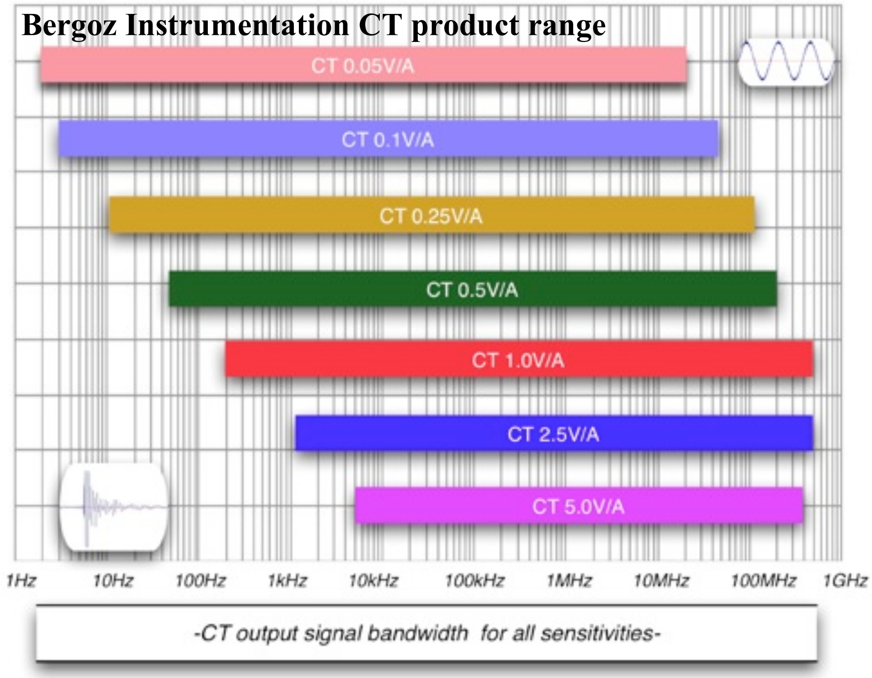

The current transformer's (**CT**) intrinsic noise source is the Barkhausen noise of the magnetic core. It is several orders of magnitude below other noise sources affecting current measurements with a **CT**:

1. **Noise of the amplifier or instrument measuring the CT signal**
2. **Noise coupled to the CT case**
3. **Noise picked up by the cable connecting the CT to an oscilloscope or amplifier**

1. Amplifier or measuring instrument noise

The amplifier noise ultimately sets the noise floor of the measurement using a **CT**. Other noise sources can be reduced (see following sections). To amplify the **CT** signal, an amplifier with 50-ohm input impedance must be used. The amplifier noise is specified by its noise figure NF, expressed in dB. NF is the number of dB of the amplifier's input noise above the thermal noise of its input impedance. The thermal noise E_{rms} of 50 ohms is:

$$E_{rms} = \sqrt{(k\ T\ f\ R)}$$

Where (in MKSA units): k is the Boltzmann constant 1.38E-23 (J/K), T the temperature in kelvin, f the frequency bandwidth in Hz and R the resistance in ohms. e.g. E_{rms} of 50 ohms = 10 μV_{rms} at 300 K over 500 MHz bandwidth.

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Assuming an amplifier NF = 6dB (typical figure for 50-ohm wideband commercial amplifiers), the amplifier input noise = 20uV_{rms}. The current-through-the-**CT** or primary current noise floor is obtained by dividing the voltage noise by the **CT** sensitivity.
E.g. **CT-C1.0-B** has 0.5 V/A sensitivity when terminated in 50 ohms, hence the current-through-**CT** noise floor is 20µV_{rms}/0.5V/A or 40µA_{rms}.

To lower the noise floor:

- Use a more sensitive **CT**, if feasible.
- Filter the amplifier input (high-pass then low-pass) to reduce the bandwidth.
- Lowering the **CT** and amplifier temperature does not reduce the noise much: At –20°C (253 K), the minimum operating temperature for the **CT**, the noise is reduced by about 8%.

Calculated noise floor (absolute amplifier noise floor), expressed in current-thru-the-**CT**, for various **CT** models:

Model	Bandwidth (MHz)	Noise floor (uArms)
CT-...5.0	400	7.28
CT-...2.5	500	16.7
CT-...1.0	500	40.7
CT-...0.5	200	51.4
CT-...0.25	100	72.8
CT-...0.1	50	128
CT-...0.05	20	163

at 300 K (27°C, 81°F), amplifier bandwidth = **CT** bandwidth, NF = 6dB

If the **CT** signal is entered directly into an oscilloscope 50-ohm input, the oscilloscope input noise must be taken into consideration: fast sampling oscilloscopes have a trace width (noise) between 1 and 5mV_{pp}. Assuming 1mV_{rms} oscilloscope noise, the noise floor expressed in current-thru-the-**CT**, for various **CT** models is:

Model	Noise floor (mA_{rms})
CT-...5.0	0.4
CT-...2.5	0.8
CT-...1.0	2
CT-...0.5	4
CT-...0.25	8
CT-...0.1	20
CT-...0.05	40

This shows the advantage of amplifying the signal before input to an oscilloscope. The amplifier gain required to overcome the oscilloscope noise limitation is: Gain = Oscilloscope noise / Amplifier input noise.
Beyond this gain, the oscilloscope noise is no longer the limiting factor.
E.g. required gain = 34 dB (factor x50) when oscilloscope noise is 1mV_{rms} and amplifier input noise is 20µV_{rms}.
Other noise sources can be much higher, but can be often successfully reduced as indicated below.

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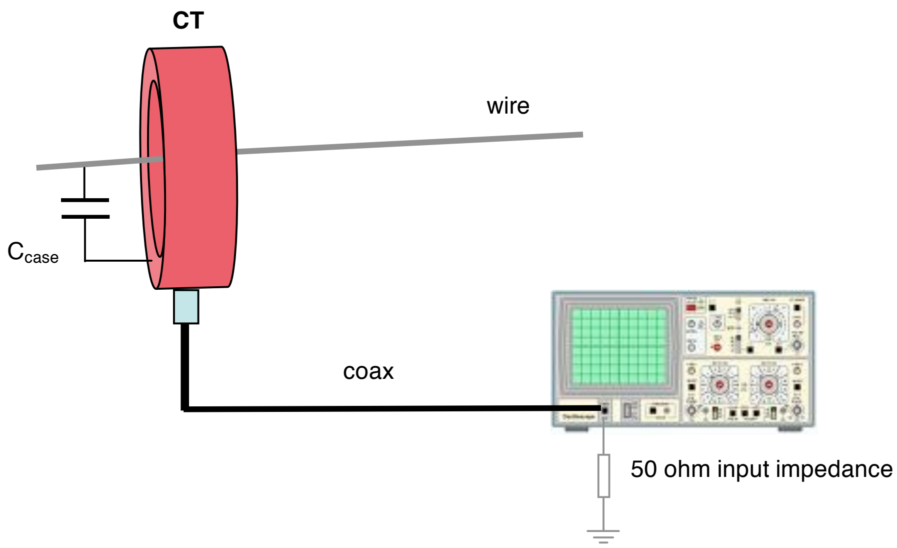
2. Noise coupled through the CT case

This is usually due to the capacitive coupling between the primary wire voltage and the **CT** copper case. An isolated wire passed thru the **CT** aperture has a coupling capacitance with the **CT** case in the order of a few picofarads.

Through this capacitance, the wire voltage is coupled to the **CT** case. E.g. the wire carries a 100V pulse with 2ns rise time; the coupling capacitance C_{case} is 1pf. The frequency to consider is ca. 0.35 / 2ns = 175 MHz. At 175 MHz, the coupling impedance of 1pf is 908 ohms. The 100V signal coupled to the **CT** thru 908 ohms generates a 5.22V error signal at the 50-ohm oscilloscope input.



A 5000-Volt pulse rising slowly, say in 5µs, would generate only 110mV error signal. This unwanted signal could be attenuated by a common-mode filter installed on the cable. The common-mode core material must be effective at the frequency of the error signal (175 MHz in the above example).

3. Noise picked up by the cable

This is often due to the so-called "ground loop". The cable forms a loop to ground. Electromagnetic fields generated by near-by apparatus induce a current in the cable braid. This current generates an unwanted error voltage in the 50-ohm oscilloscope input, which can be attenuated by common-mode filters on the cable.

It may occur that the cable to the oscilloscope is connected through a patch panel bulkhead connector. If the bulkhead is grounded, a ground loop is formed by the cable shield and the connection between the patch panel and oscilloscope ground. The **CT** output can be amplified before it enters the cable, to bring the signal level above the noise induced in the cable. If needed, an attenuator at the oscilloscope input attenuates both the signal and the noise.

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