Evaluating the ADA4870, 2500 V/µs Slew Rate, High Voltage, 1 A Output Drive Amplifier

FEATURES

- Enables easy evaluation of the ADA4870
- Single-supply or dual-supply operation
- Robust thermal management

APPLICATIONS

- Organic light-emitting diode (OLED) panel driver
- Active matrix organic light-emitting diode (AMOLED) panel driver
- Base transceiver station (BTS) envelope tracking
- Power field effect transistor (FET) driver
- Ultrasound
- Piezoelectric driver
- PIN diode driver
- Waveform generation
- Automatic test equipment (ATE)
- Charge-coupled device (CCD) panel driver

GENERAL DESCRIPTION

The ADA4870 is a unity-gain stable, high speed current feedback amplifier capable of delivering 1 A of output current and 2500 V/µs slew rate from a 40 V supply. Manufactured using the Analog Devices, Inc., proprietary high voltage extra fast complementary bipolar (XFCB) process, the innovative architecture of the ADA4870 enables high output power, high speed signal processing solutions in applications that require driving a low impedance load.

The ADA4870 is ideal for driving high voltage power FETs, piezoelectric transducers, P-type intrinsic N-type (PIN) material diodes, CCD panels, and a variety of other demanding applications that require high speed from high supply voltage and high output current.

The ADA4870 is available in a 48-lead frame chip scale package (LFCSP) with an exposed pad that provides high thermal conductivity to the printed circuit board (PCB), enabling efficient heat transfer for improved performance and reliability in demanding environments. The ADA4870 operates over the industrial temperature range of −40°C to +85°C.

The EVAL-ADA4870EBZ evaluation board provides a platform for quick and easy evaluation of the ADA4870. Figure 1 shows the top side of the evaluation board. Figure 2 shows the bottom side of the board with the large exposed copper area for applying a heat sink as needed.

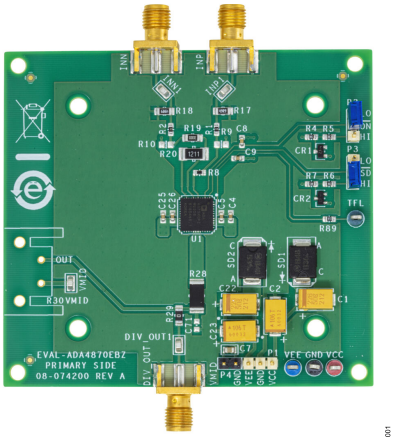

Figure 1. Evaluation Board, Top Side

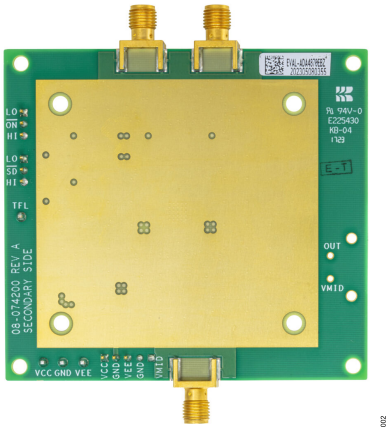

Figure 2. Evaluation Board, Bottom Side

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REVISION HISTORY

11/2023—Rev. C to Rev. D

Changes to Figure 1 and Figure 2 ... 1
Changes to Figure 6 ... 5

10/2023—Rev. B to Rev. C

Changed ADA4870ARR-EBZ to EVAL-ADA4870EBZ (Throughout) ... 1
Changes to User Guide Title ... 1
Changes to General Description Section, Figure 1, and Figure 2 ... 1
Changes to Power Supplies and Decoupling Section ... 3
Changes to Input and Output Section ... 3
Changes to Symmetrical Supplies and DC-Coupled Inputs Section ... 3
Changes to Asymmetrical Supplies and Mid Supply Bias (VMID) Section, Figure 4, and Figure 5 ... 3
Changes to Thermal Design and Heat Sink Selection Section and Figure 6 ... 5
Changes to Thermal Performance Section, Figure 8, and Figure 9 ... 6
Changes to Figure 10 ... 7
Changes to Table 2 ... 8

11/2022—Rev. A to Rev. B

Changes to Figure 6 ... 5

EVALUATION BOARD HARDWARE

BOARD STACK UP

The EVAL-ADA4870EBZ evaluation board is a 6-layer board. All signal routing is on the top layer; the bottom layer is an exposed copper ground plane to facilitate the use of a heat sink. The heat sink is needed for high power dissipation projects, such as driving a 20 Ω load with the maximum output swing. The internal layers (Layer 2 to Layer 5) consist of the GND, VCC, VMID, and VEE planes.

POWER SUPPLIES AND DECOUPLING

The evaluation board can be powered using a single supply or dual supplies. The total supply voltage (V_{CC} − V_{EE}) must be in the 10 V to 40 V range. The board provides sufficient power supply decoupling for high current, fast slewing signals with 22 µF and 10 µF tantalum capacitors installed at C1 and C2 where the V_{CC} supply voltage is applied to the board; 22 µF and 10 µF tantalum capacitors are installed at C22 and C23 where the V_{EE} supply voltage is applied to the board. In addition, 0.1 µF ceramic chip capacitors (C4 and C5) are placed in close proximity to the VCC pins (Pin 38 to Pin 41). And 0.1 µF ceramic chip capacitors (C25 and C26) are placed in close proximity to the VEE pins (Pin 20 to Pin 23).

INPUT AND OUTPUT

Figure 10 shows the evaluation board schematic for the factory default settings when the board is shipped.

The evaluation board uses edge-mount SubMiniature Version A (SMA) connectors and surface-mount test points on the inputs and outputs for easy interfacing to signal sources and test equipment. When evaluating high voltage output signals using standard 50 Ω test equipment, R29 can be replaced with a 2.45 kΩ resistor that provides a signal division of 49.6 at the DIV_OUT SMA connector and test point. The board can accommodate a capacitor load (C71) referenced to GND, and/or a power resistor in the TO-220 package (R30) referenced to VMID.

When using input signals of 5 V and lower, the board is equipped with 49.9 Ω, 0.25 W resistors at R17 and R18 that are capable of handling the power when using the factory default settings. The factory default configuration enables operation on dual symmetrical supplies in noninverting and inverting gains of +4.5 V/V, and −4.0 V/V, respectively. For single-supply and asymmetrical supply operation, see the Asymmetrical Supplies and Mid Supply Bias (VMID) section and Table 1 for guidance on configuring the input terminations and supply settings.

SYMMETRICAL SUPPLIES AND DC-COUPLED INPUTS

Figure 3 shows the noninverting or inverting configuration schematic when using dual, symmetrical supplies. When using the factory default settings with noninverting input, the ground reference is established through the 49.9 Ω termination resistor, R18, and the gain can be calculated using 1 + (R20/(R19 + R18)). The gain is +4.5 V/V for the factory default settings. When using the factory default settings with inverting input, the ground reference is established through the 49.9 Ω termination resistor, R17, and the gain can be calculated using −(R20/R19). The gain is −4.0 V/V for the factory default settings. In dual-supply operation, when installing R30 in either inverting or noninverting applications, position the jumper at P4 to short VMID to GND.

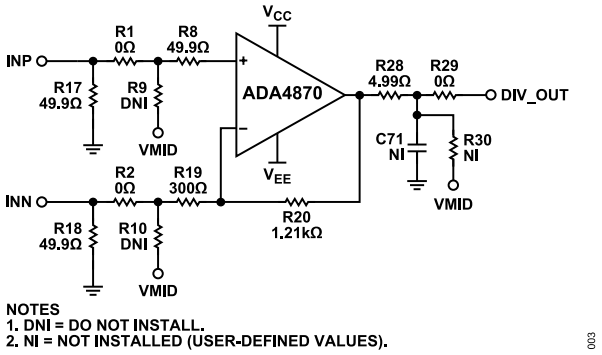

Figure 3. Schematic of Dual, Symmetrical Supplies with Noninverting or Inverting Input

ASYMMETRICAL SUPPLIES AND MID SUPPLY BIAS (VMID)

Figure 4 and Figure 5 show schematics when using a single supply with AC-coupled input.

The ADA4870 must be referenced to a DC operating point. When using a single supply or asymmetrical dual supplies, apply the appropriate reference voltage to the VMID pin of P4 using a low impedance source, such as a DC supply. The recommended VMID reference voltage is V_{EE} + (V_{CC} – V_{EE})/2.

When AC coupling into the noninverting input (INP), the DC operating point of the amplifier can be established by installing a resistor at R9 connected to VMID and replacing R1 with an AC coupling capacitor (C1), as shown in Figure 4. The AC coupling capacitor (C1) combined with the VMID bias resistor (R9) form a high-pass filter with the cutoff frequency at 1/(2 × π × R9 × C1). The value of the AC coupling capacitor (C1) can be calculated based on the desired cutoff frequency. Do not install R2. Short R10 to VMID.

When AC coupling into the inverting input (INN), the DC operating point of the amplifier can be established by shorting R9 to VMID and replacing R2 with an AC coupling capacitor (C2), as shown in Figure 5. Do not install R1 and R10.

EVALUATION BOARD HARDWARE

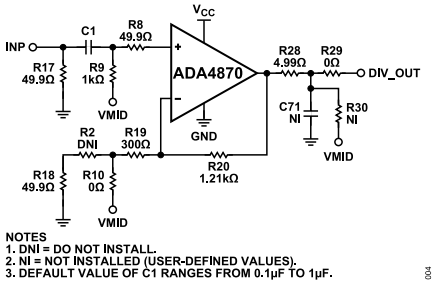

Figure 4. Schematic of Single Supply with Noninverting Input

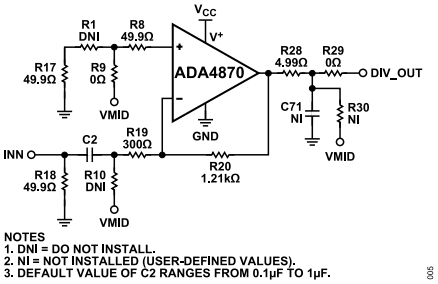

Figure 5. Schematic of Single Supply with Inverting Input

Table 1. Configuration of Input Components

Supply[1]	Configuration	Coupling	Gain (V/V)	R9 (Ω)	R10 (Ω)	R1 (Ω)	R2 (Ω)	P4 (VMID)
Dual	Noninverting	DC	+4.5	Do not insert	Do not insert	0	0	Open[2]
Dual	Inverting	DC	−4.0	Do not insert	Do not insert	0	0	Open[2]
Single	Noninverting	AC	+5.0	1,000	0	Capacitor[3]	Do not insert	DC voltage supply
Single	Inverting	AC	−4.0	0	Do not insert	Do not insert	Capacitor[3]	DC voltage supply

[1] Dual means symmetrical supplies; single means any non symmetrical supplies.

[2] If R30 is installed, short VMID to GND.

[3] When input AC coupling is required, replace the DC coupling resistor with an AC coupling capacitor.

$\overline{ON}$, INITIAL POWER-UP, AND SHORT CIRCUIT

The board is shipped with the $\overline{ON}$ pin pulled low to V_{EE} at P1 to ensure that the amplifier is enabled. Subsequently, floating the $\overline{ON}$ pin enables the short-circuit protection feature while the amplifier remains on. While $\overline{ON}$ is held low, the short-circuit protection feature is disabled.

The $\overline{ON}$ pin turns on the amplifier after initial power-up and after a short-circuit event. The pin is referenced to the negative supply (V_{EE}).

When a short-circuit condition is detected, the amplifier is disabled, the supply current drops to approximately 5 mA, and the TFL pin outputs a DC voltage of approximately 300 mV above V_{EE}. To turn the amplifier back on after a short-circuit event, follow the previously described sequence for initial power-up.

Pulling the $\overline{ON}$ pin high disables the amplifier and causes the supply current to drop to approximately 5 mA, as if a short-circuit condition had been detected. Pin 3 of P2 uses a 5 V Zener diode (CR1) to set the high level at 5 V above V_{EE}.

The impedance at $\overline{ON}$ is approximately 20 kΩ. The $\overline{ON}$ pin is decoupled to V_{EE} via C8 to shunt noise away from $\overline{ON}$ and to help avoid false triggers.

SHUTDOWN ($\overline{SD}$)

The board factory default setting for the (P3) jumper pulls the $\overline{SD}$ pin to the HI position, V_{EE} + 5.2 V. Pulling the $\overline{SD}$ pin low to V_{EE} places the amplifier in a low power shutdown state, reducing the quiescent current to approximately 750 µA. The $\overline{SD}$ pin must be pulled low to a maximum of V_{EE} + 0.9 V for shutdown, or pulled high to a minimum of V_{EE} + 1.1 V to enable the amplifier. Do not float the pin. When turning the amplifier back on from the shutdown state, pull the $\overline{SD}$ pin high and then pull the $\overline{ON}$ pin low. Following this sequence is required to turn on the ADA4870. To enable the short-circuit protection, the $\overline{ON}$ pin must float following the turn on sequence.

EVALUATION BOARD HARDWARE

THERMAL MONITOR/SHORT-CIRCUIT FLAG (TFL)

The TFL pin can be used to monitor relative changes in die temperature and to detect a short-circuit condition. During normal operation, the TFL pin outputs a DC voltage that is approximately 1.7 V (typical) above V_{EE} and is related to the die temperature. The TFL voltage changes at approximately −3 mV/°C. When the die temperature exceeds approximately 140°C, the amplifier switches to an off state, dropping the supply current to approximately 5 mA while TFL continues to report a voltage indicative of the die temperature. When the die temperature returns to an acceptable level, the amplifier automatically resumes normal operation.

THERMAL DESIGN AND HEAT SINK SELECTION

In some applications, the ADA4870 may be required to dissipate as much as 10 W at elevated ambient temperatures of up to +85°C. The evaluation board provides robust thermal management under these conditions.

The top of the board has an exposed copper area to which the ADA4870 LFCSP package must be soldered. The exposed copper area allocated to the attachment of the LFCSP slug is connected to the exposed copper ground plane on the bottom by an array of 25 thermal vias. A single internal ground layer (Layer 2) is also attached. Figure 7 shows a model of the ADA4870 package mounted to the evaluation board with an applied heat sink.

When necessary, a heat sink can be mounted to the bottom exposed copper using the mounting holes and an applied thermal interface material (TIM), such as the GC Electronics 10-8109. Refer to the manufacturer guidelines when applying the TIM; the TIM thermal resistance (θ_{TIM}) must be no more than 0.3°C/W. See Figure 6 for the dimensions of the heat sink and mounting hole locations. The approximate thermal resistance of the heat sink can be calculated from Equation 1, where θ_{JC} equals 1.3°C/W and θ_{CBOT} is approximately equal to 1.0°C/W.

$$\theta_{HS} = \left(\frac{T_J - T_A}{P_{DISS}}\right) - (\theta_{JC} + \theta_{CBOT} + \theta_{TIM}) \quad (1)$$

where:
T_J is the junction temperature.
T_A is the ambient temperature.
P_{DISS} is the chip power dissipation.
θ_{JC} is the chip thermal resistance.
θ_{CBOT} is the thermal resistance of the chip solder material and the PCB.
θ_{TIM} is the TIM thermal resistance.

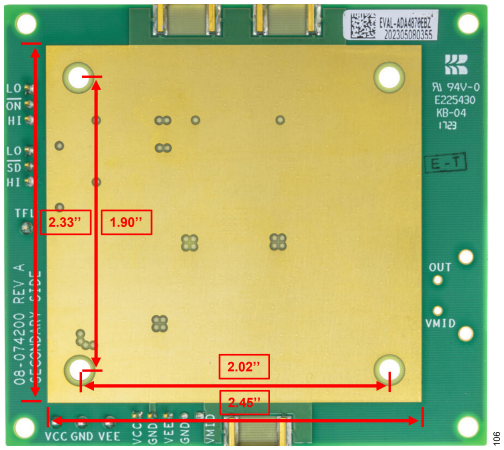

Figure 6. Dimensions of the Heat Sink and Mounting Holes

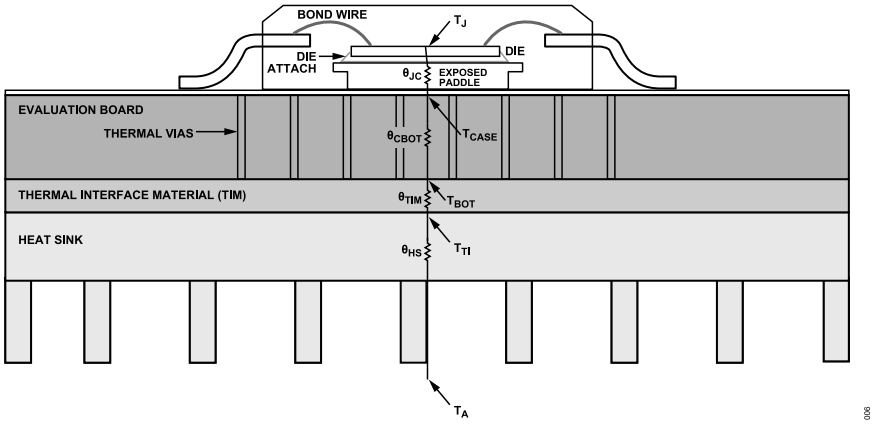

Figure 7. Thermal Model for ADA4870 with Heat Sink

EVALUATION BOARD HARDWARE

THERMAL PERFORMANCE

Figure 8 and Figure 9 show the die temperature vs. time while the internal power dissipation is increased over several hours. The ambient environment for Figure 8 is 25°C in still air; for Figure 9, the ambient environment is 85°C in still air. Both Figure 8 and Figure 9 show the die temperature in two conditions: one without a heat sink and the other with a heat sink rated at 5.45°C/W. For both Figure 8 and Figure 9, the board is positioned with the bottom side or heat sink facing up to facilitate natural convection. Using AC power dissipation and/or forced convection result in lower temperature.

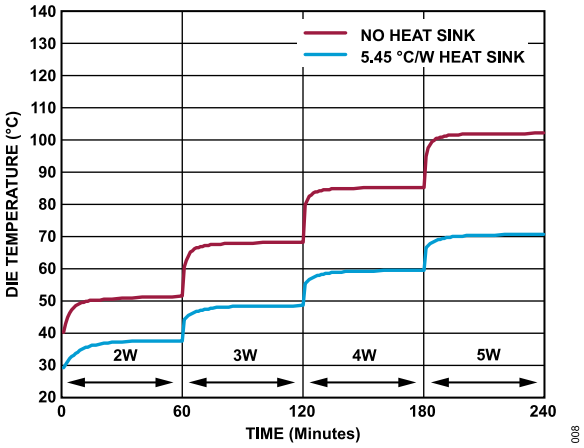

Figure 8. Die Temperature vs. Time and Internal Power Dissipation on the Evaluation Board, Ambient Temperature = 25°C, No Air Flow

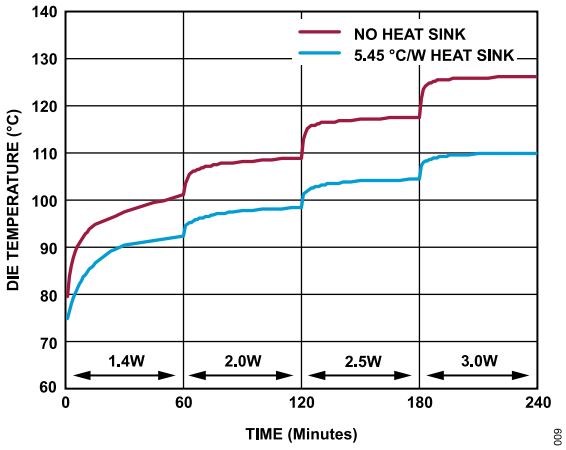

Figure 9. Die Temperature vs. Time and Internal Power Dissipation on the Evaluation Board, Ambient Temperature = 85°C, No Air Flow

EVALUATION BOARD SCHEMATIC

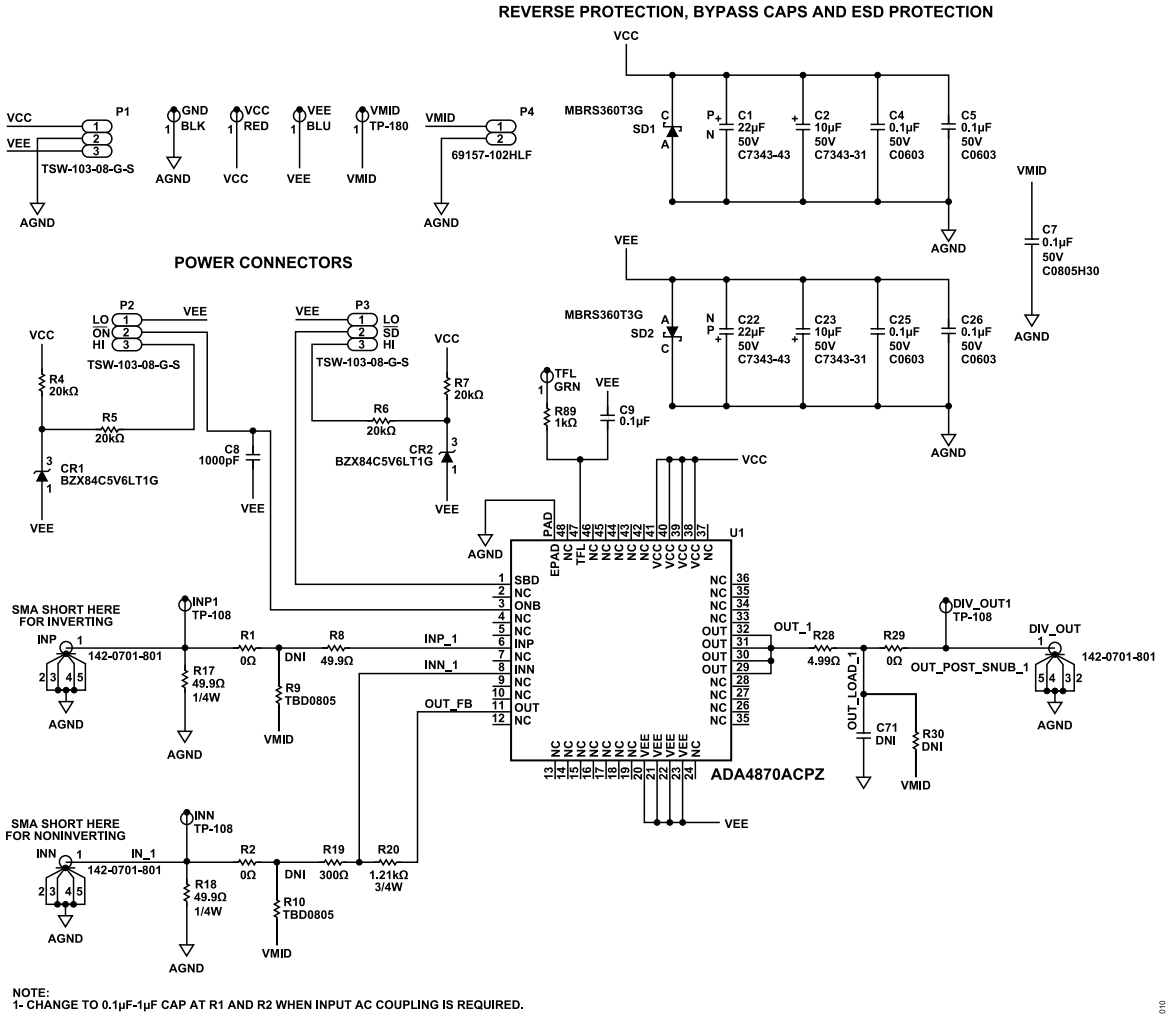

Figure 10. Evaluation Board Schematic

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

Item	Qty.	Reference Designator	Description	Value	Part No.	Manufacturer
1	1	Not applicable	ADA4870 evaluation board	Not applicable	EVAL-ADA4870EBZ	Analog Devices
2	1	U1	ADA4870	Not applicable	ADA4870ACPZ	Analog Devices
3	2	C1, C22	Capacitor, tantalum, 50 V, 7343-43, 10%	22 µF	T491X226K050AT	KEMET
4	2	C2, C23	Capacitor, tantalum, 50 V, 0.8 Ω, 7343-31, 20%	10 µF	TAJD106M050RNJ	AVX
5	5	C4, C5, C9, C25, C26	Capacitor, ceramic, 50 V, X7R, 0603, 10%	0.1 µF	06035C104KAT2A	AVX
6	1	C7	Capacitor, ceramic, 50 V, X7R, 0805, 10%	0.1 µF	CC0805KRX7R9BB104	YAGEO
7	1	C71	Capacitor, ceramic, 300 pF, 50 V, COG, 0603, 5%	Not installed	GRM1885C1H301JA01D	Murata
8	1	C8	Capacitor ceramic, 50 V, X7R, 0603, 10%	1000 pF	06035C102KAT2A	AVX
9	2	CR1, CR2	Diode, Zener, SOT-23	5.6 V	BZX84C5V6LT1G	ON Semiconductor
10	3	INP, INN, DIV_OUT	Connector, coax SMA end launch	Not applicable	142-0701-801	Cinch Connectivity Solutions
11	4	DIV_OUT1, INN1, INP1, VMID	Connector, test point, surface mount	Not applicable	TP-108	Components Corporation
12	1	TFL	Connector, test point	Green	TP104-01-05	Components Corporation
13	1	VCC	Connector, test point	Red	TP104-01-02	Components Corporation
14	1	VEE	Connector, test point	Blue	TP104-01-06	Components Corporation
15	1	GND	Connector, test point	Black	TP104-01-00	Components Corporation
16	3	P1, P2, P3	Connector, PCB, berg, header, straight, male, 3P	Not applicable	TSW-103-08-G-S	Samtec
17	1	P4	Connector, PCB, berg, jumper, straight, male, 2P	Not applicable	69157-102HLF	Amphenol FCI
18	2	R1, R2	Resistor, jumper, 1/10 W, 0603	0 Ω	ERJ-3GEY0R00V	Panasonic
19	2	R9, R10	Resistor, 0805	Not installed		
20	2	R17, R18	Resistor, ¼ W, 1206, 1%	49.9 Ω	RK73H2BTTD49R9F	KOA Speer Electronics, Inc.
21	1	R19	Resistor, ¼ W, 1206, 1%	300 Ω	CRCW1206300RFKEA	Vishay
22	1	R20	Resistor, ¾ W, 2010, 1%	1.21 kΩ	RK73H2HTTE1211F	KOA Speer Electronics, Inc.
23	1	R28	Resistor, 1 W, 2512, 1%	4.99 Ω	CRCW25124R99FKEG	Vishay
24	1	R29	Resistor, ¼ W, 1206, 5%	0 Ω	CRCW12060000Z0EA	Vishay
25	1	R30	Resistor, 10 Ω, 25 W, TO-220, 5%	Not installed	TBH25P10R0JE	Ohmite
26	4	R4, R5, R6, R7	Resistor, 1/10 W, 0603, 1%	20 kΩ	ERJ-3EKF2002V	Panasonic
27	1	R8	Resistor, 1/10 W, 0603, 1%	49.9 Ω	ERJ-3EKF49R9V	Panasonic
28	1	R89	Resistor, 1/10 W, 0603, 1%	1 kΩ	ERJ-3EKF1001V	Panasonic
29	2	SD1, SD2	Schottky diode, power rectifier, surface-mount component (SMC)	60 V	MBRS360T3G	ON Semiconductor
30	2	Jumper	Jumper socket for P2 and P3	Not applicable	65474-001LF	FCI

ORDERING INFORMATION

NOTES

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.