From the basic formula we note that C varies directly with the dielectric constant (K) and area (A); and inversely with the distance between the plates (d). Both (A) and (d) are geometrically controlled figures, but what is this dielectric constant (K) and how is *it* determined?

The dielectric constant (K) of a material is a direct measure of its ability to store electrons when compared to air.

If we make a capacitor with given "A" and "d" dimensions, and use just clean dry air as our dielectric, it will measure a certain value of capacitance. Now, if we substitute some other dielectric for the air and remeasure the capacitance, we will find that our capactance value has increased. If the capacitance figure doubled, for instance, this would mean that the second dielectric had a dielectric constant of 2 (twice that of air).

Figure 4 is a chart of various common dielectric materials and their approximate dielectric constants.

DIELECTRIC CONSTANTS AT 25°C

Dielectric Material	K(Dielectric Constant)
Vacuum	1.0 (exact)
Air	1.0001
Teflon	2.0
Polystyrene	2.5
Polypropylene	2.5
Polycarbonate	2.7
Polysulfone	2.7
Mylar	3.0
Kapton	3.2
Polyethylene	3.3
Kraft Paper (impregnated)	2.0 to 6.0
Mica	6.8
Aluminum Oxide	7.0
Tantalum Oxide	11.0
Ceramics	35.0 to 6000+

Figure 4

And that's what a capacitor is!

What is a capacitor? Why it's "something that an electronic circuit won't work without!"

TECHNICAL BULLETIN NO. 02

CAPACITORS...VERSATILE JOB PERFORMERS

Whenever a capacitor is designed into an electronic circuit, it has been selected to do a specific job - and certain capacitors will perform certain jobs better than some others.

Let us examine these jobs that must be performed by the capacitors and analyze the important factors leading to the proper selection.

BLOCKING

Whenever direct current (DC) is applied to a capacitor, the capacitor effectively "blocks" this current and will not allow it to pass through. Utilizing this property of the capacitor, a design engineer can isolate a circuit element from the DC supply. For this job, he has a choice to make among many dielectrics, each of which will allow a different amount of tiny "leakage current" to pass through itself. This "leakage current" is a normal result of the random passage of electrons through or around the dielectric (usually in the microampere range), and should not be confused with the normal DC current supply. Thus, the design engineer can match the dielectric with the critical value of "leakage current" that his curcuit can tolerate without malfunction.

COUPLING (DE-COUPLING)

Just as the capacitor will block out direct current, it will appear to pass alternating current (AC). The capacitor is really charging and discharging in opposite directions each half-cycle as the impressed AC voltage alternates in polarity. To the rest of the circuit this has the same effect as though the capacitor were allowing the passage of the AC signal. By using this ability of the capacitors, the design engineer can "couple" one portion of a circuit to another portion of a circuit or even to a different circuit. Here, the inherent dissipation factor of the capacitor style can be critical if the heating effect of the AC voltage is appreciable.

BY-PASSING

This job is a good example of the combination of blocking and coupling functions. In this case, the capacitor is used to separate the DC and AC portions of a mixed signal current. Here, the capacitor is placed in parallel with a circuit element. The purpose here is to insure that the DC portion does appear on the circuit element —but not the AC portion! By properly choosing the capacitor rating, the AC signal sees an apparently low impedance path "through" the capacitor compared to the circuit element and consequently "by-passes" the circuit element. The DC signal sees a low impedance path through the circuit element and travels that way. Obviously, both the leakage current and dissipation factor parameters are to be considered in any application where these factors are critical.

FREQUENCY DISCRIMINATION

Somewhat related to the coupling function of the capacitor is the characteristics of a capacitor that allows an engineer to discriminate between AC signals of different frequencies. In general, the greater the capacitance of a unit, the greater the current will be at any given frequency; and for a given capacitance, the higher the frequency, the more current will pass (up to the resonant frequency of the capacitor — the point of maximum current transfer). By utilizing this characteristic, an engineer can distinguish between AC currents of different frequencies. Again, as in the coupling application, the dissipation factor (heat producer under AC applications) can be critical.

TIMING

This function is really a control on the "speed of response" of the charging and discharging time for a capacitor and its associated circuitry. The rate at which charge flows in and out of the capacitor is directly controlled by the capacitance (C) and series resistance (R) of the circuit. Therefore, the "timing" or speed of response of a circuit can be controlled by using various RC combinations. This combination of R and C is known as the "TC" or "time constant". Usually, the most critical parameter to be considered in a "timing" appljcation is that of capacitance change with temperature (temperature coefficient). The variance of capacitance with time, and the retrace capabilites of the capacitance after temperature excursions can also be critical in certain circuit applications.

TRANSIENT VOLTAGE SUPPRESSION

This characteristic of a capacitor is widely used to provide "voltage stabilization." Most unregulated power supplies are subject to transient peaks of voltage surges which can cause malfunction in the circuit. By utilizing capacitors, these transient peaks are absorbed or stored by the capacitor and a steady voltage signal is supplied to the circuit. This same principle is used to reduce AC ripple voltages in rectified power supplies. Parameter behavior of the various kinds of capacitors is usually of no critical importance for this application.

ENERGY STORAGE

By using the capacitor to store energy over a long period of time and then discharging this total energy in a very short time, high currents can be made available to perform welding, photo-flash, heating, and other similar jobs. For the case of fairly high pulsing service, the dissipation factor may be of concern from a heating consideration. The most critical factor here is the current-carrying capabilites of the unit, leads, and connections.

ARC SUPPRESSION

"Make-break" type circuits, whereby mechanical relays or similar devices are used to periodically interrupt a current flow, causes arcing at the contact points. This results in a "noise" signal that can interfere with nearby radio and television reception. The use of capacitor-resistor and/or inductor combinations will reduce or eliminate this interference and prolong the life of the contacts by absorbing the voltage pulse resulting from this current interruption.

POWER FACTOR CORRECTION

Part of the total power generated by, or supplied to a circuit must be used to energize or activate certain components within the circuit. This power is effectively lost within the circuit and therefore not available for other uses. By using capacitors, this percent loss of power can be and is reduced, thus "correcting" or "improving" the power factor of the circuit. The immediate benefit from this "corrected" power factor is the reduction in lost power from the original total power generated, or the ability to increase the total power generated without additional equipment.

Specialized jobs such as voltage and frequency doubling, commutating, etc., are really combinations of the basic functions already described.

The selection of the "right capacitor for a specific job is really a matter of matching the capabilites of the capacitor to the requirements of the job.

TECHNICAL BULLETIN NO. 03

CAPACITORS...CAPACITANCE CHANGES —WHY?

In our circuit applications, the capacitor can be and is subjected to various electrical, mechanical, and environmental stresses. One of the most noticeable effects of these stresses is the phenomena of capacitance variation.

Now, the fact that the capacitance does vary will come as no surprise to most design engineers. Further, the fact that different kinds of capacitors will vary in different ways is also fairly common knowledge to those concerned. Our purpose in this article is to examine what causes this variation, determine why the capacitance changes, and compare the extent of the variation for the common capacitor dielectrics.