# Analyzing the Power Supply Design of Operational Amplifiers with Examples

Power supplies are like the cardiovascular system of the human body and are the source of system energy. From the perspective of designers, power supply design is very important. An ideal voltage source has zero ripples, does not change the voltage with load or input voltage, and has 100% efficiency. Obviously, due to the power supply architecture and device characteristics, an ideal power supply does not exist. This puts forward requirements for circuit designers.

An unreasonable power supply design may bring about a decrease in circuit performance, and more seriously, a decrease in system stability and reliability. The design of the power system follows some general rules in principle. Below, we analyze the power supply design through the power supply system of a unit circuit.

The TPF632A is an audio driver designed by 3PEAK for audio signal processing, which is widely used in set-top boxes, TVs, speakers, and other products.

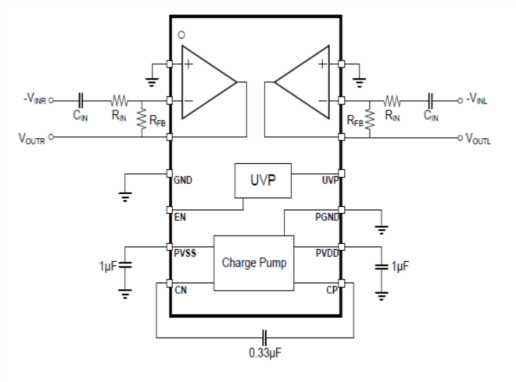


Figure 1. TPF632A functional block diagram and application circuit

The integrated design greatly simplifies the circuit structure. PVDD is a single power supply input pin. The built-in charge pump converts the single power supply of the system into a corresponding negative voltage while also supplying power to the circuit. PVDD provides maximum dynamic range and output amplitude for op-amp operation. It also has a built-in anti-pop noise circuit (UVP) suitable for audio signal processing.

So, here comes the question: does such a highly integrated chip solution mean that the power supply can be designed freely?

The following tips for designing the power supply usually cannot be ignored:

## 1. Selection for External component

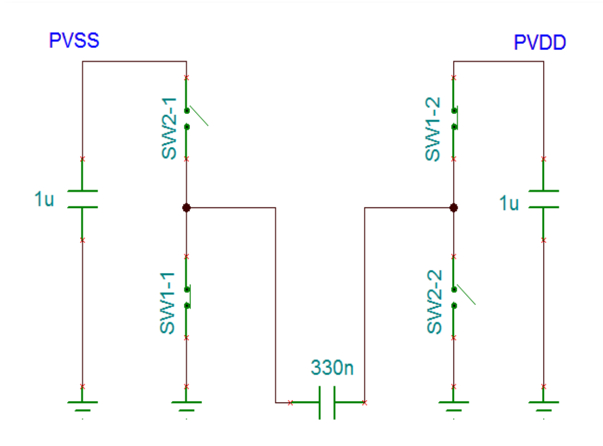


Figure 2. External Components for the Charge Pump

The charge pump operates in a switching state, and the switching frequency is about 330 kHz. In a switching cycle, two transistors are turned on for the first half cycle, and the other two transistors are turned on for the second half cycle.

For the selection of capacitance, the most reasonable reference values have been provided according to the requirements of ripple, and start-up current.

For the selection of capacitor material, X5R or higher grade is required. This is also a common requirement for DCDC power converters.

Choosing inappropriate materials may lead to a significant drop in capacitance under specific operating temperature conditions, resulting in a decrease in the performance or even failure of the switching power supply.

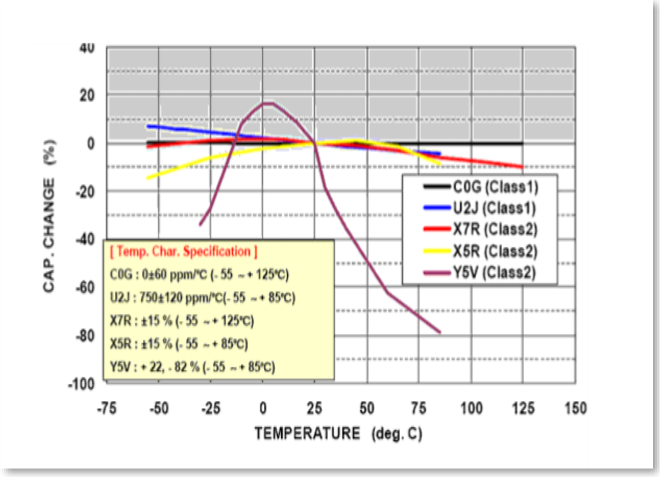


Figure 3. Capacitor Characteristics vs. Temperature

## 2. Layout Considerations

When considering the layout, the placement of the three capacitors of the charge pump needs to be close to the chip. Try not to use through-hole traces. This can minimize the routing path and reduce parasitic parameters. A rapidly switching current can cause a large instantaneous voltage overshoot or drop across the parasitic inductance.

## 3. Decoupling Circuits

For the PVDD power supply pin, the pre-stage source may be an LDO or the output voltage of a DCDC converter. The voltage itself carries high-frequency noise. This is a more serious problem for DCDC converters. The PSRR of the op amp decreases at high frequencies. An optimal consideration is to introduce an RC or LC decoupling network at the PVDD power supply pin. The circuit form is as follows:

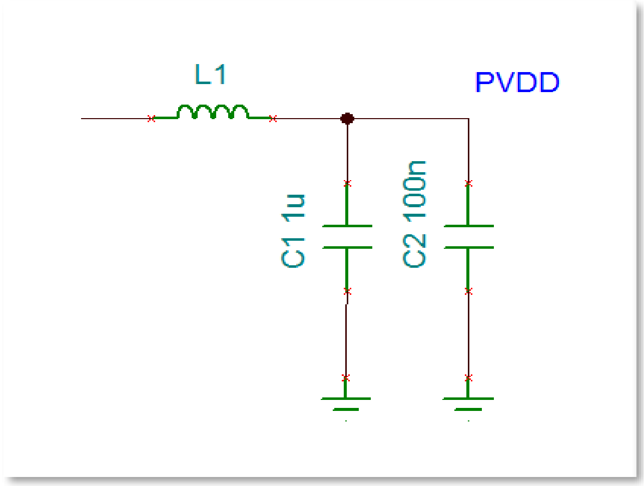


Figure 4. Decoupling Circuit for PVDD

The recommended capacitor for C1 is 1 μF or above to meet the requirements of the charge pump operation. For L1, a simplified approach is to use a resistor. Considering that chip operation draws mA-level current, excessive resistance values can cause excessive voltage drops. It is recommended that the value should not exceed 10 ohms.

A better choice for L1 is to place a magnetic bead. The important parameters of magnetic beads are DC resistance (DCR), AC resistance, and rated current. The obvious advantage of magnetic beads is that the DCR is very low and presents a large AC impedance.

## Summary

The design of the power system follows some general methods and principles:

1. Priority should be given to the power circuit when laying out the board. Distinguish the power path and signal path. Optimize traces and grounding.

2. Component selection should consider various important parameters to ensure design margins.

3. High-voltage and high-current systems introduce safety and EMC requirements.