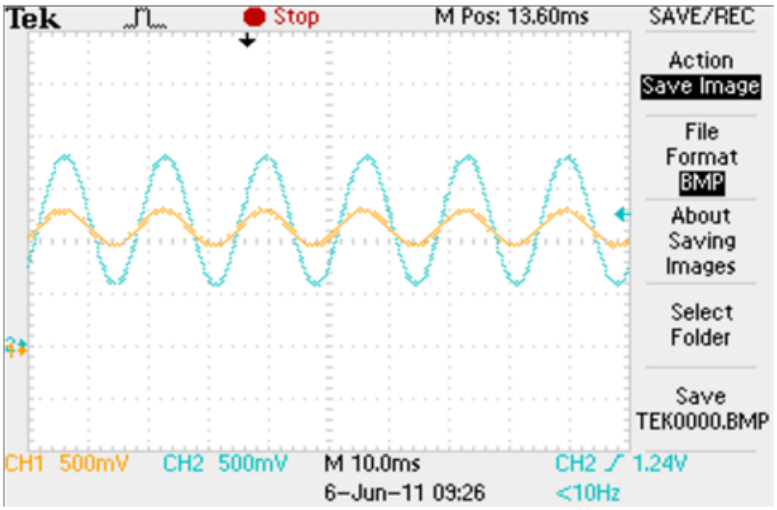


Figure 8. AC Voltage (Blue) and Current (Yellow) Waveform from Analog Output of the Master Controller (C8051F007) as Displayed on the Oscilloscope

6. Schematics

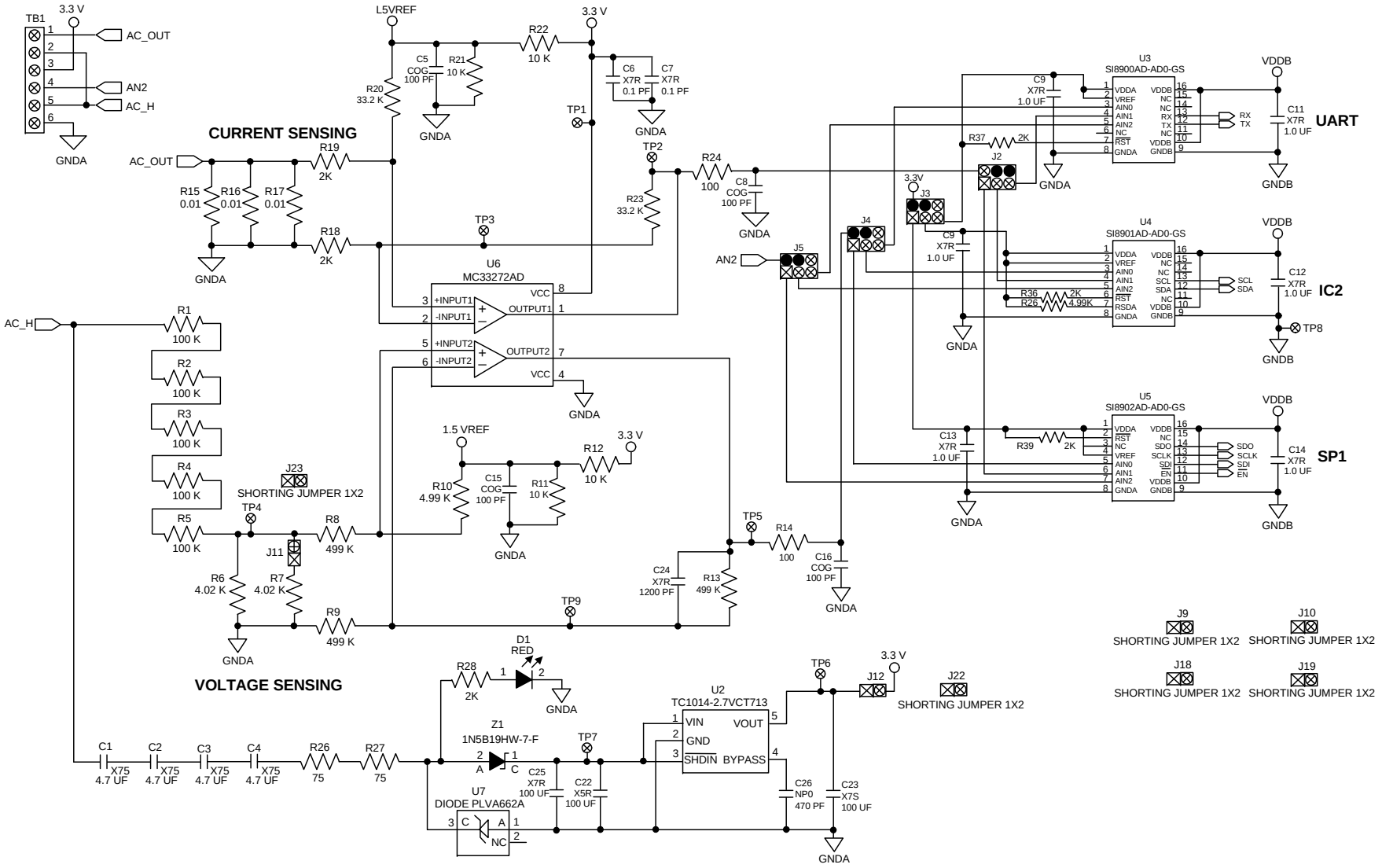


Figure 9. Measurement Circuits

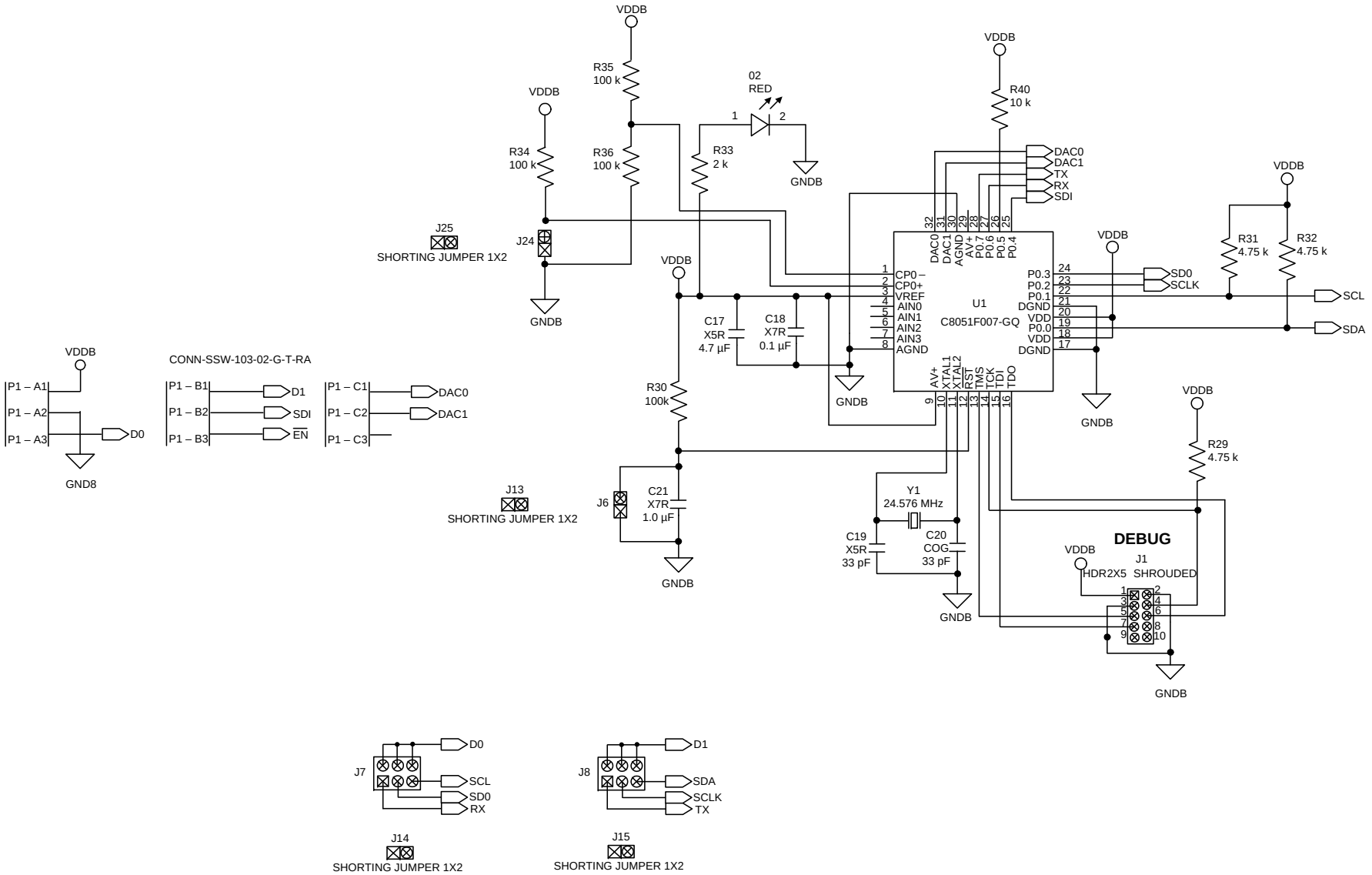


Figure 10. Master Controller Circuit

7. Bill of Materials

Table 3. Si890xPWR Bill of Materials*

Item	Quantity	Reference	Part Number	Source	Description
1	1	U1	C8051F007-GQ	Silicon Labs	MIXED SIGNAL 32 kB ISP FLASH, MCU, LQFP32-7X7, RoHS
2	2	C6 C18	399-1282-1-ND		CAP, 0.1 µF, X7R, CERAMIC, 0603, 25 V, ±5%, or EQ, RoHS
3	8	C7,9-14,21	490-3899-1-ND		CAP CERAMIC, 1.0 µF, X5R, 0603, 10 V, ±10%, RoHS.
4	4	C5,8,15,16	478-1175-1-ND		CAP, 100 pF, C0G, CERAMIC, 0603, 50 V, ±5%, or EQ, RoHS.
5	2	C22 C25	445-1437-1-ND		CAP, 100 µF, X5R, CERAMIC, 1210, 6.3 V , ±20%, or EQ, RoHS.
6	1	C23	445-4536-1-ND		CAP, 10 µF, X7S, CERAMIC, 1210, 100 V, ±10%, RoHS.
7	1	C24	PCC122BNCT-ND		CAP CERAMIC, 1200 pF, X7R, 0805, 50 V , ±10%, or EQ, RoHS.
8	2	C19-20	PCC330CGCT-ND		CAP, 33 pF, NPO,CERM, 0805, 50 V, ±5%, or EQ, RoHS.
9	1	C17	PCC2318CT-ND		CAP, 4.7 µF, X5R, CERAMIC, 0603, 6.3 V, ±20%, or EQ, RoHS.
10	4	C1-4	445-5211-1-ND		CAP, 4.7 µF, X7S, CERAMIC, 1812, 100 V, ±10%, RoHS.
11	1	C26	0603CG471G9B200-ND		CAP, 470 pF, NP0, CERAMIC, 0603, 50 V, ±2%, or EQ, RoHS.
12	1	P1	SSW-103-02-G-T-RA		CONN, 3X3-RA, RoHS
13	1	Z1	1N5819HW-FDICT-ND		DIODE SCHOTTKY, 40 V, 1A, SOD123, RoHS.

***Note:** All components on this BOM are Lead Free.

Table 3. Si890xPWR Bill of Materials*

Item	Quantity	Reference	Part Number	Source	Description
14	1	U7	PLVA662A,215-ND		DIODE ZENER 6.2 V 250 mW, SOT-23, RoHS.
15	4	J6,11,12,24	S1011E-02-ND		STAKE HEADER, 1X2, 0.1"CTR, GOLD, OR EQ, RoHS.
16	6	J2-5 7-8	S2011E-03-ND		STAKE HEADER, 2X3, 0.1"CTR, GOLD, OR EQ, RoHS.
17	1	J1	MHC10K-ND		HEADER, SHROUDED, 2X5, OR EQ, RoHS.
18	2	D1-2	350-1555-ND		LED RED, T1, 3 mm, 2.0 V, DIFF DBL-FLANGE, or EQ, RoHS.|
19	1	U6	MC33272ADR2GOSCT-ND		OPAMP, DUAL, HI SPEED, 8SOIC, RoHS.
20	3	R15-17	985-1197-1-ND		RES, 0.01 Ω, 1.0 W, 2010, 1%, SMD, or EQ, RoHS.
21	2	R14 R24	P100ACT-ND		RES, 100 Ω, SMT, 0805, 1/8W, ±5%, or EQ, RoHS.
22	4	R30,34-36	P100KACT-ND		RES, 100 k, SMT, 0805, 1/8W, ±5%, or EQ, RoHS.
23	5	R1-5	541-100KUCT-ND		RES, 100 k, SMT, 1206, 1/2W, ±1%, or EQ, RoHS.
24	5	R11-12,21-22,40	P10.0KCCT-ND		RES, 10.0 kΩ, SMT, 0805, 1/8W, ±1%, or EQ, RoHS.
25	7	R18-19,28,33,37-39	311-2.0kARCT-ND		RES 2 kΩ, SMT, 0805, 1/8W, ±5%, or EQ, RoHS.
26	2	R20 R23	RT0805FRE0733K2L-ND		RES, 33.2 kΩ, SMT, 0805, 1/8W, ±1%, or EQ, RoHS.

***Note:** All components on this BOM are Lead Free.

Table 3. Si890xPWR Bill of Materials*

Item	Quantity	Reference	Part Number	Source	Description
27	2	R6-7	311-4.02KCRCT-ND		RES, 3.85 kΩ, SMT, 0805, |1/8W, ±1%, or EQ, RoHS.
28	3	R29,31-32	P4.75KCTR-ND		RES, 4.75 kΩ , SMT, 0805, |1/8W, ±1%, or EQ, RoHS.
29	1	R25	P4.99KCCT-ND		RES, 4.99 kΩ, SMT, 0805, 1/8W, ±1%, or EQ, RoHS.|
30	4	R8-10 R13	P499KCCT-ND		RES, 499 kΩ, SMT, 0805, 1/8W, ±1%, or EQ, RoHS.
31	2	R26-27	RHM75ERCT-ND		RES, 75 Ω, SMT, 1206, 1/4W, ±5%, OR EQ, RoHS.
32	1	J9-10,13-15,18-19, 22-23,25	S9001-ND		CONN, JUMPER SHORTING, TIN, OR EQ, RoHS. (INSERT AFTER TEST)
33	1	U3	Si8900AD-A00-GS	Silicon Labs	IC, ISOLATED MONITORING ADC, RoHS.|
34	1	U4	Si8901AD-A00-GS	Silicon Labs	IC, ISOLATED MONITORING ADC, RoHS.
35	1	U5	Si8902AD-A00-GS	Silicon Labs	IC, ISOLATED MONITORING ADC, RoHS.
36	1	U2	TC10143.3VCT713CT-ND		IC, CMOS, LDO, 3.3 V, 50 MA, SOT23-5, RoHS.
37	9	TP1-9	NO POP		TEST POINT, WIRE WRAP VIA, OR EQ, RoHS.
38	1	TB1	277-1251-ND		TERM. BLOCK, 5.08 mm CTRS, 6 POS, RoHS.
39	1	Y1	CTX092-ND		CRYSTAL, 24.576 MHz SERIES, RoHS.
***Note:** All components on this BOM are Lead Free.					

8. Ordering Guide

Table 4. Product Ordering Information[1,2,3]

Part Number (OPN)	Serial Port	Package	Isolation Rating	Temp Range
Si8900B-A01-GS	UART	WB SOIC	2.5 kV	–40 to +85 °C
Si8900D-A01-GS	UART	WB SOIC	5.0 kV	–40 to +85 °C
Si8901B-A01-GS	I^2C/SMBus	WB SOIC	2.5 kV	–40 to +85 °C
Si8901D-A01-GS	I^2C/SMBus	WB SOIC	5.0 kV	–40 to +85 °C
Si8902B-A01-GS	SPI Port	WB SOIC	2.5 kV	–40 to +85 °C
Si8902D-A01-GS	SPI Port	WB SOIC	5.0 kV	–40 to +85 °C

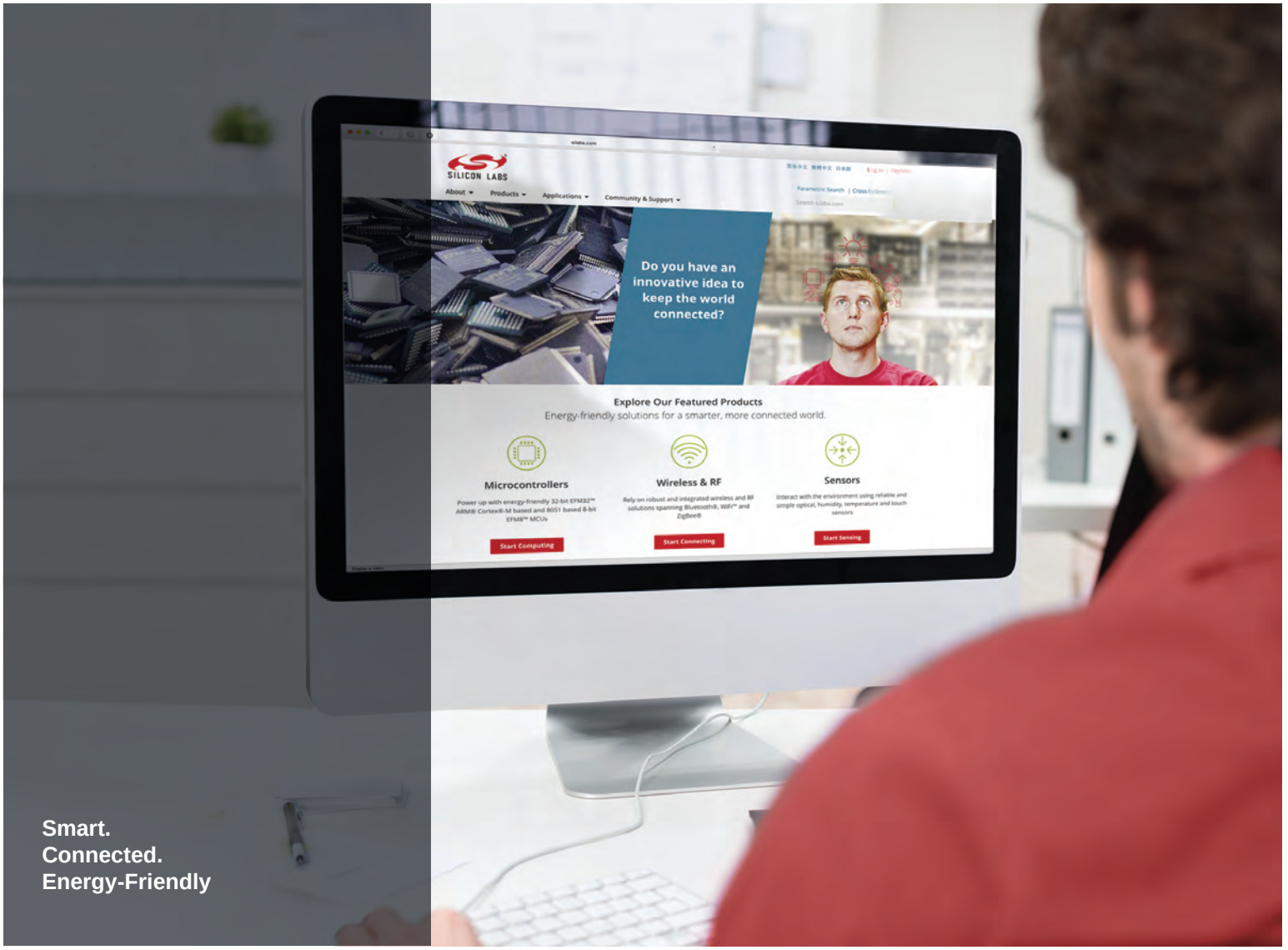
Notes:
1. Add an “R” suffix to the part number to specify the tape and reel option. Example: “Si8900AB-A-ISR”.
2. All packages are RoHS-compliant.
3. Moisture sensitivity level is MSL3 for wide-body SOIC-16 package with peak reflow temperatures of 260 °C according to the JEDEC industry standard classifications and peak solder temperatures.

DOCUMENT CHANGE LIST

Revision 1.0 to Revision 1.1

- Updated Figure 7 on page 8.

NOTES:



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