Thermal Simulation Is Key to JVC CCTV Product Reliability

by Matt Barrett

With the continuing trend toward lower cost of manufacturing for electronic devices and greater use of integrated components, we have become used to seeing manufacturer warranty periods well in excess of the traditional 12 months. This does not necessarily mean that the manufacturer of the device actually expects the product to last as long as the warranty. It simply means the manufacturer has made a cost calculation that takes into account the fact that only a percentage of products that fail within the warranty period actually end up being the subject of a warranty claim. With a relatively low-priced item like a CCTV camera, it is common to simply purchase a replacement.

However, the process of replacing that camera can be very expensive. Warranty or no warranty, the cost of sending a technician up a ladder to replace a failed CCTV camera often costs more than the camera itself. Plus, it is important to consider the potential damage or theft where the camera is not providing surveillance.

The best way to avoid the expense and inconvenience associated with a CCTV camera that fails is for the camera not to fail in the first place. But if the warranty period is not a true indicator of likely product lifespan, how is it possible to determine a realistic picture of expected reliability?

The answer is to examine data such as the FR (Failure Rate) and MTBF (Mean Time Between Failures) that a manufacturer may publish. JVC is one of the very few security products manufacturers that is proud to publish such data. FR and MTBF figures, established through well-established analytical modeling techniques, provide a clear guide for product lifetime expectations. JVC's mini-dome cameras, for example, have a published MTBF figure of 90,000 hours. That's more than 10 years of 24/7 usage. These calculations are borne out in the field by users all over the world. For example, a well known national supermarket chain, which has had more than 7,500 JVC security cameras installed over the past eight years, has experienced less than 40 failures. That's less than one in 200 over a significant timespan.

Causes of mechanical failure

The reason for the incredible longevity of JVC products can be traced to a fundamental design philosophy relating to thermal and environmental issues. To a great extent, the longevity of key components such as integrated circuits and capacitors determines the life span and failure rate of the products in which they are used.

Selecting the right components is an important first step. For example, not all capacitors are alike. Some manufacturers prefer ceramic capacitors, which can be more tolerant of heat but are highly intolerant of voltage fluctuations. Outside the product design laboratory, power fluctuations can be a regular occurrence. JVC uses electrolytic capacitors that are far more reliable under power fluctuations (and are carefully tested for heat tolerance).

Better parts only provide part of the key to better reliability. The internal temperature of products significantly affects how long these components will last. As illustrated in Figure 1, some repercussions of excessive heat include:

- failure of solder joints due to component swelling.
- shorter component life span.
- loss of mechanical safety due to component degradation.

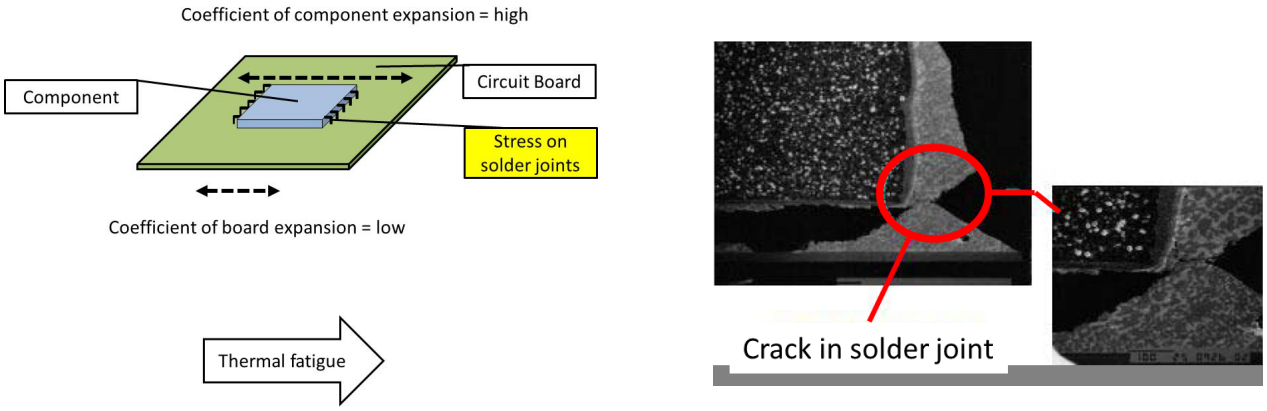

Figure 1. Failure of solder joints (where the components connect to the board) due to component swelling.

The electronic components for which temperature most affects longevity are electrolytic capacitors. Figure 2, which illustrates the life span of typical electrolytic capacitors, shows that **every 10° rise in internal temperature halves the life span,** clearly demonstrating how product longevity benefits from lower internal temperature.

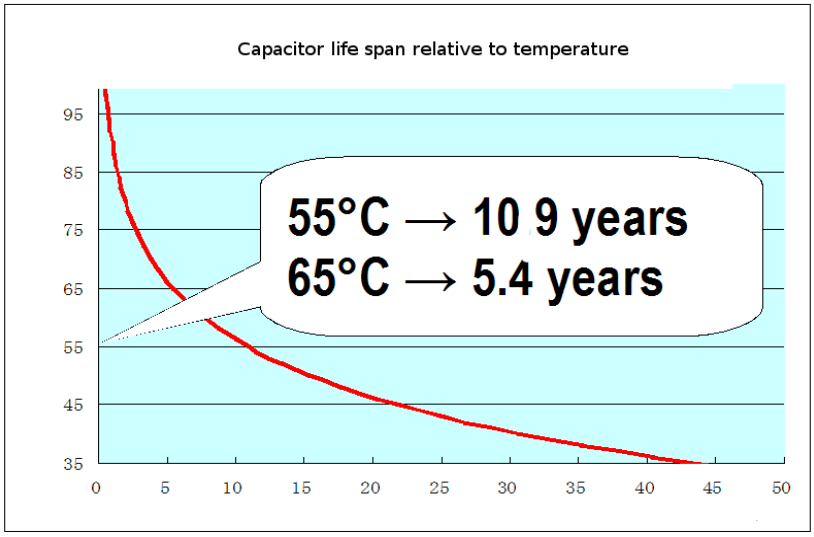

Figure 2. Correlation of capacitor longevity to temperature

$$L = L_0 \times 2^{\frac{T1-T2}{10}}$$

L: Estimated capacitor life (h)
L_0: Capacitor rated life (h)
T1: Capacitor rated temperature (°C)
T2: Capacitor actual temperature (°C)

For this reason, JVC conducts thermal simulations, verifies capacitor longevity, and reduces component power consumption in thermal design for greater reassurance about product life spans.

Why thermal simulation has become critical

Electronic components used to be larger and circuit boards were less highly integrated, which reduced the likelihood of thermal issues. However, now that electronic components are more compact and include highly integrated circuitry, manufacturers can no longer disregard potential thermal issues.

Traditional product engineering relied on prototyping at a relatively late stage of development to determine temperatures of various parts and take appropriate measures. But as electronic components have become more compact, the temperature of smaller, more constricted circuits and other components has become almost impossible to measure. In some cases, the nature of these thermal countermeasures may have had a severe impact on reliability.

In addition to product performance tests, JVC regularly performs advanced thermal simulations, such as ones shown in Figure 3, to improve product design. The use of thermal simulation earlier in development makes it easier to visualize heat in every part of every component, thus enabling engineers to prevent thermal issues and create products with significantly greater reliability.

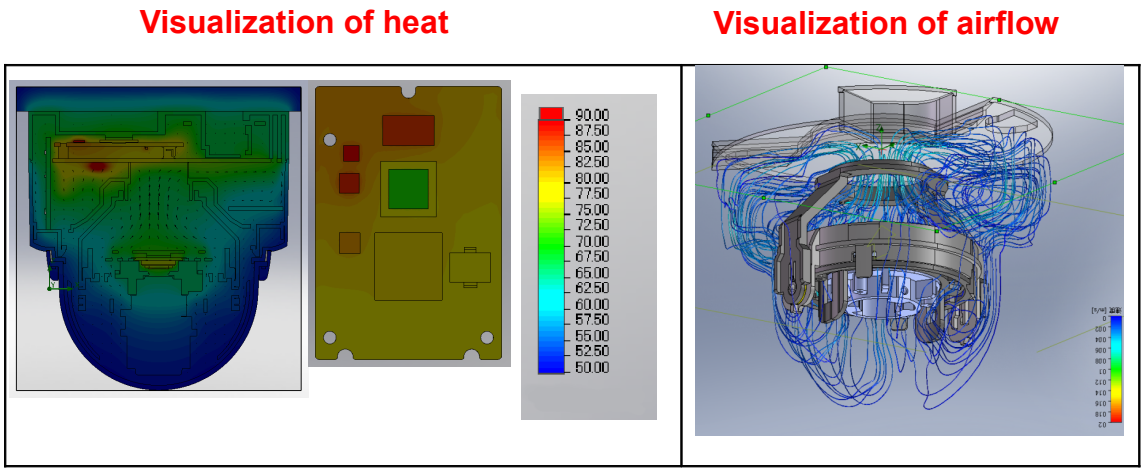

Figure 3. Thermal simulation illustrates potential design issues.

Preventing thermal issues through thermal analysis and design requires careful electronic and mechanical engineering. As show in Figure 4, the process is repeated through a number of iterations to resolve any thermal issues at an early stage of development.

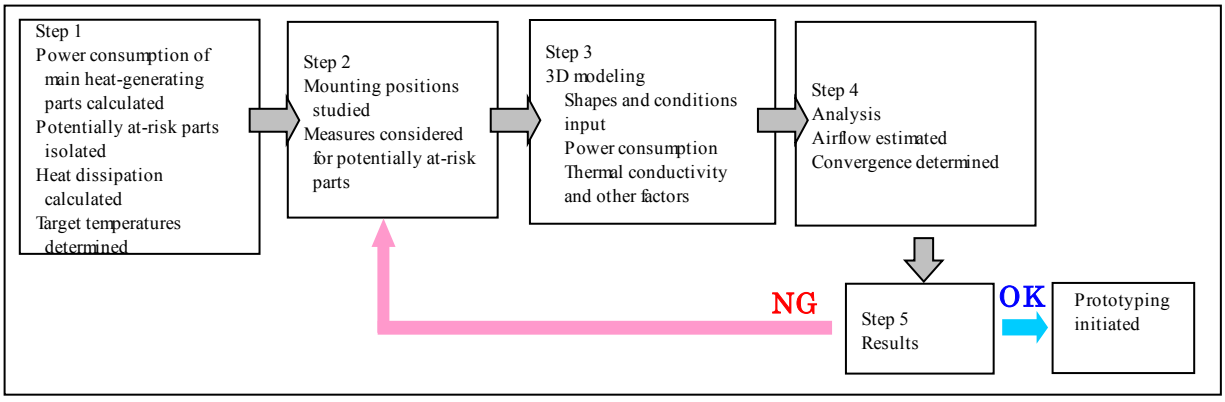

Figure 4. Early product development workflow.

The following measures can be taken for sensitive internal components:

- modify the product body shape to facilitate component heat dissipation (radiation).
- modify the board pattern.
- investigate channels of direct heat dissipation from components to the product body.
- rearrange the board and component layout to separate heat-generating parts.
- determine any areas where energy is wasted and reduce load circuit consumption.
- make power circuits highly energy efficient.

The process of conducting thorough and comprehensive thermal simulations prior to prototyping enables JVC engineers to eliminate thermal issues earlier in the product development cycle, which results in extremely stable and reliable finished products.

Environmental initiatives

Linked to JVC's goal of product reliability is another goal of creating products that have minimal environmental impact. Apart from the normal "best practice" manufacturing techniques, as well as recycling and waste management policies, JVC also strives to design products that operate with the absolute minimum power consumption. This drive toward greater energy efficiency also has a reciprocal impact on the ultimate reliability of the product.

As mentioned, thermal simulation is very useful in controlling temperature in electronics, and one specific approach to keeping products cool is to reduce power consumption. Controlling temperature helps capacitors and circuits last longer. In thermal simulation, engineers seek better product reliability by controlling the heat generated inside (through dissipation and uniform internal distribution of heat), but the goal of energy efficiency involves minimizing this heat in the first place.

To demonstrate how significant energy efficiency is to better environmental performance, Figure 5 compares internal temperature and power consumption of two JVC video cameras (the current TK-C9200UA and an older TK-C920U) at an ambient temperature of 35°C. The graph expresses this information in terms of product longevity and CO_2 emissions.

	Power Consumption(W)	CO Emissions (t/Y)
TK-C920U	4.7	16.88
TK-C9200U A	2.3	8.26
Difference	2.4	8.62

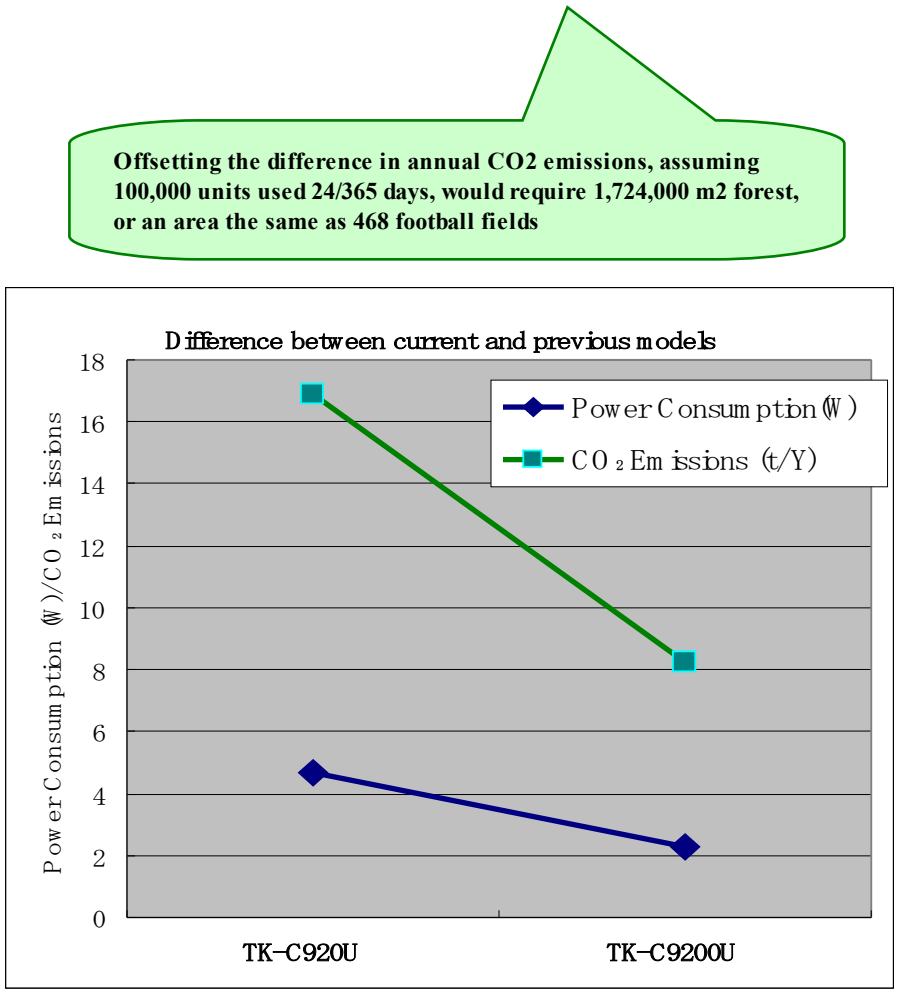

Figure 5. Comparison of internal temperature and power consumption of current model TK-C9200UA and older TK-C920U CCTV cameras.

Conclusion

Our commitment to design excellence has led to the creation of products that provide users with real benefits in both energy consumption and overall reliability. Such benefits may be difficult to express in a product brochure, but thermal simulation and environmental initiatives are two of the reasons there are satisfied customers around the world who rely on JVC CCTV equipment.