# Owner's Manual

WCP52

March 14, 2015

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# 4 Theory of Operation

This section contains a decription of the operation of the gain/phase analyzer. Explanations start from the simple and broad, and descend to very specific levels. It is expected that the reader has an understanding of the basics of gain/phase analysis itself, which is explained in the Introduction section.

## 4.1 Block Diagram

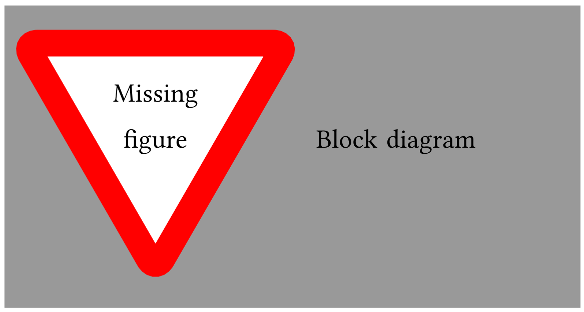


Figure 1: Block diagram

## 4.2 Power Input Circuit

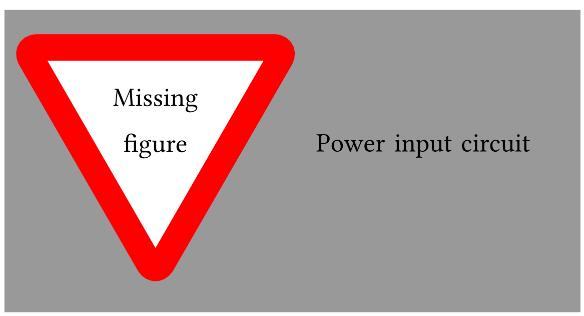


Figure 2: Power input circuit

This instrument is complex and has many somewhat expensive parts, so a full input subsystem was designed to ensure that these parts are always supplied correctly with power. This subsystem provides the following features:

- Overcurrent protection
- Reverse polarity protection
- Undervoltage lockout
- Overvoltage protection
- Inrush current limiting

The first piece of this input system, and possibly the simplest, is R81. R81 is a *resettable fuse*, a type of resistor with a positive temperature coefficient. Its resistance is very low (around $0.5\ \Omega$) at room temperature. As the current flowing through it increases, it heats up, and as it heats up, its resistance increases. Eventually, it will reach a point where this process 'snowballs', and its resistance is high enough that almost no current can flow through it. This allows it to act like a fuse, but without permanently blowing: as soon as it cools back down, it will conduct again.

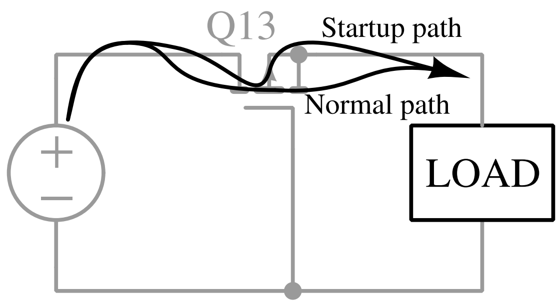


Figure 3: MOS reverse polarity protection circuit, simplified

Once input current has passed through the resettable fuse, it encounters `Q13`. A simplified form of this part of the circuit can be seen in figure 3. Remember that a MOSFET has 'parasitic' diodes connected from the transistor's channel to its substrate; in a standard power MOSFET, one ends up connected between the two ends of the channel (the other ends up shorted to itself). In a P-channel MOSFET, this diode points from the source to the drain. In this circuit, when power is applied with the correct polarity, this diode allows current to initially take the path labeled *startup path*. When it does so, the voltage applied to the load begins to rise, but the gate stays low, as it is tied to ground. Eventually, the voltage rises high enough that the gate-source voltage switches on the MOSFET, and current begins to flow through the *normal path* instead. This path takes the current through the low-impedance MOSFET channel, rather than through the diode where the forward threshold voltage of the diode would be lost.

If power is applied in the incorrect polarity, the substrate diode never conducts, so the MOSFET never switches on.

After the reverse polarity protection, the current must flow through `Q14`, which is connected as a traditional switch. `R88` holds its gate and source together when the power is switched off, keeping the MOSFET also turned off.

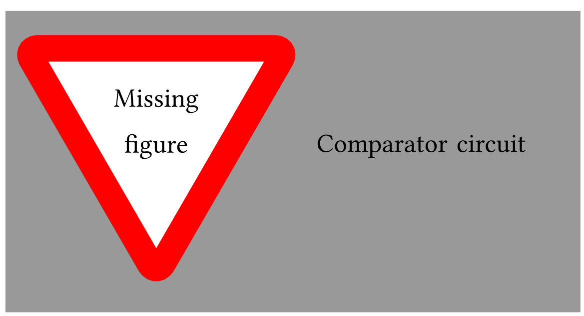


Figure 4: UVLO and OVLO circuit

To simplify things, the subcircuit in figure 4 is powered through a simple diode for its own reverse-polarity protection. Bandgap voltage reference `U11` does not need this, as its internal circuit has an antiparallel diode built in [1].

`U11` provides an accurate 2.5 V level against which the input voltage can be compared.

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# 5 References

[1] Texas Instruments, "TL43xx Precision Programmable Reference," TL431 datasheet, Aug. 2004 [Revised Jan. 2015].