Solid Tantalum Capacitors

Tantalum electrolytic capacitors are the preferred choice in applications where volumetric efficiency, stable electrical parameters, high reliability and long service life are primary considerations. The stability and resistance to elevated temperatures of the tantalum/tantalum oxide/manganese dioxide system make solid tantalum capacitors an appropriate choice for today's surface mount assembly technology. Vishay Sprague has been a pioneer and leader in this field, producing a large variety of tantalum capacitor types for consumer, industrial, automotive, military and aerospace electronic applications.

Tantalum is not found in its pure state. Rather, it is commonly found in a number of oxide minerals, often in combination with Columbium ore. This combination is known as "tantalite" when its contents are more than one-half tantalum. Important sources of tantalite include Australia, Brazil, Canada, China and several African countries. Synthetic tantalite concentrates produced from tin slags in Thailand, Malaysia and Brazil are also a significant raw material for tantalum production.

Electronic applications and particularly capacitors consume the largest share of world tantalum production. Other important applications for tantalum include cutting tools (tantalum carbide), high temperature super alloys, chemical processing equipment, medical implants and military ordnance.

Vishay Sprague is a major user of tantalum materials in the form of powder and wire for capacitor elements and rod and sheet for high temperature vacuum processing.

THE BASICS OF TANTALUM CAPACITORS

Most metals form crystalline oxides which are non-protecting, such as rust on iron or black oxide on copper. A few metals form dense, stable, tightly adhering, electrically insulating oxides. These are the so-called "valve" metals and include titanium, zirconium, niobium, tantalum, hafnium and aluminum. Only a few of these permit the accurate control of oxide thickness by electrochemical means. Of these, the most valuable for the electronics industry are aluminum and tantalum.

Capacitors are basic to all kinds of electrical equipment from radios and television sets to missile controls and automobile ignitions. Their function is to store an electrical charge for later use.

Capacitors consist of two conducting surfaces, usually metal plates, whose function is to conduct electricity. They are separated by an insulating material or dielectric. The dielectric used in all tantalum electrolytic capacitors is tantalum pentoxide.

Tantalum pentoxide compound possesses high dielectric strength and a high dielectric constant. As capacitors are being manufactured, a film of tantalum pentoxide is applied to their electrodes by means of an electrolytic process. The film is applied in various thicknesses and at various voltages and although transparent to begin with, it takes on different colors as light refracts through it. This coloring occurs on the tantalum electrodes of all types of tantalum capacitors.

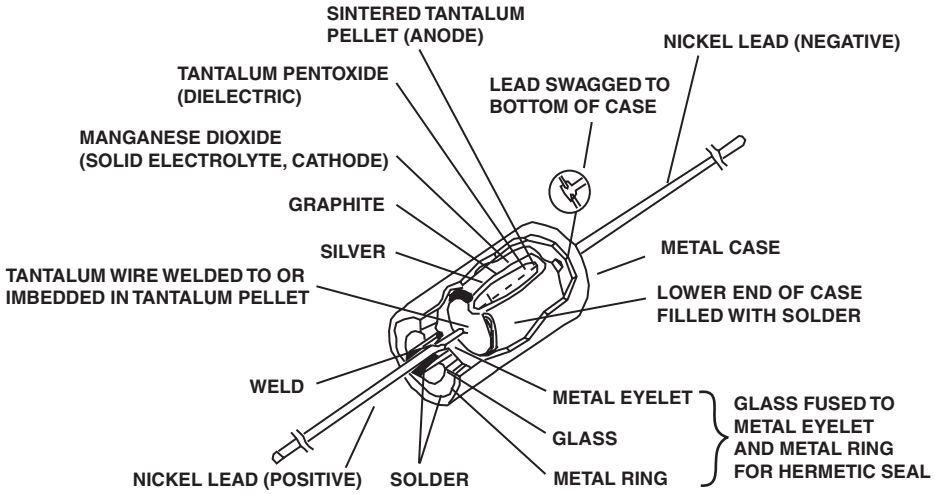
Rating for rating, tantalum capacitors tend to have as much as three times better capacitance/volume efficiency than aluminum electrolytic capacitors. An approximation of the capacitance/volume efficiency of other types of capacitors may be inferred from the following table, which shows the dielectric constant ranges of the various materials used in each type. Note that tantalum pentoxide has a dielectric constant of 26, some three times greater than that of aluminum oxide. This, in addition to the fact that extremely thin films can be deposited during the electrolytic process mentioned earlier, makes the tantalum capacitor extremely efficient with respect to the number of microfarads available per unit volume. The capacitance of any capacitor is determined by the surface area of the two conducting plates, the distance between the plates and the dielectric constant of the insulating material between the plates.

COMPARISON OF CAPACITOR DIELECTRIC CONSTANTS

DIELECTRIC	K DIELECTRIC CONSTANT
Air or Vacuum	1.0
Paper	2.0 - 6.0
Plastic	2.1 - 6.0
Mineral Oil	2.2 - 2.3
Silicone Oil	2.7 - 2.8
Quartz	3.8 - 4.4
Glass	4.8 - 8.0
Porcelain	5.1 - 5.9
Mica	5.4 - 8.7
Aluminum Oxide	8.4
Tantalum Pentoxide	**26**
Ceramic	12 - 400 000

150D AND MIL STYLE CSR13

HERMETICALLY-SEALED, SOLID ELECTROLYTE
(MILITARY SPECIFICATION NO. MIL-PRF-39003)



Voltage Range:
6 WVDC to 125 WVDC
Capacitance Range:
0.0047 µF to 330 µF
Size Range:
0.125" [3.175 mm] Ø x 0.250" [6.350 mm] long to
0.341" [8.661 mm] Ø x 0.750" [19.050 mm] long
Primary Applications:
Industrial and military equipment where reliability, low leakage current, low dissipation factor and stability with time and temperature are required.

In the tantalum electrolytic capacitor, the distance between the plates is very small since it is only the thickness of the tantalum pentoxide film. As the dielectric constant of the tantalum pentoxide is high, the capacitance of a tantalum capacitor is high if the area of the plates is large:

$$C = \frac{eA}{t}$$

where

C = capacitance

e = dielectric constant

A = surface area of the dielectric

t = thickness of the dielectric

Tantalum capacitors contain either liquid or solid electrolytes. The liquid electrolyte in wet slug capacitors - generally sulfuric acid - forms the cathode (negative) plate. In solid electrolyte capacitors, a dry material, manganese dioxide, forms the cathode plate. The anode lead wire from the tantalum pellet consists of two pieces. A tantalum lead embedded in, or welded to the pellet, which is in turn connected to a termination or lead wire. The drawings clearly show the construction details of the frequently used types of tantalum capacitors.

VISHAY'S LINE OF HIGH QUALITY LEADED TANTALUM CAPACITORS

Vishay manufactures two categories of leaded tantalum capacitors:

1. Solid electrolyte, sintered anode leaded tantalum capacitors as shown in this data book

2. Wet electrolyte, sintered anode leaded tantalum capacitors - see Vishay data book, Wet Tantalum Capacitors

SOLID ELECTROLYTE TANTALUM CAPACITORS

Solid electrolyte, sintered anode tantalum capacitors in their original hermetically-sealed designs differ from the wet versions in their electrolyte. Here, the electrolyte is manganese dioxide, which is formed on the tantalum pentoxide dielectric layer by impregnating the pellet with a solution of manganous nitrate. The pellets are then heated in an oven and the manganous nitrate is converted to manganese dioxide.

The pellet is next coated with graphite followed by a layer of metallic silver, which provides a solderable surface between the pellet and the can in which it will be enclosed.

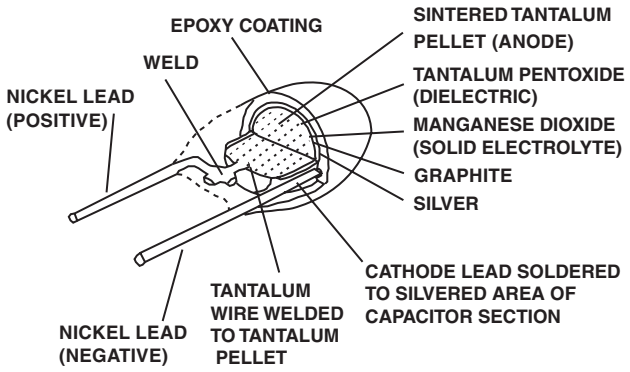
The pellets, with lead wire and header attached, are inserted into the can where the pellet is held in place by solder. The can cover is also soldered into place.

After assembly, the capacitors are tested and inspected to assure long life and reliability. Another variation of the solid electrolyte tantalum capacitor encases the element in plastic resins, such as epoxy materials. It offers excellent reliability and high stability for consumer and commercial electronics with the added feature of low cost.

Surface mount designs of “Solid Tantalum” capacitors use lead frames or lead frameless designs as shown in the accompanying drawings.

199D

EPOXY-DIPPED, SOLID ELECTROLYTE



Voltage Range:
3 WVDC to 50 WVDC.
Capacitance Range:
0.10 µF to 680 µF.
Size Range:
0.177" [4.496 mm] diameter x 0.340" [8.636 mm] high to
0.380" [9.652 mm] diameter x 0.710" [18.034 mm] high
Primary Applications:
On printed circuit boards in entertainment, commercial and industrial equipment where low cost, small size, high stability, low DC leakage and low dissipation factor are important.

TANTALUM CAPACITORS FOR ALL DESIGN CONSIDERATIONS

In choosing between the two basic types of tantalum capacitors, the circuit designer customarily uses wet sintered anode capacitors, or wet “slug” tantalum capacitors, where the lowest DC leakage is required. The conventional silver can design will not tolerate any reverse voltages. However, in military or aerospace applications, tantalum cases are used in place of silver cases where utmost reliability is desired. The tantalum cased wet slug units will withstand reverse voltages up to 3 V, will operate under higher ripple currents and can be used at temperatures up to + 392 °F (+ 200 °C).

Solid electrolyte designs, which are the least expensive for a given rating, are used in many applications where their very small size for a given unit of capacitance is of importance.

They will typically withstand up to about 10 % of the rated DC working voltage in a reverse direction. Also important are their good low temperature performance characteristics and freedom from corrosive electrolytes.

Vishay Sprague patented the original solid electrolyte capacitors and was the first to market them in 1956. Vishay has the broadest line of tantalum capacitors and has continued its position of leadership in this field. Data sheets covering the various types and styles of Vishay tantalum capacitors for consumer and entertainment electronics, for industrial and for military applications are available where detailed performance characteristics must be specified.