CalPlug Wattmeter

Parent Project: Projector Buddy

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Introduction

The CalPlug Wattmeter has been been developed to work with Projector Buddy and other projects. At its current state, the wattmeter measures RMS voltage and current, apparent, active, and reactive powers, and power factor. Atmel microcontrollers can be used to communicate with the wattmeter using the Serial Peripheral Interface (SPI) protocol. A library has been created to facilitate the integration of the wattmeter with the rest of the project.

Methods

The CalPlug Wattmeter based on the ADE7953 IC by Texas Instruments is shown below is in Figure 1. The schematic of the wattmeter is shown in Appendix A.

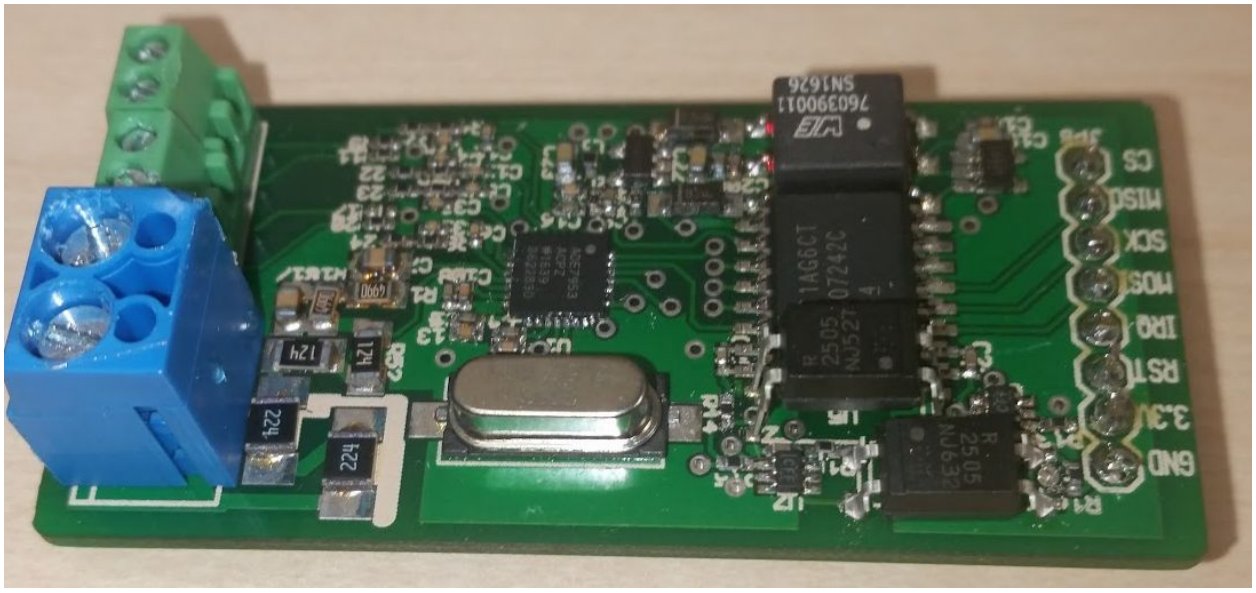

Figure 1: CalPlug Wattmeter

Care has to be taken when working with the pads of the ADE7953. The pads are narrow and can get shorted when soldering the IC in its place. To prevent that from happening, the

pads are tinned. First, soldering paste is applied to the pads for the IC on the PCB. Then a heat gun is set to 350°C, and minimum air speed, and heat is applied for about 30 seconds for tinning. After the heat is removed, and if any two pads are shorted, the tip of a hot soldering iron can remove the excess solder from between pads. The process is repeated with the pads under the ADE7953 itself. Then the chip is placed and oriented on the PCB. No more soldering paste is applied. Then heat is again applied using the heat gun with the same settings. These are the steps required to place the IC on the PCB to ensure good contact. Figure 2 shows the ADE7953 IC making good contact with the pads on the PCB after tinning is done.

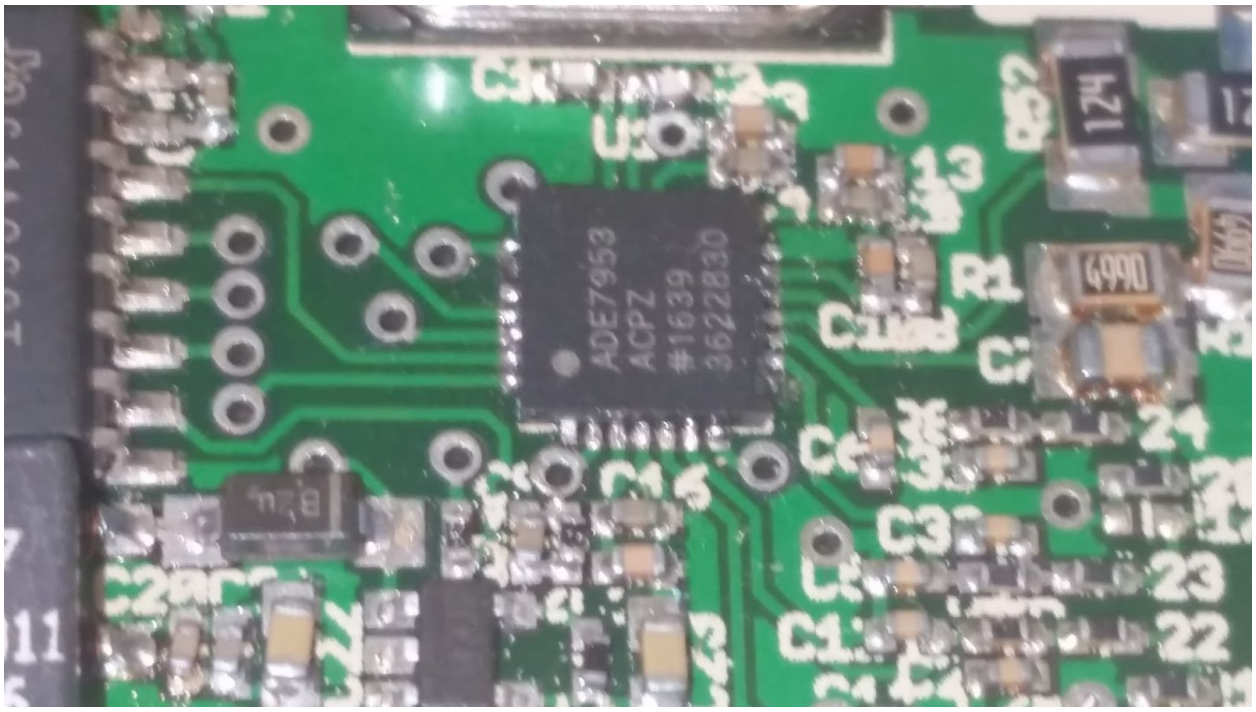

Figure 2: ADE7953 IC on tinned pads

Some boards were not tinned properly, before they were placed on the PCB. That resulted in the IC not being able to communicate with the Atmel microcontroller. In that case, a heat gun and a pair of tweezers are used to take the IC off of the board. Then the above steps are followed to place the IC on the board.

The slot for the isolator for the RESET pin, U5 on the schematic, is not large enough to accommodate it. So a stilted version of the same isolator is used, as shown in Figure 3. A drawback of using a stilted component is that if it is subjected to any pressure, it can come off. Not only that, it can tear the pad off of the board as well, as show in Figure 4. If that happens, the isolator can't be soldered onto the board anymore. In that case the RESET is connected to the appropriate input of the IC directly through wet-wiring as shown in Figure 5.

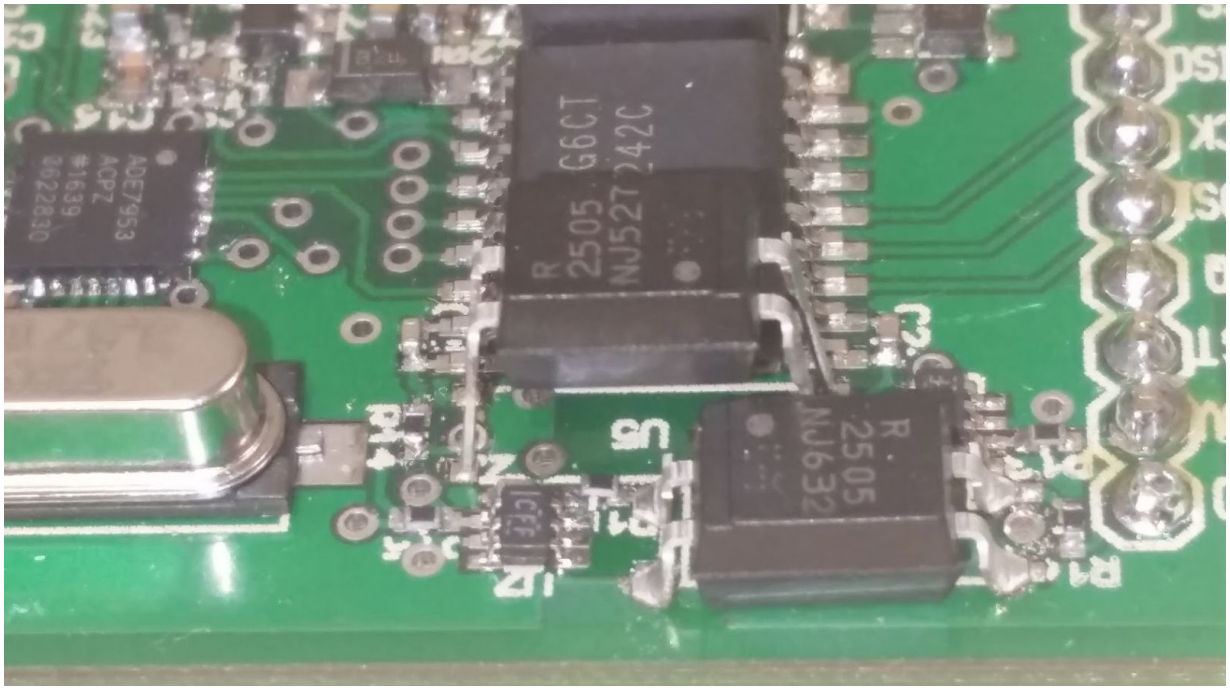

Figure 3: Stilted isolator at U5

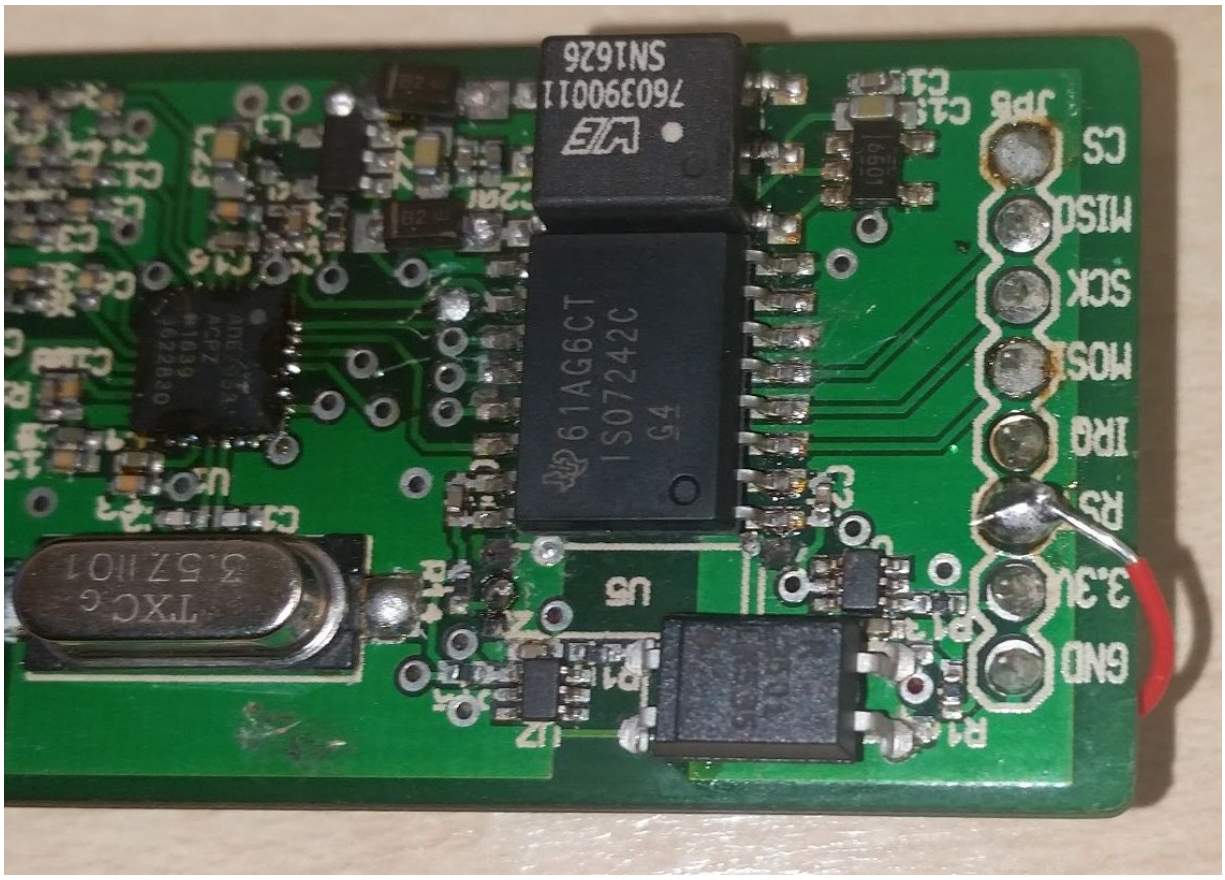

Figure 4: Pads for U5 torn off of PCB

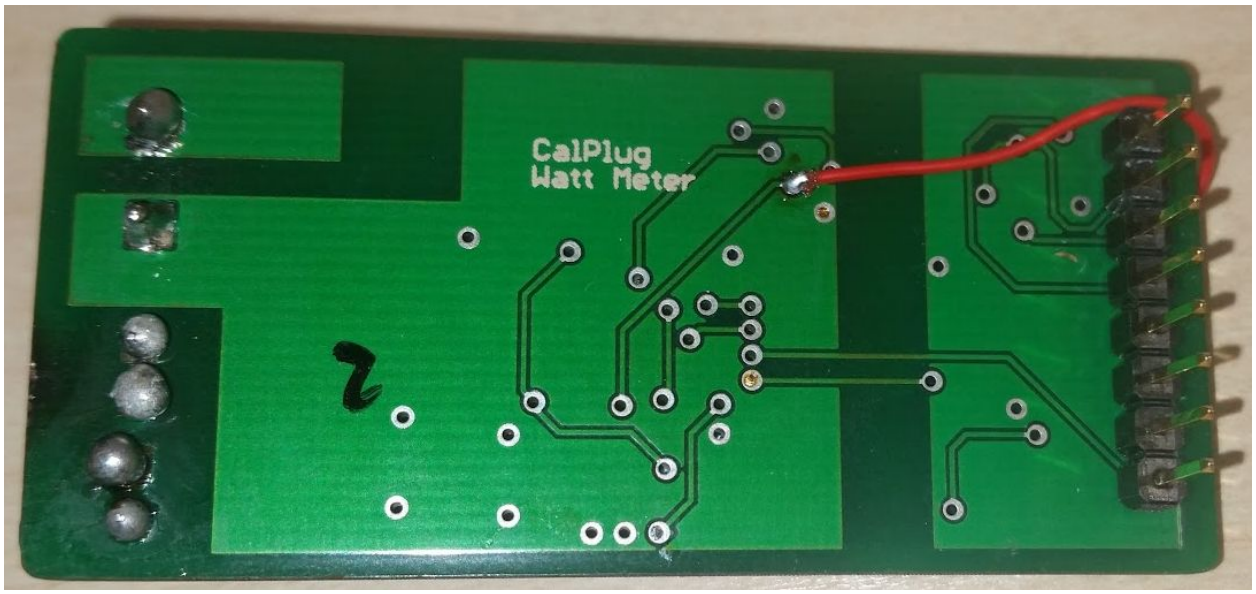

Figure 5: RESET pin wet-wired to an input of ADE7953 IC

The wattmeters are tested using the code which is also posted in CalPlug's folder at github.uci.edu. A fan rated 120V/20W is connected to an accurate AC voltage supply, a power analyzer, and a wattmeter. The readings obtained from the power analyzer are shown below in Figures 6 and 7. The readings of interest are Vrms, Irms, Watt (apparent power), VA (active power), VAr (reactive power), and PF (power factor).

Figure 6: Readings for fan rated 120V/20W

Figure 7: Readings for fan rated 120V/20W

The wattmeters are connected to an Atmel microcontroller board and the readings are obtained from the Serial Monitor. When nothing is connected to the microcontroller board's SPI lines, the readings obtained are shown below in Figure 8. When a wattmeter with bad connections is connected to the SPI lines, the readings in Figure 9 are obtained. A working wattmeter gives the readings shown in Figure 10, which are very close to the power analyzer readings shown in Figures 6 and 7. As of now only current channel A of the wattmeters have been configured. Current channel B has not been configured.

Figure 8: Readings for no wattmeter connected to microcontroller board

Figure 9: Readings for faulty wattmeter connected to microcontroller board

Figure 10: Reading for working wattmeter connected to microcontroller board

Conclusion

Ten Calplug Wattmeters have been made and tested successfully using the methods described in this report. As of now, many of the functionalities offered by the ADE7953 have not been used. For future work, current channel B can be configured, and the library that has been created can be edited to unlock the other functionalities offered by the IC. Also, if PCBs for the wattmeters are reordered, the design will be revised to fit the isolator, so that stilting and wet-wiring would no longer be necessary.

Appendix A

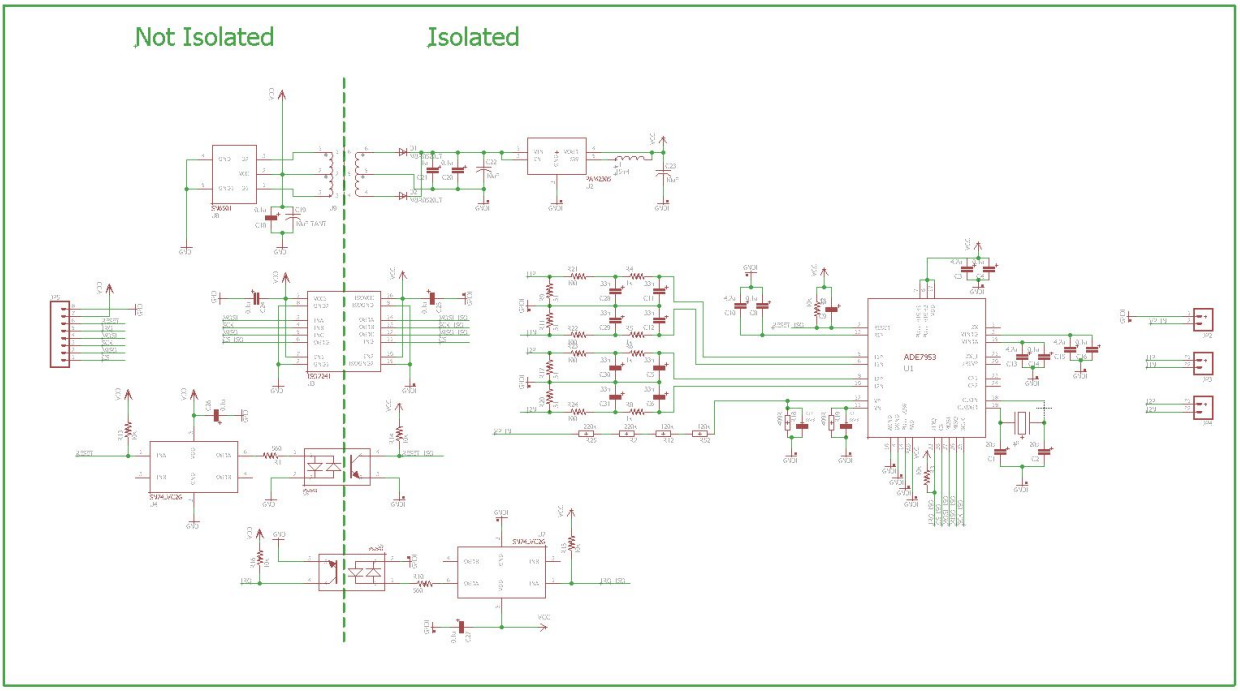

Figure: Wattmeter Schematic

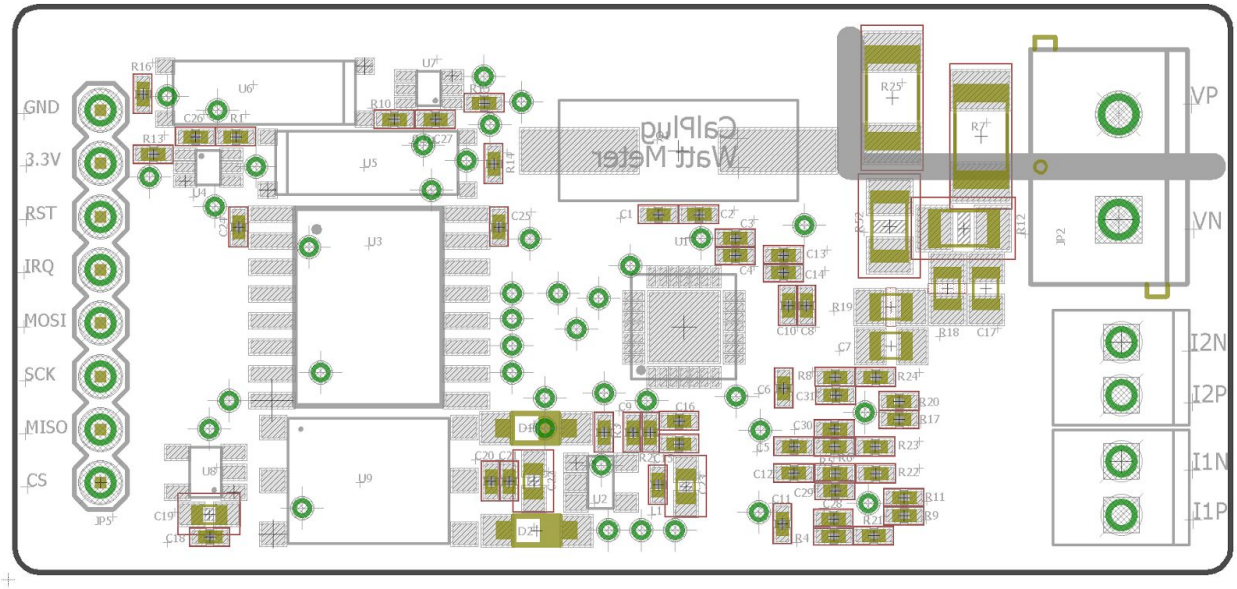

Figure: Wattmeter Layout