LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
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Resistor and Capacitor Recommendations

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all

This is an internal working note
of the LIGO Project.

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1 SUMMARY

We recommend the use of metal film resistors in all low noise analog circuits of LIGO. Surface mount metal film resistors are available from Susumu Co Ltd. and can be ordered from Digi-Key in the 0805 size package with tolerances between 0.05% and 0.5%. One disadvantage is that the 0805 size package is only rated for 100 mW dissipation. If higher dissipation is required, the component has to be doubled up, a 1206 has to be used or a through-hole device has to be used instead.

Capacitors which are used in building analog filters have to be of the film type (polycarbonate or PPS), mica or of the ceramic type NP0/C0G. Other ceramic capacitors have a large piezoelectric effect and their capacitance changes with bias voltage. Special care must be taken when soldering plastic film capacitors, so that they don't overheat—only through-hole components are suitable. They have to be hand soldered.

The ceramic types X7R, X5R can be used as bypass capacitors. All other ceramic types (Y and Z) should be avoided due to their large temperature coefficient. Tantalum and aluminum electrolytes can also be used as bypass capacitors.

2 RESISTORS

SMD resistors are divided into thick and thin film type. The difference being that thick film type are made from a layer of paste which is then baked, whereas thin film type are made by sputtering. For thick film resistors the material can be a metal oxide or carbon based mixed together with sintered (powdered) glass, whereas the thin film is either made of metal or metal oxides. Since the 1/f (in the power spectrum) flicker noise of a resistor is due to the variations of resistivity within the conducting material itself, only metal film resistors experience truly low noise.

Table 1 is showing typical values [Journal of Applied Physics V52, p4128 (1981)] of the 1/f noise for different resistor materials. The lower range limits are typically for resistors in the 100 Ω to 1 kΩ regime, whereas the higher range limits are for resistor in the 10 kΩ to 100 kΩ regime.

Table 1: Typical values for 1/f noise in resistors.

material	1 Hz to 100 Hz [nV/V]	at 100Hz [nV/V/√Hz]
carbon film	250–2000	12–100
thick oxide film	125–300	6–15
thin oxide film	25–150	1–7
wire wound	<12	<0.6
metal film	<10	<0.4

We see that with a 10V bias this noise can be in the 100s of nV/√Hz for a carbon film resistor. Not at all small and totally unusable in low noise circuits.

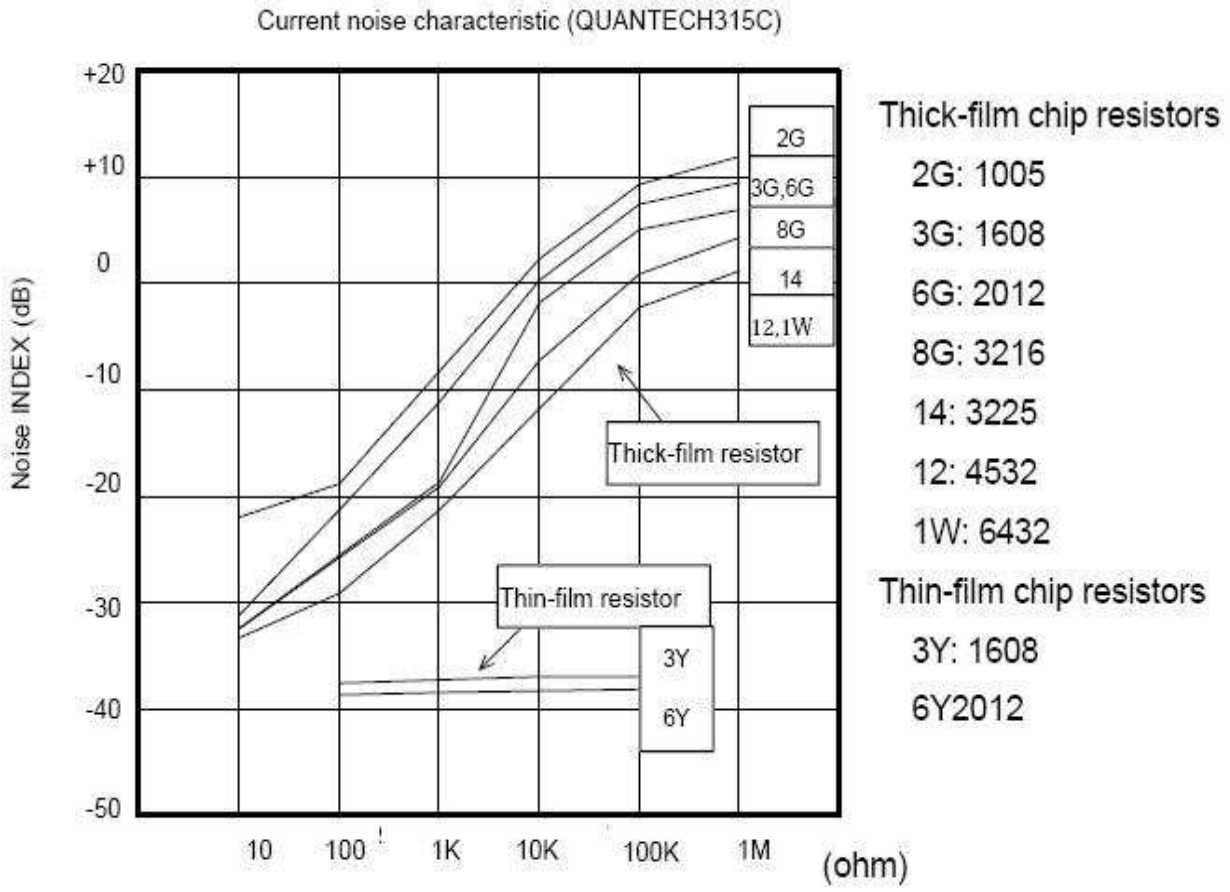

Figure 1: Measure values of 1/f noise from the Panasonic resistors. A noise index of 0 dB corresponds to 1 µV/V of flicker noise integrated from 1 Hz to 100 Hz.

Figure 1 shows measured values of surface mount resistors from Panasonic. These measurements are in agreement with the typical values listed above.

3 CAPACITORS

Table 2 lists maximum temperatures for film capacitors for different materials. Since they are made of plastic, they melt above the specified temperature. In the worst case the component in destroyed or changes its value significantly.

Table 2: Maximum temperature of film capacitors.

Material	temperature [C]	Material	temperature [C]
Polycarbonate	125	Polyester	125
PPS (Polyphenylene sulfide)	150	Teflon	200–250
Polypropylene	105	Polystyrene	85