# RADIAL ENGINEERING PRINTED CIRCUIT BOARD LAYOUT GUIDELINES

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# DOCUMENT IN PROGRESS

**Radial engineering practices for printed circuit layout.**

## Autorouting

**Do not trust the autorouter. While it may make all the connections on a PCB, the program has no idea of how the wiring of components needs to be sequenced and will almost always do power and ground sequencing incorrectly. It is recommended to not even use it as the time needed to correct its errors will often exceed the time needed to manually route a PCB.**

## Connectivity Check

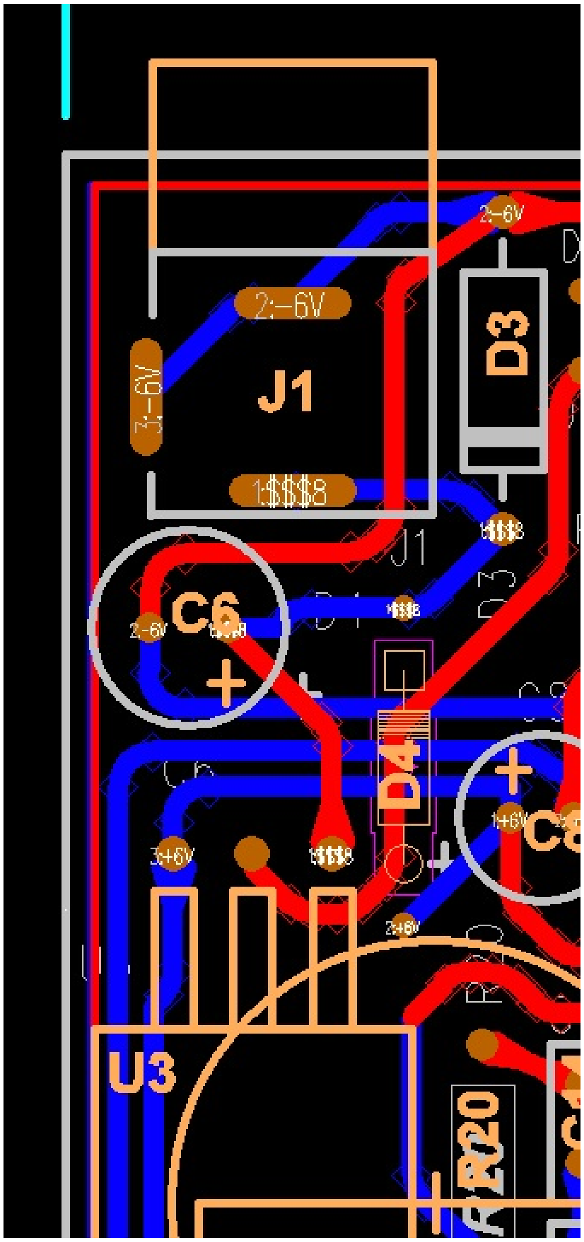
**While it is very important to use the Connectivity checking function on a printer circuit layout, the connectivity checking does not tell you anything is connected in the correct sequence. If there is an error on the schematic, this function will propagate it to the PCB.**

## DC power input connector wiring

**The example is the Bassbone 1 V2.**

**Note how trace $$$8 goes from the DC input connector, to the reverse polarity protection diode D3, to the power input filter capacitor C6 then to the input pin of the voltage regulator U3.**

**Also note how the negative input, -6V, is routed to the polarity protection diode before being routed to the negative pin of the power input capacitor C6. In this case the ground plane grounds do not connect to the power input filter as there is a ground splitter in the circuit. The planes connect to the ground splitter output.**

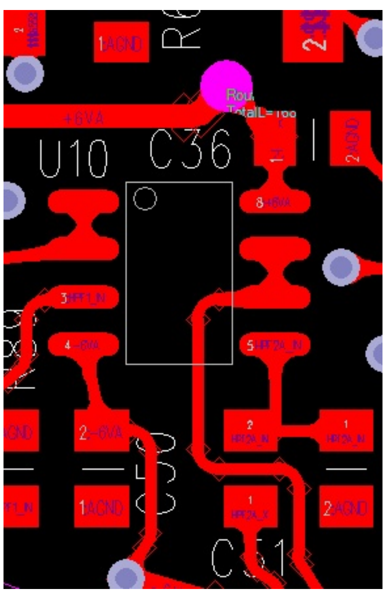



## Bypass Capacitors on ICs

This is rarely made clear on the schematic and the board designer must take care to place bypass capacitors correctly. Bypass and filter capacitors are identifies as in most cases, one of the pads connects to ground. All IC power pins must have a bypass capacitor as close to the power pins as possible. The only exception is that if there are multiple adjoining power pins that may share a capacitor. The power from the power source must ALWAYS go to the capacitor before going to the IC. The power must never be directly connected to the IC. The ground side of the bypass capacitor must be connected to whichever ground is required for that IC. They are never to be connected to the Chassis ground.


Figure 12. Poor and Good Placement and Routing of Bypass Capacitors

In this graphic from the Decoder Ring one can see the bypass capacitors on pins 4 and 8 or the IC. The positive power trace +6VA goes to the capacitor C36 then to pin 8 of the IC. Likewise negative power trace -6VA goes to C50 then to pin 4 of the IC.




Power must never go to the IC then to the capacitor.

**On larger ICs, the manufacturer's spec sheet may have bypassing recommendations and these should be closely followed.**

## Power supply filter capacitor wiring.

**Traces must always go from the power source, to the capacitor then to the load. This includes both sides of the capacitor. Ground planes may have to have cutouts so that the input ground goes to the capacitor first before connection to the ground plane.**

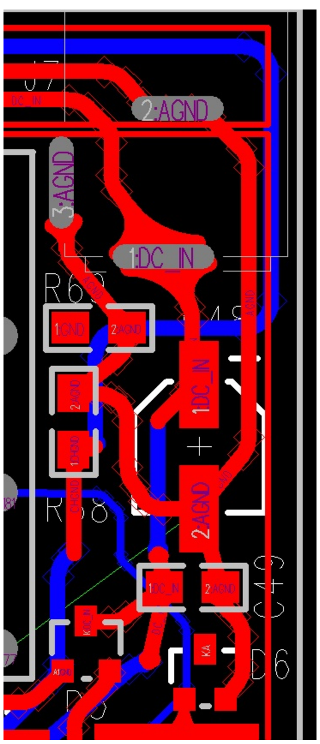
## PCB Decals

**As much as possible, PCB decals should have their origin point in the physical center of the part to allow easy rotation. And in the case of SMT parts, the center of the decal will then also be at the pick and place center.**

## Multiple Grounds

**Many products will have multiple grounds with connection between them being made with zero ohm resistors at the ground connection of the power input filter capacitor. Care must be taken that analog, power, digital, chassis and other grounds share no other common connections. If connections must be made elsewhere they must be isolated with small inductors. Connections to the zero ohm jumpers must either directly to a plane of with conductors as wide as possible. At least 25mils wide, preferably wider.**

**In this graphic from the Twinline R62 R68 are the zero ohm jumpers for the connection id the various grounds and they connect to the ground of C48 through a ground plane... The point here is that are all located at the power input.**




**In the case where the power input has no connection to ground and there is a ground splitter, the ground plane grounds do not connect to the power input filter but to the ground splitter output as close as possible to the output of the ground splitter.**

## Chassis Ground

**Care must be taken that no current flows through chassis ground connections. Any current flow will impair the effectiveness of shielding. The chassis ground must be connected to the power input filter capacitor ground connection through a trace as wide as possible. Chassis ground has to be routed in most products to at least one mounting pad so that a connection is made to the case when the product is assembled. While no current flows through a chassis ground conductor it is important that the impedance be kept low which means a trace as wide as practical.**

**Besides the single connection to the power ground, balanced audio connectors such as XLR connectors may have a chassis ground connection on pin 1. Unbalanced inputs are not connected to chassis ground.**

## Switching Regulators

**Switching regulators can be a huge problem for emissions causing problems passing FCC requirements. It is recommended that the manufacturer's spec sheet be obtained and checked to see if a recommended board layout is available. If there is one, follow it as precisely as possible.**

## Miters

**Traditionally miters have been done at 45° angles. In the case of high speed circuits it has been recommended that arcs be use instead. These are not difficult to do in Pads and the writer likes how they look as well. It is suggested that the designer consider the use of arcs miters in cases where PCBs will be in products sent for EMI approval.**

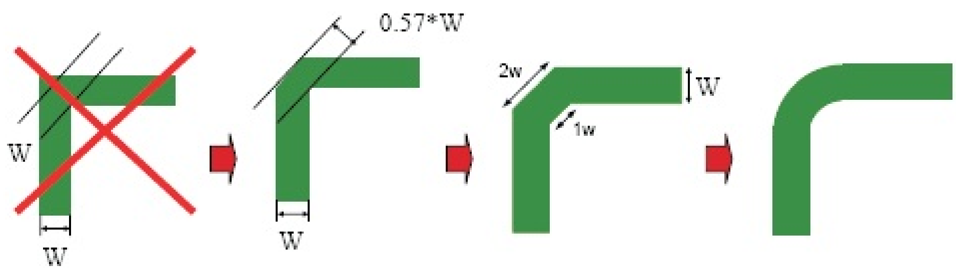



Figure 13. Poor and Good Right Angle Bends

## Routing

**Digital signals must not cross analog ground planes and vice versa.**

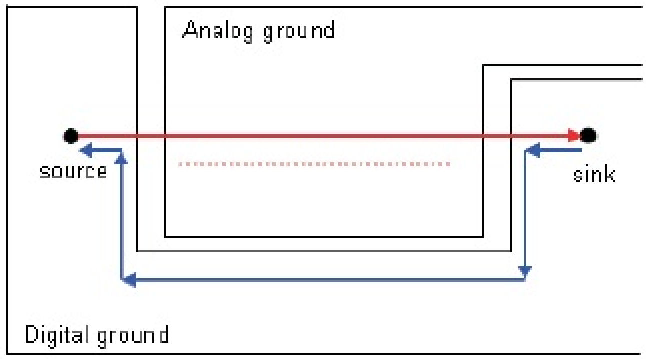


Figure 7. Loop Area and Crosstalk Due to Poor Signal Routing and Ground Splitting

**In digital boards there are often sets of traces that need to be run in as close to parallel as possible and end up about the same length. These sets may include**

**SDA and SCL**

**MCLK, SCLK, LRCK and SDATA. SCLK may be called BICK. LRCK may be called LRCLK. SDATA may be called SDIN, SDOUT and may have a number after the name in some cases.**

**Similarly, balanced audio lines should also run as parallel as possible and be about the same trace length. These trace names often start or end with "+" and "-"**

## Ground Planes

**Ground planes should only connect to each other at the ground terminal of the power input filter capacitor. In no case may the ground current from one ground plane pass through a different ground.**

Figure 8: Do not let one ground plane pass another ground plane to get connected to the common ground (a). Every ground plane must have its own path to the common ground to reduce noise (b).

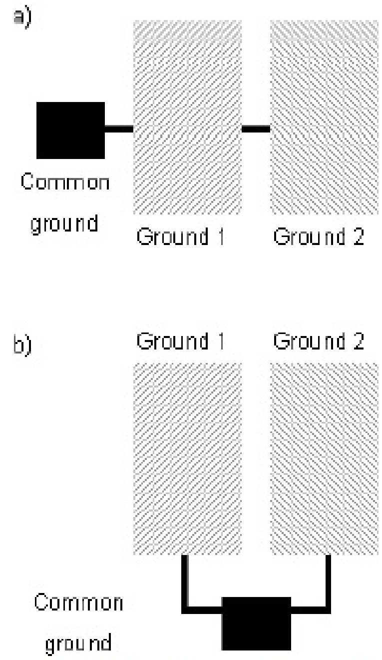



Figure 8. Poor and Good Placement of the Common Ground in a Split Ground Environment

## Component Spacing

**External Parts**

**Consistent spacing of external components is important to achieve a consistent look. External parts are defined as those that require coordination with the external housing. Usually mounting holes in the case and seen by the user. However they also include mounting pads. The final determination for the placement of these parts is determined by the designer of the external enclosure in consultation with the design engineer. However the engineer can determine the required sequence of the external components in consultation with the requirements of marketing.**

**All the dimensions listed are in mils. 1 mil = 0.001 inch. The spacings given are center to center on all components. If wider spacings are used, they must be consistent on a product.**

**Push Switch to Push Switch = 350**

**Push Switch to 16mm Pot = 550. These pots are also known as RV122 or R800 9012 or R800 9036 series.**

**16mm Pot to ¼" jack = 750**

**16mmPot to 16mm Pot = 700**

**¼" jack to ¼" jack = 900 to 1000. 800 can be tolerated but would mean that the larger plugs may not be able to be used.**

**¼" Jack to XLR connector = 1000**

**Push Switch to XLR = 675**

**XLR Power Jack (4 or 5 pin) to ¼" jack = 875**

**LEDs mounted 90 degrees under a push switch are normally mounted at the same position as the push switch.**

**Depth behind board edge**

**Push Switch = 555 or 590. The lower dimension is where a button goes through the panel. The larger dimension is where the switch is recessed and there is no button.**

**¼" Jack = 355**

**LED – Mounted 90 degrees = 100**

**Tab Route for LED = -15**