Radio Frequency Electronics

Construction Techniques

- Developed by Phillip Hagar Smith at Bell Labs between 1936 and 1939
- Phillip Smith was an authority on antennas
- He designed submarine radar antennas for during WWII
- Had a reputation of being very well-organized
- Was an IEEE Fellow
- Held 20 U.S. patents
- Passed away in 1987
Concepts

Circuit layout is crucial for proper operation of RF circuits

In many/most circuits, the layout/connections is part of the circuit

This type of circuit construction will not work for RF
For some parts of the circuit, layout is less critical, but the RF parts need special consideration.

Keep leads short:

50 mm of 22 AWG wire $\Rightarrow$ 50 nH

Avoid large loops

Inductance $\propto$ area enclosed

Components may change with $f$

Capacitors become inductors and inductors can become capacitors

At high frequencies, must use Tx-line concepts

Any piece of wire can become a Tx at high frequencies

Signal return currents follow path of least $Z$
“Staying Well Grounded,” Analog Dialogue 46-06, June (2012), Hank Zumbahlen. See website of Analog Devices
Ground Plane

Note Tx Line

Ground plane

Vias
A ground plane on a PCB is a large, dedicated layer of copper. It is connected to the system ground. A ground plane as much area as possible under components. It is often continuous, but may have to be broken into smaller pieces. In complex circuits there may be several ground planes. Connections from one side to another are made through vias. A ground plane provides a low inductance, low impedance path for return signals. Provides shielding, heat dissipation.
Reducing Inductance

Inductance \propto \text{area enclosed}
Ground Plane

Images from Analog Devices website
Ground Plane

Images from Analog Devices website
The ac return path is different from the dc return path.

The path shown has the least inductance $\Rightarrow$ lowest $Z$.

Between dc and ac the current flows partially under top trace.

Even at low frequencies (1 MHz, current flows mostly under top trace.

Don’t break ground plane below the top trace.
Ground Plane

- THIS VIEW FROM PCB CONDUCTOR (TRACK) SIDE
- NOTE: RETURN CURRENTS A AND B MAY INTERACT

RETURN CURRENT B DIVERTS AROUND GROUND PLANE BREAK, RAISING INDUCTANCE

BREAK IN GROUND PLANE

CROSSOVER “B” ON GROUND PLANE SIDE

RETURN CURRENT A DIVERTS AROUND GROUND PLANE BREAK, RAISING INDUCTANCE

SIGNAL CURRENT B

SIGNAL CURRENT A
Ground Plane

Decoupling

Power Supply ($V_{CC}$)

Decoupling
Ground Plane

Notice short leads

Decoupling Capacitor

Decoupling Capacitor
Dead Bug Construction

Notice dead bug
Manhattan Construction

Small Copper disks
Manhattan Construction

Copper ground plane

Disks are glued to ground plane and components are soldered to disks
Manhattan Construction

Ground Plane

Small copper disk
Here little squares are used

Ground Plane
Manhattan Construction

Ground Plane
Manhattan Construction
Manhattan Construction

Here little squares are used

Ground Plane
These are power supply lines

Connector soldered directly to ground plane
That's All Folks