



Evaluation Board Documentation

ADE7757 Energy Metering IC

Preliminary Technical Data

EVAL-ADE7757EB

FEATURES

- Single +5 V Power Supply
- Easy Connection of External Transducers via Screw Terminals
- Easy Modification of Signal Conditioning Components Using PCB Sockets
- Trim Pot for Analog Calibration of Meter Constant
- Optically Isolated Output for Calibration/Test Purposes
- External Reference Option Available for Reference Evaluation

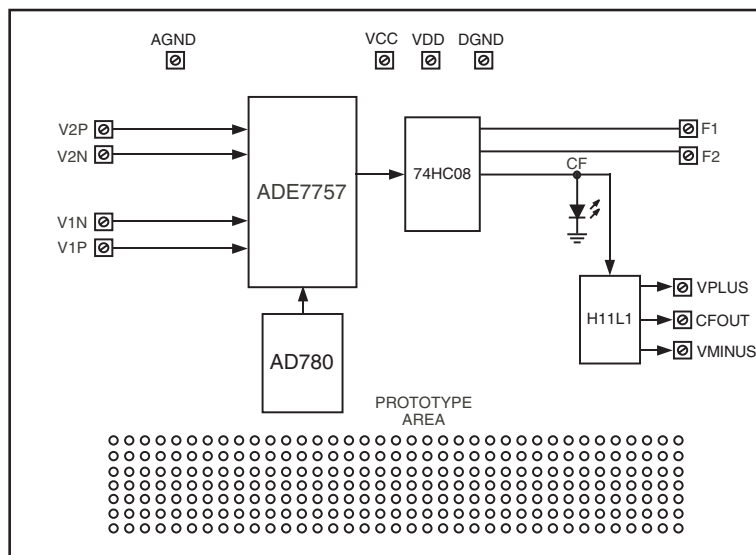
GENERAL DESCRIPTION

The ADE7757 is a high accuracy energy measurement IC with integrated oscillator. The part specifications surpass the accuracy requirements as quoted in the IEC1036 standard.

The ADE7757 supplies average real power information on the low frequency outputs F1 and F2. These logic outputs may be used to directly drive an electromechanical counter or interface to an MCU. The evaluation board provides screw connectors for easy connection to an external counter. The CF logic output gives instantaneous real power information. This output is intended to be used for calibration purposes. The evaluation board allows this logic output to be connected to an LED or optoisolator.

The ADE7757 evaluation board can easily be converted into an energy meter by the addition of a local power supply and the connection of the appropriate current sensor. A large amount of prototype area is made available on the evaluation board for this purpose.

FUNCTIONAL BLOCK DIAGRAM



REV. PrF

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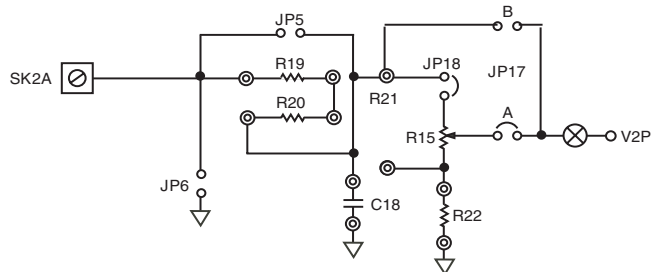
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ANALOG INPUTS (SK1 AND SK2)

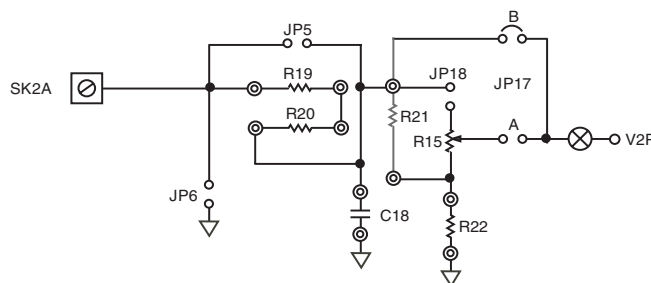
Voltage and current signals are connected at the screw terminals SK1 and SK2 respectively. All analog input signals are filtered using the on-board antialias filters before being presented to the analog inputs of the ADE7757. Some analog inputs offer additional signal conditioning, e.g., attenuation on the voltage channel. The default component values included with the evaluation board are the recommended values to be used with ADE7757. The user can easily change these components, but this is not recommended unless the user is familiar with sigma-delta converters as well as the criteria used for selecting the analog input filters—see ADE7757 datasheet.

Voltage Input

SK2 is a two-way connection block that can be directly connected to a high voltage source, e.g., 220 V rms. The resistor network R15 (trim pot), R19, R20, R21, and R22 make up a very flexible attenuation and calibration network—see schematic. The attenuation network is designed such that the corner frequency (-3 dB frequency) of the network matches that of the RC (antialiasing) filters on the other analog inputs. This is important, because if they do not match there will be large errors at low power factors. Figure 1 shows how the attenuation network may be used with fixed resistors or the trim pot. The trim pot allows the voltage signal on V2P to be scaled to calibrate the frequency on CF to some given constant, e.g., 100 imp/kWhr. Some examples are given later.



a. Attenuation Using Trim Pot (R15)



b. Attenuation Using Fixed Resistors
Figure 1. Attenuation Network on Channel 2

If Channel 2 is being used in a single-ended mode of operation, the unused input of the pair should be connected to analog ground (AGND) via an antialias filter. This is shown in Figure 2 where V2N is connected to AGND using jumper JP8.

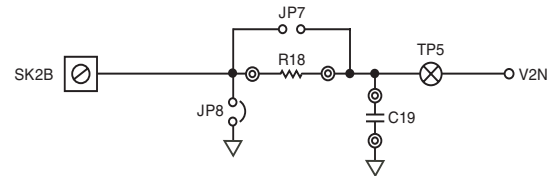


Figure 2. Unused Analog Inputs Connected to AGND

All passive components (resistors and capacitors) which make up the attenuation network and antialias filters may be modified by the user. The components are mounted using PCB jack sockets for easy removal and replacement of components.

Current Input

SK1 is a two-way connection block, which allows the ADE7757 to be connected to a current sensor through one differential input channel. In this example, we chose a shunt as the current sensor. Figure 3 shows a typical connection diagram for shunt connection.

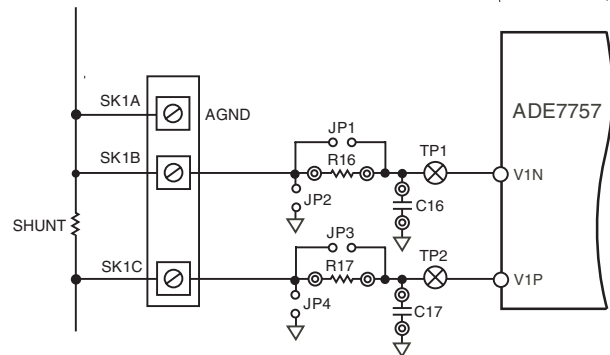


Figure 3. Typical Shunt Connection for Channel 1

EVALUATION BOARD SETUP (ANALOG INPUTS)

Figure 4 shows how the ADE7757 evaluation board can be set up for a simple evaluation. Two signal generators are used to provide the sinusoidal (ac) signals for Channel 1 and Channel 2. The user must have some way of phase locking the generators. Also if the ADE7757 performance-over-power factor is being evaluated, two separate signal sources will be required. The generators are shown connected in a single-ended configuration. The grounded analog inputs of Channel 1 and Channel 2 (V1N and V2N) are connected to AGND via an antialias filter. In Figure 4, analog input V2N is grounded via R21 and R22. The capacitor C18 is connected in parallel.

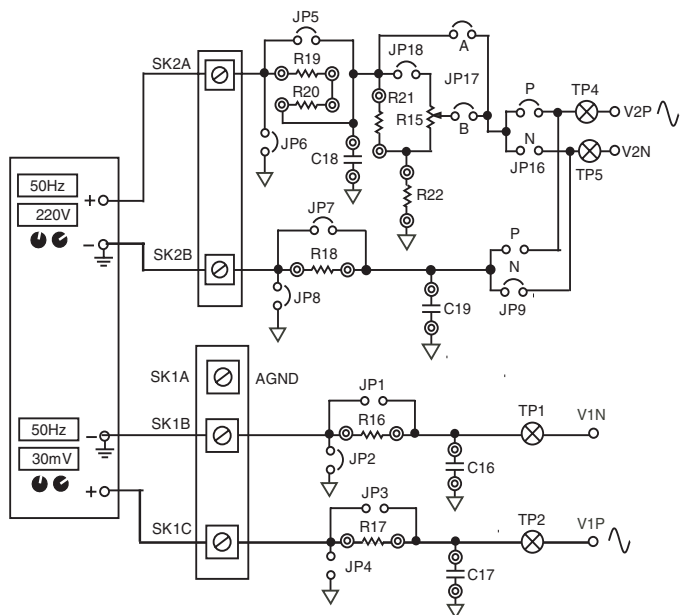


Figure 4. Typical Connection for Analog Inputs

LOGIC OUTPUTS

ADE7757 provides the active power information in the form of an output frequency. The three frequency outputs are F1, F2 and CF. Consult the datasheet for more information on these outputs. The logic outputs F1 and F2 are intended to be used to drive an impulse counter or stepper motor. The outputs are buffered and available at the connector SK6. A stepper motor may be directly connected here. The power supply for the buffer is +5V (SK4A) and may be connected to the ADE7757 supply using jumper JP15, or to its own supply.

The logic output CF can be directly connected to an LED using JP14 (Position B) or to an optically isolated output (Position A). By closing Positions A and B, both options are selected. The optically isolated output is available at connector SK5. This isolated output is useful when the evaluation board is connected directly to a high voltage (e.g., 220 V residential). A typical connection diagram for this isolated output is shown in Figure 5.

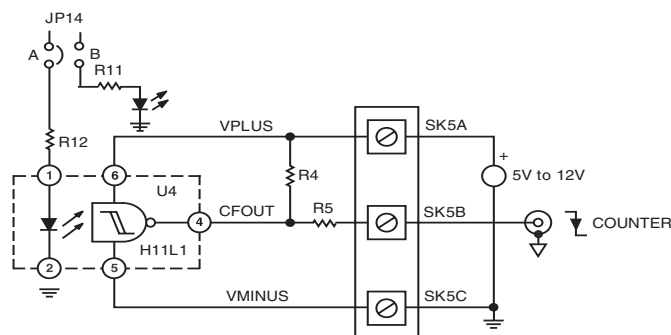


Figure 5. Typical Connection for Opto Output

All logic outputs can be monitored via test points 6 to 8 (TP6 to TP8). These test points provide easy access for scope probes and meter probes.

OUTPUT FREQUENCY SELECTION

ADE7757 provides up to four different output frequencies on F1 and F2. The output frequency selection is made via the logic inputs S0 and S1—see ADE7757 datasheet. On the evaluation board these inputs are set by using jumpers JP12 and JP13. The logic input SCF is set via jumper 11 (JP11). For a full explanation of the ADE7757 output frequency selection see the datasheet.

INTERNAL CLOCK

The ADE7757's integrated oscillator serves as the clock source to the chip. A precise 6.2 kΩ resistor with low tolerance and low drift is used to drive the internal oscillator.

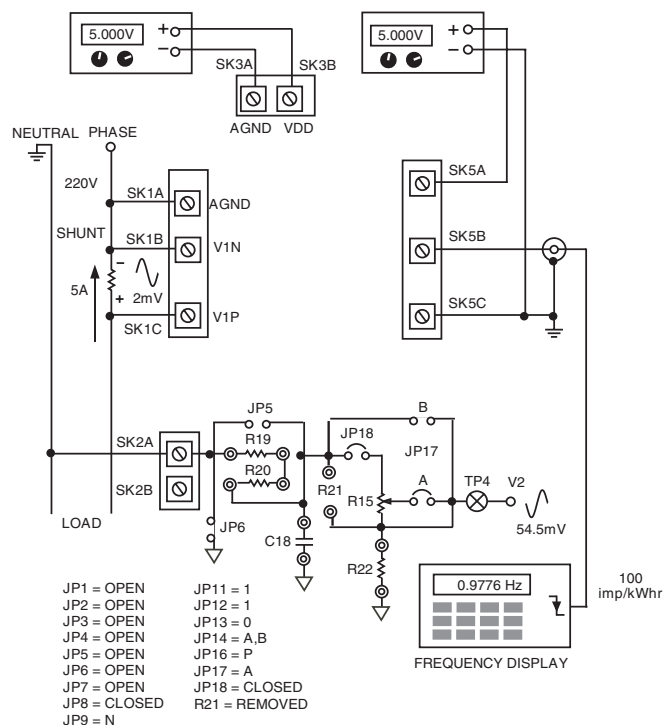


Figure 6. ADE7757 Evaluation Board as an Energy Meter

EVALUATION BOARD SET UP AS AN ENERGY METER

Figure 6 shows a wiring diagram that allows a simple energy meter to be implemented using the ADE7757 evaluation board. The current transducer used in this example is a 400 μΩ shunt. The meter is intended to be used with a line voltage of 220 V and a maximum current of 25 A. The frequency outputs F1 and F2 can be used to drive a mechanical counter. These outputs will be calibrated to provide 100 imp/kWhr. The logic output CF has an output frequency that can be up to 2048 times higher

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than the frequency on F1 and F2. This output can be used for calibration purposes and is shown connected to a frequency counter via the optoisolator in Figure 6.

At maximum current (25 A), the power seen by the meter will be 5.5 kW. This will produce a frequency of 0.153 Hz on F1 and F2 when these outputs are calibrated to 100imp/kWhr (100imp/hr = 0.02777 Hz, $0.02777 \times 5.5 = 0.153$ Hz). From Table V in the ADE7757 datasheet, the closest frequency to 0.153 Hz in the half-scale ac inputs column is for F_3 , i.e., 0.18 Hz for a nominal internal oscillator frequency of 466k Hz. Therefore F_3 is selected by setting $S1 = 1$ and $S0 = 0$. The choice of CF frequencies in this mode (see Table III in the ADE7757 datasheet) are 32 times F1 and 16 times F1. For this example 32 times F1 is selected by setting $SCF = 1$.

Since the voltage on Channel 1 is fixed, the only possible way of calibrating (adjusting) the output frequency in F1 and F2 is by varying the voltage on Channel 2. This is carried out by varying the attenuation of the line voltage using the trim pot.

First we can calculate the voltage required in Channel 2 in order to calibrate the frequency on the logic outputs F1 and F2 to 100imp/kWhr. The ADE7757 datasheet gives the equation which relates the voltage on Channel 1 and Channel 2 to the output frequency on F1 and F2.

$$Freq = \frac{515.84 \times V_1 \times V_2 \times F_{1-4}}{V_{ref}^2} \quad (1)$$

First a current is selected for calibration, 5 A for example. This gives a Channel 1 voltage of $400 \mu\Omega \times 5 \text{ A} = 2 \text{ mV}$ rms. The on-chip or external reference of 2.5 V is selected using JP10.

The output frequency at 5 A on F1 and F2 should be $(100\text{imp/kWhr}) \times 1.1 \text{ kW} = 0.03055 \text{ Hz}$, where $(220 \text{ V} \times 5 \text{ A} = 1.1 \text{ kW})$.

From Equation 1 the voltage on Channel 2 should be set to 54.4 mV. The attenuation network as shown in Figure 1 is used to attenuate 220 V to 54.4 mV. $R19 = 590 \text{ k}\Omega$, $R20 = 200 \text{ k}\Omega$, $R22 = 100\Omega$ and the trim pot $R15 = 100\Omega$.

However, since the meter is being calibrated at CF and CF is set to 32 times F1, the voltage on Channel 2 should be adjusted until $CF = 32 \times 0.03055 \text{ Hz} = 0.9776 \text{ Hz}$ is registered on the frequency counter. The counter should be set up to display the average of ten frequency measurements on CF. This will remove any ripple due to the instantaneous power signal. See the ADE7757 datasheet for more details.

JUMPER SELECTION

The ADE7757 evaluation board comes with several jumper selections that allow the user to exercise all of the ADE7757 functionality. There are also some options such as attenuation networks and optically isolated outputs that allow the ADE7757 to be evaluated under the same conditions as the end application. Table I outlines all the jumper options and explains how they are used. Table I should be used in conjunction with Figure 7, which will make it easier to locate the jumper in question.

Table I.

Jumper	Option	Description
JP1	Closed	Closing this jumper will short resistor R16 and connect analog input V1N directly to SK1B. This has the effect of removing the antialias filter from this input.
	Open	Antialias filter in input V1N is enabled.
JP2	Closed	Analog input V1N is connected to analog ground (AGND) via the antialias filter. This jumper should be closed if the Channel 1 is used in a single-ended mode.
	Open	When evaluating the ADE7757, Channel 1 is best used in a differential mode and this jumper should be left open. An example is shown in Figure 3. In this example a shunt is used to sense the current. The shunt can be referenced to the AGND of the board by using TP9 as shown.
JP3	Closed	Closing this jumper will short resistor R17 and connect analog input V1P directly to SK1C. This has the effect of removing the antialias filter from this input.
	Open	Antialias filter in input V1P is enabled.
JP4	Closed	Analog input V1P is connected to analog ground (AGND) via the antialias filter.
	Open	Normal operation.
JP5	Closed	Closing this jumper will short resistors R19 and R20. The analog input V2P is connected directly to SK2A. This has the effect of removing the antialias filter/attenuation network from this input. Note: if the board is being connected to a high voltage, this jumper must be left open.
	Open	Antialias filter/attenuation network on the input V2P is enabled.
JP6	Closed	Analog input V2P is connected to analog ground (AGND) via the antialias filter/attenuation network. Note: SK2A is also connected to AGND. Be careful when connecting this input a high voltage source.
	Open	Normal operation.
JP7	Closed	Closing this jumper will short resistor R18 and connect analog input V2N directly to SK2B. This has the effect of removing the antialias filter/attenuation network from this input.
	Open	Antialias filter/attenuation network in input V2N is enabled.

JP8	Closed	Analog input V2N is connected to analog ground (AGND) via the antialias filter/attenuation network. This option should be selected if Channel 2 is used in a single-ended mode.
	Open	V2N connected to SK2B for differential operation.
JP9	N	SK2B connected to V2N.
	P	SK2B connected to V2P.
JP10	Open	ADE7757 internal (on-chip) reference selected.
	Closed	External (AD780) reference selected.
JP11	1	SCF connected to VDD.
	0	SCF connected to DGND.
JP12	1	S1 connected to VDD.
	0	S1 connected to DGND.
JP13	1	S0 connected to VDD.
	0	S0 connected to DGND.
JP14	A	CF logic output connected to optically isolated output at SK5.
	B	CF logic output connected to LED.
JP15	Closed	VDD and +5V connected together. Note: VDD is power supply for ADE7757 IC (U1) and +5V is power supply for buffer (U2)
JP16	N	SK2A connected to V2N.
	P	SK2A connected to V2P.
JP17	A	Trim pot R15 is connected to V2P or V2N (depending on the position of JP16)—see Figure 8. This allows the output frequency to be scaled using the voltage on V2P.
	B	When option B is selected, the jumper JP18 should be left open. In this configuration the attenuation for V2P is provided via the fixed resistors R19, R20, R21 and R22.
JP18	Open	When open, the attenuation on V2P is provided by fixed resistor as explained above. Also see Figure 10.
	Closed	When closed, the trim pot becomes part of the attenuation network. In this mode of operation, the resistor R21 should be removed from its PCB jack sockets and JP17B must be opened

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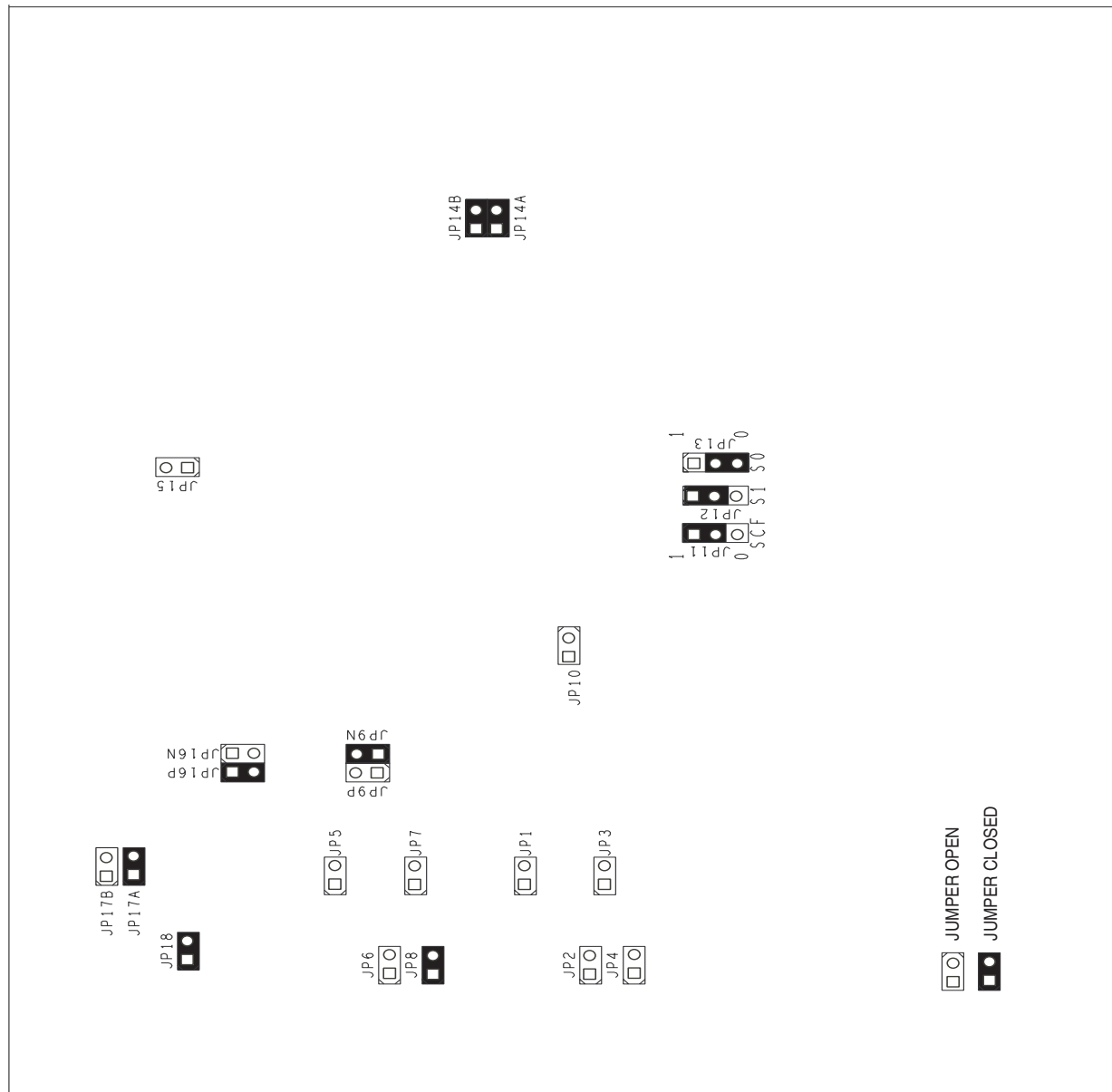


Figure 7. ADE7757 Evaluation Board Jumper Positions

Evaluation Board Bill of Material

Designator	Value	Description
R1, R2, R3, R4	1 k Ω , 5%, 1/4 W	Resistor, No Special Requirements.
R5	100 Ω , 5%, 1/4 W	Resistor, No Special Requirements.
R7, R8, R9	10 k Ω , 5%, 1/4 W	Resistor, No Special Requirements.
R11, R12	820 Ω , 1%, 1/4 W	Resistor, No Special Requirements.
R13, R14	20 Ω , 5%, 1/4 W	Resistor, No Special Requirements.
R15	100 Ω , 10%, 1/2 W	Trim Pot Resistor, 25 Turn. BOURNS.
R16, R17, R18	200 Ω , 0.05%, 1/8 W	± 15 ppm/ $^{\circ}$ C Resistor, good tolerance, used as part of the analog filter network. These resistors are not soldered, but are plugged into PCB mount sockets for easy modification by the customer. Low drift WELWYN RC6 Series, FARNELL Part No. 339-179.
R19	402 k Ω , 1%, 1/4 W	± 50 ppm/ $^{\circ}$ C, FARNELL Part No. 336-660.
R20	200 k Ω , 1%, 1/4 W	± 15 ppm/ $^{\circ}$ C, FARNELL Part No. 341-094.
R21, R22	100 Ω , 0.1%, 1/4 W	± 15 ppm/ $^{\circ}$ C Resistor, Good Tolerance. Low Drift. FARNELL Part No. 338-886.
C1	1 μ F, 10% 16V	Voltage reference decoupling capacitor.
C2, C3, C4	10 μ F, 10% 16V	Power supply decoupling capacitors, 20%, Philips CW20C 104, FARNELL Part No. 643-579.
C5	6.2 k Ω , 0.1%, 1/4 W	± 15 ppm/ $^{\circ}$ C Resistor, Good Tolerance. Used to drive internal oscillator.
C7, C8, C9, C10, C11, C12, C20	100 nF, 10% 100 V	Power Supply Decoupling Capacitors, 10%, X7R type, AVX-KYOCERNA, FARNELL Part No. 146-227.
C13, C14, C15	10 nF 10% 100V	Philips CW15C 103 M, FARNELL Part No. 146-224.
C16, C17, C18, C19	0.15 μ F, 10%, 50 V	X7R Capacitor, Part of the Filter Network. These resistors are not soldered, but are plugged into PCB mount sockets for easy modification by the customer. SR15 series AVX-KYOCERNA, FARNELL Part No. 108-948.
C21	N/A	Capacitor placeholder for external reference compensation
SKT1	SOIC-nb socket	Socket to hold ADE7757 chip. Loranger International Corp., 16 Gull Wing Leaded, SOT-109A (so16), File NO. 3337161S
U1	ADE7757	Energy measurement IC by Analog Devices Inc. (see ADE7757 datasheet)
U2	74HC08	Quad CMOS AND gates.
U3	AD780	2.5 V Reference, Supplied by Analog Devices Inc.
U4	H11L1	Optical Isolator, by QT, FARNELL Part No. 326-896.
D1	LED	Low Current, Red, FARNELL Part No. 637-087.
SK2, SK3, SK4, SK6	2-pin Screw Terminal	15 A, 2.5 mm Cable Screw Terminal Sockets. FARNELL Part No. 151-785. Length 10 mm, Pitch 5 mm, Pin diameter 1 mm.
SK1, SK5	3-pin Screw Terminal	15 A, 2.5 mm Cable Screw Terminal Sockets. FARNELL Part No. 151-786. Length 15 mm, Pitch 5 mm, Pin diameter 1 mm.

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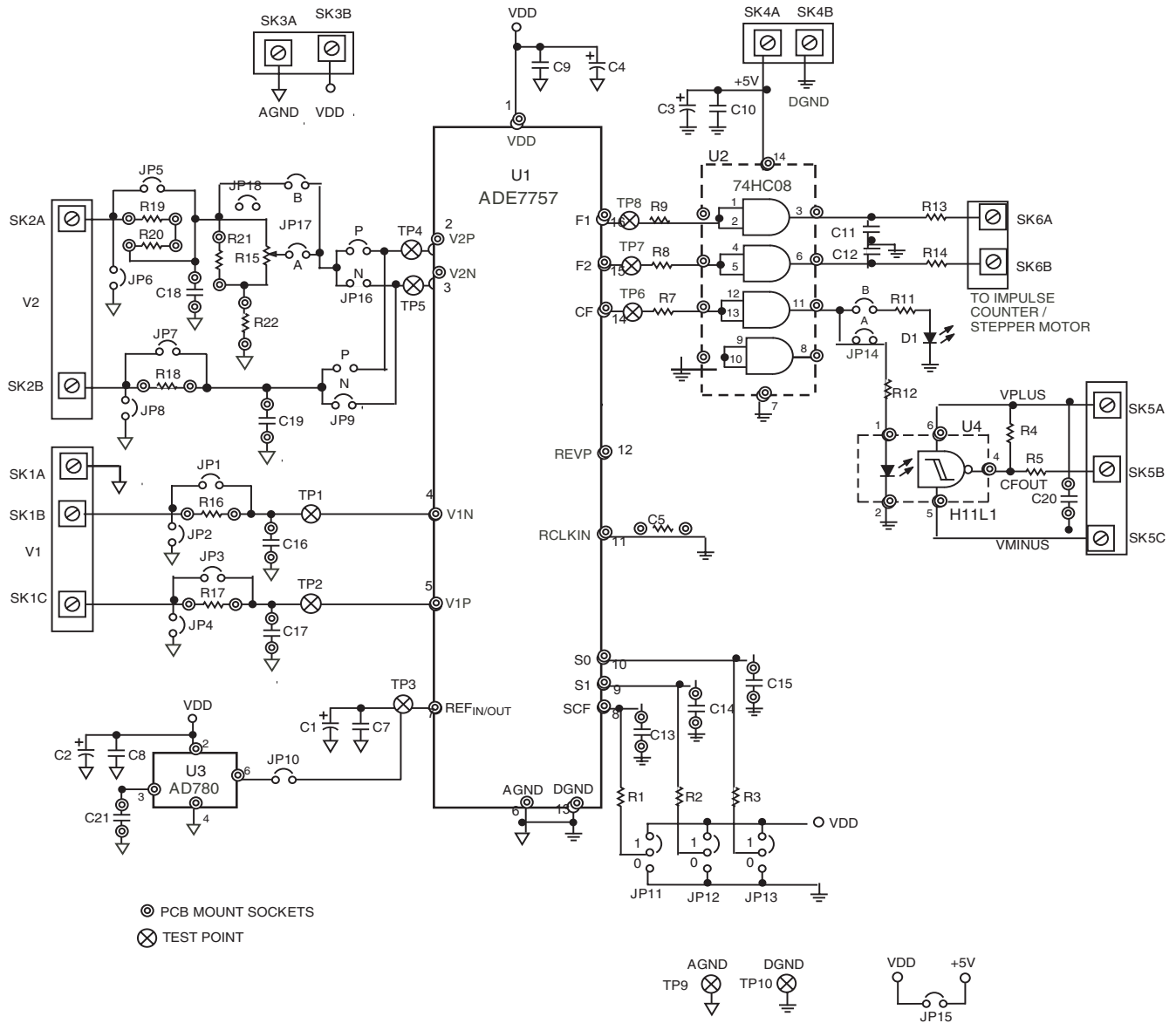


Figure 8. Evaluation Board Schematic

COMPONENT SIDE
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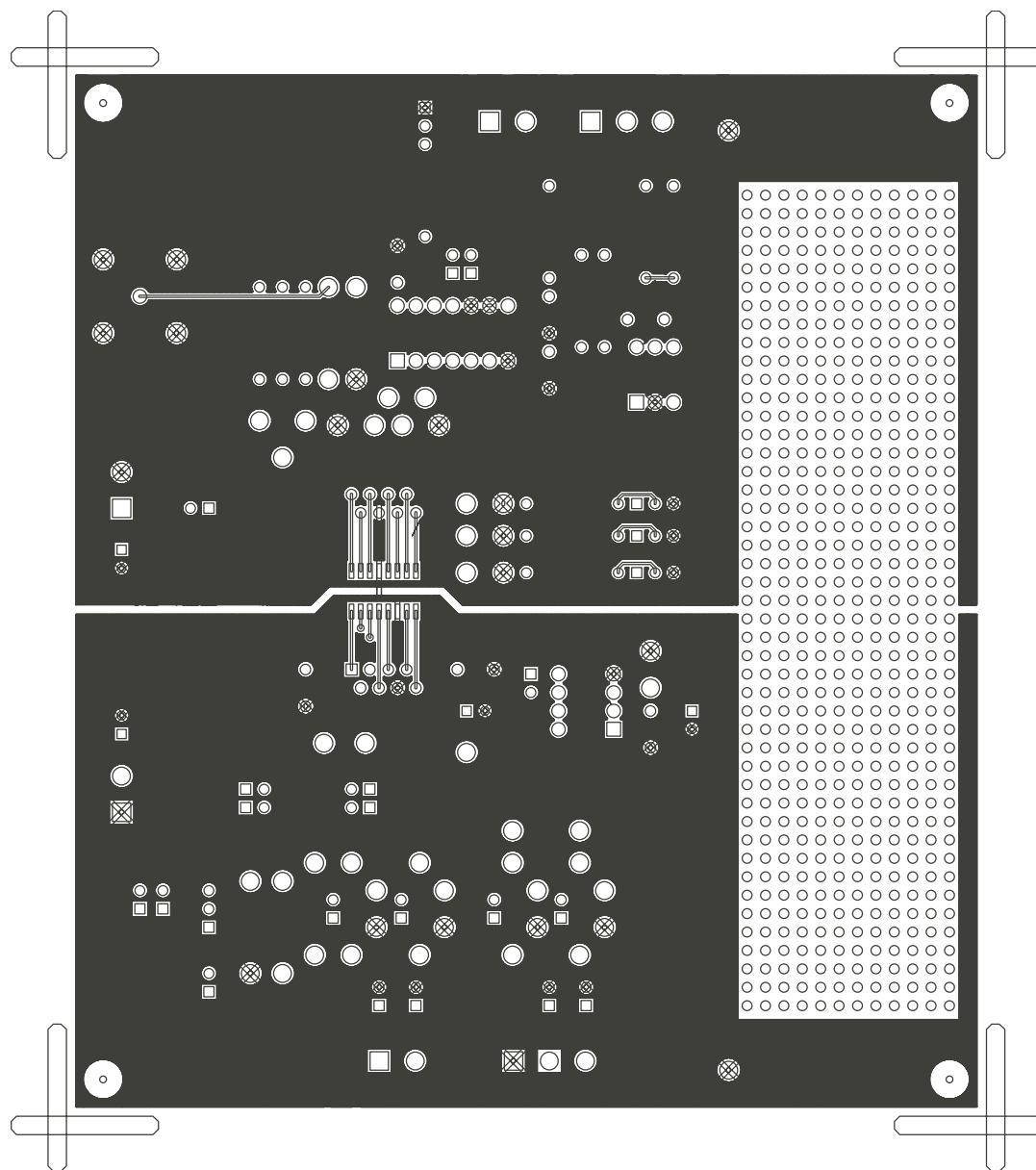


Figure 9. PCB Layout-Component Side

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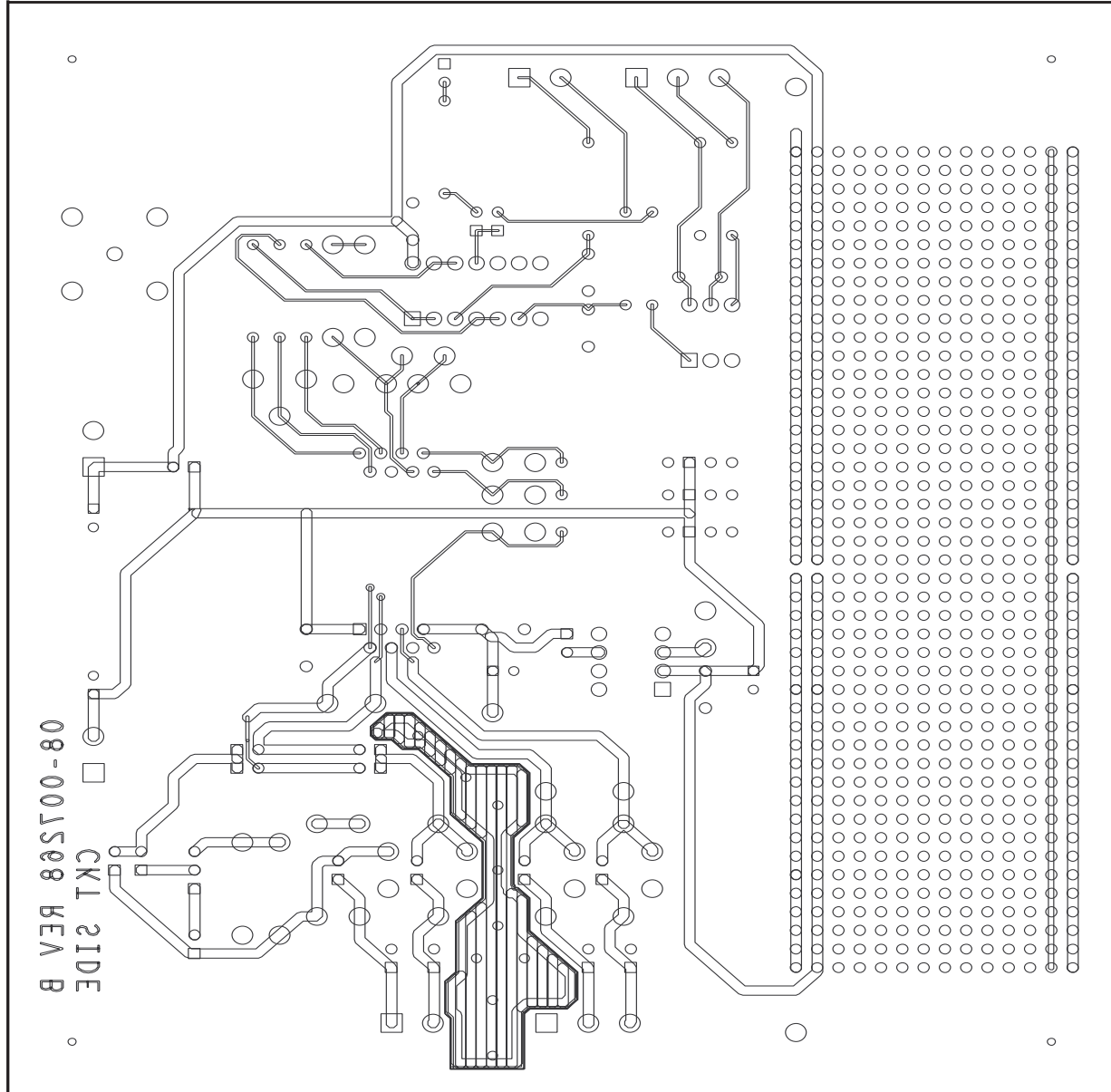


Figure 10. PCB Layout-Solder Side

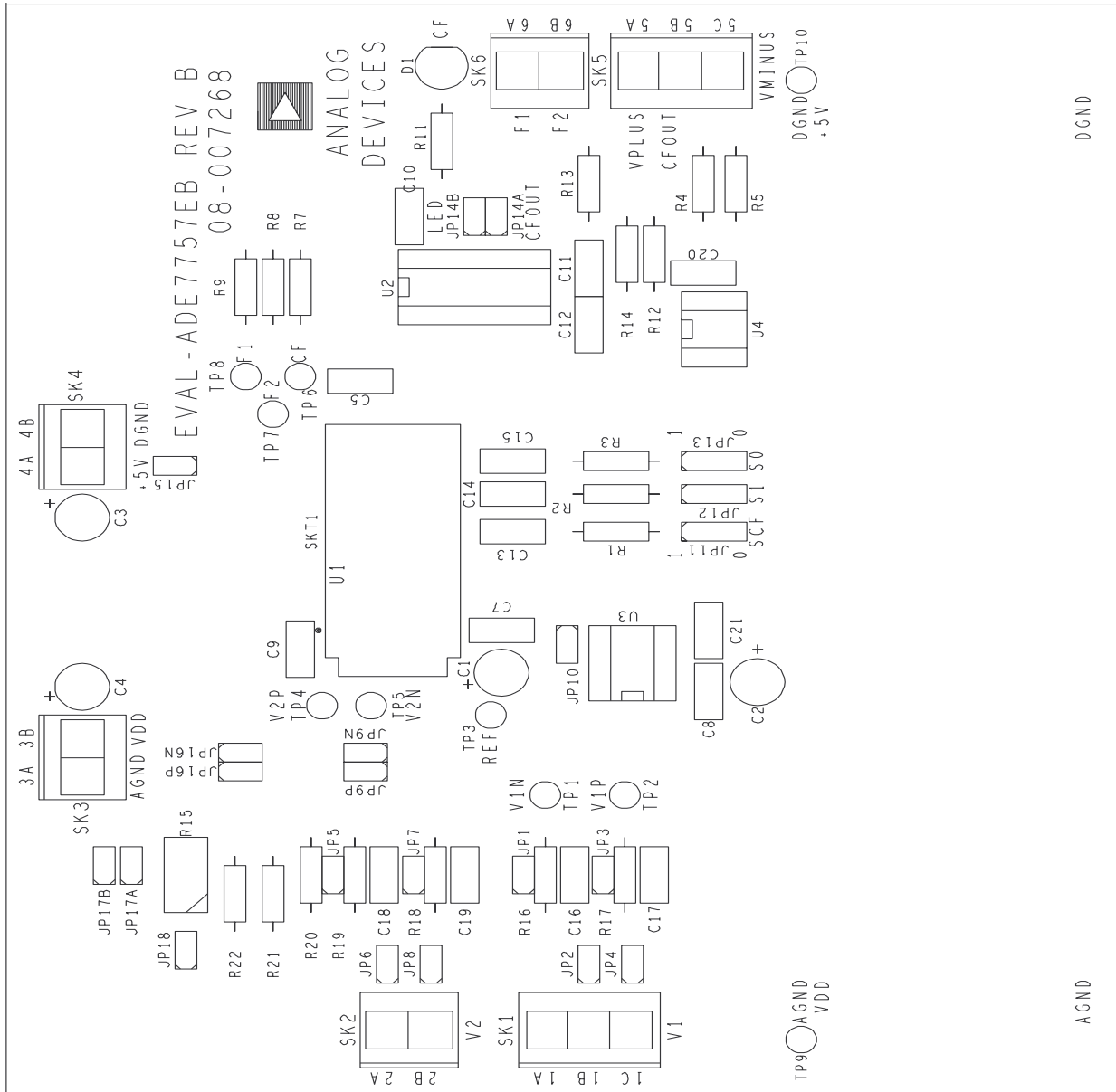


Figure 11. PCB Layout-Component Placement