A Note on Reading Capacitor Values

Why you may need this note

Most students learn pretty fast to read resistor values. They tend to have more trouble finding, say, a 100 pF capacitor.

That's not their fault. They have trouble, as you will agree when you have finished reading this note, because the cap manufacturers don't want them to be able to read cap values. ("Cap" is shorthand for "capacitor," as you probably know.) The cap markings have been designed by an international committee to be nearly unintelligible. With a few hints, however, you can learn to read cap markings, despite the manufacturers' efforts. Here are our hints:

Big Caps: electrolytics

These are easy to read, because there is room to write the value on the cap, including units. You need only have the common sense to assume that

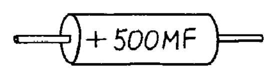


Figure CAP.1: A big cap is labeled intelligibly

means 500 micro farads, not what it would mean if you took the capital M seriously.

All of these big caps are *polarized*, incidentally. That means the capacitor's innards are not symmetrical, and that you may destroy the cap if you apply the wrong polarity to the terminals: the terminal marked + must be at least as positive as the other terminal. (Sometimes, violating this rule will generate gas that makes the cap blow up; more often, you will find the cap internally shorted, after a while. Often, you could get away with violating this rule, at low voltages. But don't try.)

Smaller Caps

As the caps get smaller, the difficulty in reading their markings gets steadily worse.

Tantalum

These are the silver colored cylinders. They are polarized: a + mark and a metal nipple mark the positive end. Their markings may say something like

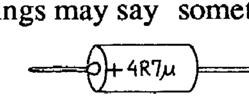


Figure CAP.2: Tantalum cap

That means pretty much what it says, if you know that the "R" marks the decimal place: it's a 4.7 μF cap.

The same cap is also marked,

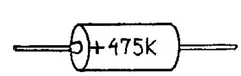


Figure CAP.3: Tantalum cap: second marking scheme on same part

Here you meet your first challenge, but also the first appearance of an orderly scheme for labeling caps, a scheme that would be helpful if it were used more widely.

The challenge is to resist the plausible assumption that "k" means "kilo." It does not; it is not a unit marking, but a *tolerance* notation (it means ± 10%). (Wasn't that nasty of the labelers to choose "K?" Guess what's another favorite letter for tolerance. That's right: M. Pretty mean!)

The orderly labeling here mimics the resistor codes: 475 means
47 × ten to the fifth.

What units?

10^5 what? 10^5 of something small. You will meet this question repeatedly, and you must resolve it by relying on a few observations:

1. The only units commonly used in this country are

   - microfarads: 10^{-6} Farad
   - picofarads: 10^{-12} Farad

   (You should, therefore, avoid using "mF" and "nF," yourself.)
   A Farad is a huge unit. The biggest cap you will use in this course is 500 µF. That cap is physically large. (We do keep a 1F cap around, but only for our freak show.)
   So, if you find a little cap labeled "680," you know it's 680 **pF**.
2. A picofarad is a tiny unit. You will not see a cap as small as 1 pF in this course. So, if you find a cap claiming that it is a fraction of some unstated unit—say,".01"—the unit is µF's: ".01" means 0.01 **µF**.
3. *Beware* the wrong assumption that a *picofarad* is only a bit smaller than a microfarad. A *pF* is *not* 10^{-9} F (10^{-3} µF); instead, it is 10^{-12}F: a *million* times smaller than a microfarad.

So, we conclude, this cap labeled "475" must be 4.7×10^6 ***picofarads***. That, you will recognize, is a roundabout way to say

$$4.7 \times 10^{-6}\ \text{F}$$

We knew that was the answer, before we started this last decoding effort. This way of labeling is indeed roundabout, but at least it is unambiguous. It would be nice to see it used more widely. You will see another example of this *exponential* labeling in the case of the CK05 ceramics, below.

Mylar

These are yellow cylinders, pretty clearly marked. .01M is just 0.01 µF, of course; and .1MFD is *not* a tenth of a megafarad. These caps are not polarized; the black band marks the outer end of the foil winding. We don't worry about that fine point. Orient them at random in your circuits.

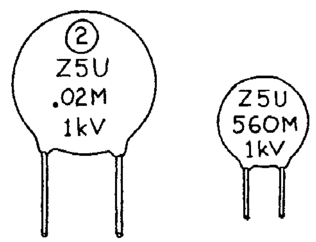
Figure CAP.4: Mylar capacitor

Because they are long *coils* of metal foil (separated by a thing dielectric—the "mylar" that gives them their name), mylar caps must betray their coil-like construction at very high frequencies: that is, they begin to fail as capacitors, behaving instead like inductors, blocking the very high frequencies they ought to pass. Ceramics (below) do better in this respect, though they are poor in other characteristics.

Ceramic

These are little orange pancakes.. Because of this shape (in contrast to the *coil* format hidden within the tubular shape of mylars) they act like capacitors even at high frequencies. The trick, in reading these, is to reject the markings that can't be units:

Disc



Z5U: Not a unit marking: cap type

.02M, 560M That's it: the M is a tolerance marking, as you know (± 20%); not a unit

Common sense tells you units:

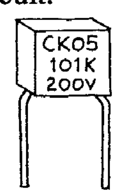
".02?" microfarads. "560?" picofarads.

1kV Not a unit marking. Instead, this means—as you would guess—that the cap can stand 1000 volts.

Figure CAP.5: Disc capacitor markings

CK05

These are little boxes, with their leads 0.2" apart. They are handy, therefore, for insertion into a printed circuit.



101k: This is the neat resistor-like marking. This one is 100 pF.

Figure CAP.6: CKO5 capacitor markings

Tolerance Codes

Just to be thorough—and because this information is hard to come by—let's list all the tolerance codes. These apply to both capacitors and resistors; the tight tolerances are relevant only to resistors; the strangely-asymmetric tolerance is used only for capacitors.

Tolerance Code	Meaning
Z	+80%, –20% (for big filter capacitors, where you are assumed to have asymmetric worries: too small a cap allows excessive "ripple;" more on this in Lab 3 and Notes 3)
M	± 20%
K	± 10%
J	± 5%
G	± 2%
F	± 1%
D	± 0.5%
C	± 0.25%
B	± 0.1%
A	± 0.05%
Z	± 0.025 (precision resistors; context will show the asymmetric cap tolerance "Z" makes no sense here)
N	± 0.02%

Figure CAP.7: Tolerance codes