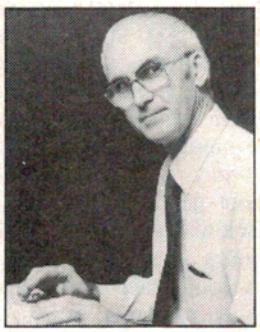
FORUM

Conducted by Jim Rowe



Is the nanofarad really necessary – or even handy?

Sometimes I'm surprised how much controversy can be generated by things that superficially seem quite small and unimportant. Take the nanofarad, for example: it may be small, but it certainly seems capable of producing strong reactions.

When I was a kid at primary school, one of my teachers drummed into us the rule that the words "got" and "get" should never be used. They were apparently too vulgar, or too gutteral, or too direct, or something. Anyway there were lots of other words that had similar meanings, and well educated people were always supposed to use one of these instead.

I can remember thinking at the time that this was rather interesting: presumably "got" and "get" were special words that had been put into the English language as kind of black sheep, never to be used. They must have been naughty at some time in the past, and had to be punished by no-one ever using them.

Certainly if that teacher ever heard you using them, *you* got punished by having to write out "I must never use GOT" 500 times, or whatever.

It wasn't until later that I discovered other people used these words quite freely, and didn't seem to think they were *verboten* at all. In fact I discovered that many people (and very well educated people at that) took a much more flexible view of language than had my old primary school teacher. They regarded language as a growing and dynamic thing, which was constantly changing and being adapted to suit the needs of its users as a means of communication.

Sure, I also found out there were a few people like my old teacher, who had a very rigid view of language. In fact I even worked with one for quite a few years, who believed that English was absolutely immutable and forever defined by *his* old school dictionary. But by and large, most people seemed to be more flexible and open minded.

All of which is of course preamble, to this month's opening topic: the *nanofarad*. I'm beginning to think that at least some of our readers regard this in much the same way as my old primary teacher viewed "got" and "get".

But let's start at the beginning. As many readers will already be aware, "nano" is one of the standard quantifier prefixes in the metric/SI system. It means a billionth or thousand-millionth, or if you prefer, the base unit multiplied by 10^{-9}.

So a nanometre is a thousand-millionth of a metre, for example, or 10^{-9} metres.

This means that "nano" is kind of midway, in a logarithmic sense, between "micro" (meaning millionth, or 10^{-6}), and "pico" (meaning trillionth or million-millionth, or 10^{-12}). Hence 1000 picometres make one nanometre, and 1000 nanometres make one micrometre (or micron).

Now there aren't all that many SI units where we need to measure and talk much about billionths, but like the metre itself, one unit where we *do* need to do this is the unit of capacitance: the farad (for which the contraction is F).

In practice, one farad is an awful lot of capacitance. Most of the time in electronic circuits we use much smaller values. In fact most discrete capacitors have values falling in the range between a picofarad (10^{-12}F, or 1pF) and a microfarad (10^{-6}F, or 1uF).

By the way, capacitances inside integrated circuit chips are measured in *femtofarads*, where a femtofarad is a thousand-billionth of a farad, or 10^{-15}F. So 1000 femtofarads make one picofarad, for example. Which all goes to show how far away the farad itself is from practical values of capacitance, at least in modern electronics.

But with commonly used discrete capacitor values ranging from around 1pF to the 1uF level, over a range of about a million to one, it's not surprising that this is one of those situations where the "nano" prefix has been applied (at least in some parts of the world). In fact it would be pretty surprising if it hadn't been.

From a logical point of view the situation is very similar to that with resistance, and the prefix "kilo". Most commonly used values for discrete resistors range from about one ohm to around one megohm (a million ohms, or 10^6 ohms). This is again a range of about a million to one, and as a result many years ago people began using the "kilo" prefix for convenience. It saved using so many zeroes . . .

So it's always been very common, all over the electronics world, to talk of a resistor with a value of 4.7 kilohms, for example, or of 68 kilohms. Instead of describing them as 4700 ohms or .068 megohms, respectively.

It's interesting, though, that use of the term nanofarad as a unit in electronics is still almost unknown in countries like Japan and the USA. And it's probably quite significant that these are the countries which are still not fully "convinced" about the metric/SI system of measurement.

Not surprisingly, it was electronics people in continental Europe who first started using the nanofarad, and its use has gradually spread from there as the metric/SI system itself has achieved more "converts". Although electronics people in places like Japan and the USA are happy using parts of the SI system like kilohms and megohms, kilohertz and megahertz (even gigahertz) and microfarads and picofarads, they draw the line at the nanofarad.

No, it's all a wicked plot by those

Europeans, they seem to believe. If we start using the nanofarad, we'll be surrendering to the onslaught of international European imperialism in electronic measurement. For the sake of Mom and Apple Pie, we must hold out.

Besides, who needs the nanofarad? It's perfectly easy to write 2200pF or .0047uF, and everyone knows what we mean . . .

As you can probably sense from the above, I'm personally fairly happy with the nanofarad. It seems to me a pretty logical and convenient part of the overall SI system, like the kilohm and the gigahertz. But I don't think I'm fanatical about it; I don't go around madly crossing out all the 2200pF's or .0068uF's I come across in American circuits, and replacing them with 2.2nF's and 6.8nF's.

In fact by now I seem to have become fairly fluent in both the "nanofarad" and "no-nanofarad" dialects, and can convert from one to the other without any conscious hassle. And I suspect that many of our readers are the same way. But not all of them, obviously.

A few months ago, as you probably noticed, we changed to a new draftsperson for our circuit diagrams. Karen Rowlands, the lady concerned, is an experienced drafter who has been quite used to labelling her circuits according to SI standards — including the use of nF.

Before she started to do our circuits, we had a discussion about the style and standards to be used. She pointed out that there were quite a number of areas in which *EA* was still not conforming to established SI practice, and we considered each of these in turn.

Some I decided not to change, on the grounds that clarity had to remain our prime consideration. For example, we haven't adopted the practice of using the unit or multiplier symbol instead of the decimal point, like "4R7" instead of 4.7 ohms, or "6n8" instead of 6.8nF. Frankly I don't think these are either particularly clear or self-evident, and I decided against 'em.

But when we discussed the pro's and con's of using labels like 6.8nF instead of .0068uF, I finally had to admit that both logic and clarity seemed to support a change.

No sooner had the first few circuits including nanofarad labels been published, though, before the calls and letters started to arrive. Not many of them, to be sure, but enough to notice.

One reader from Tasmania, an experienced service technician, really took us to task:

Capacitors are rated and sold in Australia in microfarads and picofarads, and nanofarads have to be converted to one or the other before use. I have lost track of the number of appliances with performance degraded by the application of the wrong conversion factor. This is particularly so with Philips TV's, where nF is used extensively in their circuit diagrams. My colleagues in the industry abhor nF, preferring uF and pF in all diagrams and calculations. I would suggest that you do the same.

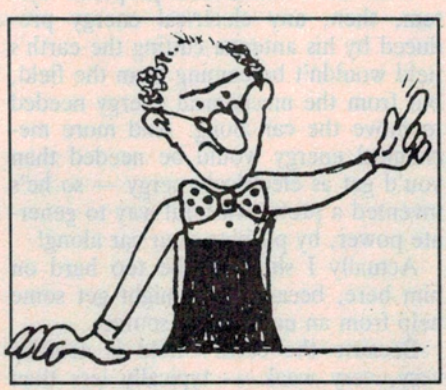
Among 19 colleagues spoken to on this subject, only one (a German born technician) would admit to confidence in using nF, and even he had to convert to uF or pF before buying capacitors here in Australia.

Another writer from Victoria, a tech college teacher, noted that not only did his students find the nanofarad confusing, but most of his fellow teachers found it so as well. In fact an impromptu check among both students and teachers found them all quite clumsy at converting from pF and uF to nF and back, and prone to make a lot of mistakes.

Still another unhappy reader 'phoned to complain that when he asked for capacitors at his local supplier, they wouldn't serve him if he gave the value in nanofarads. He had to convert them into pF and uF, before they knew what he wanted!

Oh dear. All this about a unit related to the uF and the pF by simple ratios of 1000? Some people just don't like change, do they — even if it's a change which makes things easier, once you get used to it . . .

I seem to recall that there were similar reactions when magazines like *EA* started to use picofarads. Sometime back in the 1950s, I think it was. I'm sure there were people who wrote in all upset, to ask why we were confusing them with this strange and totally unnecessary new unit.



Nanofarads? Capacitors? True-blue Aussie condensers come only in microfarads, mate!

What was wrong with good old microfarads, they asked. After all, everyone knew what was meant by a .0001uF mica capacitor, or a .00002-.00005uF trimmer. Why change?

You'll probably find there was the same sort of fuss when the kilohm was brought in, sometime in the thirties or forties. What's wrong with labelling voltage dividers as 20,000 ohms, or 47,000 ohms for a plate resistor?

Sorry for the sarcasm, but there do seem to be quite a few parallels here.

Perhaps you think I'm being too hard on the anti-nanofarad brigade. If so, write in and tell me what you think. But please give sensible reasons *why* we shouldn't use the nanofarad — and reasons that wouldn't logically force us to stop using the kilohm and gigahertz as well. Just don't come up with arguments like the chooks will give bigger eggs and the cows creamier milk, if only we go back to feet and inches.

I really would like to hear from you, if you can give me a good logical argument — honest!

But for the present, let's leave the subject and turn to an amazing little item I came across a couple of days ago.

Perpetual motion?

One of the publications sent to me regularly (at least up until now, but perhaps not any more, after this) is *Electric Vehicle News*, a monthly newsletter produced by the Australian Electric Vehicle Association of Victoria.

It's an interesting little publication, and I enjoy looking through it each month when it arrives. The people in the AEVA are real enthusiasts when it comes to electric vehicles, and they put a lot of effort into promoting their hobbyhorse. And that's great, especially when you believe as I do that electric vehicles do have a lot of potential.

They'll have even more potential, when or if the R&D people can come up with the necessary breakthrough in battery technology — one that finally does provide an energy density somewhere within coo-ee of the ubiquitous tank of petrol. The only problem is there have been so many "breakthroughs" in this area that have turned into phurphys, I guess like many people I'm getting a little cynical.

Not surprisingly the AEVA people are not the least cynical, and good for them. We need more enthusiasts and positive thinkers, because it's from them that the breakthroughs tend to come.

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But sometimes their enthusiasm runs away with them, and they lose contact with reality — and the laws of nature.

There was an amazing example of this in the latest issue of *EVN* to reach me. It was in a section called "Novel Ideas From The Road", and seemed to be extracts from a book called *The Consumer's Electric Car*, credited to one Earnest H. Wakefield, PhD.

I can only assume that Mr Wakefield's PhD was in a subject far removed from electronics or physics, like dancing. Either that, or he somehow acquired it from a rather dubious correspondence college, or by saving up the necessary number of breakfast cereal tokens. Because the "novel idea" concerned is a real doozey:

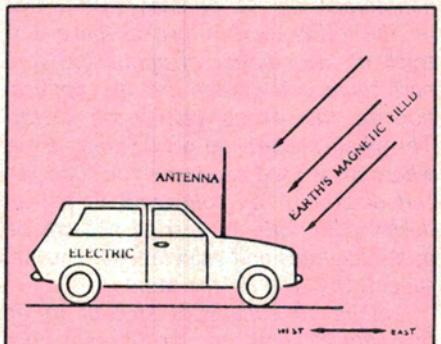
Since electricity can be generated by a wire cutting a magnetic field, equip the electric car with an antenna for cutting the earth's magnetic field. Feed the electricity generated to the motor which, in turn, drives the wheels. The earth's magnetic field runs from the North Magnetic Pole to the South Magnetic Pole, and power from the motor comes from the battery when the vehicle travels either north or south.

Well — why didn't we all think of that before? All those old codgers like Otto, Daimler, Royce, and Ford didn't need to fool around with petrol engines — there was unlimited energy there all along in the earth's magnetic field, free for the taking!

The idea's so incredibly crazy it's hard to know where to start, in explaining why. But here goes.

For a start, an EMF isn't generated in a wire/conductor in a magnetic field unless it's *moving* with respect to that field. When it's stopped, nothing is generated. So there would be no electricity produced by Mr Wakefield's proposed car (I refuse to call him Dr Wakefield), until it was moving. Yet if it was powered from the earth's field, as he proposes, it presumably wouldn't be able to start moving until there was some power generated. Sounds like a stalemate to me, already.

But that's only one part of Mr Wakefield's clanger. Another reason why it couldn't work is that when a wire moves through a magnetic field, and generates an EMF, *no energy whatever* comes from the magnetic field. ALL of the electrical energy produced comes from the mechanical energy used to move the wire, just as in any other kind of electrical generator.



Here's the illustration that accompanied the item on using the earth's field to provide power for electric cars . . .

The magnetic field itself only provides the right environment — rather like the "catalyst" needed for some kinds of chemical reaction.

In fact it's precisely *because* no energy is drawn from the field in either electric motors or generators, that we can use permanent magnets to produce their fields. Many modern motors use permanent magnet fields (including those used in electric cars), while most of the small alternators traditionally used on push-bikes to power the lights also use a permanent magnet for the field.

Electrical generators and motors are simply energy transducers, converting mechanical energy into electrical energy or vice-versa. And like all such devices, they're all imperfect in terms of efficiency. So with a generator, for example, you never get out as much electrical energy as the mechanical energy you put in. A proportion gets turned into heat, due to things like friction, resistance in the wires and so on.

With Mr Wakefield's proposed system, then, any electrical energy produced by his antenna cutting the earth's field wouldn't be coming from the field, but from the mechanical energy needed to move the car along. And more mechanical energy would be needed than you'd get as electrical energy — so he's invented a pretty wasteful way to generate power, by pushing your car along!

Actually I shouldn't be too hard on him here, because you might get some help from an unexpected source.

Because the earth's field is actually very, very weak — typically less than 0.1 of a millitesla (remember? a tesla is a weber per square metre) — you would need rather more of an aerial than the little diagram in *EVN* suggests. In fact with such a weak field you'd need an enormous multi-turn coil, umpteen square metres in area, in order to produce any significant EMF. And with that kind of area, it would almost certainly make a better sail than an electrical generator. So if the wind was blowing in the direction you wanted to go, you mightn't have to push at all.

You might have the opposite kind of problem, though — stopping the car from taking off!

Even this is ignoring the fairly fancy electronic commutation circuitry you'd need to extract the electrical energy from that large multi-turn "antenna coil", of course. This would be necessary, because with all sides of the coil moving in the same direction through the field, their induced EMF's would otherwise cancel out, and you'd get nothing.

I suppose I've been too hard on Mr Wakefield's Folly, by really rubbing his nose in it. But I just couldn't resist, when he'd come up with such patent nonsense. I can only hope that his original book was published tongue in cheek, and that the AEVA people had theirs firmly tucked in too, when they reprinted it.

I have a suspicion that this is the case, because the other "Novel Ideas" in the same section look pretty crazy too . . .

The only problem is that many of the readers of *Electric Vehicle News* may not be capable of recognising these kinds of item as a joke, and might take them seriously. I'm half expecting a crop of letters soon, asking if we've ever described an electronic commutator suitable for a large multi-turn car antenna!

Seriously though, *EVN* is normally quite a good little newsletter. Most of their stuff is much more sensible, and quite interesting if you're into electric vehicles. You can contact the AEVA at PO Box 273, Mitcham 3132. Perhaps if I give them this plug, they mightn't stop sending me their newsletter after all . . .

Well, I've run out of space again without dealing with an interesting letter on double insulation and earthing, which turned up just after last month's column had gone to press. So I'll kick off with that one next month, all going well. I hope you'll join me again then.

Don't forget, if there's anything you'd like discussed here, please write in and let me know. I want to write about topics that interest you, but I'm no mind reader.