# LTC2978 Octal Digital Power Supply Manager with EEPROM

## DESCRIPTION

The DC1540A is a demonstration system for the LTC2978 Octal I²C/SMBus/PMBus Power Supply Monitor and Controller with EEPROM. It consists of 2 circuit boards namely the DC1360A and DC1361A. The DC1360A contains all the circuitry needed to insert the LTC2978 into a power system and control eight power supplies. The DC1361A contains 8 power supplies (LTM4603EV) which are configured to be controlled by an LTC2978. Together these two boards form a sophisticated, 8 channel, digitally programmable power supply.

This demonstration system is supported by LTpowerPlay™ software and a graphical user interface (GUI) that enables complete control of all the LTC2978 features. You can obtain this GUI from the website www.ltpowerplay.com. LTpowerPlay and the DC1540A, create a powerful development environment in which you can design configuration settings for the LTC2978. The configuration settings can be stored in the LTC2978 EEPROM and also in a file, which can be used to order pre-programmed devices. LTpowerPlay displays all of the configuration settings and real time measurements that the LTC2978 performs and allows easy access to the fault log created by the LTC2978. The LTC2978 on the DC1360A comes pre-programmed with EEPROM values appropriate for the 8 power supplies used on the DC1361A. Other configuration files are available on www.ltpowerplay or in the GUI.

The LTC2978 can be configured to monitor current on odd numbered channels. In the DC1540A, this feature can be enabled on Channel 7 (see “Measuring Current”). A configuration file for this mode can be obtained on the LTpowerPlay website. Channels 1 and 2 can be configured to do coincident tracking of Channel 0 by using JP2 and JP3 (see “DC1361A Details – Top Side”). An LTC Hot Swap™ circuit on the DC1361A enables the LTC2978 to soft-start $V_{IN}$ and shut off $V_{IN}$ in response to output faults.

Multiple DC1540As can be cascaded together to form a high channel count power supply (see “Multi-Board Arrays”). This configuration demonstrates features of the LTC2978 which allow timing and fault information to be shared across multiple LTC2978s, allowing the formation of a single, coherent power supply control system. This configuration is easily supported by the LTpowerPlay GUI and allows the user to configure up to 9 LTC2978s, controlling up to 72 separate power supplies.

To get this demo system up and running, connect the DC1540A to your computer using a DC1427A or a DC1613A (USB to I²C/SMBus/PMBus Controller). The following is a checklist of items which you can obtain from LTpowerPlay.com, LTC website or LTC Field Sales.

- USB to I²C/SMBus/PMBus Controller (DC1427A or DC1613A)
- LTpowerPlay GUI
- DC1540A Configuration Files
- LTC2978 Resistor Selection Tool for calculating resistors values and proper DAC range settings

### LTC2978 Features

- I²C/SMBus/Communication
- Configuration EEPROM
- PMBus Compliant
- Fault Logging to internal EEPROM
- Differential Input, 15-bit Δ-Σ ADC with less than ±0.25% of Total Unadjusted Error using On-Chip Reference
- Monitors Eight Output Channels and One Input Voltage
- Programmable Watchdog Timer
- 8-Channel Sequencer
- Eight 10-Bit OV/UV Supervisors
- Eight 10-Bit Margin/Trim DAC’s with Soft-Connect
- A Closed Loop Digital Servo Accurately Trims the Outputs
- Supports Multi-Channel Fault Management
- Programmable Fault Responses
- On-Chip Digital Temperature Sensor

**PCB Design files for these circuit boards are available. Call the LTC factory.**

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**Table 1. LTC2978 Performance Summary (Specifications Over Temperature –40°C ≤ $T_A$ ≤ 85°C)**

| PARAMETER | CONDITION | | VALUE |
|---|---|---|---|
| $V_{\overline{PWR}}$ Supply Input Voltage Range | | | 4.5V to 15V |
| $V_{DD33}$ Supply Input Voltage Range | | | 3.13V to 3.47V |
| ADC Total Unadjusted Error | $V_{IN}$ = 3V | | ±0.25% |
| ADC Voltage Sensing Input Range | | | –0.1V to 6V |
| ADC Current Sensing Input Range | | | –170mV to 170mV |
| ADC Voltage Sensing Resolution | Resolution = 8.192V/32768 | | 122µV/LSB |
| ADC Current Sense Resolution | 0mV <$\|V_{IN_ADC}\|$ < 16mV<br>16mV <$\|V_{IN_ADC}\|$ < 32mV<br>32mV <$\|V_{IN_ADC}\|$ < 63.9mV<br>63.9mV <$\|V_{IN_ADC}\|$ <127.9mV<br>127.9mV <$\|V_{IN_ADC}\|$ | | 15.6µV/LSB<br>31.25µV/LSB<br>62.5µV/LSB<br>125µV/LSB<br>250µV/LSB |
| Voltage Buffered IDAC Resolution 10 bits | Buffer gain setting 0 | | 1.38mV/LSB |
| | Buffer gain setting 1 | | 2.65mV/LSB |
| Temperature Sensor Resolution | | | 0.25°C/LSB |
| Voltage Supervisor Input Voltage Range (Programmable) | $V_{SENSEP[n]}$ | Low resolution | 0 to 6V |
| | | High resolution | 0 to 3.8V |
| | $V_{SENSEM[n]}$ | | –0.1 to 0.1V |
| Voltage Supervisor Sensing Resolution | 0V to 3.8V range: 4.096/1024 | | 4mV/LSB |
| | 0V to 6V range: 8.192/1024 | | 8mV/LSB |
| Voltage Supervisor Total Unadjusted Error | 2V < $V_{IN_VS}$ < 6V, Low Resolution Mode | | ±1.25 % |
| | 1.5V < $V_{IN_VS}$ < 3.8V, High Resolution Mode | | ±1.0 % |
| | 0.8V < $V_{IN_VS}$ < 1.5V, High Resolution Mode | | ±1.5 % |
| $I^2C$ Serial Clock Frequency | | | 10kHz to 400kHz |

## Demo System Specifications

**Table 2. Specifications-DC1361A**

| $V_{OUT}$ Name | Nominal Voltage-Untrimmed |
|---|---|
| $V_{OUT_0}$ | 3.325V ± 1.5% |
| $V_{OUT_1}$ | 2.497V ± 1.5% |
| $V_{OUT_2}$ | 1.989V ± 1.5% |
| $V_{OUT_3}$ | 1.804V ± 1.5% |
| $V_{OUT_4}$ | 1.502V ± 1.5% |
| $V_{OUT_5}$ | 1.200V ± 1.5% |
| $V_{OUT_6}$ | 0.999V ± 1.5% |
| $V_{OUT_7}$ | 0.799V ± 1.5% |

## Notes:

- Load current less than 2A on each output is recommended.
- Max current into J11 (+12V) should be < 6A max.
- Output voltages can be margined by a minimum of ±15% from nominal with the default resistor values on the DC1361A. These values can be easily changed. See section “Changing DC1361A Nominal Output Voltages. Use the LTC2978 Resistor Selection Tool, (Spreadsheet) which is accessed from LTpowerPlay.



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### What Can You Do With This Demo System ?

- Prototype your system. You can change the nominal $V_{OUT}$'s of the modules to match your system. You can also change the range and resolution of margining. Set sequencing. Set OV/UV limits. And much more!
- Create your own configuration that you can store in the EEPROM of the LTC2978 or save to a file. This file can be used to order pre-programmed parts.
- Test most conceivable fault scenarios. All outputs can be shorted.

### Demo System Hardware

Hardware required:

1. PC + USB cable
2. 12V > 0.5A power supply
3. USB to I²C/SMBus/PMBus Controller
4. DC1540A = DC1360A + DC1361A

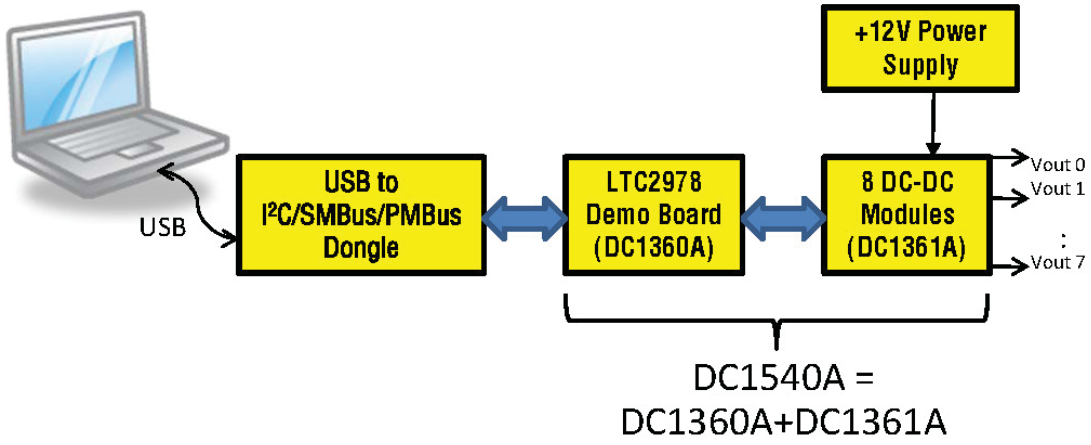


**Figure 1. Single LTC2978 Demo Setup Using DC1540A**

## DOWNLOAD GUI TO YOUR PC

LTpowerPlay can be downloaded from www.ltpowerplay.com. Complete instructions are located there.



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## QUICK START PROCEDURE

The following procedure describes how to set up one DC1540A.

1. Remove both boards from bag.
2. Place boards on level surface. Connect boards together using the 54-pin edge connector. See below.

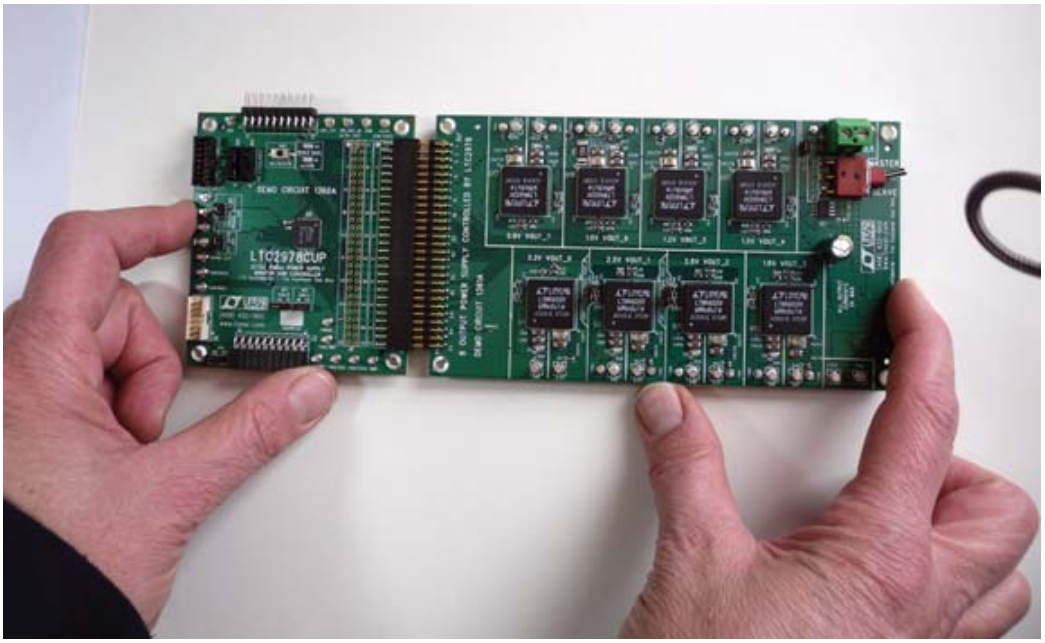

**Figure 2. Plug Boards Together**

3. On DC1360A, set jumpers and switches as follows. See also Table 3.
   a. Set both SW1 and SW2 (CONTROL0 and CONTROL1) to GND.
   b. Set JP5 to OFF.
   c. Make sure JP6 is installed.
   d. Set JP3 (ASEL0) to LO and JP2 (ASEL1) to LO.
   e. Set JP4 to ON.
4. On DC1361A, set jumpers and switches as follows. See also Table 3.
   a. JP1 = INSTALLED
   b. JP2, JP3 = SOFT START
   c. SW1 = MASTER
5. Plug in the USB to $I^2C$/SMBus/PMBus Controller into a USB port on your PC.
6. Connect a 12V power supply with > ½ Amp capacity to the $V_{IN}^+$ and $V_{IN}^-$ inputs of the green terminal block J11 on DC1361A. Do not turn on 12V yet. Be careful to hook up polarity correctly! See Figure 5.



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## QUICK START PROCEDURE

7. If you have a DC1427A, connect to J4 on DC1360A as shown below.

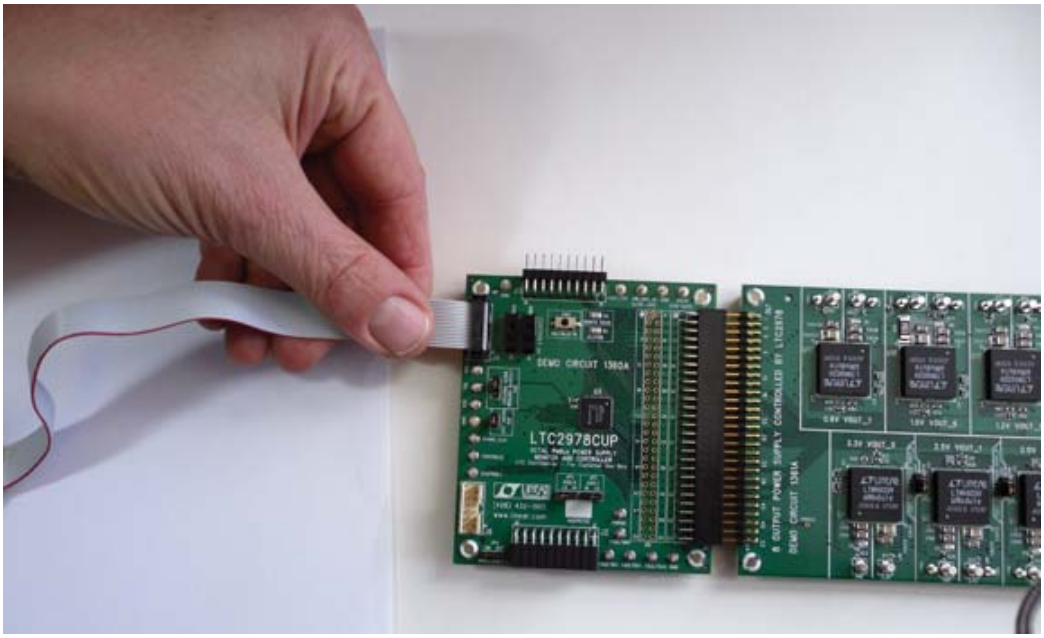


**Figure 3. DC1427A Connection**

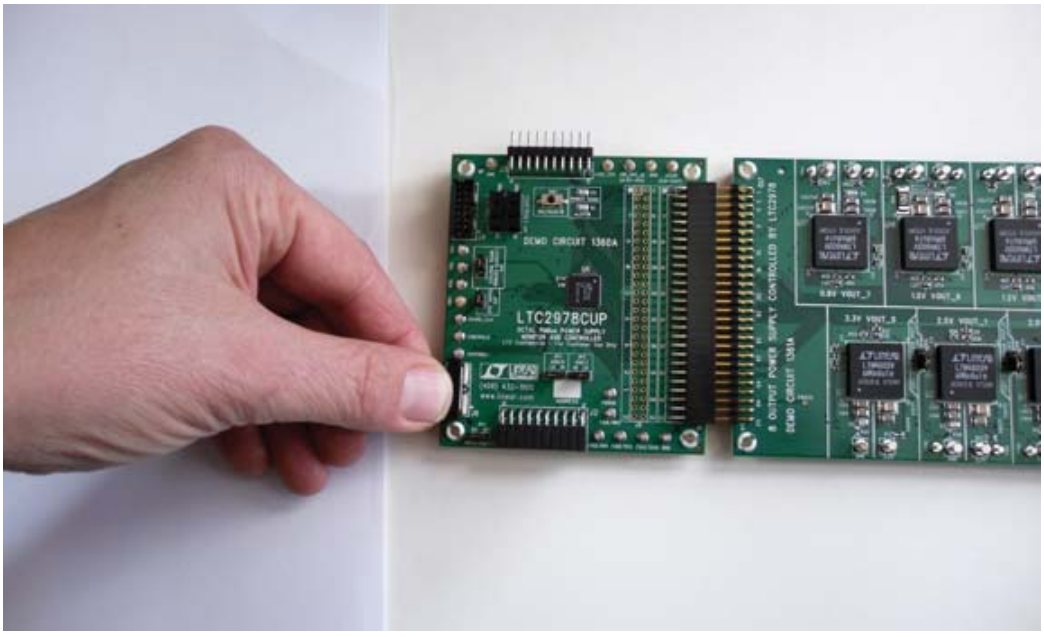


**Figure 4. DC1613 Connection**



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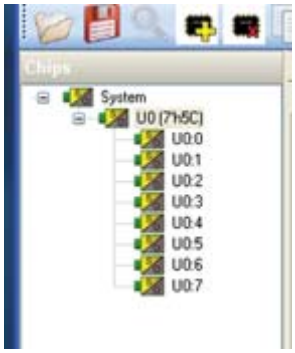
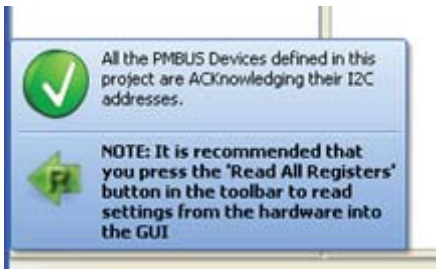
## QUICK START PROCEDURE

8. Launch the LTpowerPlay GUI.

   a. The GUI should indentify the LTC2978. The system tree on the left hand side should look like:




   b. Confirm that the LTC2978 is communicating. A green message box shows for a few seconds in the lower left hand corner




   c. In the Toolbar, click the "R" icon to read the RAM from the LTC2978. This reads the default configuration from the RAM in the LTC2978 on the DC1360A and loads it into the GUI.

   d. Save the demo board default configuration to a (*.proj) file. Click the "Save" icon and save the file. You can chose your own filename.

9. Turn on the +12V power supply.

10. Slide the 2 black switches CONTROL 0, CONTROL 1 to the HI position. This turns on the board.



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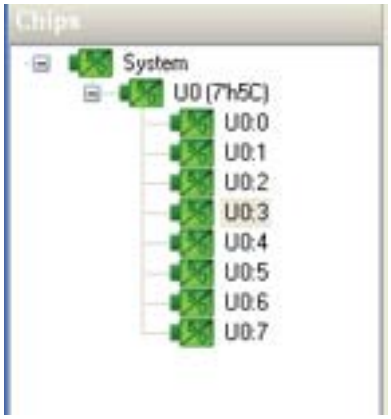
## QUICK START PROCEDURE

The System Tree on the left hand side should turn all green. All 8 green LEDs on the DC1361A should illuminate.




11. You are now ready to execute one of the LTC2978 demos embedded in the GUI or experiment with the part.

### LOADING A CONFIGURATION (*.proj) FILE WITH THE GUI

1. In the upper left hand corner of the GUI, File > Open > browse to your *.proj file. This will load the file into the GUI.
2. Click on the arrow. This loads the file into RAM.
3. To store in EEPROM, click on the STORE button. It is the button on the left below.

### NOTES:

1. To configure the jumpers and switches, see Tables 3, 4, 5 and 6. If using more than one LTC2978, use the ASELs to assign different addresses for each LTC2978.
2. On DC1361A, set the MASTER / SLAVE switch to MASTER if you want the Hot Swap chip to shut off in response to an output OV fault. To recover from shut off, you must command the channel that produced the OV off then on with the OPERATION command or you can toggle the VinShareEnable bit in MFR_CONFIG_ALL_LTC2978 to 0 then 1.
3. When the USB to $I^2C$/SMBus/PMBus controller power is applied, the LTC2978 will load the contents of its EEPROM into operating RAM.
4. For help on any command, highlight the command in the GUI and press F1.
5. The LTM4603 outputs may be shorted indefinitely. This is a good way to induce UV faults.
6. If the DC1360A is used without the DC1361A, it will report an overtemperature fault because its $V_{SENSE}$ inputs are floating. This may be avoided by tying the $V_{SENSE}$ inputs to defined voltages.



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## DC1540A - DETAILS (DC1360A +DC1361A)

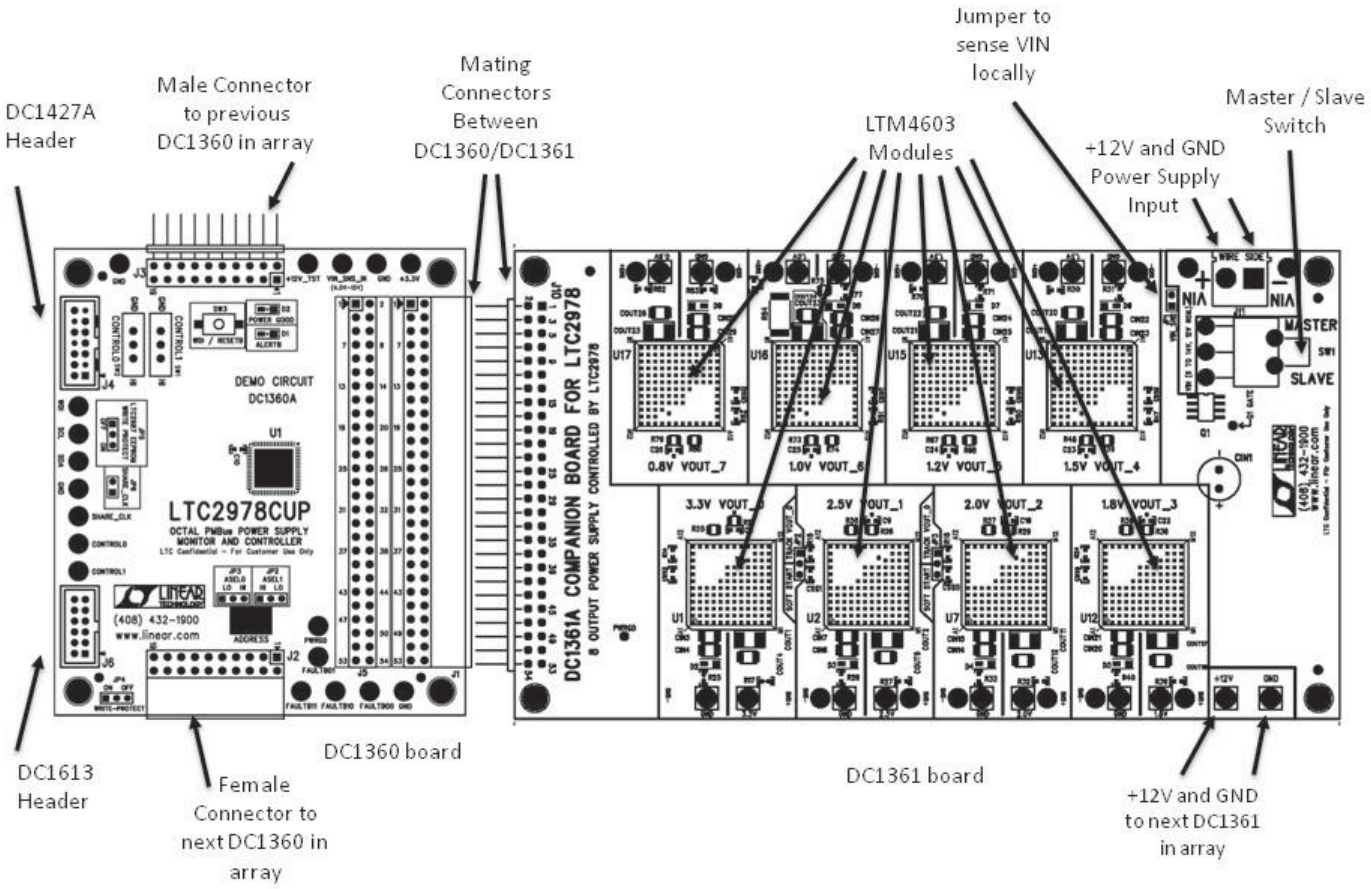


**Figure 5. DC1540A Details**



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## DC1360A DETAILS - TOP SIDE

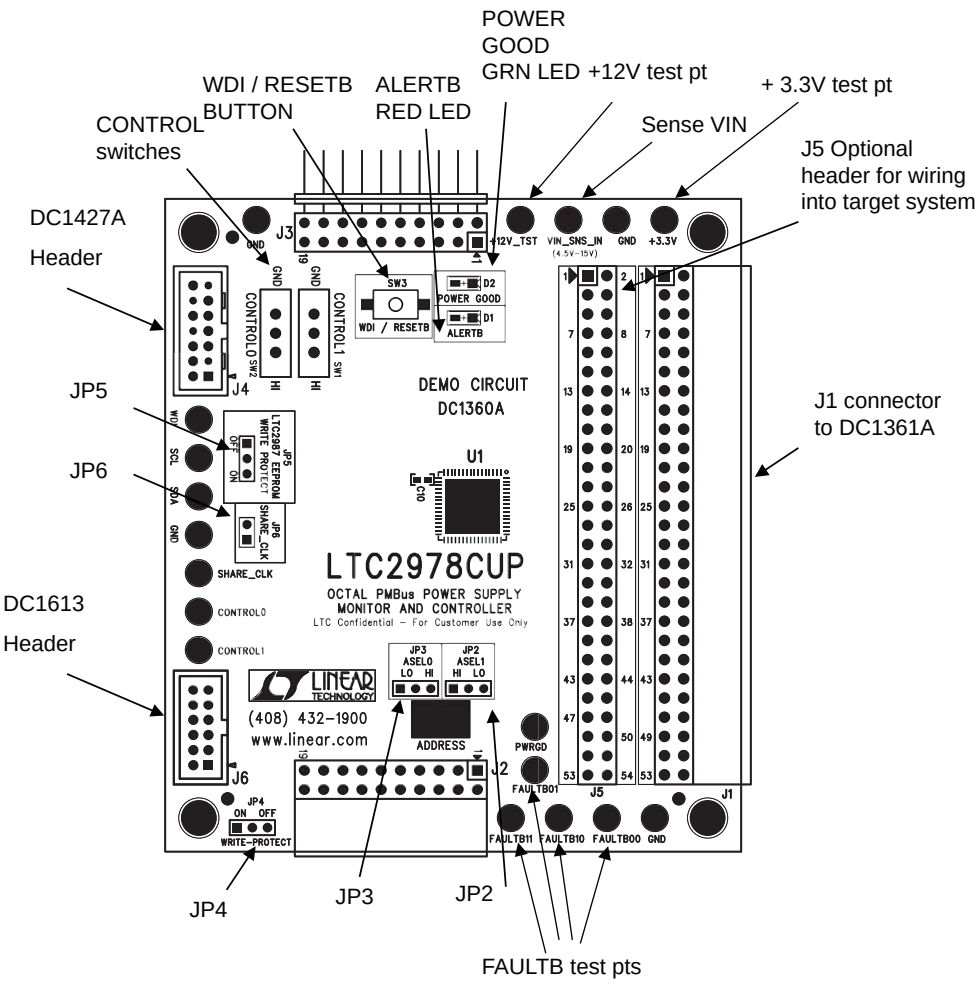


**Figure 6. DC1360A Top Side**

**Table 3. DC1360A - Default Jumper Configuration. Use ASEL's to Select $I^2C$ Address.**

| JP2 ASEL1 | JP3 ASEL0 | JP4 Write-Protect | JP5 LTC2978 Write Protect | JP6 Share_CLK |
|---|---|---|---|---|
| LO | LO | ON | OFF | Installed |



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## DC1360A DETAILS - BOTTOM SIDE

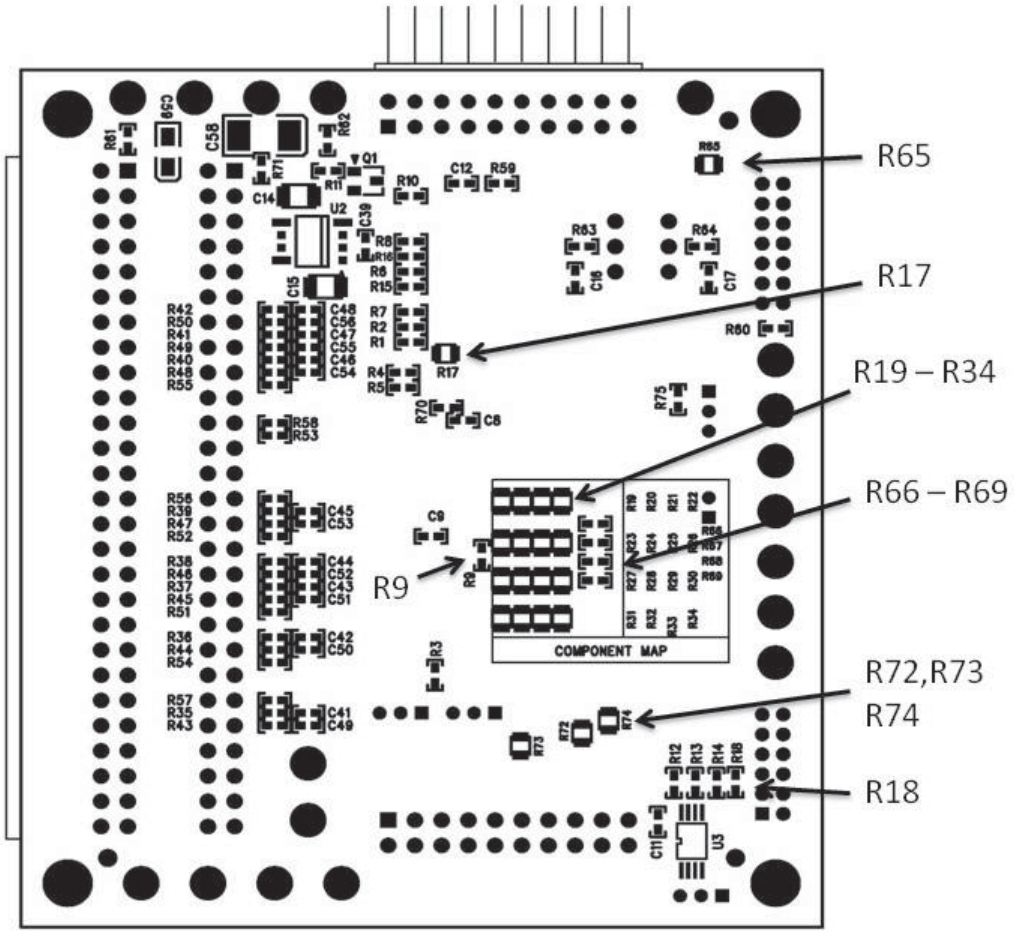


**Figure 7. DC1360A Bottom Side Configuration Resistors**

Configuration resistors are on the bottom side. They allow multiple ways to make fault dependencies between boards.

**Table 4. Optional Configuration Resistors**

| REF Des | Signal | Usage | Default | Comment |
|---|---|---|---|---|
| R9 | FAULTB10 to FAULTB01 | Connect Fault Zone 0 to Fault Zone 1 | INSTALLED | Allows Fault Zone 0 to Connect to Fault Zone 1 |
| R19, R24, R29, R34 | FAULT1 to FAULT4 to FAULT00 to FAULT11 | Connect LTC2978's FAULTB Pin to Demo Board FAULT Lines | INSTALLED | Allows Faults to Propagate Between Boards |
| R21, R22, R23, R25, R26, R27, R28, R30, R31, R32, R33 | FAULT 1 to FAULT 4 | Connect any FAULTB Pin to any of Fault Line: FAULT 1,2,3,4 | OPEN | Allows Faults to Propagate Between Boards. |
| R17 | ALERTB | Allow DC1427A to Receive ALERTB | OPEN | |
| R65 | WDI/RESET | DC1427A Drives WDI/RESETB | OPEN | |
| R18 | AUXP | DC1427A Sources BIGPWR | INSTALLED | BIGPWR + LGKPWR must be <= 100mA max TOTAL |
| R72 | WDI/RESET | DC1427A Drives WDI/RESET | OPEN | |
| R73 | CONTROL0 | DC1427A Drives CONTROL0 | OPEN | |
| R74 | CONTROL1 | DC1427A Drives CONTROL1 | OPEN | |



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# DC1360A DETAILS - BOTTOM SIDE

### Setting the Device Address

The LTC2978 can be configured to respond to one of 9 addresses for a given MFR_I$^2$C_BASE_ADDRESS value (the factory default value base address is 7'h5C). In addition, the LTC2978 will always respond to its global address and the PMBus Alert Response address regardless of the state of the address select pins.

By connecting each of the address inputs to $V_{DD33}$, GND, or by floating them, the user determines the slave address, as shown in Table 4.

**Table 5. Address Look-up Table**

| Description | HEX Device Address | | Binary Device Address | | | | | | | | Address Pins | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7'h | 8'h | 6 | 5 | 4 | 3 | 2 | 1 | 0 | R/W | ASEL1 | ASEL0 |
| Alert Response | 0C | 19 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | X | X |
| Global | 5B | B6 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | X | X |
| *0 | 5C | B8 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | L | L |
| 1 | 5D | BA | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | L | NC |
| 2 | 5E | BC | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | L | H |
| 3 | 5F | BE | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | NC | L |
| 4 | 60 | C0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | NC | NC |
| 5 | 61 | C2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | NC | H |
| 6 | 62 | C4 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | H | L |
| 7 | 63 | C6 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | H | NC |
| 8 | 64 | C8 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | H | H |

H = Tie to $V_{DD33}$; NC = No Connect, Open or Float; L = Tie to GND; X = Don't Care
* MFR_I$^2$C_BASE_ADDRESS = 7'h5C (factory default). LO = L



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## DC1361A DETAILS - TOP SIDE

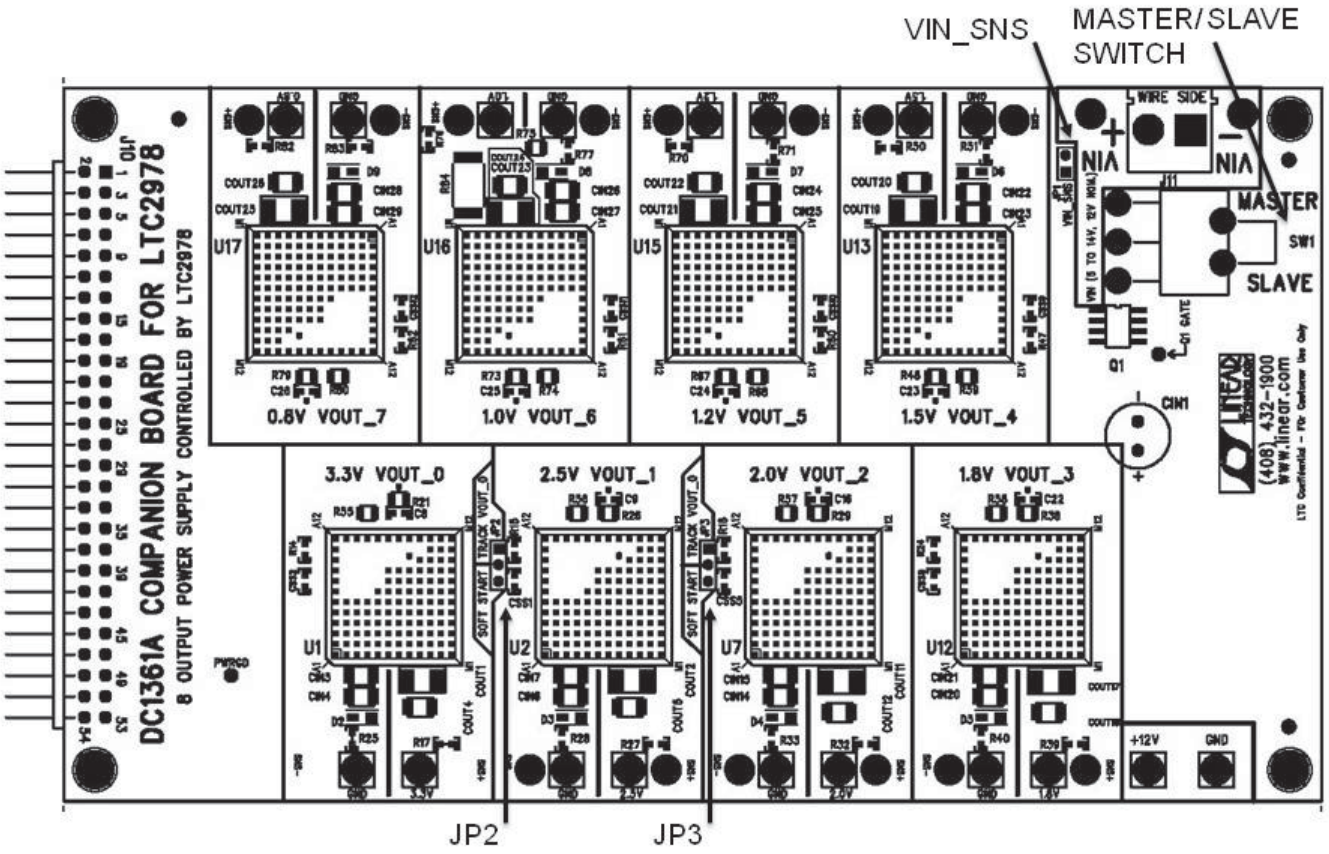


**Figure 8. DC1361A Top Side**

**Table 6. DC1361A - Default Jumper and Switch Configurations**

| JP1 $V_{IN_SNS}$ | | JP2 Track $V_{OUT_0}$/Soft-Start | JP3 Track $V_{OUT_0}$/Soft-Start |
|---|---|---|---|
| Installed = Master | Removed = Slave | Soft-Start | Soft-Start |

| SW1 | |
|---|---|
| Master | Slave |

JP2, JP3 in soft start position allows $V_{OUT1}$, $V_{OUT2}$ to start up with their turn on ramp determined by their soft-start caps. Their sequence position is determined by the LTC2978. In TRACK_$V_{OUT_0}$ position, they coincident track to $V_{OUT_0}$. TON_DELAY for all tracking channels must be equal. SW1 in the MASTER position allows the Hot Swap circuit to ramp up the $V_{IN}$ and also allows the LTC2978 to open the series MOSFET in case of an Overvoltage on any output. SW1 in SLAVE position defeats the hot swap and passes $V_{IN}$ through so multiple DC1361As can be cascaded in an array.



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## DC1361A - CHANGING THE NOMINAL OUTPUT VOLTAGES

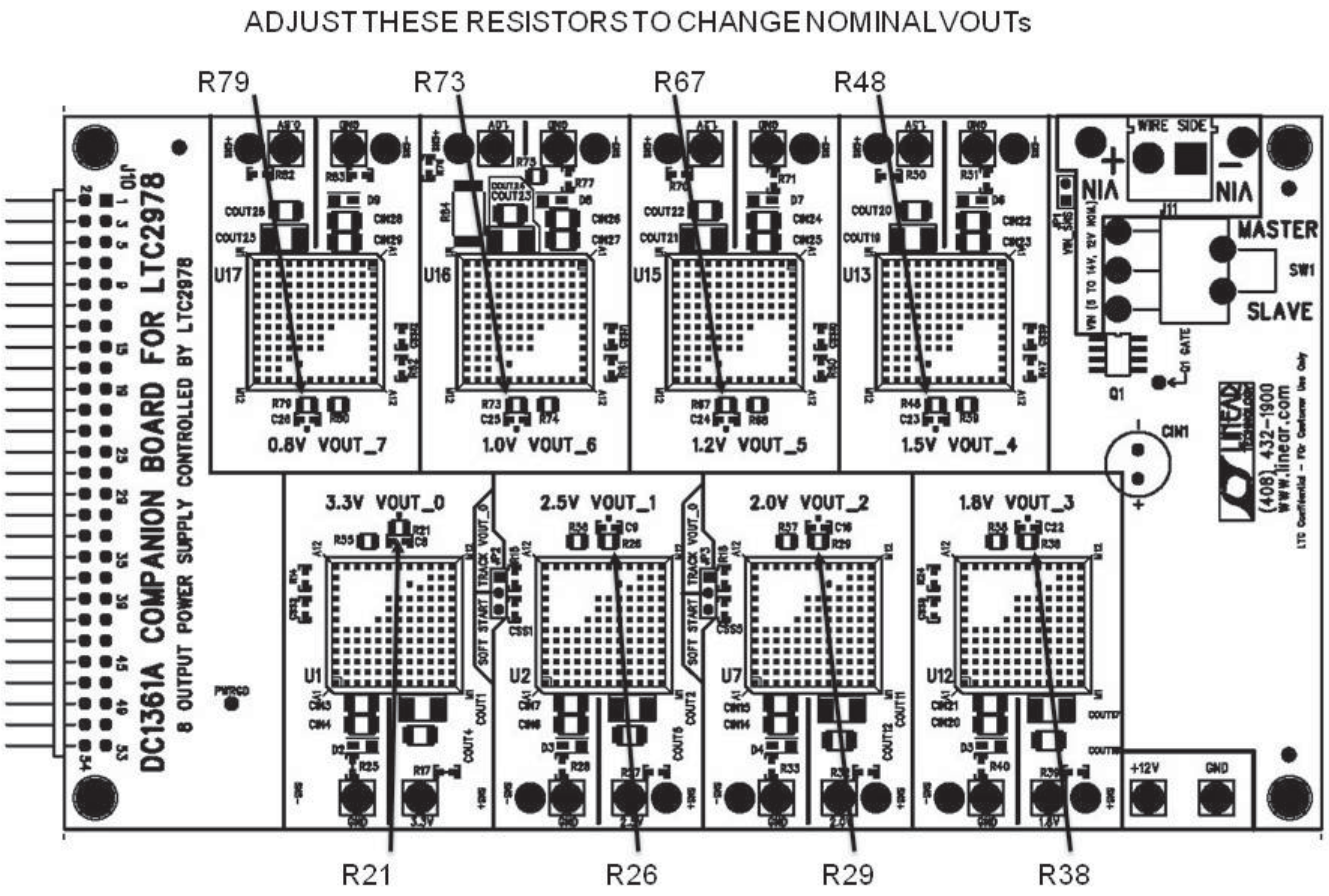


**Figure 9. DC1361A Output Voltage Setting Resistor Locations**

The Nominal $V_{OUT}$ of any channel on the DC1361A can be changed by changing the $R_{SET}$ resistor from $V_{FB}$ to SGND. These are: R21, R26, R29, R38, R48, R67, R73, R79. See Figure 9. The value for the $R_{SET}$ resistor is:

$R_{SET} = 60.4k/((V_{OUT}/0.6) – 1))$

See also the LTM4603 datasheet Table 2. $V_{OUT0}$ may be adjusted up to 5V. The other channels may be adjusted up to 4V.



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## DC1361A – ADJUSTING THE MARGIN/TRIM RANGE AND RESOLUTION

The resolution and range can be adjusted for any output on the DC1361A by simply replacing the below resistors. Use the LTC2978 Resistor Selection Tool (spreadsheet) for calculating resistors values and proper DAC range settings.

The design tool refers to R20. This is the upper divider resistor which is 60.4kΩ inside the LTM4603.

The design tool refers to R10. This is the lower divider resistor which is $R_{SET}$ (See Figure 9).

The design tool refers to R30. This is the margin/trim adjustment resistor.

On the DC1361A, the lower divider resistors (R10) are = $R_{SET}$ for each channel = R21, R26, R29, R38, R48, R67, R73, R79.

On the DC1361A, the adjustment resistors (R30) are = R55, R56, R57, R58, R59, R68, R74 and R80.

**CHANGE THESE RESISTORS TO ADJUST THE MARGIN RANGE/RESOLUTION**

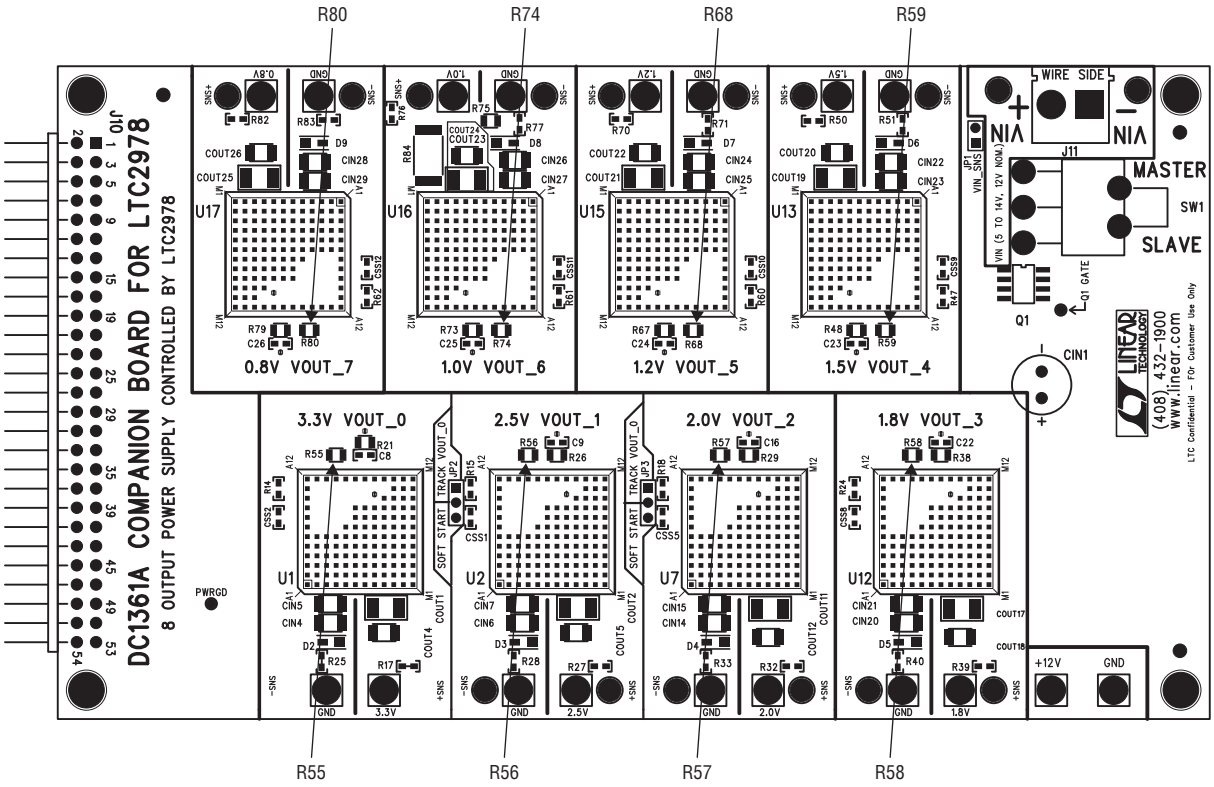


**Figure 10. Margin/Trim Resistor Locations**



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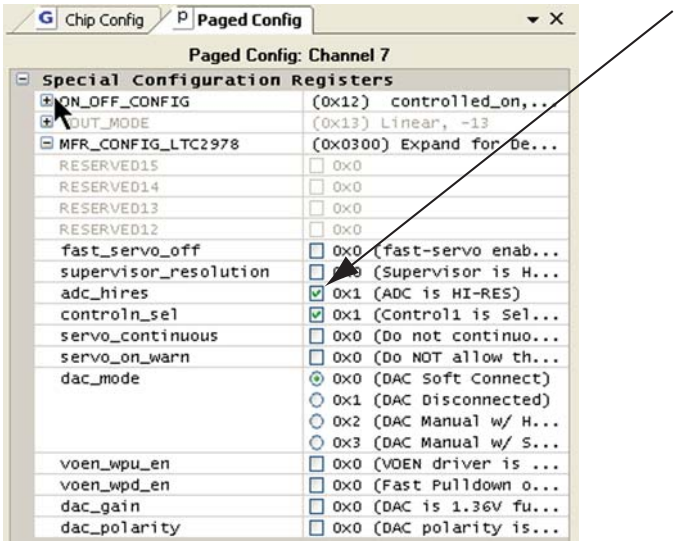
## MEASURING CURRENT

It is possible to measure the current on Channel 6 by using Channel 7 in “Hi Res” mode. Follow the instructions on pp.9 and 10 of DC1361A schematic. Remove R88, R89 and move them to R86, R87. Also remove the preload resistor R75 (top side) on DC1361A schematic p.9 to measure only the current going out of the board.

One simple checkbox in the GUI sets up Channel 7 to measure current. In the MFR_CONFIG_LTC2978 register check the box that says “adc_hires”. Apply a load between the big turrets 1.0V and GND on $V_{OUT_6}$ and read the voltage across the 10mΩ current sense resistor on the output of Channel 6 in the GUI.



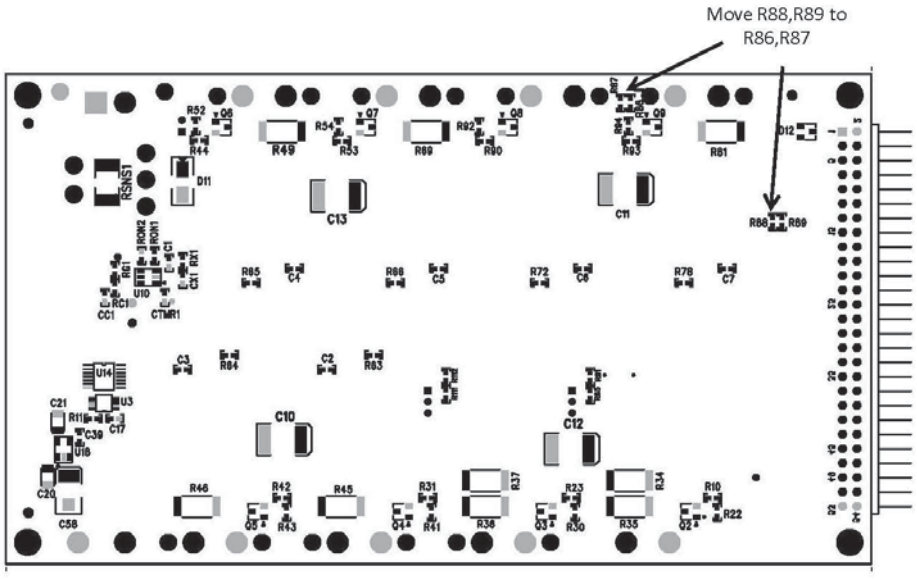




**Figure 11. Current Sensing Modifications (Bottom Side of Board)**



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## COMMON DEMO BOARD OPERATIONS

### Reset the LTC2978

To reset the LTC2978 and reload the EEPROM contents into operating memory (RAM), press SW3.

### DC1360A LEDs

The Red ALERTB LED indicates a fault has occurred. The Green LED indicates the status of the PWRGD signal.

### DC1361A Remote Sense

Remote sense Test Points are included for channels 1-7. There is no remote sense for Channel 0.

### Faulting an Output

Use a jumper wire or a coin to short any output. For an OV fault, short a lower voltage to a higher one momentarily.

### Fault Sharing Setup in GUI

Use the Fault Sharing Diagram Tool to setup the fault sharing in the GUI. Before doing so, view the fault sharing Demo in the GUI. Go to Tools > Fault Sharing Diagram.

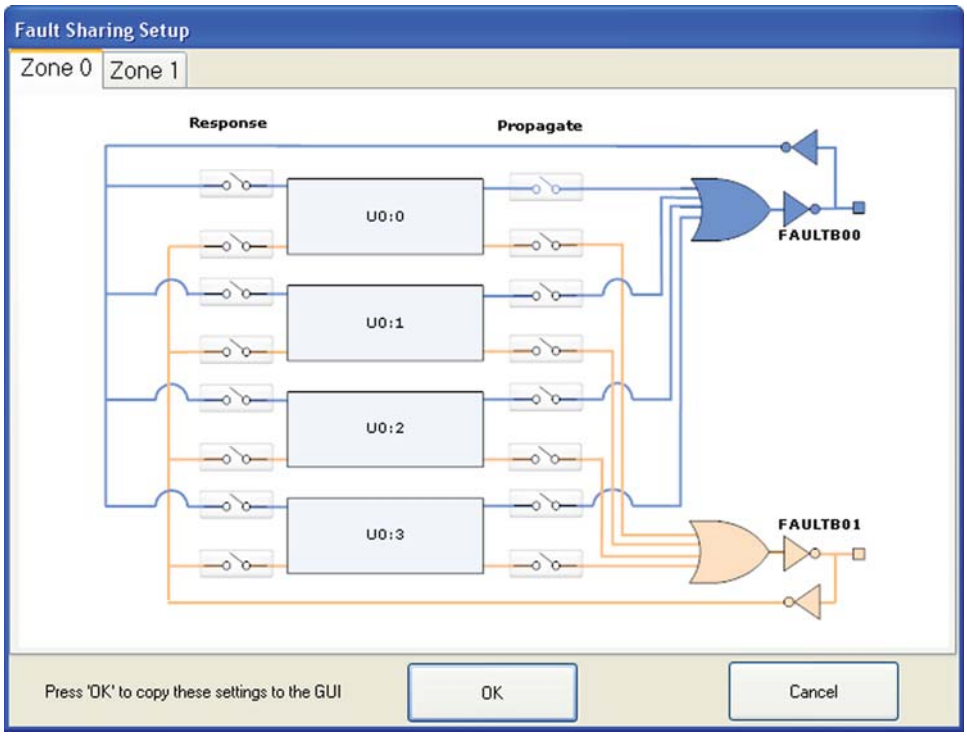


**Figure 12. GUI Fault Sharing Setup Tool**



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## FAULT ZONE CONFIGURATION AND FAULT PROPAGATION

The LTC2978 has four FAULTB pins within two fault zones. Each channel can pull FAULTB pins within its zone low. Also, any channel can shutdown in response to FAULTB pins within its zone, therefore, dependencies between any channel(s) can be established. See Applications section of the datasheet. See Figure below. Zone 0 and 1 are tied together on the DC1360A through R9. Therefore, any channel can shut off in response to any other channel on the LTC2978. Additionally, each FAULTBz pin ties to a FAULTn (n =1,2,3,4) line on the DC1360A which is bussed to other DC1360A's in a multiboard array. Therefore, it is possible for any channel in an array to shutoff in response to any other channel.

FAULTn lines are on p.2 DC1360A schematic J2, J3.

To disconnect Fault zone 0 from Fault zone 1, remove R9 on DC1360A.

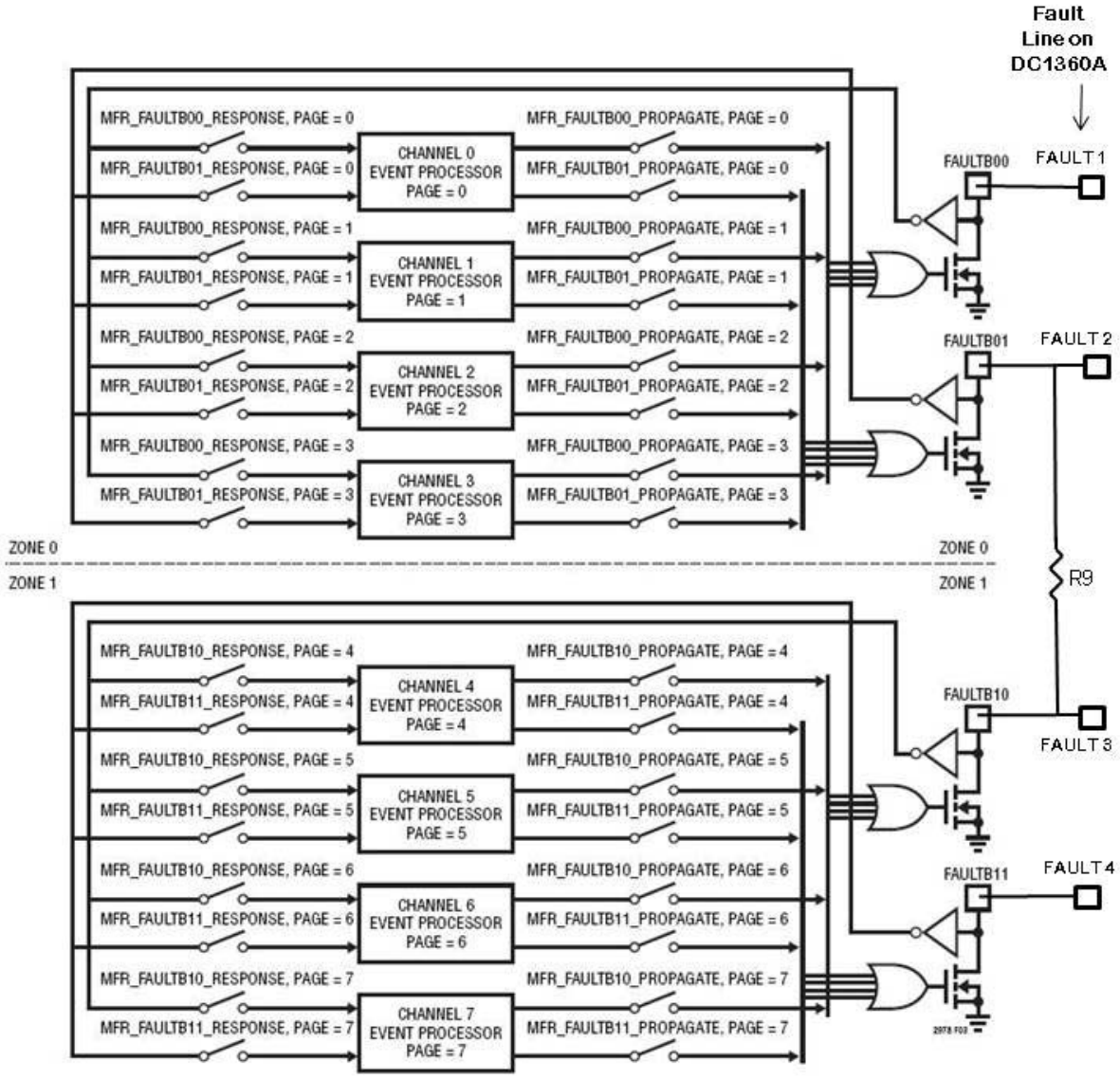


**Figure 13. Fault Zones and Fault Pins on DC1360A**



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## SETUP PROCEDURE FOR MULTI-BOARD ARRAYS

Multiple DC1540As can be combined to control as many output voltages as desired.

1. Connect DC1360A's to DC1361A's.
2. Solder wires from the +12V and GND turrets of Master DC1361A and connect into the terminal block of the Slave board.
3. Leave JP1 INSTALLED in the first (Master) board. Remove JP1 jumpers from all others (Slaves).
4. Plug DC1360A's together. J3 to J2.
5. Set the Master/Slave switch on the first DC1361A in the array to Master. Set other boards to Slave.
6. Set a unique address for each LTC2978 in the array using ASEL0 (JP3) and ASEL1 (JP2).
7. Plug the ribbon cable of the DC1427A into J4 OR DC1613 into J6 of any DC1360A.
8. Hook up power supply (5-14V, at least 0.5A times the number of boards) to J11 Terminal Block to power the array of modules.

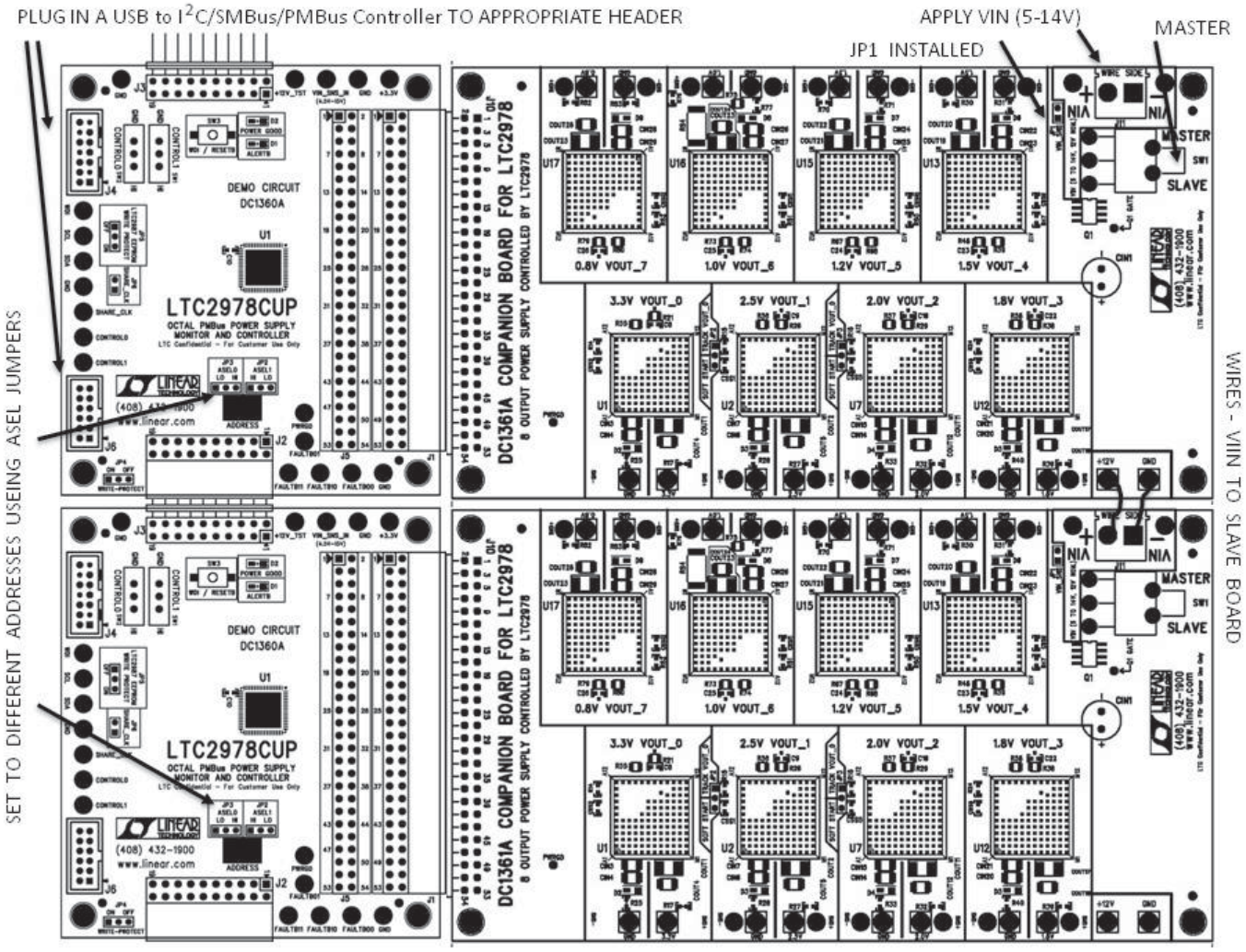


**Figure 14. Array of Multiple Demo Boards**



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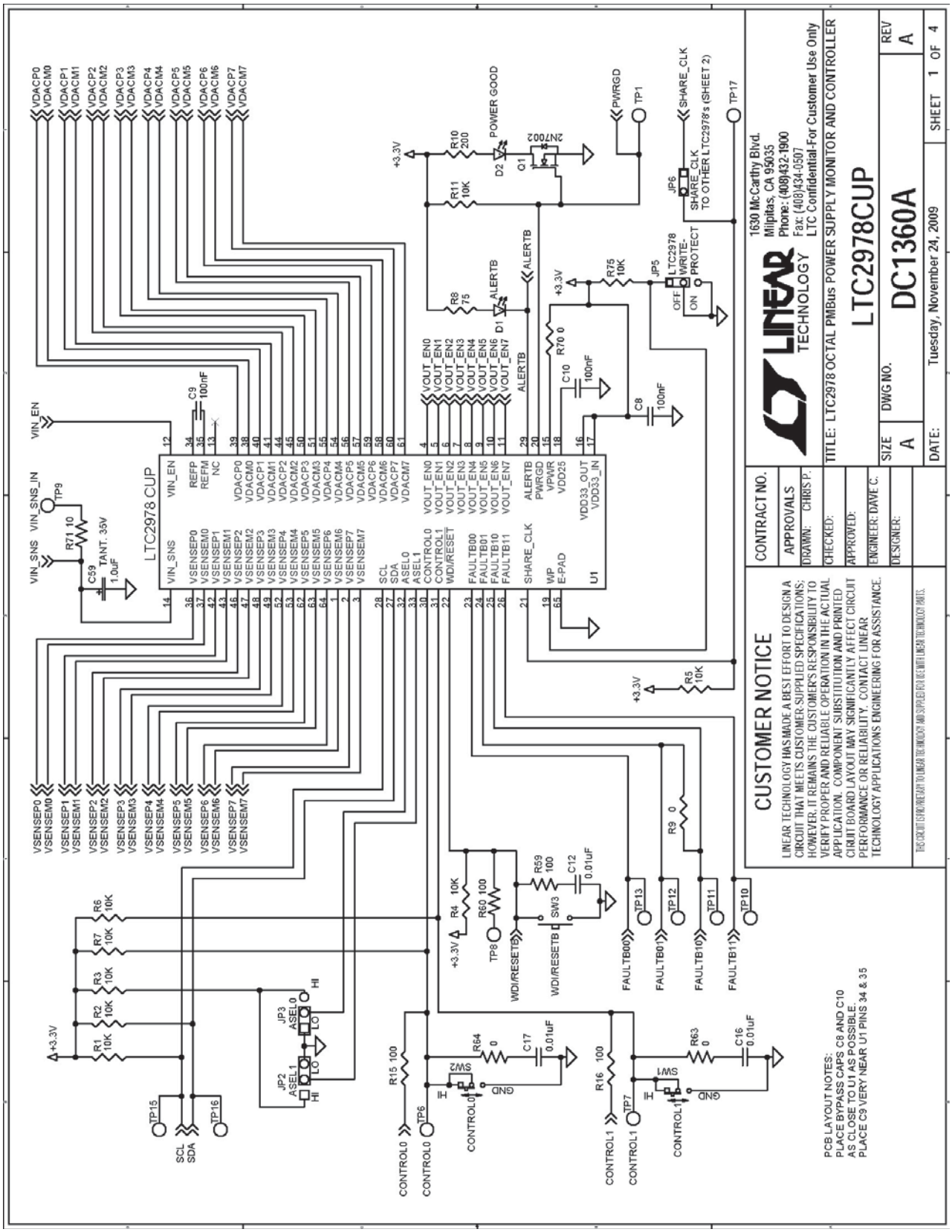
## SCHEMATIC DIAGRAM



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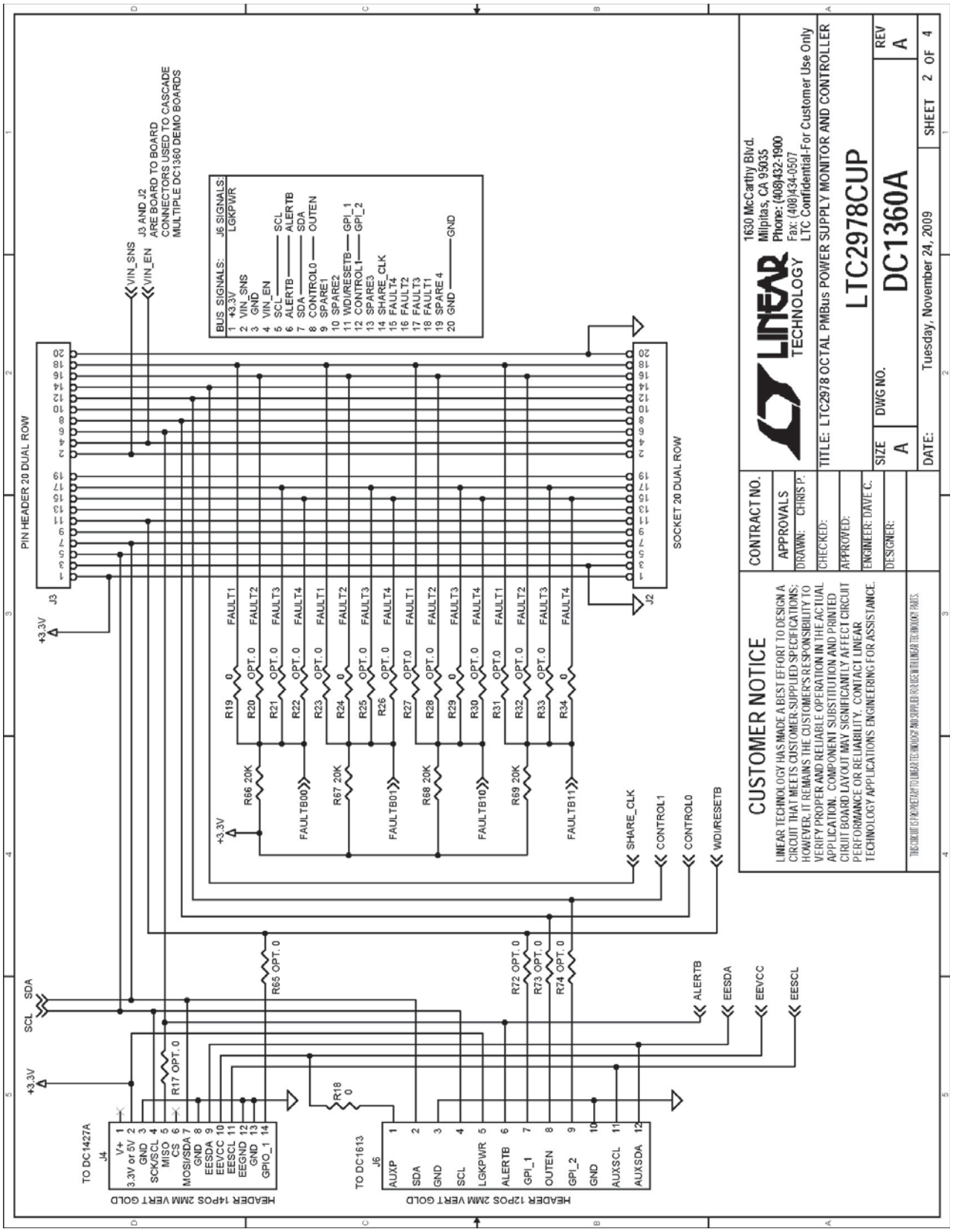
## SCHEMATIC DIAGRAM



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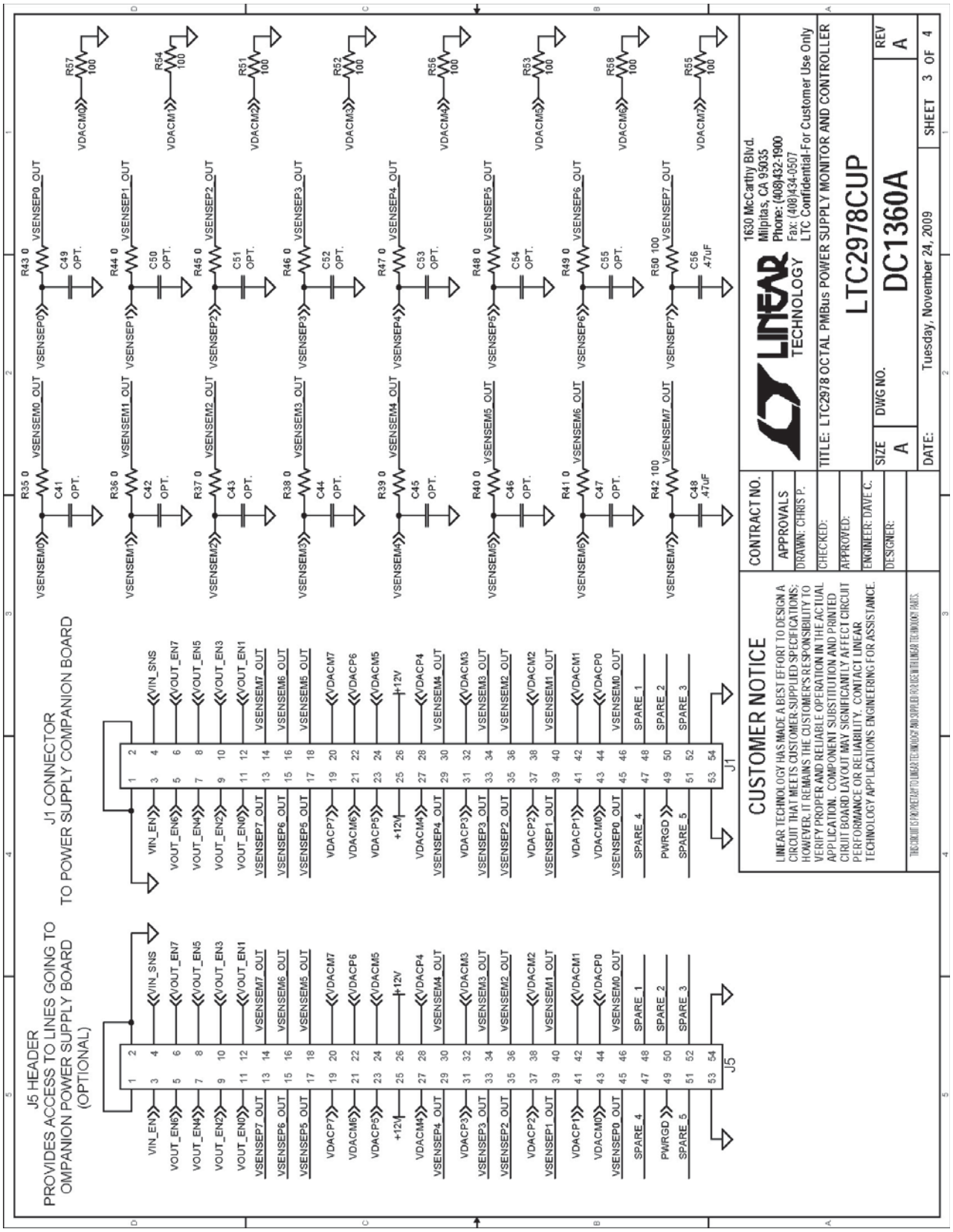




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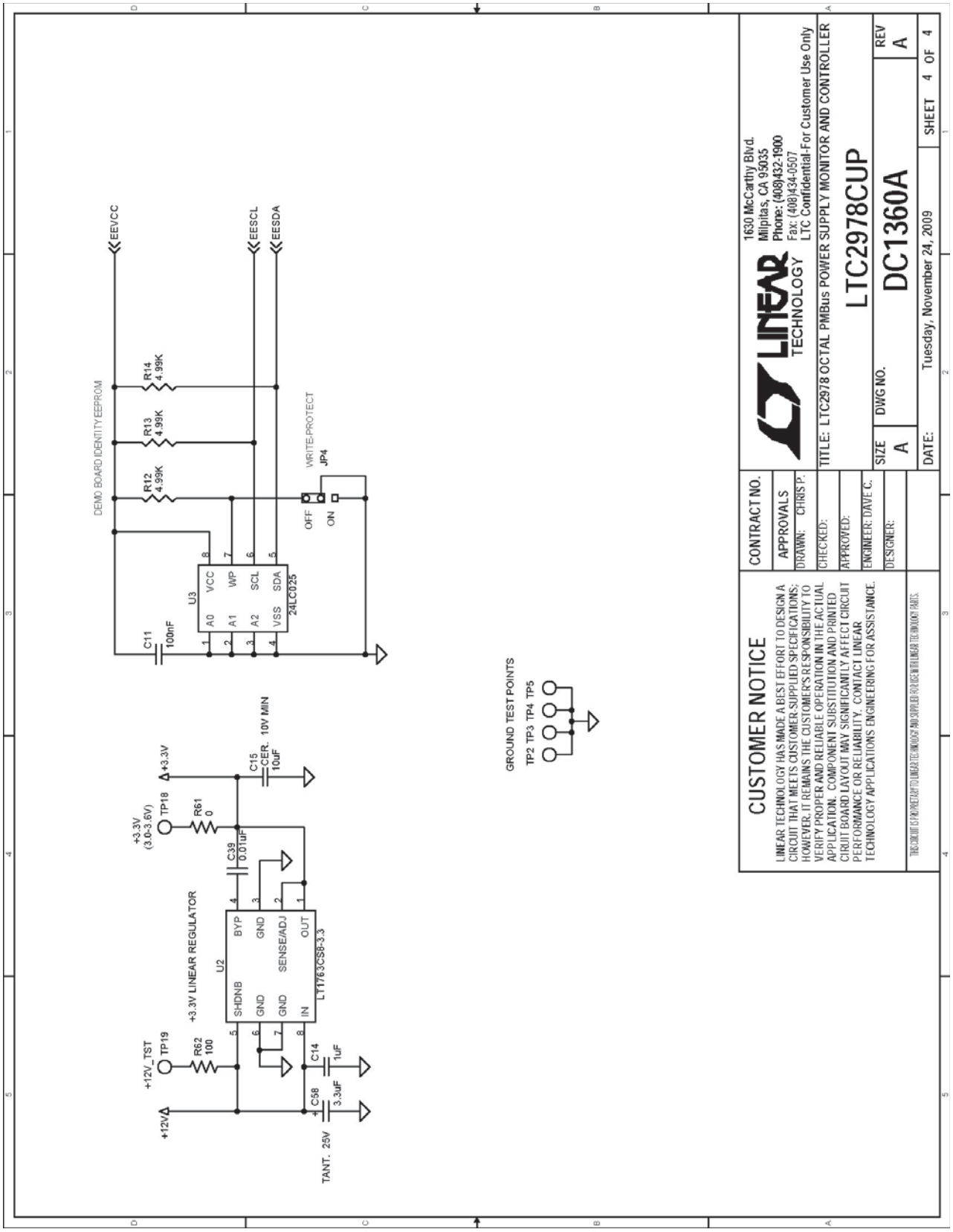
## SCHEMATIC DIAGRAM



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## PARTS LIST

**Linear Technology Corporation**
*LTC2978CUP*

***Bill Of Material***
***Demo Bd. #1360A***

| Item | Qty | Reference | Part Description | Manufacturer / Part # |
|---|---|---|---|---|
| **REQUIRED CIRCUIT COMPONENTS[1]** | | | | |
| 1 | 1 | U1 | IC 8CH SUPRVSR, MON, MARGIN CTRLR | LINEAR TECH LTC2978CUP |
| 2 | 3 | C8,C9,C10 | CAP CERM .10UF 20% 16V X7R 0603 | AVX 0603YC104MAT2A |
| 3 | 6 | R1,R2,R4,R5,R11,R75 | RES 10K OHM 1/10W 5% 0603 SMD | VISHAY CRCW060310K0JNEA |
| **ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS[2]** | | | | |
| 4 | 2 | C48,C56 | CAP CERM .47UF 10% 16V X5R 0603 | AVX 0603YD474KAT2A |
| 5 | 4 | C12,C16,C17,C39 | CAP CERM .01UF 10% 50V X7R 0603 | AVX 06035C103KAT2A |
| 6 | 1 | C11 | CAP CERM .10UF 20% 16V X7R 0603 | AVX 0603YC104MAT2A |
| 7 | 2 | C14,C15 | CAP CERM 1UF 10% 25V X7R 1206 | AVX 12063C105KAT2A |
| 8 | 1 | C58 | CAP TANTALUM 3.3UF 25V 20% SMD | AVX TAJC335M025R |
| 9 | 1 | SW3 | SWITCH TACT MINI PB SPST SLV GWING | C&K KSR211GLFS |
| 10 | 1 | D1 | LED 637NM RED DIFF SMD 0805 | PANASONIC LN1271RTR |
| 11 | 1 | D2 | LED GREEN CLEAR 560NM 0805 SMD | Panasonic LN1371SGTRP |
| 12 | 2 | SW1,SW2 | SWITCH SLIDE SPDT 30V.2A PC MNT | E-SWITCH EG1218 |
| 13 | 1 | Q1 | MOSFET N-CH 60V 115MA SOT-23 | FAIRCHILD 2N7002_NL |
| 14 | 1 | C59 | CAP TANTALUM 1.0UF 35V 20% SMD | KEMET B45196H6105M109 |
| 15 | 1 | U2 | IC REG 3.3V 100MA LDO LN SOT23-5 | LINEAR TECH LT1763CS8-3.3 |
| 16 | 1 | U3 | IC, SERIAL EEPROM | MICROCHIP 24LC025-I/ST |
| 17 | 19 | R18,R9,R35,R36,R37,R38,R39, R40,R41,R43,R44,R45, R46,R47,R48,R49,R61, R63, R64,R70 | RES 0.0 OHM 1/10W 5% 0603 SMD | Vishay CRCW06030000Z0EA |
| 18 | 14 | R15,R16,R42,R50-60,R62 | RES 100 OHM 1/10W 1% 0603 SMD | VISHAY CRCW0603100RFKEA |
| 19 | 3 | R3,R6,R7 | RES 10K OHM 1/10W 5% 0603 SMD | VISHAY CRCW060310K0JNEA |
| 20 | 1 | R71 | RES 10 OHM 1/10W 1% 0603 SMD | VISHAY CRCW060310RFKEA |
| 21 | 1 | R10 | RES 200 OHM 1/10W 1% 0603 SMD | VISHAY CRCW0603200RFKEA |
| 22 | 1 | R08 | RES 75 OHM 1/10W 5% 0603 SMD | VISHAY CRCW060375R0JNEA |
| 23 | 4 | R66,R67,R68,R69 | RES 20K OHM 1/10W 5% 0603 SMD | VISHAY CRCW060320K0JNEA |
| 24 | 3 | R12,R13,R14 | RES 4.99K OHM 1/10W 1% 0603 SMD | VISHAY CRCW06034K99FKEA |
| 25 | 3 | R19,R24,R29,R34 | RES 0.0 OHM 1/8W 5% 0805 SMD | VISHAY CRCW08050000Z0EA |
| **HARDWARE-FOR DEMO BOARD ONLY:** | | | | |
| 26 | 4 | MTG1,MTG2,MTG3,MTG4 | STAND-OFF NYLON 1/4" SNAP IN | KEYSTONE 8831 |
| 27 | 18 | TP01-TP13,TP15-TP19 | TP TURRET SMALL FOR .063 HOLE | MILL-MAX 2308-2-00-44-00-00-07-0 |
| 28 | 1 | J3 | PIN HEADER 20 DUAL ROW RA | MILL-MAX 802-40-020-20-001 |
| 29 | 1 | J2 | CONN SOCKET 20 DUAL ROW RA | MILL-MAX 803-93-020-20-001 |
| 30 | 1 | J6 | CONN HEADER 12POS 2MM STR DL PCB | FCI 98414-G06-12ULF |
| 31 | 1 | J4 | HEADER 14POS 2MM VERT GOLD | MOLEX 87831-1420 |
| 32 | 5 | JP2-SH,JP3-SH,JP4-SH, JP5-SH,JP6-SH | CONN SHUNT 2MM 2POS GOLD BLACK | SAMTEC 2SN-BK-G |
| 33 | 1 | J1 | CONN FEMALE 54POS DL .1 R/A TIN | SULLINS PPTC272LJBN-RC |
| 34 | 0 | Opt | CONN HDR BRKWAY OPT | OPTION |
| 35 | 0 | R72,R73,R74 | RES 0.0 OHM 1/8W 5% 0805 SMD | OPTION |
| | | | | |
| **Notes:** | | | | |
| | 1. | Required Circuit Components are those parts that are required to implement the circuit function | | |
| | 2. | Additional Demo Board Circuit Components are those parts that provide added functionality | | |
| | | for the demo board butare not required in the actual circuit. | | |



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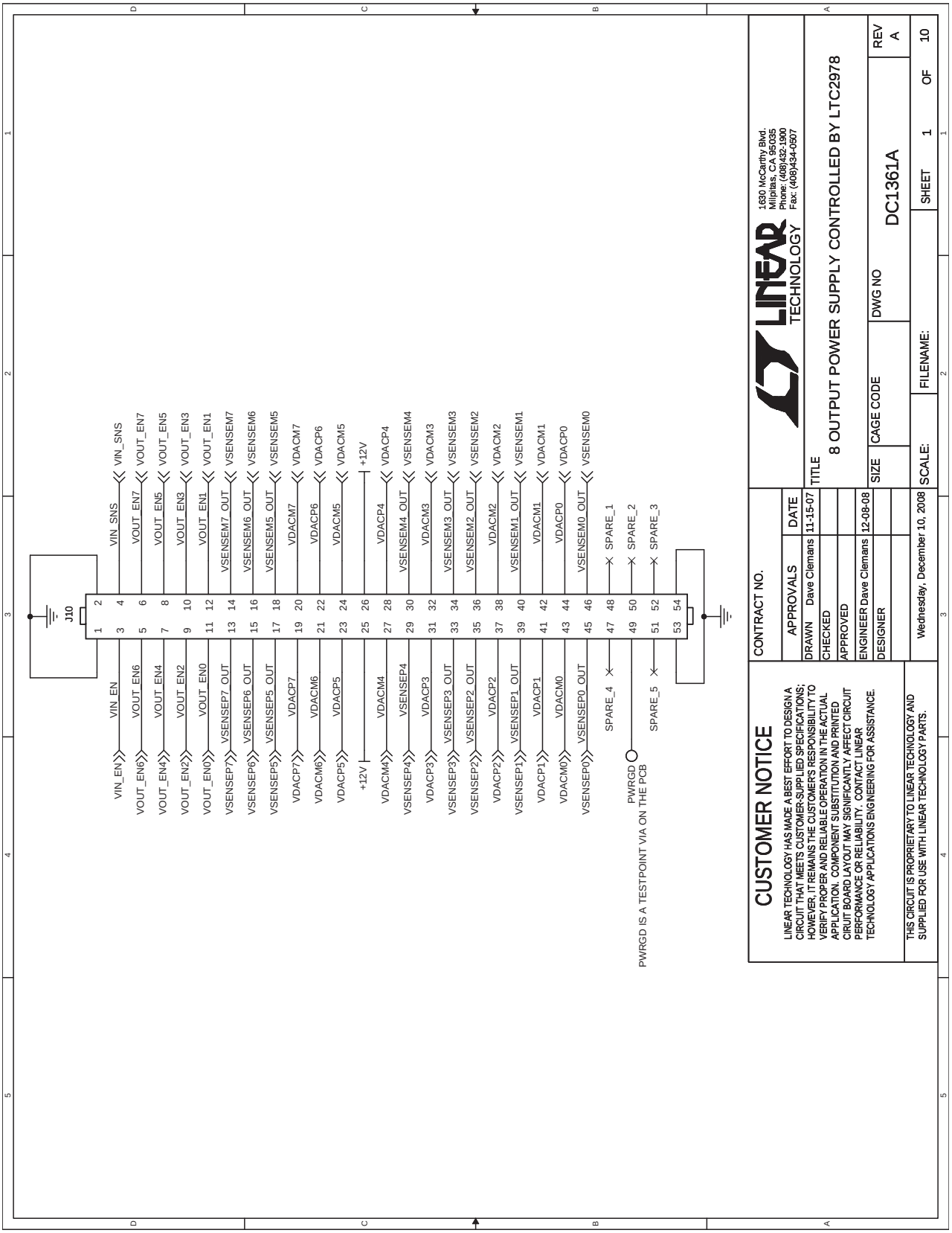
## SCHEMATIC DIAGRAM



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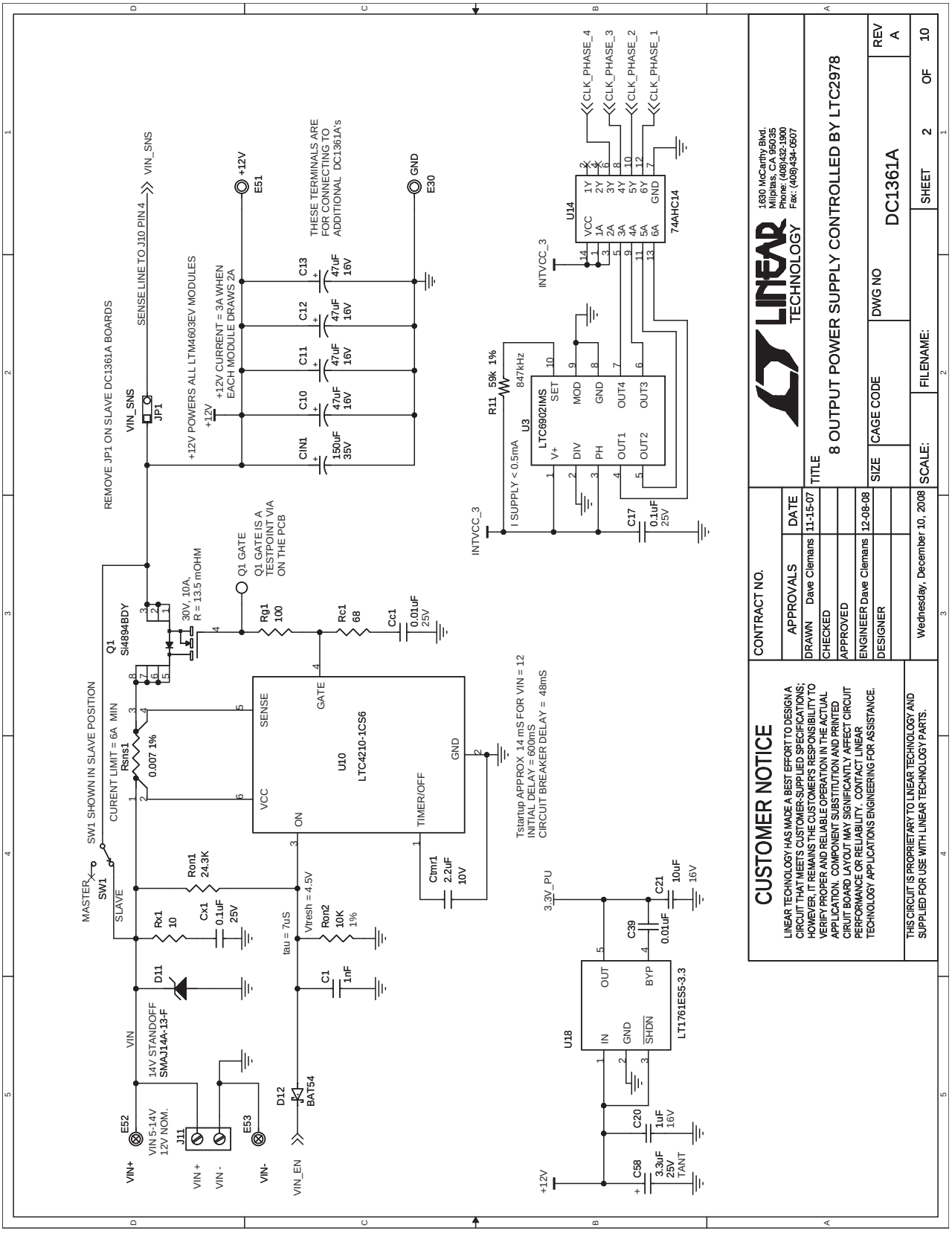




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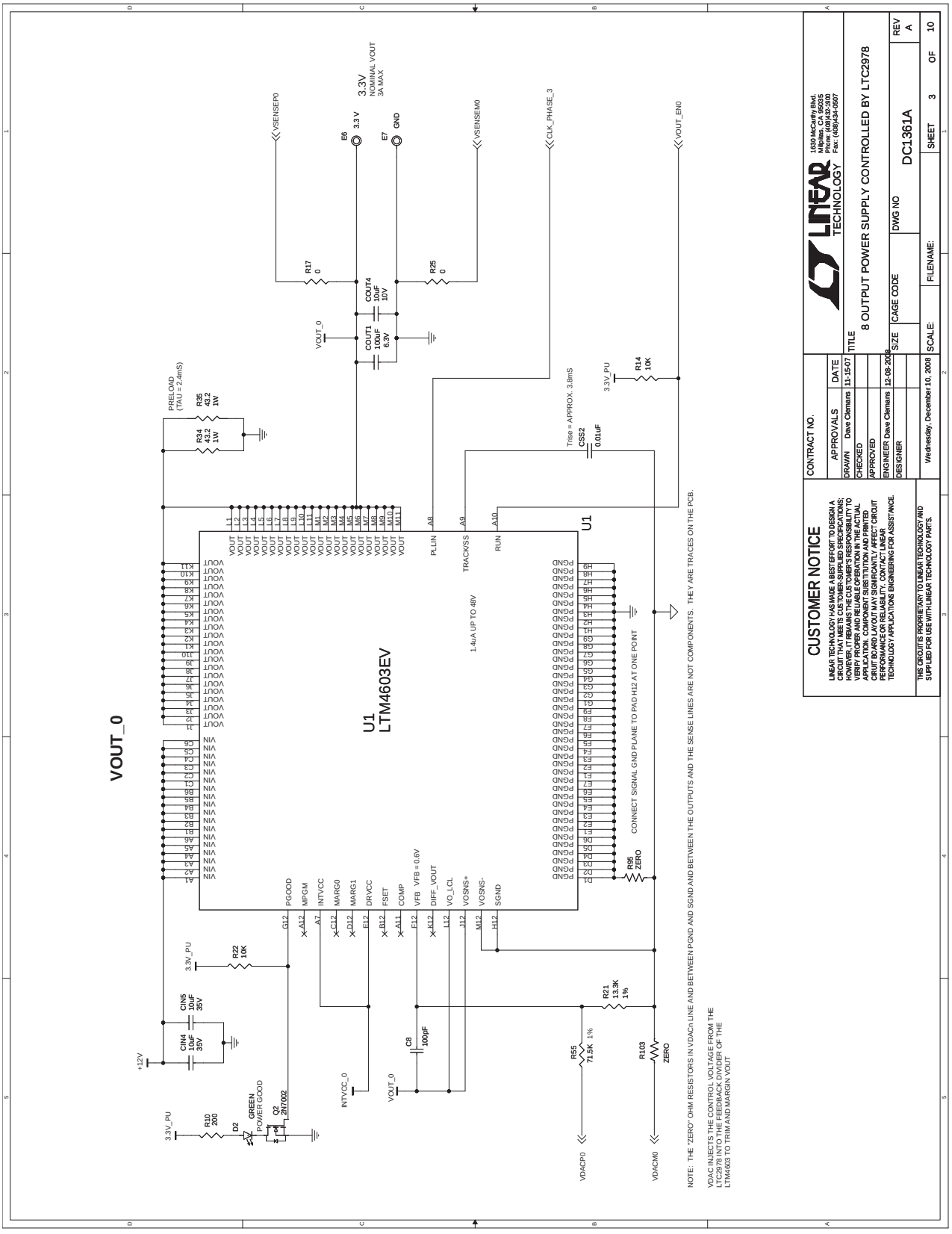




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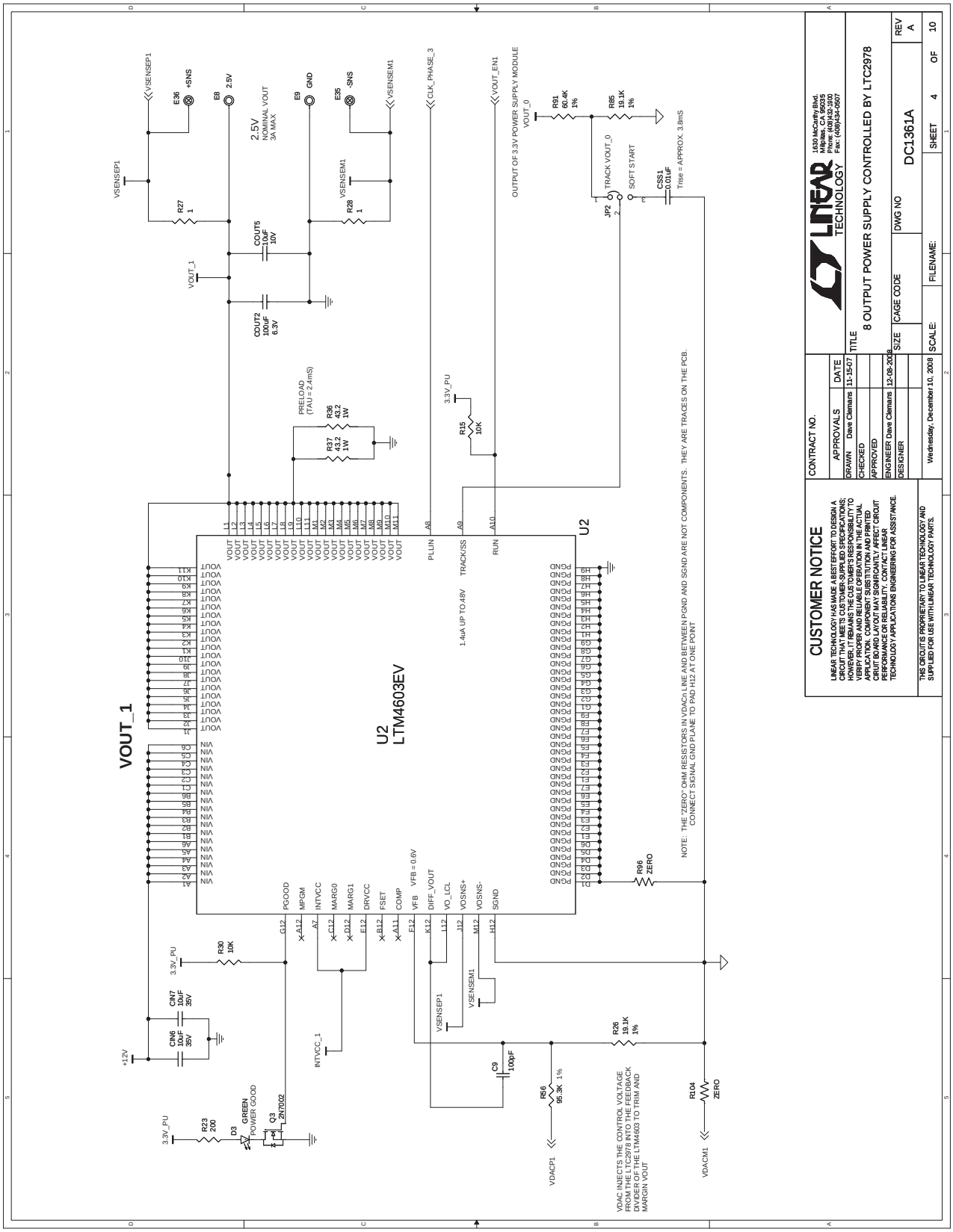




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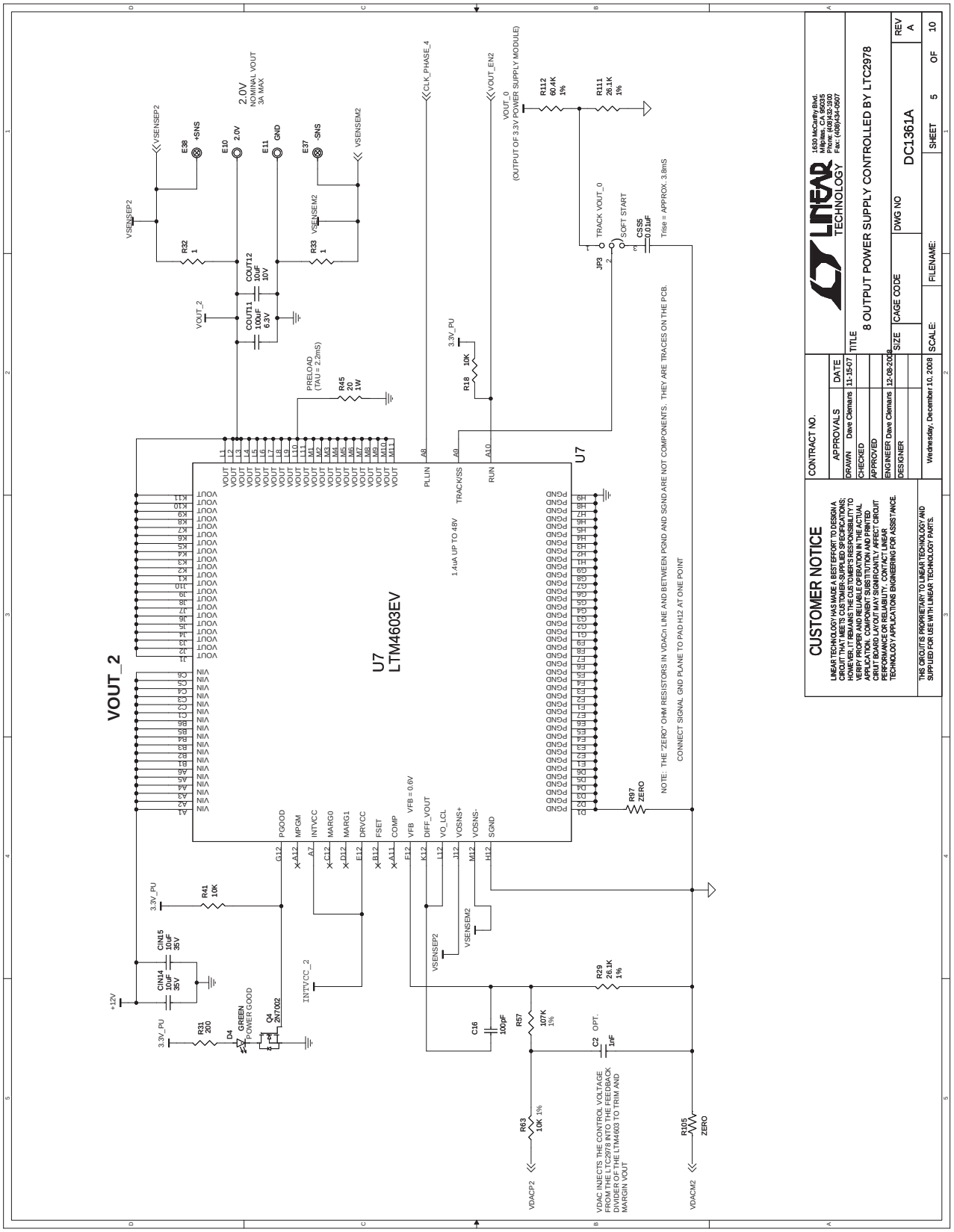




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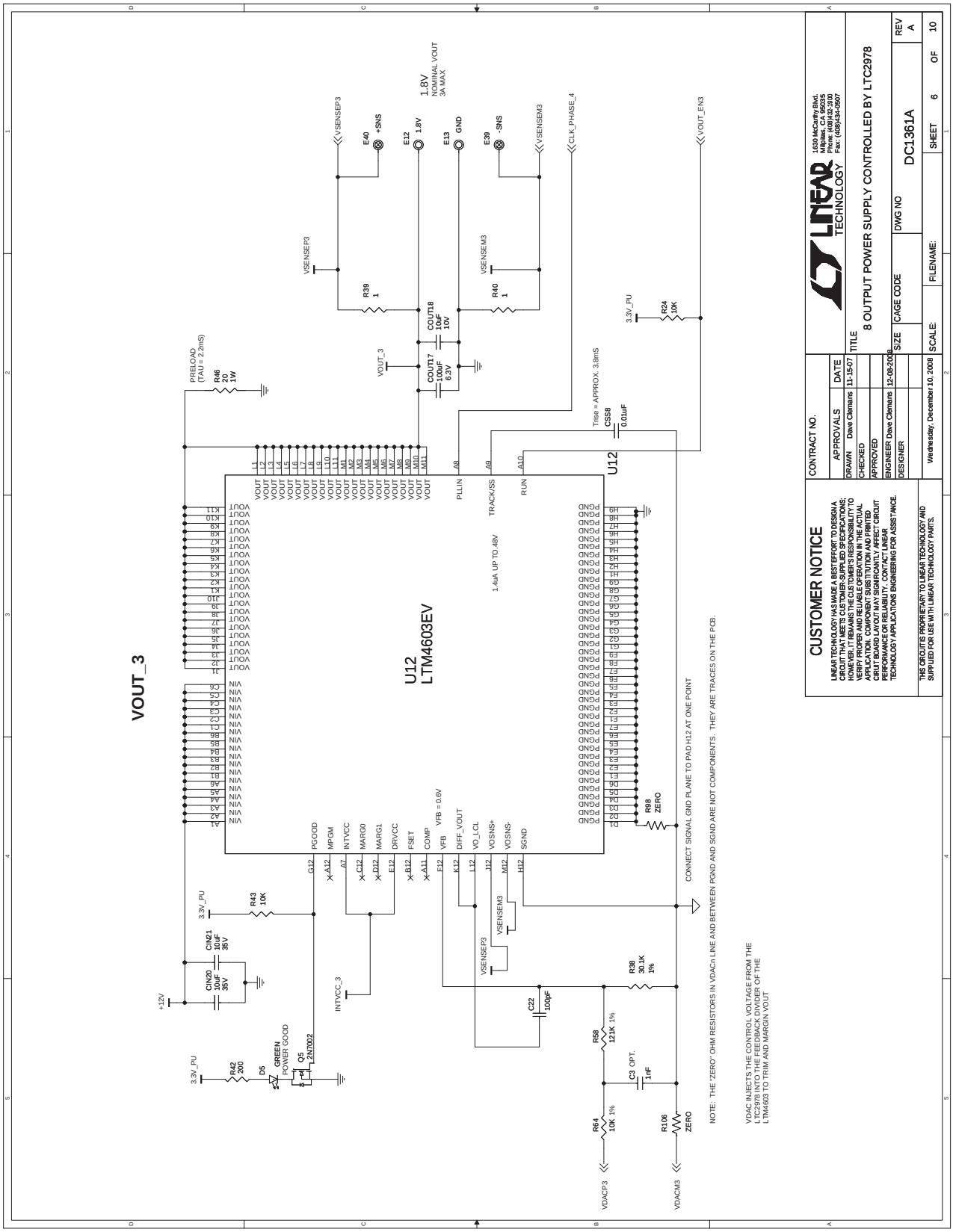




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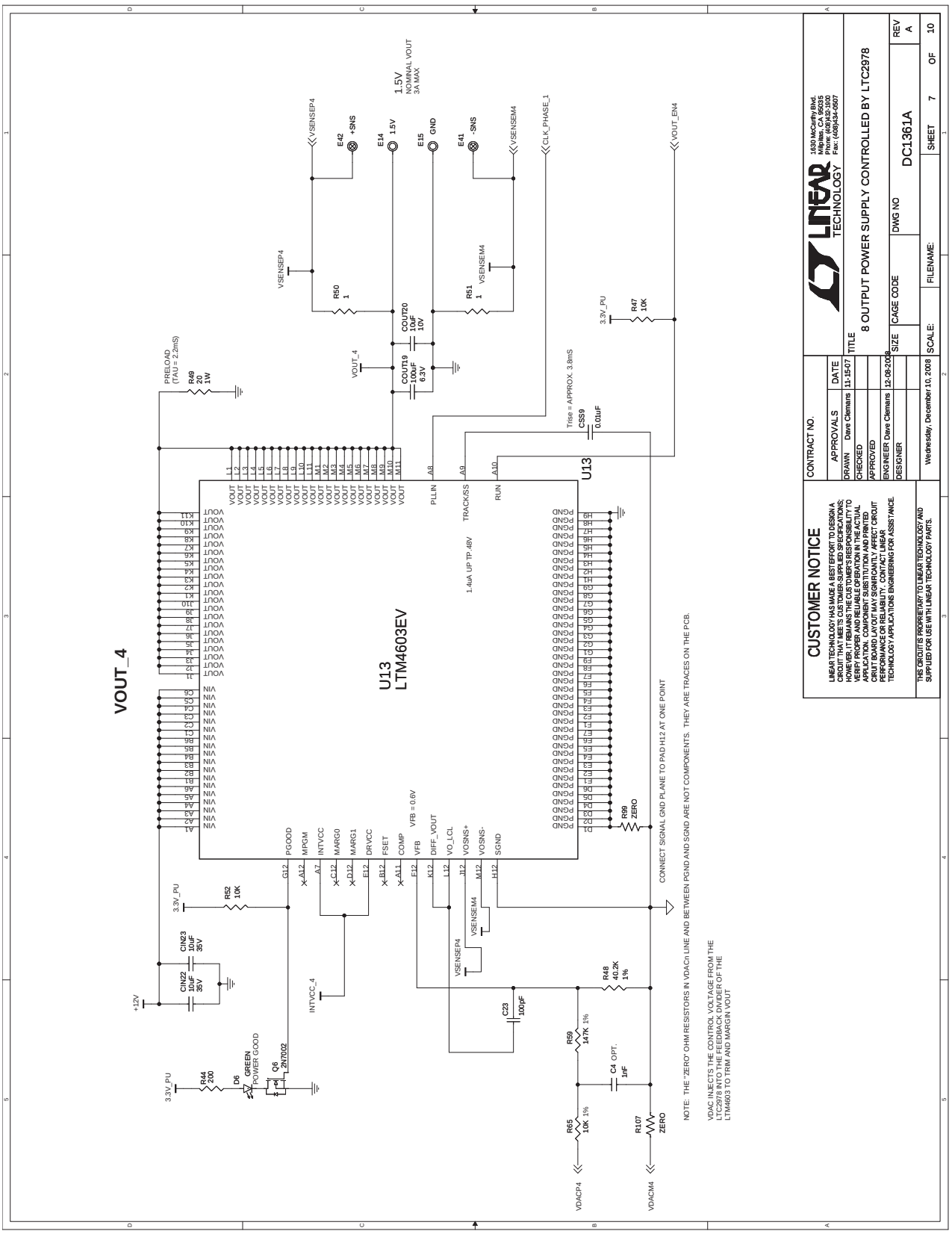




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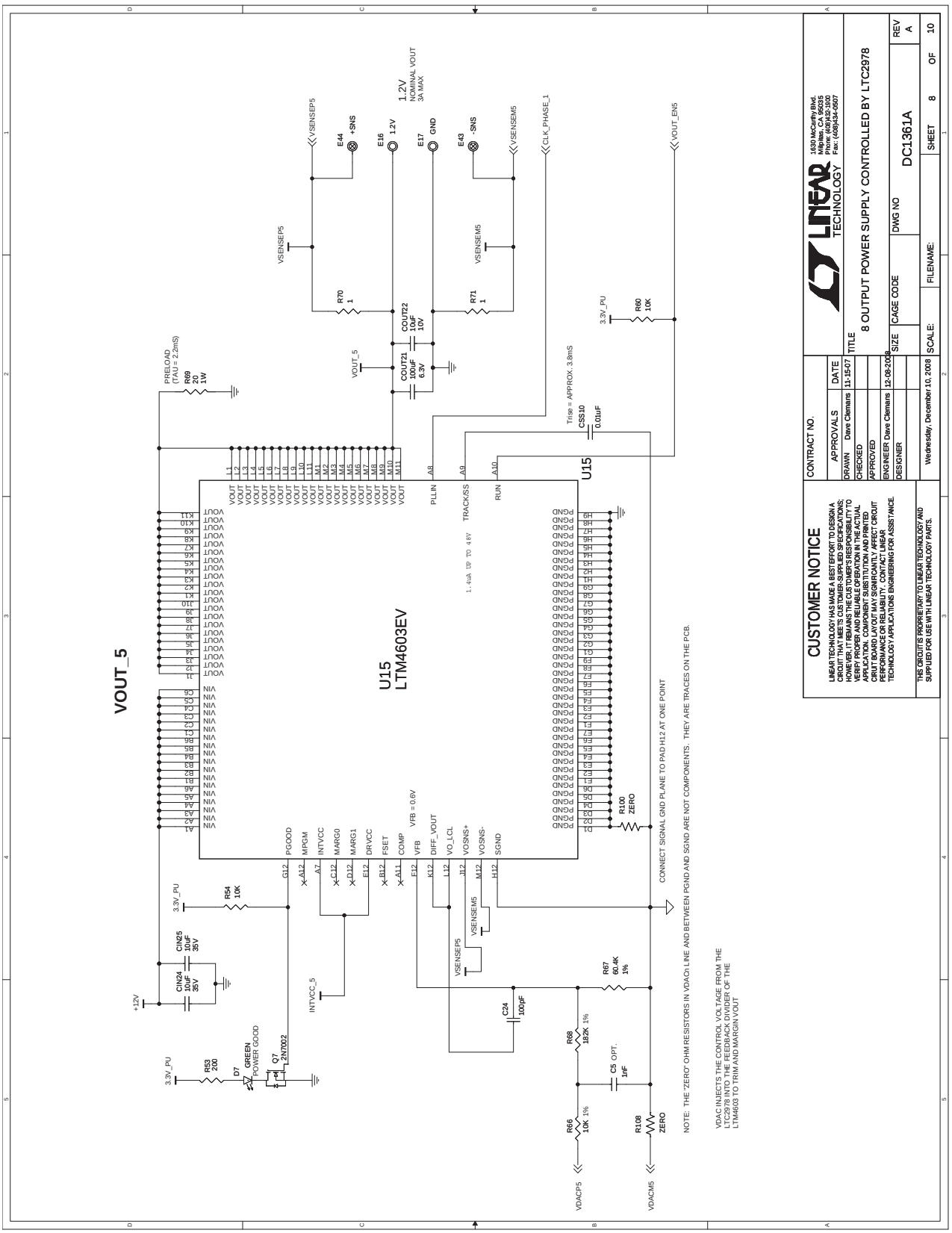




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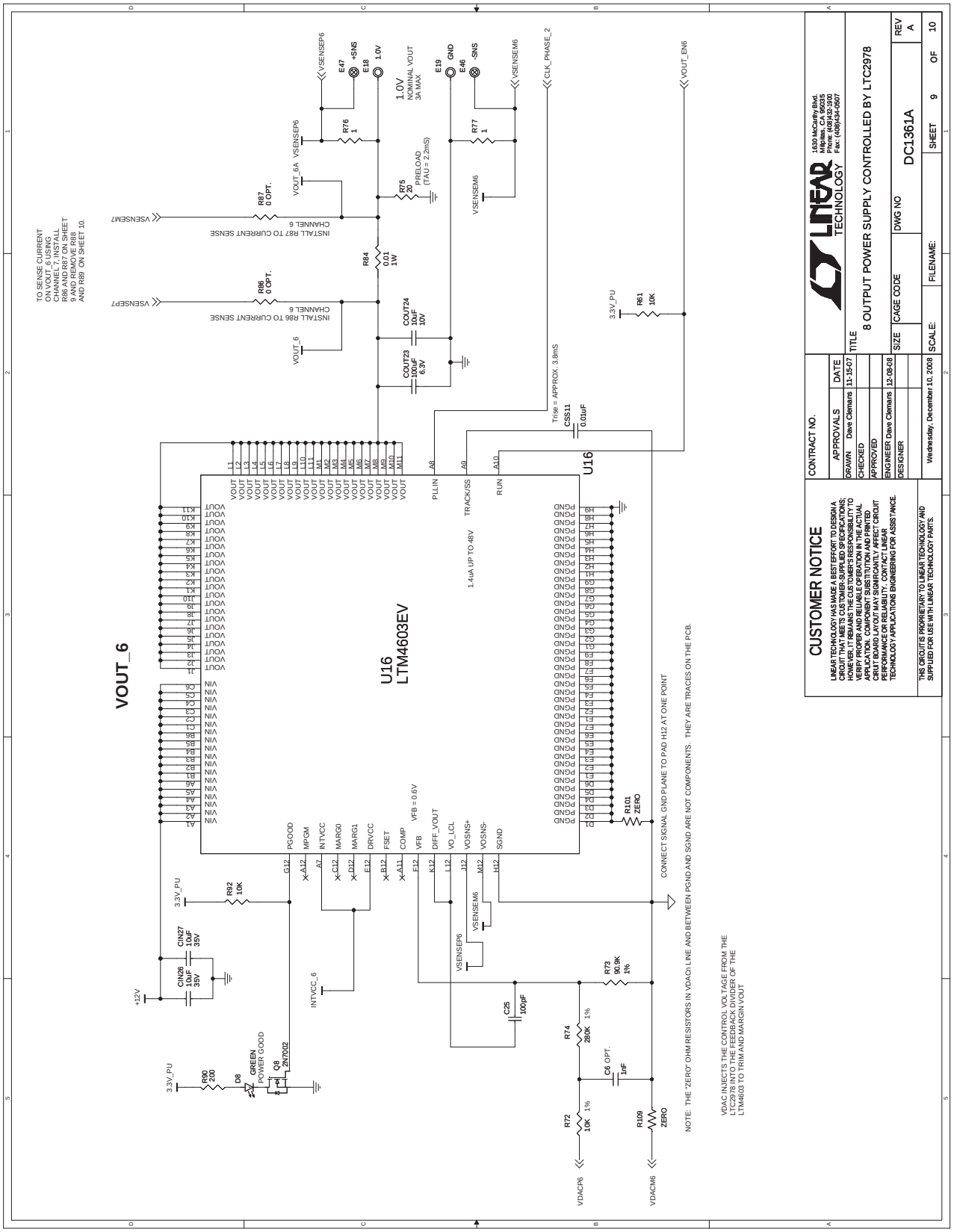




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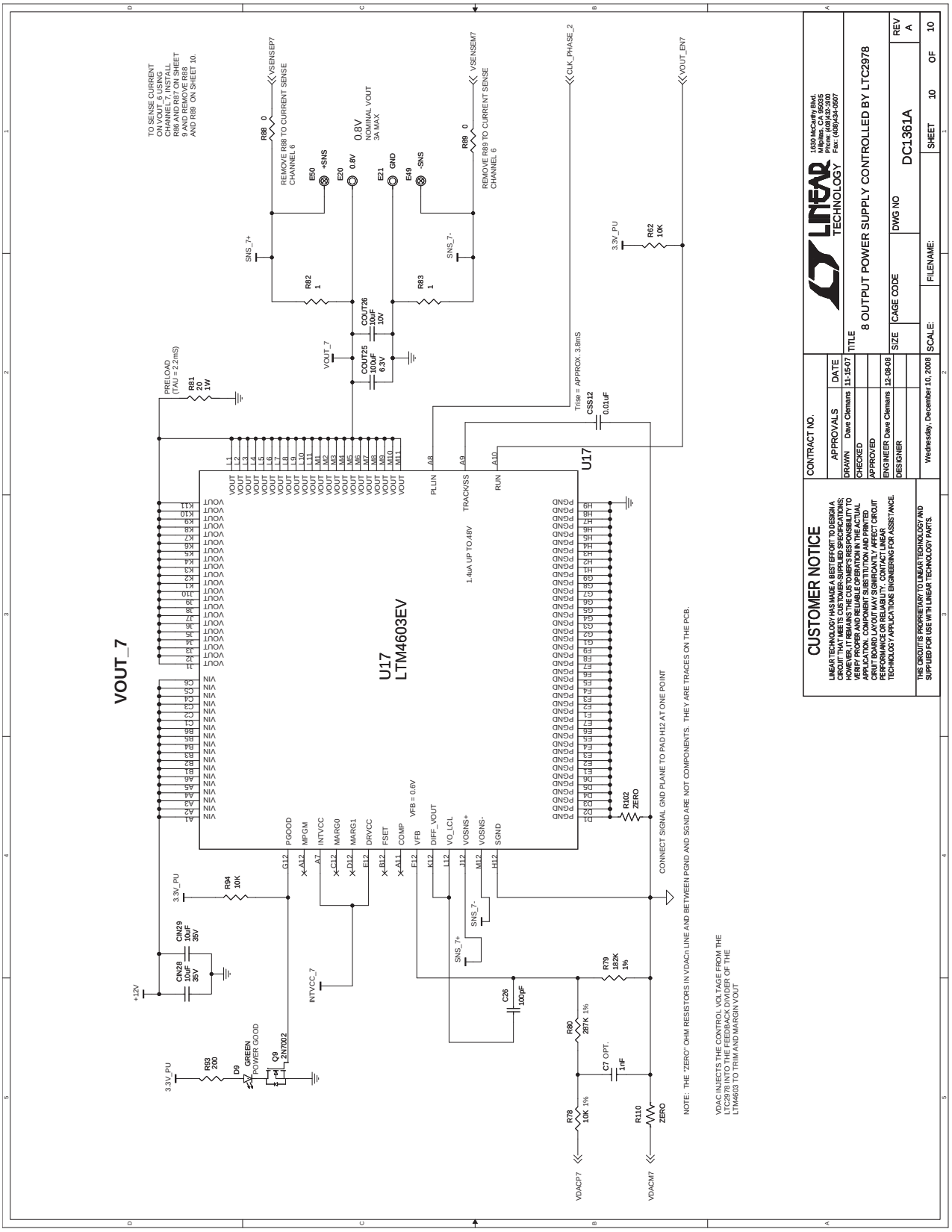




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## PARTS LIST

**Linear Technology Corporation**

***Bill Of Material***
***Demo Bd. #1361A***

| Item | Qty | Reference | Part Description | Manufacturer / Part # |
|---|---|---|---|---|
| **REQUIRED CIRCUIT COMPONENTS[1]** | | | | |
| | DC1361A is only a companion board to the DC1360A. None of these parts are required for LTC2978 operation. | | | |
| **ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS[2]** | | | | |
| 1 | 4 | C10,C11,C12,C13 | CAP, TANT 47UF 16V 20% SMD 7343-31 | KEMET_T520D476M016ATE035 |
| 2 | 1 | C20 | CAP CERM 1.0UF 10% 16V X7R 1206 | AVX_1206YC105KAT2A |
| 3 | 25 | C21,COUT4,CIN4,COUT5,CIN5, CIN6,CIN7,COUT12,CIN14,CIN15,COU T18,COUT20,CIN20,CIN21, COUT22,CIN22,CIN23,COUT24, CIN24,CIN25,COUT26,CIN26, CIN27,CIN28,CIN29 | CAP CER 10UF 16V X7R 20% 1206 | TDK_C3216X7R1C106M |
| 4 | 10 | C39,Cc1,CSS1,CSS2,CSS5, CSS8,CSS9,CSS10,CSS11, CSS12 | CAP, 0603, .01uF 20% 25V, X7R | MURATA_GRM188R71E103KA01D |
| 5 | 1 | C58 | CAP TANTALUM 3.3UF 25V 20% SMD | AVX_ TAJC335M025R |
| 6 | 8 | C8,C9,C16,C22-C26 | CAP, 0603, 100pF 10% 25V, NPO | AVX_06033A101KAT2A |
| 7 | 1 | CIN1 | CAP, 150uF 20% 35V ALUM | SANYO_35ME150WXV+TS |
| 8 | 8 | COUT1,COUT2,COUT11,COUT17,COU T19,COUT21,COUT23, COUT25 | CAP CER 100UF 6.3V X5R 1210 | AVX_12106D107KAT2A |
| 9 | 1 | Ctmr1 | CAP CER 2.2UF 10V X7R 0603 | MURATA_GRM188R71A225KE15D |
| 10 | 2 | Cx1,C17 | CAP, 0603, .1uF 20% 25V, X5R | AVX_06033D104MKAT2A |
| 11 | 1 | C1 | CAP, 0603, 1000pF 50V 10% X7R | AVX_06035A102KAT2A |
| 12 | 1 | D11 | TVS UNIDIRECT 14V 400W SMA | DIODES INC._SMAJ14A-13-F |
| 13 | 1 | D12 | DIODE SCHOTTKY 30V 200MW SOT23 | DIODES INC. BAT54-7-F |
| 14 | 8 | D2,D3,D4,D5,D6,D7,D8,D9 | LED GREEN 565NM 0805 SMD | PANASONIC_LN1371SGTRP |
| 15 | 1 | Q1 | MOSFET N-CH 30V 8.9A 8-SOIC | VISHAY_Si4894BDY |
| 16 | 8 | Q2,Q3,Q4,Q5,Q6,Q7,Q8,Q9 | MOSFET N-CH 60V 300MA SOT-23 | VISHAY_2N7002K-T1-E3 |
| 17 | 8 | R10,R23,R31,R42,R44,R53,R90, R93 | RES 200 OHM 1/10W 5% 0603 SMD | YAGEO_RC0603JR-07200RL |
| 18 | 1 | R11 | RES 59.0K OHM 1/10W 1% 0603 SMD | VISHAY_CRCW060359K0FKEA |
| 19 | 1 | R111 | RES 26.1K OHM 1/10W 1% 0603 SMD | VISHAY_CRCW060326K1FKEA |
| 20 | 1 | R21 | RES 13.3K OHM 1/10W 1% 0805 SMD | VISHAY_CRCW080513K3FKEA |
| 21 | 8 | R22,R30,R41,R43,R52,R54,R92, R94 | RES 10K OHM 1/10W 5% 0603 SMD | YAGEO_RC0603JR-0710KL |
| 22 | 1 | R26 | RES 19.1K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW080519K1FKEA |
| 23 | 14 | R27,R28,R32,R33,R39,R40,R50, R51,R70,R71,R76,R77,R82,R83 | RES 1.0 OHM 1/10W 5% 0603 SMD | VISHAY_ CRCW06031R00JNEA |
| 24 | 1 | R29 | RES 26.1K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW080526K1FKEA |
| 25 | 4 | R34,R35,R36,R37 | RES 43.2 OHM 1W 1% 2512 SMD | PANASONIC_ ERJ-1TNF43R2U |
| 26 | 1 | R38 | RES 30.1K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW080530K1FKEA |
| 27 | 5 | R45,R46,R49,R69,R81 | RES 20.0 OHM 1W 1% 2512 SMD | PANASONIC_ERJ-1TNF20R0U |
| 28 | 1 | R48 | RES 40.2K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW080540K2FKEA |
| 29 | 1 | R55 | RES 71.5K OHM 1/8W 1% 0805 SMD | PANASONIC ERJ-6ENF7152V |
| 30 | 1 | R56 | RES 95.3K OHM 1/8W 1% 0805 SMD | PANASONIC ERJ-6ENF9532V |
| 31 | 1 | R57 | RES 107K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW0805107KFKEA |
| 32 | 1 | R58 | RES 121K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW0805121KFKEA |
| 33 | 1 | R59 | RES 147K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW0805147KFKEA |
| 34 | 1 | R67 | RES 60.4K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW080560K4FKEA |



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# PARTS LIST

## Linear Technology Corporation

***Bill Of Material***
***Demo Bd. #1361A***

| *Item* | *Qty* | *Reference* | *Part Description* | *Manufacturer / Part #* |
|---|---|---|---|---|
| 35 | 2 | R68,R79 | RES 182K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW0805182KFKEA |
| 36 | 1 | R73 | RES 90.9K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW080590K9FKEA |
| 37 | 1 | R74 | RES 280K OHM 1/8W 1% 0805 SMD | VISHAY_ CRCW0805280KFKEA |
| 38 | 1 | R75 | RES 20 OHM 1/8W 5% 0805 SMD | VISHAY_CRCW080520R0JNEA |
| 39 | 1 | R80 | RES 287K OHM 1/8W 1% 0805 SMD | VISHAY_CRCW0805287KFKEA |
| 40 | 1 | R84 | RESISTOR .010 OHM 1W 1% 2512 | PANASONIC_ERJ-M1WSF10MU |
| 41 | 1 | R85 | RES 19.1K OHM 1/10W 1% 0603 SMD | VISHAY_ CRCW060319K1FKEA |
| 42 | 2 | R88,R89 | RES 0.0 OHM 1/10W 5% 0603 SMD | VISHAY_CRCW06030000Z0EA |
| 43 | 2 | R91,R112 | RES 60.4K OHM 1/10W 1% 0603 SMD | VISHAY_CRCW060360K4FKEA |
| 44 | 1 | Rc1 | RES 68 OHM 1/10W 5% 0603 SMD | VISHAY_CRCW060368R0JNEA |
| 45 | 1 | Rg1 | RES 100 OHM 1/10W 5% 0603 SMD | VISHAY_CRCW0603100RJNEA |
| 46 | 1 | Ron1 | RES 24.3K OHM 1/10W 1% 0603 SMD | VISHAY_CRCW060324K3FKEA |
| 47 | 15 | Ron2,R14,R15,R18,R24,R47,R60,R61, R62,R63,R64,R65,R66,R72, R78 | RES, 10K OHM 1/10W 1% 0603 SMD | VISHAY_CRCW060310K0FKEA |
| 48 | 1 | Rsns1 | RES .007 OHM 1W 1% 2512 SMD | VISHAY_WSL25127L000FEA |
| 49 | 1 | Rx1 | RES 10 OHM 1/10W 5% 0603 SMD | VISHAY_CRCW060310R0JNEA |
| 50 | | | | |
| 51 | 8 | U1,U2,U7,U12,U13,U15,U16,U17 | IC, uMODULE, POWER SUPPLY | LINEAR TECH_LTM4603EV |
| 52 | 1 | U10 | IC, uCIRCUIT | LINEAR TECH_LTC4210-1CS6 |
| 53 | 1 | U14 | IC, HEX SCHMITT-TRIG INV 14TSSOP | TEXAS INS._SN74AHC14PWR |
| 54 | 1 | U18 | IC, uCIRCUIT | LINEAR TECH_LT1761ES5-3.3 |
| 55 | 1 | U3 | IC, uCIRCUIT | LINEAR TECH_LTC6902IMS |
| **HARDWARE-FOR DEMO BOARD ONLY:** | | | | |
| 56 | 3 | JP1 JP2 JP3 | SHUNT 2MM | SAMTEC, 2SN-BK-G |
| 57 | 16 | E35,E37,E39,E41,E43,E46,E49, E36,E38,E40,E42,E44,E47,E50, E52,E53 | TURRET, Testpoint | MILL-MAX 2308-2-00-80-00-00-07-0 |
| 58 | 18 | E6,E7,E8,E9,E10,E11,E12,E13, E14,E15,E16,E17,E18,E19,E20, E21,E30,E51 | TURRET, Testpoint | MILL-MAX 2501-2-00-80-00-00-07-0 |
| 59 | 1 | J10 | CONN HEADER 72PS .100 R/A 15GOLD | FCI_68021-272HLF |
| 60 | 1 | J11 | TERMINAL BLOCK 5MM 2POS PCB | ON-SHORE-TECH_ED700/2 |
| 61 | 1 | JP1 | CONN HDR 2MM MALE 1ROW 2POS | COMM CON 2802S-02G2 |
| 62 | 2 | JP2,JP3 | CONN HDR 2MM MALE 1ROW STR 3POS | COMM CON 2802S-03G2 |
| 63 | 4 | MTG1,MTG2,MTG3,MTG4 | STAND-OFF NYLON 1/4" SNAP IN | KEYSTONE 8831 |
| 64 | 1 | SW1 | SWITCH TOG. SPDT RT ANGLE | C&K_E101MD1AQE |
| 65 | 3 | JP1 JP2 JP3 | SHUNT 2MM | SAMTEC, 2SN-BK-G |
| | | | | |
| | **Notes:** | | | |
| | 1. | Required Circuit Components are those parts that are required to implement the circuit function | | |
| | 2. | Additional Demo Board Circuit Components are those parts that provide added functionality | | |
| | | for the demo board butare not required in the actual circuit. | | |



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