GETTING TECHNICAL

BIG CHANGES IN ROOFTOP SOLAR

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ROOFTOP SOLAR INSTALLATIONS CONTINUE TO INCREASE AND WE ARE COMFORTABLY ABOVE 1 MILLION SOLAR PANEL HOUSEHOLDS, WITH QUEENSLAND LEADING AT 30 PER CENT OF THE TOTAL NATIONAL INSTALLATIONS FIGURE.

TOTAL NATIONAL CAPACITY is in excess of 4600MW – it's an impressive figure, and currently represents a bit under 8 per cent of national generation capacity. And, yes, rooftop solar capacity is beginning to cause power quality problems to distribution network providers – to a sufficient level that they want to be able to switch off inverters remotely. Read the AS/NZS4777 2015 edition and, among other things, you will find reference to a DRM0 (remote demand control) which is now a requirement for inverters to be Clean Energy Council approved. The new standard came into force last year but there was a grace period which has now expired. All new installations post October 9, 2016, must comply with the 2015 edition. The change is a bit of a double whammy in that the most likely times for DRM0s activation is in high insolation periods – just when domestic consumption is likely to be low because occupants are at work, thus preventing feed-in of excess energy. Although it is dangerous to predict changes in feed-in tariffs (or their abolition), existing owners of rooftop PV systems are best off to stick with the older standard as far as replacement inverters are concerned.

Enquiries made to State Electrical Inspector Offices and their equivalents indicates legacy installations can have faulty inverters replaced with non 2015 edition-complying ones – and that is important news for accredited installers. There's business to be had, testing installations for efficient operation, and to verify the inverter is operating according to specs. A common area of failure is the DC link capacitor – easy to fix, but not so easy are, for example, the maximum power point tracker failures. The documentation for board fixing is often just not there and fault finding procedure frequently requires bench testing with a simulator. Therefore, the most cost-effective solution is often replacement.

Other important changes in the current standard relate to islanding, and low and high voltage limits. In sum, we are catching up with European requirements that have been in force for years and this article goes into some details relating to feed-in solar power.

Voltage and DRM0 remote switch-off

Voltage limits have been sharpened and are indicated in the box below. The overvoltage maximum values are of concern here because they can be easily reached in weak networks on days of high insolation. As to weak (high impedance) networks our extended suburbs, and for economy's sake dearth of local distribution transformers, work towards voltage build-up at household points of connection. And in any event the DRM0 remote switch off can override the over/under voltage considerations.

PASSIVE ANTI-ISLANDING SET-POINT VALUES	Set point value	Trip Delay Time	Maximun
Undervoltage (V<)	180V	1s	2s
Overvoltage 1 (V>)	260V	1s	2s
Overvoltage 2 (V>>)	265V	–	0.2s
Under-frequency (F<)	47 Hz	1s	2s
Over-frequency (F>)	52Hz	–	0.2s

Voltage balance, three-phase inverters

Yes, you've read that correctly. Three-phase inverters are supposed to feed in balanced voltage. That is a tough requirement and should be difficult to enforce. The fact is, solar systems are generally single phase and are not nicely balanced around the phase conductors – nor are they of identical power rating, thus further adding to unbalance. And, yes, to the network provider it can be a problem, and not that easy to fix.

Frequency stability

This is a hairy subject. Isn't it so that inverters cannot do anything about frequency stability since they depend on the network frequency for synchronisation? That's a definite yes and no! Yes, inverters are synchronised via the grid voltage and, no, despite this they can be subject to frequency oscillation. This can happen via sudden load changes on the network. Such a change, for example, in the MV network causes phase angle changes that feed through the LV distribution transformers. A sudden phase change throws the synchronisation feedback loops (PLL) into 'confusion' and starts a hunt back to stability. At the upper frequency end, there are 10 cycles to get the 'act together' – and depending on what's happening upstream, that may be insufficient time.

Power factor

Power factor is also tricky. Depending on the distribution network provider, power factor values – lagging, that is, usually 0.9 – are required of the inverter. Have a look first at the diagram in figure 1. It shows graphically the change to poorer power factor as more feed-in occurs. The reactive power supplied via the distribution transformer stays the same but the effective power is reduced because of feed-in, so power factor worsens. So what, since no additional reactive power need be supplied by the network provider!

So, why have inverters supply lagging power factors? The answer is likely to be because of the increasing the proportion of technical losses. Technical loss is the power, the network provider cops without recovery from retailers/consumers. So, here's what happens: because of solar feed in, less kilowatt-hours are sold, but the I2R losses due to reactive supply stay the same as before the feed-in. In other words, a bad business deal as tariffs do not reflect this change in supply conditions!

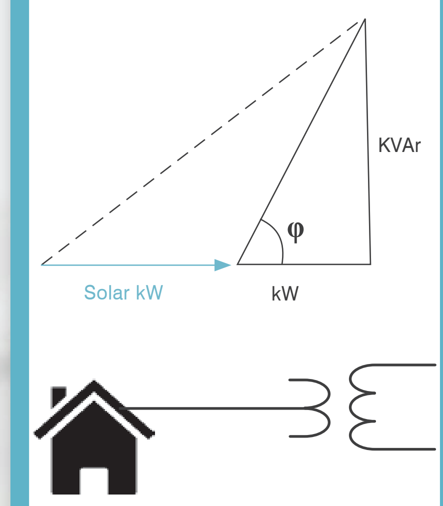
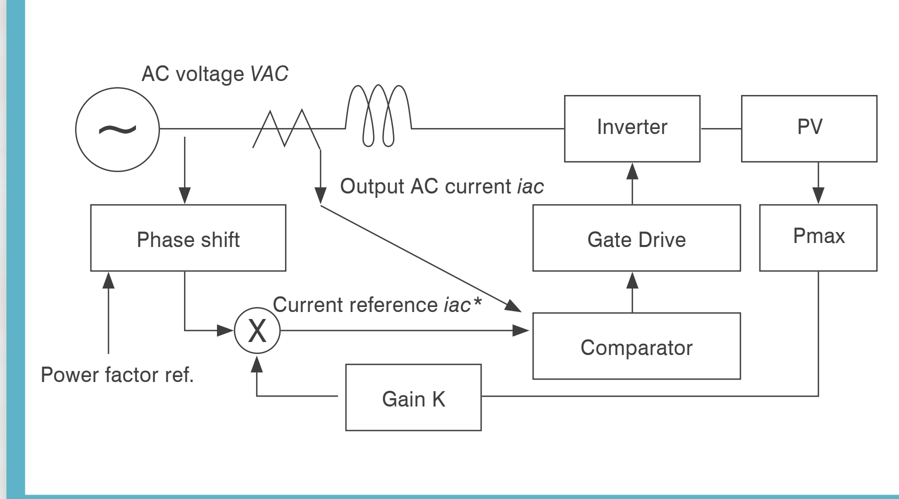


FIGURE 1

The effect of solar feed-in reduces net power required from the distribution transformer, and the effect is that cosφ, the power factor, becomes smaller



Inverter power factors

Many inverters, certainly the single phase ones, have a power factor of unity or very close to unity. Note: it isn't, of course, what the domestic load represents, which might be a lagging factor of somewhere around 0.9. Many three-phase inverters have a lagging power factor, and even provision for leading power factor, which can be of advantage to industrial and commercial installations on kVA tariffs. By requiring a lagging power factor, the distribution network providers save on kVArs—and technical losses. Based on 0.9, kVARs saved could amount to nearly 44 per cent that would have previously been supplied to domestic loads by the distribution network.

Functionally power factor setting, or control of power factor (that's more sophisticated) is done by comparing the phase of the voltage output of the inverter with the phase of the grid voltage. They do differ because there's a filter comprising of inductors and a capacitor separating the inverter from the grid. A fixed phase angle can be added or subtracted to delay or advance the firing of the inverter transistors that are supplied by the DC link capacitor.

That's the case for the usual inverter as most are 'voltage controlled'. A current controlled inverter, one using an inductor as a storage element in the DC link, is a little simpler to visualise but the basic principle of delaying or advancing the firing of the inverter transistors. ESAA requirements on power factor are somewhat puzzling in that inverters must appear as lagging loads as viewed form the grid. It is therefore possible that in theory at least, an inverter would push out net vars.

Harmonics

The H-bridge single phase inverters provide both even and odd harmonics because of small DC offsets. ESAA requirements on voltage harmonics at the point of connection to the grid are as follows: 3 – 9th <4%; 11 – 15th <2%; and 17 – 21st <1.5% relative to the fundamental. Apart from these restrictions, there is also a presence of switching frequencies and these are of the order of tens of kilohertz. Potentially these can interfere with power line communication systems. The combined output of many inverters can cause predominant harmonics problems in the MV distribution network.

Conclusion

It is a safe bet there will continue to be changes to AS/NZS 4777 because the problems due to 'distributed generation' in the LV side of things will only increase with more take up of solar PV. So, now is the time to make a list of your solar installations and to test them from time to time as a service for your customers.