



Impact of Load Control Signalling on Household Lighting Systems

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1 WHAT IS LOAD CONTROL SIGNALLING?

Electricity providers have used ripple injection load control signals also known as audio frequency injection control (AFIC) in order to control loads connected to the electricity distribution network since the 1960s [1]. The most common examples of these loads are off-peak hot water heaters and street lights. Controllable loads offer many advantages to electricity providers, primarily better use of network infrastructure and generation. For customers, the main advantage is access to cheap off-peak electricity tariffs. Ripple injection control systems work by superimposing a coded control signal on to the normal 50 Hz voltage waveform. This allows for one way communication with loads without additional communications infrastructure. The injection system leads to some distortion of the 50 Hz sinusoidal waveform. Typical ripple injection signal frequencies used in Australia range from 167 Hz to 1050 Hz. A more detailed list of the frequencies and their locations can be found in the NSW Service and Installation Rules (Section 6) [2]. The signals are injected at or near the nominal injection frequency and are applied in bursts. An entire single injection run lasts approximately 3 minutes. The signal is typically injected at the medium voltage substation. It then propagates throughout the distribution network and is detected by special receiving relays which switch loads on or off as appropriate.

2 LOAD CONTROL SIGNAL OPERATION

Under normal operating conditions, there is little impact on equipment due to ripple injection signals. In fact operation of the system is unlikely to be noticeable unless something goes wrong, for example, hot water not heating due to the signal being too small for the receiving relay to detect and turn on the water heater. Figure 2.1 shows the impact of a 1050 Hz signal of magnitude approximately 6 V (2.6% of 230 V) on a waveform measured in the field. The injection signal can be seen to commence approximately 1.5 cycles after the start of the waveform capture.

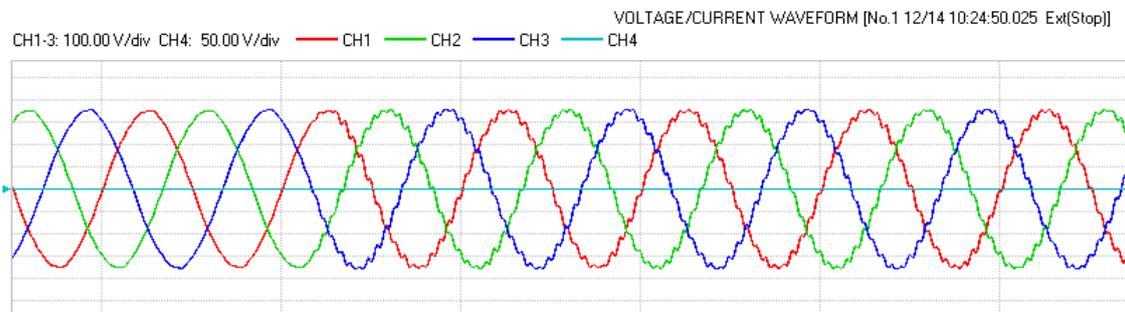


Figure 2.1: Field Measurement of 1050 Hz Injection Signal

Ripple injection signal compatibility levels are often specified using the Meister Curve which is referenced in AS/NZS 61000.2.2 [3] and reproduced in Figure 2.2 below. Compatibility levels are disturbances levels which should be able to be tolerated by most equipment without any operational problems. From the curve, appropriate levels for 750 Hz and 1050 Hz signals appear to be approximately 6% and 4% respectively.

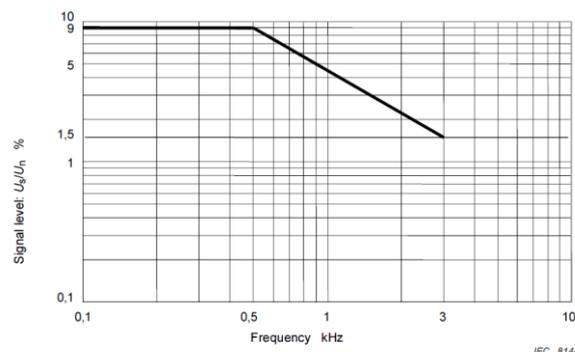


Figure 2.2: Meister Curve for Ripple Injection Signal Compatibility Levels [3]



3 INTERACTION BETWEEN LOAD CONTROL SIGNALLING AND LED LIGHTING SYSTEMS

Under some circumstances ripple injection signals can cause flicker and other undesirable operation of lighting systems. This includes incandescent (traditional and halogen) and LED lighting systems. This phenomenon has become much more prevalent in recent time due to advances in lighting technology including the wide scale deployment of LED lighting and technologically advanced dimmers which appear to be more susceptible to waveform distortion due to load control signalling than traditional lighting sources.

LED lighting consists of an LED and a driver circuit which converts the AC voltage to the DC voltage required by the LED. Consequently, LED lamps are much more complex than the relatively simple traditional incandescent lighting sources. Modern electronic dimmers used in conjunction with LEDs add another level of complexity to the lighting system. Under certain circumstances, in the presence of waveform distortion caused by ripple injection signalling, some LED lighting systems will not operate as intended and will produce undesirable changes in light output ranging from subtle flicker through to strobing in extreme cases.



4 SOLUTIONS

This problem is very difficult for the electricity service provider to solve. At present, a single effective solution applicable in all scenarios is yet to be identified. Ripple injection signalling remains an important part of network operation and will not be phased out in the near future. If load control signalling voltages are found to be excessive, steps can be taken to reduce them. These include changes of injection levels or change to the supply network. However, it has been found that the problem can occur even when injected voltage levels are within prescribed limits making reduction of signal levels



difficult. Further complicating the issue is the fact that some lamp/dimmer/driver combinations appear to be immune to the ripple injection signal while others are highly susceptible. In some cases, combinations that work in one location do not work in another. Given the very large number of lamp/dimmer/driver combinations, there is no simple solution to this issue. Indeed, laboratory testing has shown that some dimmers which claim to be specially designed for use with LEDs are not immune to injected ripple control signals as advertised.

If signal levels are appropriate or cannot be changed, two main solutions have been applied in the field. The first is trial and error of different LED lamps and dimmers until an acceptable combination is found. This solution can be costly and inconvenient. The second possible solution is the application of a filter specifically designed to filter the ripple injection system. However, such filters must be used judiciously and if they are applied incorrectly, they can interfere with normal operation of the ripple injection signals, potentially resulting in incorrect operation of off peak tariff relays impacting on hot water heater operation. In addition, there is anecdotal evidence that such filters can produce significant audible noise.



References

- [1] F. J. Backer, "An Introduction to Ripple Control - Lecture Held 29th July 1970 at the NSW Institute of Technology", 1970.
- [2] *Service and Installation Rules of New South Wales*, August 2012.
- [3] Standards Australia, "Electromagnetic compatibility (EMC) - Part 2.2: Environment—Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems", AS/NZS 61000.2.2:2003, 2003.

5 MORE INFORMATION

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