

## Resistors in Medical Applications

One of the most significant changes to the medical device market over the last ten years has been the rapid integration of electronics. Two primary factors for this change have been an increase in the individual's desire to monitor their own health, and the need for increased accuracy of high-end devices. These market drivers are creating interesting new applications for resistors with challenging requirements. This article will discuss those applications, end uses and describe the resistors needed to fulfill the requirements of those medical devices.

### Home Health

Electronics are booming in the home health market. Digital thermometers, CPAP machines, motorized wheelchairs, blood pressure and blood glucose monitors, all have significant electronic content. Digital thermometers and digital skin temperature sensors require small size precision resistors for the detection and analysis circuitry of the devices. The RNCF is an ideal choice for precision and small size. It offers a wide value range, wide range of TCR and tolerance options. You may also expect these portable electronics would require a small current sense resistor for battery / power control. However, these devices rarely have a battery meter on their display; if the device doesn't turn on when you push the button, you assume the battery is dead and replace it. That coupled with the low power levels of such devices mean current sensing isn't typically necessary.



CPAP machines utilize brushless DC motors which require current sense resistors with at least 2W power ratings and resistance values of 1 to 10 milliohm. Depending on whether the machine is high end or more budget friendly, these could be a thick film device such as the CSRN2512 or a metal element based shunt such as the CSNL2512.

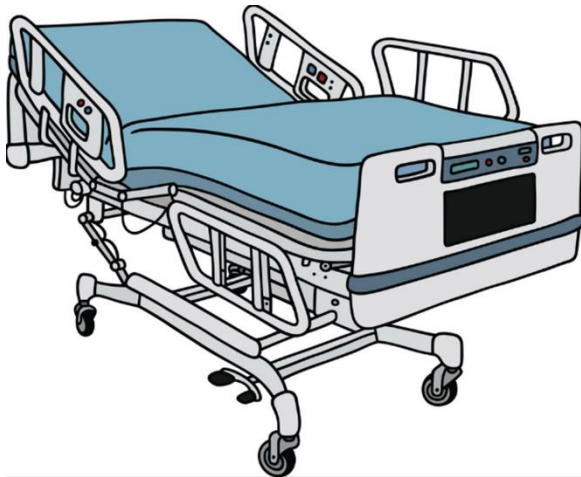
Additional control and monitoring circuitry is typically done with 0402 and 0603 size AEC qualified chip resistors. Higher reliability components are sought here because of the potential health risks for CPAP machine failures for those with severe sleep apnea.

Motorized wheelchairs and personal three wheeled scooters for the elderly will typically use high voltage stepper motors with a 3 phase inverter or brushless DC motors depending on the size of the chair or scooter. For the high voltage stepper motor driver, normally a 3W 2512 size chip resistor in a 1 to 5 milliohm value is required. The CSSH2512 and CSM2512 are good options with 1% tolerances and good TCR. For the vehicles using brushless DC motors similar to the CPAP machine, where a thick film solution such as the CSRN2512 may be used although higher currents or surge requirements would mean using an all metal device such as the CSNL2512.

## In-hospital Equipment

A wide range of medical devices found in hospitals and clinics require more specialized resistors. X-ray machines will typically require a 2W current sense resistor in the 25 milliohm to 50 milliohm range with low TCR of 50 ppm or better required. This can be accomplished with the CSRF2512, or for more robust requirements, the CSS2512 is a good choice. MRI machines will use similar circuitry, but since size is of a premium also require a significant amount of 0201 thick film chip resistors for much of the other electronics.

Dialysis machines will typically use some type of universal stepper motor, or brushless DC motor for fluid propulsion. Mostly these designs use AEC qualified 0603 through 1206 thick film chips, but the motor driver requires a robust 3W 2512 size metal element device in resistance values in the range of 40 milliohms. The CSM2512 is a good choice here. Similarly ventilators and respirators will utilize DC motors and require current sense resistors for the DC to DC converters running those motors.



Hospital beds require a significant amount of electronics for bed position, motorized wheels, and pump controls. Stepper motors or brushless DC motors are incorporated for the beds. These controls are considered critical functions; therefore, AEC qualified components are normally specified. The CSSH2512 and CSM2512 in resistance values from 5 to 20 milliohms are typically required for the motor control circuitry.

Personal wellness monitors are regularly used in hospitals for patients who have had heart related issues. The patient wears the monitor around their neck and is allowed to be on their feet and potentially moving around their room or through the hospital while still being monitored. Battery management for these monitors is typically done with a 3W 2512 size current sense resistor in the 5 milliohm range, such as the CSSH2512FT5L00. If the patient wearing the monitor has another cardiac arrest, the monitor must be protected from defibrillation of the patient. Pulse withstanding chip resistors such as the RPC2512 in resistance values from 50 to 200 ohms are normally used here because of their ability to withstand pulses. They are thick film technology, they will ultimately fail open safely with no possibility for shorting.

Defibrillators themselves are another interesting medical device from a resistor standpoint. Portable defibrillators require battery management through current sense resistors. Normally a thick film device such as the CSRN will suffice. In the event the paddles are charged and the patient revives and does not require defibrillation, there needs to be a discharge path for that energy. This discharge path usually includes some type of high voltage chip resistor such as the HVC or UHV series as well as a wirewound resistor such as the WW, CB, or SM series to absorb and limit the current.



EKG, ECG, and heart rate monitors follow similar design requirements as those previously discussed for digital thermometers and skin temperature sensors. They require relatively small size resistors from 0201 up to 0603 size, prefer AEC qualified products, and need high precision in terms of tolerance, TCR, and stability over life.

The RNCF is ideally suited for applications with these kinds of requirements due to its wide range of sizes, resistance values, tolerances, and TCR's offered with excellent environmental and long term stability.



Ultrasound machines function using a high voltage pulse generator to power the ultrasound waves. This pulse generator typically employs a high voltage resistor such as the HVC, UHV, or HVA series. Power control usually comes in the form of a small current sense resistor with relatively high resistance values ranging from 100 to 300 milliohm. The CSR0201 and 0402 sizes are ideally suited to these small applications with relaxed TCR requirements.

Some recent functional additions to traditional equipment include LED displays for control and monitoring as well as USB interface ports. LED applications utilize current sense resistors such as the CSR / CSRN series for current control to the LED strings to maintain uniform brightness. USB interfaces utilize high speed data transfer. This can make protecting these ports and the electronics connected to them from ESD and similar over voltage surges challenging. Use of standard ESD suppression devices may distort the data signal or compromise it entirely. The ESD series from Stackpole provides protection for high speed data ports, with little to no impact on data signal integrity due to the extremely low capacitance of that series. In addition, the ESD series is an air gap type device with extremely low leakage.

## Summary

Electronic content in medical applications has grown exponentially in the recent years. New types of home health devices, higher functionality in hospital beds, as well as patient testing and monitoring, mean increasing amounts of resistor content in these devices. The requirements for those resistors are becoming stricter. Resistor technology is advancing at an equal pace to meet these ever changing market needs.

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