

HIGH MEGOHM THICK FILM CHIP RESISTORS

ELTECdata #111

BY
David Cima

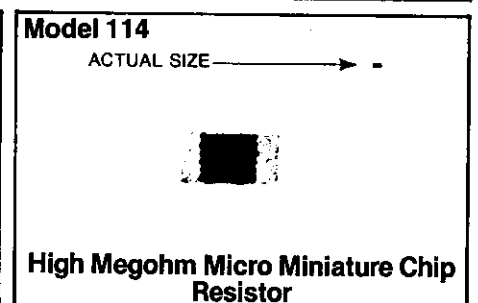
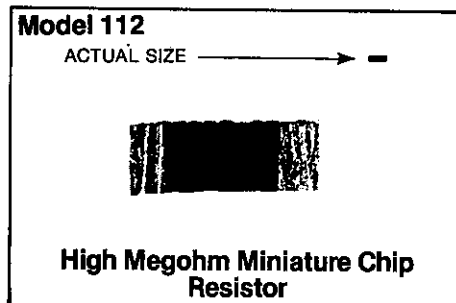
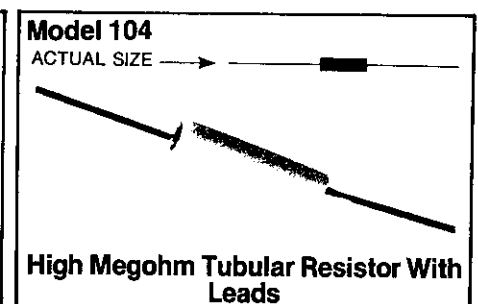
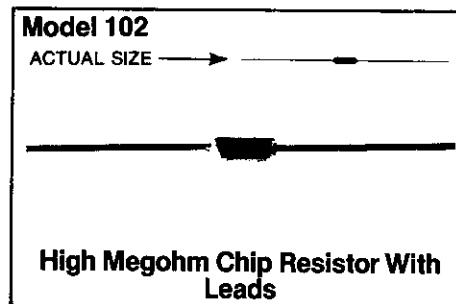
ELTEC has been manufacturing miniature resistors in values to $1 \times 10^{12} \Omega$ (a million-million ohms) since 1969. These resistors have been used in many satellites, deep-space probes and Mars landing missions. High stability and low noise quality has led to use in hydrophone preamplifiers, piezoelectric accelerometers and in low current medical and scientific experiments, even in circuits measuring currents through individual cells. Of course, ELTEC uses thousands and thousands of their own resistors in our major product—pyroelectric infrared detectors.

General Description

ELTEC resistors have a high alumina ceramic base (substrate) upon which are fired either gold or platinum/gold contacts. A resistive "paste" is applied between the contacts and then fired in a tunnel oven. Although the exact ingredients are proprietary, the paste consists of glass and metal oxide particles in a fluid that is driven off during firing. The result is a glass containing the metal oxide in suspension. In crystallographic physics, the resistors can be regarded as amorphous semiconductors or glassy colloids.

Product Mix

Essentially, two sizes of chips are manufactured by ELTEC; the Model 112 (0.100" long by 0.035" wide) and the Model 114 (0.050" long by 0.025" wide). For those who do not have hybrid bonding equipment, ELTEC at-



taches nickel leads to the Model 112 which is then renamed the Model 102. If the Model 102 is placed within a ceramic sleeve and the ends sealed with epoxy, it is then called the Model 104. Thus, product differences are generally restricted to size and mounting convenience.

Resistor Values

Resistors are available from regular production runs in values of from 1 megohm (1×10^6) to 1 teraohm (1×10^{12}). The most requested values are in 1X, 2X, and 5X multiples of the appropriate base exponent. Incremental values are also available.

Nonstandard Values

Resistor values from $100K \Omega$ to 1 megohm and above 1 teraohm are available on special order. Special orders may require additional lead-time.

Technical Applications

ELTEC resistors are primarily used in high impedance, low voltage hybrid circuits where a very small resistor is specified.

ELTEC resistors have a very small capacitance. Also, they operate with very low noise. The small size, low capacitance and low noise make ELTEC resistors ideal for medical research involving in vivo applica-

tions. In many aerospace applications, the resistors are cooled to 77°K or 4°K and become the ultra low noise first stage in extremely low current/voltage detection stages as in photon infrared detectors. They are also used for very low noise, high gain feedback resistors with specially selected op amps.

Resistor Tolerances

ELTEC recommends the choice of the widest possible tolerance commensurate with the performance needs of any particular circuit. All resistors are extremely stable regardless of the tolerance chosen. Wider tolerance values cost less and can be shipped faster. Standard tolerances are $\pm 5\%$, $\pm 10\%$, $\pm 20\%$, and $\pm 30\%$. Matching resistor pairs to within 5% in the basic tolerance ordered is an available option (see Price List). Please request a special quotation for volume applications in circuits accepting wide tolerance resistors (i.e. charge-bleed protective circuits).

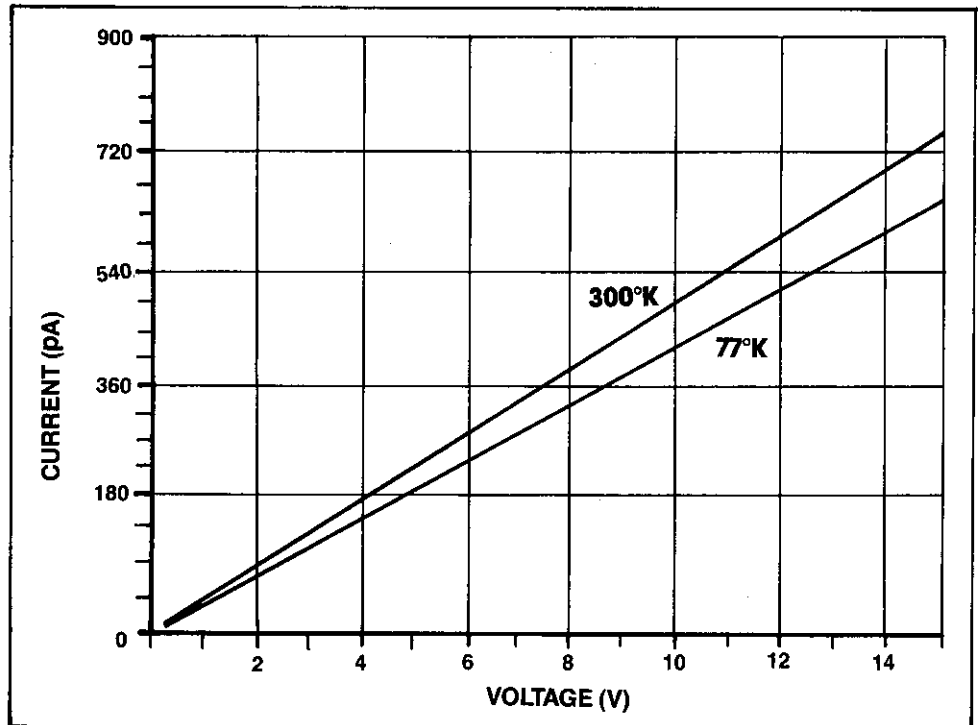
Stability

The materials and manufacturing techniques used to create ELTEC thick film resistors give them unsurpassed stability. The charge-carrying unit cell within the resistor is a chemically stable, fully oxidized metal atom within a silicate (glass) matrix formed at 900°C. The "noble" metal (gold or platinum/gold) terminals are fired onto a substrate made of highly stable electronic-grade sintered aluminum oxide.

Precautionary Data

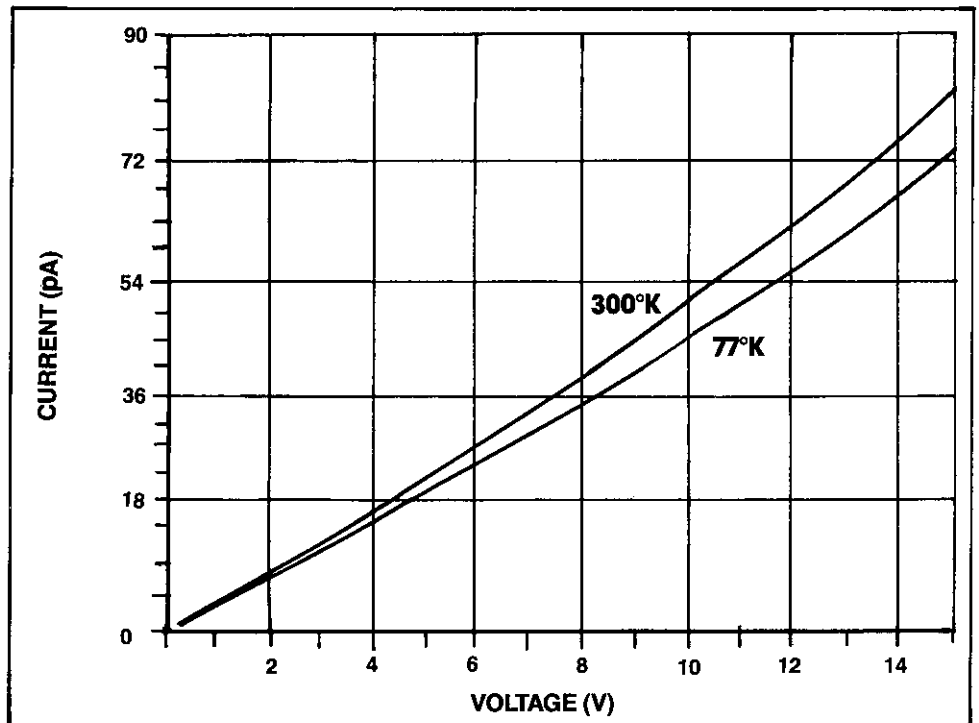
ELTEC resistors are primarily designed for operation between 0 and 1 volt. The resistors have a negative voltage coefficient of resistance (VCR) of typically 4% to 6%—primarily due to the small number of charge carriers available. This VCR should be considered in any applications beyond 1 volt to the maximum rating of 60 volts. Use of these resistors beyond 60 volts generally produces a permanent lowering of resistor value. **Maximum voltage is 60 VDC.**

Model 114 Resistor Value 1 Volt $1.95 \times 10^7 \Omega$



Resistance of ELTEC Model 114 Chip Resistor as a function of Temperature and Applied Voltage. (Customer supplied data)

Model 114 Resistor Value 1 Volt $2.15 \times 10^8 \Omega$



Resistance of ELTEC Model 114 Chip Resistor as a function of Temperature and Applied Voltage. (Customer supplied data)

ELTEC thick film resistors have a negative temperature coefficient of resistance. The graph gives approximate values of this TCR as a function of resistance magnitude. In general, resistors operated at the temperature of liquid nitrogen (77° K) have values 25% greater than at room temperature. Thus, order resistors 80% of desired value for 77° K applications. For applications at liquid helium temperatures (4° K), resistance will be from 2 to 3 times the room temperature value. NOTE: If there is a quantity or continuing need for resistors operating at cryogenic temperatures, please contact an ELTEC Applications Engineer.

Power Ratings (Watts)

ELTEC specifies that resistors not be used with voltages exceeding 60 volts because overvoltages may produce a permanent change in resistance value.

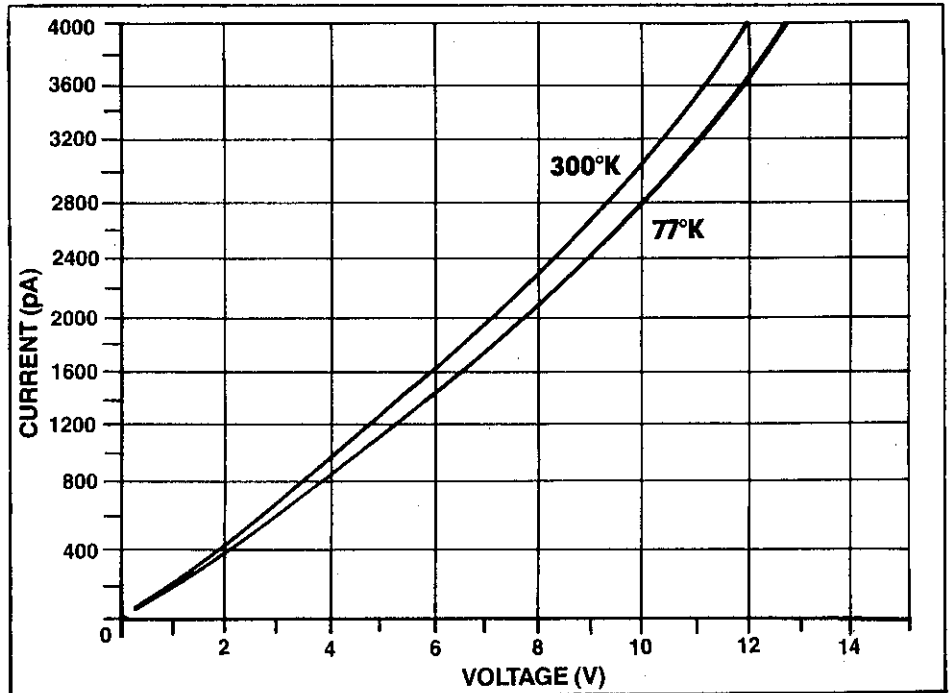
Thus, with a 60 volt maximum, the most power that can be put through a 1 megohm resistor is 4 milliwatts. For a resistor of $10^{12} \Omega$, the power maximum would be 4 nanowatts (4×10^{-9}).

Manipulating $E = IR$ to more convenient forms of $W = E^2/R = I^2R$, putting 1/4 watt through a 1 meg resistor would take 500 volts; for a 1/2 watt, 700 volts.

To put a quarter watt through the highest value resistor, $10^{12} \Omega$ would take 500,000 volts—for 1/2 watt, 700,000 volts.

Often, resistor users must meet a "blanket" specification stating "...all resistors used in this device shall have power ratings of at least 1/4 watt." To

Model 114 Resistor Value 1 Volt $4.81 \times 10^9 \Omega$



Resistance of ELTEC Model 114 Chip Resistor as a function of Temperature and Applied Voltage. (Customer supplied data)

this it can be said that thick film resistors—as a class—can meet traditional power ratings. One customer completed his specification form stating that the... manufacturer rated thick film resistors at 1/2 watt as long as the voltage applied did not exceed 60 volts.

Metalization Option

ELTEC can metalize the back of the resistor (extra charge). Mounting with conductive epoxy may accom-

plish the same result. In leaded resistors with a metallized back, the back is made accessible with a third lead.

Single Lot Option

Orders can be filled with all resistors coming from a single manufacturing lot if requested. Also, a Certificate of Compliance attesting to the single lot source will be supplied if so requested. See Price List for specific information.

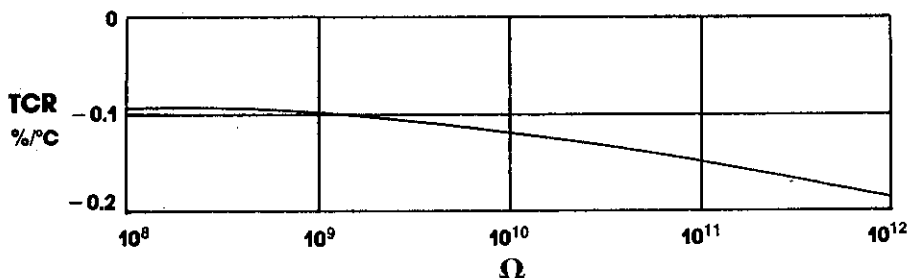
Cleaning

ELTEC resistors can be cleaned with most agents recommended for electronic components. Alcohol is not recommended as it tends to hold moisture to the surface and lower resistance values. After cleaning, a final rinse in a degreaser followed by baking at 150°C is suggested (especially if alcohol has been used). Acetone is not recommended.

Testing

All resistors are individually tested at 1 volt DC. Testing at other voltages is available on special order.

Temperature Coefficient of Resistance



Negative temperature coefficient of resistance (TCR) as a function of resistor value. Note: Typical data; user should verify TCR of specific lots as required.