ALUMINUM ELECTROLYTIC CAPACITORS

■ TECHNICAL NOTE

5 Reliability

5-1 The bathtub curve:
Aluminum electrolytic capacitors feature failure rates shown by the following bathtub curve.

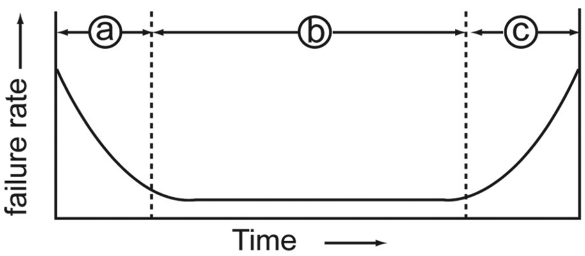

Fig. 5-1 bathrub curve

a) Infant failure period
This is a period during which failures are caused by deficiencies in design, structure, manufacturing process or severe misapplications. Such failures occur soon after the components are exposed to circuit conditions. In aluminum electrolytic capacitors, these failures are either corrected through aging process reforming or repairing a damaged oxide layer, or found by the aging process, removed by the sorting process, and thus do not reach the field.

Infant failures due to capacitor misapplication such as inappropriate ambient comditions, over-voltage, reverse voltage or excessive ripple current can be avoided with proper circuit design and installation.

b)Useful life period
This is a random failure period during which the failure rate is the lowest. These failures are not related to operating time but to application conditions. During this period, non-solid aluminum electrolytic capacitors show a slow decrease in capacitance and a slow increase in tan δ and ESR, which are caused by a small loss of electrolyte, and feature fewer catastrophic failures than semiconductors and solid tantalum capacitors.

c)Wear-out failure period
This is a period during which the properties of a component extremely deteriorate, and the failure rate increases with time. Non-solid aluminum electrolytic capacitors end their useful life during this period.

5-2 Failure types:
The two types of failures are classified as catastrophic failures and wear-out failures as follows,
① Catastrophic failure
Like a short circuit or open circuit failure, this is a failures mode which destroys the function of the capacitor.
② Wear-out failure
This is a failure mode resulted by the gradual deterioration of the capacitor electrical parameters. The criteria for judging the failures varies with application and design factors.
Capacitance decrease and tan δ increase are caused by the loss of electrolyte in the wear-out failure period. This is due primarily to loss of electrolyte by diffusion(as vapor)through the sealing material. Gas molecules can diffuse out through the material of the end seal. If the electrolyte vapor pressure within the capacitor is increased, by high temperatures for example, the diffusion rare is increased. Swelling of the seal material by electrolyte vapor pressure may also occur at elevated temperature.This swelling may further enhance diffusion and mechanically weaken the seal.

5-3 Failure modes:
Aluminum electrolytic capacitors show various failure modes in different applications.(see table below.)