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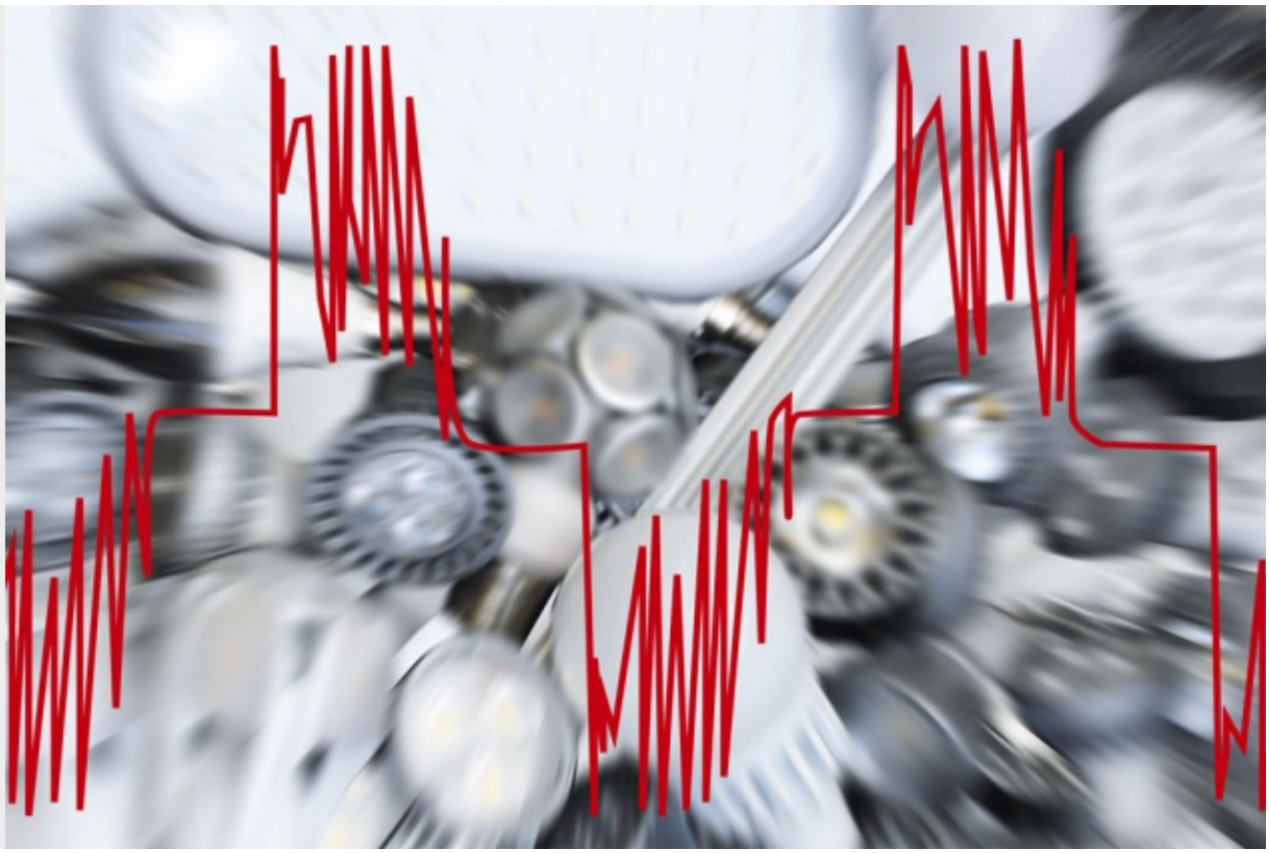

LED Lamp and Dimmer Testing Compatibility

July 2016

Prepared for: Equipment Energy Efficiency (E3) Program

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1. Overview - Project Objectives

To further transition to efficient lighting in Australia the Equipment Energy Efficient (E3) Program is undertaking a Regulatory Impact Statement, which includes investigating the option to phase-out halogen lamps from the Australian market.

Manufacturers and suppliers of dimming equipment and LED lighting technology have identified that consumers with existing dimming product installed, who currently use halogen lamps, may find the product does not operate to a satisfactory level of performance, not work or results in flickering when the halogen lamp is replaced with a dimmable LED lamp. NECA has been engaged by the E3 Program to conduct testing to determine the level of compatibility of LED dimmable lamps with existing dimmers installed in Australian homes.

The scope of testing included dimmer models most commonly installed in homes tested with dimmable LED lamp types - 240v Omni Directional type, 240v GU10 directional type and 12v MR16 Retrofit type connected to combinations of the most common transformer (MLV & EELV) types typically available in the Australian market.

In addition, associated issues such as nuisance tripping of Miniature Circuit Breakers (MCBs), Residual Current Devices (RCDs (Safety Switches)) and operability of LED lamps in conjunction with motion sensors / presence detectors is investigated but limited to the most common types of switches, sensors (outdoor sensor PAR lamps) and motion sensors found in homes.

Through testing of a comprehensive sample range of products (LED lamps / transformers / dimmers) the objective is to inform the impact assessment of the phase out option and develop a consumer guide for electricians and homeowner use for the identification of LED dimmer lamps that are compatible with existing dimmers.

The intent of the guide is to assist households to identify a suitable LED dimmable lamp that may work with their existing dimmer, avoiding the cost of replacement or upgrade.

It should be noted that these test results are not an assessment of the overall quality of the individual products selected, rather how a combination of products perform together in the tests carried out for this initial evaluation of the extent to which compatibility issues are present in the market. Further, the manufacturers of the specific products tested may not be claiming that the product combinations tested are compatible with each other.

1.1 Dimming Performance and Expectations

The general expectation and experience consumers have with dimming of incandescent and halogen lamps is that it is smooth and continuous. Specifically any change in the dimmer setting should be replicated in a corresponding change in the light level without any abrupt or dramatic steps in the light output.

When considering LED lamp products, of particular importance is the occurrence of flicker or shimmer throughout the dimmable range.

Flicker or shimmer is the modulation of light level that is visible to the human eye. It is more susceptible in LEDs due to the electronic (digital) components used within in the internal circuitry of the product. Electronic control is an essential necessity for the operation of LED lamp products compared to halogen lamp products.

Flicker in LEDs is due to the extremely fast change (microseconds) in light output caused by the LED chip reacting to changes to the input current. Flicker can be caused by numerous inputs, power system disturbances (harmonics

and line / circuit impedance), control (dimmer) disturbance, component tolerance and poor LED driver circuit design thus not all flickering of LED lamps relates to compatibility with dimmers and other lighting controls.

Flicker can be continuous (occurring all the time) or intermittent (only occurring some of the time or at certain light level settings of a dimmer). In some cases the extent and severity of flicker can change due to the number and configuration of products on a circuit and external factors such as line (network) impedance.

Our consumer research shows that many end users have an expectation that LED lamps will operate in exactly the same way on their existing dimming equipment as a halogen or incandescent light source. To achieve this outcome, the requirement is all system components (LED lamp, driver, transformer and dimmer) should be engineered in such a way as to account for all internal and external electrical factors and not result in flicker, shimmer, any transient change in light level or demonstrate any accelerated component failures or problems. When consumers do experience compatibility problems or hear of the potential problems with the change to energy efficient LED lamps some consumers may either choose to stay with the halogen lamps or revert back to halogen lamp types.

1.2 Dimming Range of LED Products

Consumer research indicates end users have varying expectations and experiences when dimming lamps. The experience for consumers has been that incandescent lamps and halogen lamps dim continuously and smoothly to 1% of full light output.

There are examples of LED dimmable lamps on the market that perform effectively, meaning that consumers who value the ability to dim their lamps in the future are able to continue to access this product range.

Expectations and specifications for dimming performance of LED lamps vary widely between product groups, manufacturers / suppliers and product combinations. This variation in performance outcomes and quality characteristics could be addressed as part of a future MEPS for LED lamp performance.

The dimming range and performance of an LED lamp or fixture is however impacted by a combination of factors and can vary substantially from one device to another and vary depending on the type of dimming control equipment and is also subject to external system factors, the number of lamps connected to a circuit and consistency of product can also effect performance outcomes. Some manufactures and suppliers of dimmers and LED lamps currently include advice and guidance on compatibility of product combinations. This infers that consumers can continue to purchase a reliable, quality system.

The key issue for consumers is that of legacy dimming products and compatibility with LED lamps. Not all dimmers will work effectively with all dimmable LED lamps due to variables in electronic compatibility. In the case of ELV halogen lamps and the associated transformer an additional variable is introduced regarding the electronic compatibility between the products and the LED lamp. In many cases it can be difficult for a consumer to identify the model of dimmer installed without the help of a qualified electrician, adding to the challenge of finding a compatible product.

1.3 Visual Perception of Light and Measurement of Dimming Levels

The visual perception of how a person views and assesses light levels in a space is a complex relationship between the retinal receptors in the eye sensing the quantity of light present and how that light is perceived and "de-coded" in the brain to inform the impression of the *amount* of light in a space.

It is important to understand the difference and relationship between "Measured" and "Perceived" light as the two results can be quite different and often confused when referenced to light levels and dimming performance.

Measured Light output is the quantifiable value of light measured (in Lux) with a light meter. It is usually described on a manufactures data sheet as the dimming ratio percentage.

Perceived Light output is the amount of light the eye interpreters a result of pupil dilation. The human eye dilates as light levels reduce. (This allows a person to better be able to "see" in low or dim light levels).

The result is the amount of light perceived is higher than that measured.

For example - 20% measured light equals 45% perceived light.

The equation for determining perceived light is the square root of the measured light. i.e $\sqrt{0.20} = 0.45$

1.4 Product Dimming Variables

The dimming range of an LED product is based on the electronic driver design and characteristics. For example the electronic driver components of a 240V supply connection omnidirectional lamp may vary dramatically from that of a ELV directional MR16 retrofit lamp connected in conjunction with a 12V transformer.

It is the design of the internal driver circuit components that will determine how effectively the connected LED lamp is capable of dimming. In addition, different drivers may produce different dimming results even though they may be specified by a manufacturer to dim to the same light level. As there is little standardisation in design and operation between different products from various manufacturers, unfortunately there is no guarantee that light levels will always match between LEDs from different brands, or when products are mixed, even when controlled by the same dimmer. This could be addressed as part of a future MEPS for LED lamp performance.

The dimming performance of an LED will also vary based on the type of dimming control used i.e. Leading Edge type or Trailing Edge type. Even if an LED lamp and driver combination provides good dimming characteristics on one type of dimmer, it can lead to poor dimming performance on another. This is due to incompatibility between the LED lamp and driver combination in conjunction with the dimmer control design or even product batch variations between dimmers and components.

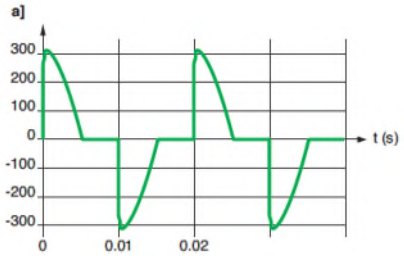
Consumers who value and require effective dimming are able to gain access to dimmable LED product but care is necessary in component selection to ensure satisfactory performance outcomes.

The testing has been conducted on small group samples of product. The objective has been to identify combinations of product that will be likely to deliver satisfactory performance outcomes for consumers and benefit electricians when advising their customers who are transitioning from halogen lamps to LED.

Due to the variables associated with the changes in electrical and electronic operating functionality of product when connected in a typical use application the test outcomes should be regarded as guidance of *likely* compatibility. Every installation has its own unique operating characteristics, combinations or equipment,

variations in electrical supply and quantity of product configurations are changeable. As these unique operations circumstances vary from installation to installation the performance outcomes may vary from expectation.

2 Dimmer Type - Leading Edge (Forward Phase)



In the context of product development over time, the most common type of dimmer used in Australia for incandescent and Extra Low Voltage (ELV) halogen lamps operating on magnetic low voltage (MLV) transformers) is the Leading Edge or Forward Phase type.

MR16 Extra Low Voltage (ELV) directional halogen lamps were introduced to the market in the mid 1980s and exclusively at that time the type of transformer available for these lamps was the magnetic (MLV) type.

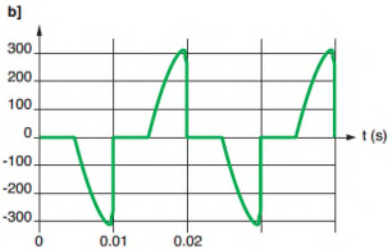
This type of Leading Edge dimmer was designed to control resistive (analogue) type loads and inductive transformers by "chopping" energy from the leading edge of the sine wave.

Leading Edge dimming technology was not designed to operate with the performance characteristics to match the particular requirements of an electronic LED (digital) load.

The operating characteristics of Leading Edge dimmers is not generally recommended for any type LED lamp due to incompatibility with the internal electronic components and rapid voltage rise time characteristics of a Leading Edge dimmer. This applies to both mains voltage 240 volt LED lamps and Extra Low Voltage LED lamps operating in conjunction with a transformer.

Acceptable performance outcomes may be achievable in some cases, however compatibility will vary widely based on the number of lamps (total circuit load) and network characteristics, etc. The combination of leading edge dimmers and LED lamps, will, in most cases cause unreliable performance outcomes due to flicker, non-linear dimming or inability of the LED lamp to dim or not dim to a low level.

2.1 Dimmer Type - Trailing Edge (Reverse Phase)



While magnetic transformers proved to be (and continue to be) reliable devices to operate ELV MR16 halogen lamps they also have limitations.

Increased energy consumption, cost to manufacture, increased weight in ceilings and lack of secondary voltage stabilisation for example promoted the development of electronic transformers as their replacement.

This type of Electronic Extra Low Voltage (EELV) transformer was introduced into the market from the late 1990s onwards.

Every ELV MR16 Halogen lamp must be paired with a transformer. Market survey estimates indicate a split of around 25% - 30% of transformers currently in service to be of the magnetic type with the balance being of electronic type.

However not every installation utilises dimmer control.

In installations where MR16 halogen lamps operate with MLV transformers they traditionally utilised Leading Edge or Forward Phase dimmers. The introduction of the EELV transformers to the market required the development of an alternate technology in dimmer design to accommodate the specific requirements of electronic devices.

Trailing Edge or Reverse Phase dimmers were developed for compatibility with the electronic capacitive loads created by the electric transformer characteristics.

While similar in operation to a Leading Edge dimmer the Trailing Edge type dimmer "chops" energy from the trailing edge of the sine wave.

While Trailing Edge dimmers have not been available in the market as long as Leading Edge Dimmers this dimmer type is generally regarded as the better type to operate LED lighting loads.

Market estimates vary regarding the split between the number of leading edge dimmers compared to trailing edge dimmers. However anecdotal evidence suggests around a 50 - 50 split. A proportion of dimmers are also of the Universal type. Accurate estimates of the number in service are difficult to quantify.

As MLV transformers have been upgraded due to end of life failure over the years, the accompanying Leading Edge dimmer has also been upgraded to a Trailing Edge type for compatibility with EELV transformers.

For new installations where EELV transformers were supplied during construction, Trailing Edge dimmers have been installed.

It should be noted that care must also be taken when selecting and matching product for compatibility between brands and LED lamp products.

2.2 Dimmer Type - Universal Dimmers

A proportion of dimmers supplied into the market are of the Universal type, estimated to be around 15%.

Universal dimmers have the ability to identify the type of load connected in the circuit. Either inductive (MLV) or capacitive (EELV) transformer. The dimmer then adjusts its operating characteristics for compatibility with the characteristics of the connected load.

Like Trailing Edge dimmers care must also be taken when selecting and matching Universal dimming products for compatibility between brands and LED lamp types. When used with LED lamps Universal dimmers are no more compatible than Leading Edge or Trailing Edge type dimmers.

2.3 LED Lamp Omni-directional, MR16 Directional, Transformers and Dimmer

Successful operation of omni-directional LED lamps incorporating integral driver electronics, directional MR16 lamps with remote magnetic or electronic transformers and dimmers is dependent on compatibility of all three

components in the system. The common conclusion when dimming functionality does meet expectations is the dimmer is the cause of the problem.

To operate an LED light source the supply voltage must be converted from nominally 240V Alternating Current (AC) to an extra low voltage, typically 12V or 24V Direct Current (DC).

For an LED chip (or lamp) to produce light it MUST operate on a DC voltage. An LED lamp cannot operate directly on Alternating Current. The voltage wave form must be rectified from AC to DC.

In the case of an omni-directional 240V mains voltage style LED lamp the voltage conversion function is processed internally within the lamp. For an MR16 LED directional lamp the voltage conversion function is firstly a conversion from 240 volts AC to nominally 12 volts AC by either an electronic or magnetic transformer. Electronic components within the LED lamp assembly then perform the function for the conversion of AC voltage to DC voltage to operate the LED chip set.

Since LED chips require regulation of current (not voltage) for proper operation, and transformers regulate voltage (not current), additional circuitry is required between a transformer and LED chip. This additional circuitry can be considered a "driver" and is located in the low voltage fixture housing at the base of the MR 16 lamp.

3 Test Methodology - Overview

Dimmers have been tested with all nominated dimmable LED lamp types - 240v Omni Directional type, 240v GU10 directional type and 12v MR16 Retrofit type connected to combinations of the most common transformer (MLV & EELV) types typically available in the Australian market.

For each combination the LED lamp has been assessed based on dimming functionality through a range of 100% light output to 1% light output.

Lamps that do not achieve a dimming level (Measured Light Level) of 30% of full light output were deemed to be not suitable.

Lamps that display any degree of flicker or shimmer in light output are deemed to have failed. Flicker or shimmer may have occurred throughout the range of dimming or have been demonstrated at a particular stage or setting of the dimmer. The visual perception of shimmer or flicker is very disconcerting and unacceptable for a consumer when in an illuminated space or home.

Lamps that achieved a measured light level of 30% with no discernible flicker or shimmer were then switched off and on at a 50% dimming setting to determine if the lamp resumes at 50% or starts at 100% and then resumes to 50% or demonstrated and light flash or flicker when re-started.

A combination of LED lamps and halogen lamps were combined onto a circuit and tested with the dimmers to determine if there was an acceptable number of LED lamps and halogen lamps that when combined achieved an acceptable result.

3.1 Light Switching Level

When an LED light source has been dimmed to a low level and then switched off some product configurations will not allow the LED to switch back on until the dimmer has been manually re-set to a range greater than 50% of the

maximum dimmer setting. This occurred with both Leading and Trailing Edge dimmers. Most users would find the requirement to re-set the dimmer after each operation to be inconvenient and unacceptable.

(At a low dimmer setting (10%) there is insufficient energy to allow the LED circuit to operate).

In isolated circumstances when a lamp is switched back on at a low dimming setting, the lamp ramps up to a higher light level (as capacitors in the electronic circuit charge up) then returns to the original dimming setting. The time duration of this may vary between 1/4 second to 1 second. This change in light levels is visually disconcerting and reports of end user opinion has indicated this situation is unacceptable for the majority of those surveyed by electricians in the field.

Other circumstances demonstrate a delay of 1/4 second when switched on at a low dimmer dial setting but instant start at full dimmer dial setting. This was deemed to be acceptable as a short delay at a dimmed level was of minor consequence provided the light level did not change or "bounce" around.

3.2 Dead Zone

Some dimmer / LED lamp configurations demonstrate a dead zone effect where the dimmer is operated and no perceptible change in light level is recorded and then a substantial drop in perceived light level is achieved.

This large step change in the dimming range is commonly considered to be unacceptable to consumers.

3.3 Audible Noise

Mainly Leading Edge dimmer / LED lamp configurations demonstrated a degree of audible noise emanating from either the transformer or dimmer or both.

The cause of the noise is due to high transient spikes in the circuit due to the electronic characteristics of the components and network circumstances.

Instances of audible noise are considered unacceptable and in addition will most likely result in premature product or component failure.

3.4 LED Lamp Flicker / Shimmer

Due to the high frequency characteristics of LED light sources, lamp flicker or shimmer is common. The two terms are sometimes interchangeable and severity is subjective between observers. Shimmer tends to be less severe and often only occurs at the periphery of vision.

3.5 Electronic Component Stress

The combination of different load types and system components can result in different electrical stresses imposed on various components and products. The design and internal construction of LED lamps and driver components can vary widely between products. Two LED lamps of the same wattage can create very different electrical stresses in an electrical system or component train.

LED product operated on phase cutting dimmers (leading or trailing edge) can create wave form stresses (instantaneous waveform spikes) in a dimming circuit due to the capacitive characteristics of LED electronics. This can far exceed the load that would have been created by a halogen load in the same circuit. This situation will contribute in most cases to premature component failure (either LED lamp, transformer or dimmer) and may, in very isolated cases result in potentially unsafe failure situations.

The occurrence of unsafe failures of product is rare. To determine the extent of this type of failure requires further investigation in collaboration with fire safety investigators to determine the precise cause of an incident.

An LED MEPS combined with effective control of product performance compliance standards should remove poor quality product for entering the market and contributing to this type of risk factor.

A review of available statistics lists occurrences "due to electrical faults". Descriptions have been grouped and described under a single category and are not specific in relation to the precise nature or cause of an electrical fault. i.e. loose terminals (causing arcing), insulation breakdown (causing arcing), poor installation practice and / or faulty workmanship or due to possible component failure, etc.

Some examples of product or component failure due to electronic stress have been identified in the market during the initial introduction phase of non-dimmable MR16 LED retrofit lamps. Through advances in product engineering and quality upgrades of these non-dimmable lamps, the majority of issues have been removed from the market.

As dimmable LED lamp technology is progressively introduced to the market and experience develops across a broad range of variable operating scenarios product compatibility is improving. However due to the complexity of individual component combinations that currently exist in operation, engineering a product solution at a price the market accepts to suit all variable is challenging.

LED lamp and dimmer testing standards have not defined a standardised procedure or process for the verification of compatibility of products. Responsibility for compatibility has been left to product manufactures to test individual LED components to ensure safe and reliable operation of equipment. Due to the differences in product design, component specifications and tolerance variables in the manufacturing process a positive test result with one brand or type cannot be generalised and transferred across to other similar types or brands. Generally LED lamps will result in some degree of wave shape distortion and lead to higher stresses on equipment circuit components than that of a halogen load of a similar or higher wattage.

An LED lamp MEPS would deliver a level of minimum performance characteristics for the operations and compatibility standards for product combinations.

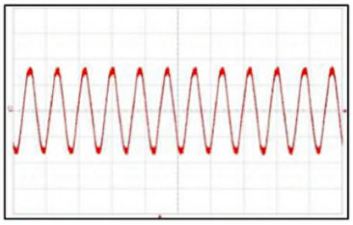
4 Transformers

Low voltage transformers for MR16 halogen lamps fall into two categories.

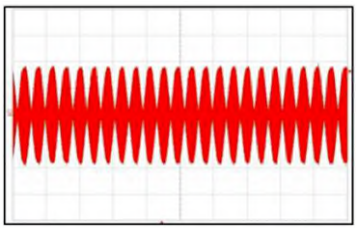
1. magnetic or Iron-core type
2. electronic type

Both types essentially perform the same function. Converting 240V AC to nominally 12V AC

Magnetic transformers are simple in construction, made from windings of copper wire around an iron core. For the purpose of this testing process magnetic transformers represent an inductive "soggy" load when matched with an LED MR16 retrofit lamp.

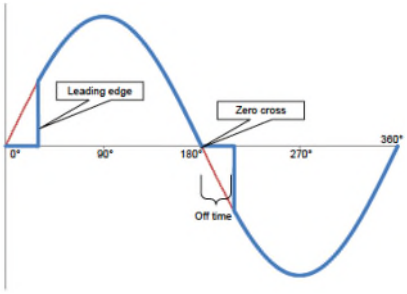


The output AC sinusoidal waveform of a magnetic transformer is an identical imprint of the input waveform, however 12V AC (secondary voltage) compared to 240V AC (primary voltage). The frequency of the secondary voltage matches that of the primary voltage. i.e 50 Hz



Electronic transformers have electronic circuitry which operates at very high frequency. Compared to magnetic transformers the electronic transformer converts the energy at higher efficiency with lower losses. This is achieved by using self oscillating electronic circuitry which drives a high frequency transformer, providing the step-down voltage function along with the required voltage regulation and electrical isolation. The output of an electronic transformer is a high frequency waveform contained within and envelope representing the input line frequency.

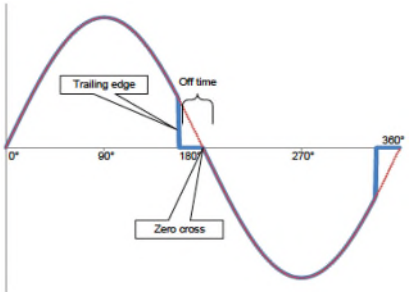
4.1 Wave Form Analysis when Dimming with Transformers



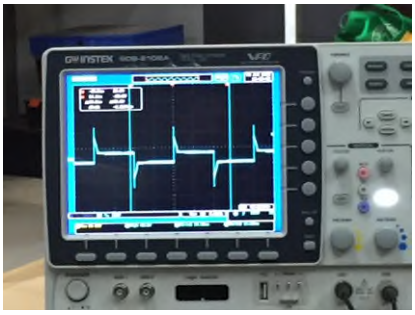
As previously described, when MR16 halogen lamps were originally introduced into the market the accompanying transformer was magnetic type and the dimmer a leading edge triac design which maintains voltage symmetry in both the positive and negative half cycles of the sine wave. As the "off time" increases the lamp dims as less energy is passing through the lamp filament.

Crucial to the correct operation of this dimming process is the identification of the zero cross over point in the sine wave as the energy transfers from the positive half cycle to negative half cycle.

Correct reference of the zero cross over triggers or "clocks" the introduction of the energy reduction in the leading part of the half cycle.

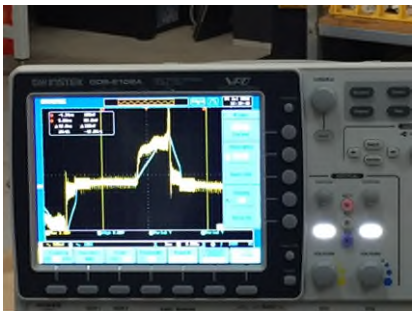


As electronic transformers were introduced into the market in the late 1990s the design requirements for dimmer technology changed from leading edge to trailing edge type to accommodate for the capacitive characteristics and high frequency of the electronic transformer.



If a leading edge dimmer is paired with an electronic transformer (capacitive load) the result is an instantaneous spike of current due to the rapid switch-on of voltage at every half cycle when a leading edge dimmer commences conducting.

As described earlier this instantaneous current spike can result in component stress and acoustic noise in both the dimmer and transformer. The adjacent images recorded during testing indicate the magnitude of the current spike in a range up to 15 - 18 amps. It is this excessively high current spike that leads to potential premature failure of either or both devices.



4.2 Installation of Dimmers with Transformers

As previously described the evolution and introduction of generations of product and combinations of equipment has resulted in the general configuration of Leading Edge dimmers operating in unison with magnetic transformers .

As technology has advanced, the introduction of electronic transformers has driven the development and introduction of Trailing Edge dimmers.

Universal type dimmers were developed for situations where the type of transformer installed was difficult to ascertain allowing the dimmer to "adapt" to the prevailing load characteristics.

4.3 Dimmer Design for EELV (Electronic) Transformers

If an electronic transformer is operated on a Leading Edge dimmer the result is a voltage spike occurring at the zero cross over point due to the rapid rise in voltage as the capacitors in the transformer charge. To avoid this repetitive current spike the a Trailing Edge dimmer is designed to begin conducting at the zero cross over of the sine wave to allow the voltage to slowly increase at the same rate as the increasing line voltage wave form.

As a result it is recommended that electronic transformers are operated on Trailing Edge dimmers.

To dim the lamp energy is removed or "chopped" from the trailing edge of the sine wave. In this case energy stored in the capacitor has time to discharge as the wave shape decays more slowly on the back half of the sine wave curve towards the zero cross over of the half wave.

The key to the operation of the Trailing Edge dimmer design is the internal electronic timing circuit that "fires" the electronics to start conducting at each zero cross over point.

An emerging problem with this product design is the increase of disturbances (harmonic distortion) on the consumer mains supply caused by the increasing proliferation of other electronic devices. As harmonic distortion increases, the zero cross over reference the dimmer uses to "sync" the commencement of conduction is getting lost and as a result instantaneous current spikes are becoming more prevalent.

In this situation it is not the fault of the equipment, but due to network distortion characteristics. The situation tends to be more severe in high density situations like CBD districts in major cities and high density multi-level housing, etc.

The instances of this occurring in suburban residential housing is less evident, however as the use of electronic components continues to rise in homes the problems is emerging. Higher instances of harmonic distortion in the mains is becoming prevalent in areas with a high density of solar energy being fed back into the grid.

Trailing edge dimmers can also create problems when combined with magnetic (inductive) transformers. Due to the rapid turn off of voltage when the dimmer stops conducting in the back half of every half cycle. When this occurs the waveform is applied to the magnetic transformer and the sudden change in voltage causes the magnetic field to collapse creating a large voltage spike that can damage the dimmer. This voltage spike can also pass through the transformer to the LED load which may exceed the maximum voltage tolerance and also destroy the LED.

In practice most electricians test and match product combinations to deliver satisfactory performance outcomes for their customers based on the particular characteristics that exist for that installation. The general consensus that electricians tend to apply is they will install trailing edge dimmers with electronic ballasts and leading edge dimmers with magnetic ballasts and test for operation and satisfactory performance outcomes. If necessary they will then vary component combinations to deliver the required result.

Due to the number of variations that occur from installation to installation differences between components and models can produce unexpected performance outcomes and hence no hard and fast rules can be identified. Only guidance as to what should deliver a likely performance and compatibility outcome.

Universal dimmers are designed to automatically adapt to either leading edge or trailing edge by detecting whether the load is either capacitive or inductive.

4.4 LED Lamp Dimming and Magnetic Transformers

From a product engineering perspective the combination of magnetic transformers and LED lamps with the combination of trailing edge dimmers requires special attention.

With magnetic transformers the wave form symmetry between positive half cycle and negative half cycle is particularly important. Any variation from the dimmer or the LED rectifier electronics may cause the transformer to saturate due to the imbalance and the light may become visually unstable.

This voltage imbalance may also cause the LED light to appear brighter or conduct current for longer during one half cycle than during the opposite half cycle leading to the lamp flickering at the frequency of the supply voltage.

In some combinations of magnetic transformers, LED lamps and Leading Edge dimmers, the "soggy" characteristics of the inductive transformer can absorb part of the repetitive voltage spike created on the leading edge of the sine wave. In some instances this may explain the successful dimming operation of some LED lamp, magnetic and Leading Edge dimmer combinations reported in the market.

For both Leading Edge and Trailing Edge dimmers \voltage imbalances and lamp flicker may also occur as a result of the line voltage noise or disturbance from external sources (Harmonics). This can pass unimpeded through a magnetic transformer and become a visual disturbance due to the fast response time of the LED matching that of the disturbances on the line. It is also possible for any line noise to cause small disturbances when the dimmer turns on and off each half cycle. This further creates light level instability.

To overcome this problem LED lamp manufactures add a filtering capacitor to the circuit. While this reduces LED flicker it can lead to problems with the dimmer. The capacitor must be properly sized to maintain its output above the forward voltage of the LED. With a leading edge dimmer the front portion of the sine wave is chopped. If this chopped portion occurs before the output voltage exceeds the voltage on the capacitor, then chopping the front of the sine wave will have little perceivable effect on the output voltage or the light level. This results in the dimmer "Dead Zone."

In addition if the dimmer begins conducting current when the capacitor voltage is significantly below the instantaneous transformer voltage this can cause momentary high current flow spikes causing component stress. This repetitive peak current occurs at twice the line frequency. As the current recovers from the high peak flow it can cause the triac device in the Leading Edge dimmer to turn off and cause LED flicker as the dimmer is unable to provide a constant amount of power to the transformer.

4.5 Magnetic Transformers and Under Loading

The "mechanical" operational characteristics of a magnetic transformer are quite different to those of an electronic transformer. Both devices deliver the same outcome i.e. convert 240 volts to nominally 12 volts, but the method in which this is achieved varies substantially.

A magnetic transformers uses the electromagnetic field priced in the windings of the transformer core to perform the voltage conversion. With an electronic transformer this function is delivered through a series electronic components delivering the voltage conversion.

Magnetic transformers are designed to operate on a balanced load. i.e the load capacity of the transformer needs to be matched to the load drawn by the connected lamp. When changing a halogen load of typically 50 watts to an LED load of under 10 watts this will result in under loading of the magnetic transformer.

When magnetic transformers are lightly loaded their high inductance combined with the non-linear characteristics of the LED load can cause the output of the transformer to "ring-up" higher than what would be expected from the turns ratio of the transformer. This "ring-up" voltage is defined as a momentary spike or ripple caused by the discharge of energy due to the inductive nature of the transformer.

With enough "ring-up" the transformer may exceed the maximum voltage rating of any components causing lamp flicker or component failure.

In installations where there is a relatively small number of lamps and transformers on a circuit (most residential locations) the cumulative effects may not create a problem causing the lamp to flicker.

However in larger commercial application the higher number of transformers may create a cumulative effect and result in lamp flicker or voltage distortion.

4.6 LED Lamp Dimming and Electronic Transformers

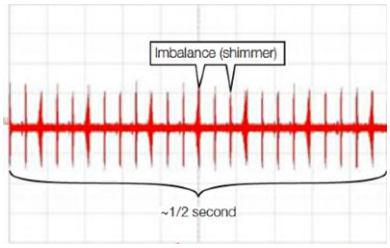
In terms of product development and evolution from magnetic transformers, electronic transformers were specifically designed to operate and match the particular characteristics of a "slow response" linear resistive type load of the halogen lamp.

The electronic transformer was designed to operate a range of connected loads from 20 watts to 50 watts corresponding to the common MR16 halogen lamp wattages available in the market.

Electronic transformers are designed as a self-oscillating circuit operating at high frequency to drive down their internal step down output. The oscillation circuit components are configured as simply as possible to reduce cost and the design relies on the expected resistive load of a halogen lamp across the secondary output. Most electronic transformers specify a minimum load (usually 20 watts minimum) to ensure that their internal oscillation circuit is stable. The oscillation only occurs during the portion of the line voltage sine wave when the dimmer is conducting.

Even if the minimum specified load is met, the non-resistive nature of LEDs may not properly meet the needs of the oscillator in the electronic transformer.

This can be observed as slight changes from half cycle to half cycle despite the input phase angle being constant and is observed as flicker or shimmer when dimming.



Unlike a halogen lamp filament that reacts slowly to minimal changes in half cycle energy due to the high thermal mass of the tungsten wire the light

output of an LED responds very quickly to minute changes in current flow. So any instability in the transformer voltage output may be directly visible in the LED light output.

Because electronic transformers appear to be capacitive to a dimmer, trailing edge dimmers are recommended for operation with an LED load.

An improper match between LED loads and electronic transformers can exaggerate the capacitive characteristics.

Multiple electronic transformers which are seen as a large capacitive load on a single dimmer can actually hold up the line voltage output of a dimmer. The more capacitance, the slower the voltage decays at the trailing edge dimmer. This large amount of slow decay affects how the dimmer recognises the phase angle and results in poor dimming characteristics, dead zone, stepped dimming, poor minimum light level achievement and variable flicker when dimming.

As the design of individual electronic transformers is highly variable between brands the exact number of devices on a dimming circuit to predict outcomes is extremely difficult thus a combination of LED, electronic transformer and dimmer that appears compatible when one LED and transformer is in use, may not be compatible with a higher number of devices on the same dimmer.

5 Application of LED Lamps, Dimmers and Transformers

It is possible to achieve satisfactory dimming performance with LED lamps through well designed and engineered product components.

Energy efficiency incentive schemes currently operated in a number of Australian States and Territories manage the risk of compatibility of product combinations well and demonstrate a high level of performance outcomes. It should be noted the majority of products installed under these schemes are non-dimmable upgrades and when dimming applications are required the supplier undertakes comprehensive assessment to ensure performance and compatibility of dimming performance for the product supplied.

However it remains difficult to predict that the successful combination of matched equipment or performance criteria will be consistently duplicated across multiple installations unless they have been specifically designed, matched and tested for compatibility.

The performance of equipment combinations are subject to external variables. What may work very successfully in one instance may not necessarily be duplicated in exactly the same way in another.

This can be due to variations in circuit impedance and the overall quality of line supply (harmonic distortion) affecting the performance of components in the system. The length of cable runs, distances between components all play a part in the overall circuit impedance and characteristics.

In general, most residential applications may not be adversely affected (due to shorter cable runs etc and more stable network supply characteristics) but larger commercial applications may demonstrate higher levels of variable performance between sites.

While it is worthwhile to note variables do exist between locations and circumstances the only guaranteed way to ensure the dimming will be smooth and continuous is to test all devices together as a complete system.

Optimum outcomes can be achieved when correctly designed and matched equipment is combined, but that can be difficult to implement in an existing installation.

It is recommended that households with Leading Edge dimmers should upgrade the equipment and verify compatibility with the lamp type to prevent possible compatibility issues.

In some market sectors consumers accept the fact that equipment requires to be upgraded on a frequent basis. Smart phones and LED televisions are examples. In the case of LED lighting transition, to achieve optimum guaranteed performance it may be necessary to implement a complete system upgrade rather than a simple lamp retrofit option.

Consideration should be given to a future LED MEPS to consider standardising the performance criteria and definition of dimming range to provide consistency across product ranges. This MEPS should also include standardisation for the interchangeability of LED lamps across a range of equipment. The objective is to identify product that does not result in noticeable difference in light output or performance.

Systems comprising of dimmers controlling LED lamps plus the combination of transformer types can have varying performance characteristics depending on a particular application or circumstance. Unexpected behaviour is likely to occur in most cases.

Mixing combinations of equipment with different amounts of load on the same circuit will most likely result in unacceptable performance due to the load characteristics and incompatibility between products counter acting together. However this can most likely be overcome by upgrading equipment that has been designed and matched as a compatible component set.

Transformers currently in operating are essentially from an "analogue" age engineered to operate halogen lamps and were not designed to be compatible with a "digital" age LED light source. Combining LED lamps with existing transformers and then operating this combination on existing vintage dimming equipment is a very challenging application. To achieve a match of electronics that will result in acceptable dimming performance, all the components have to be engineered for compatibility.

Well engineered and designed product does in most cases provide a degree of compatibility but guaranteed performance outcomes are hard to predict accurately. As product design matures and costs reduce in future a higher degree of reliability will be a likely outcome.

A successful application requires the LED manufacturer, the transformer manufacturer and the dimmer manufacturer to design their product to be compatible for delivery of smooth, continuous, flicker-free dimming down to 1% measured light output. At the current stage of the development cycle good dimming performance of LED lamps with existing dimming equipment in the market is considered to be down to 30% of the maximum light output.

The combination of existing transformers and dimmers which were designed for high wattage resistive loads will continue to pose challenges when current generation LED lamps are installed. Due to the absence of standardised

manufacturing practices all LEDs demonstrate varying electrical characteristics, when combined with older equipment, the outcome cannot possibly be accurately predicted.

The best solution for ensuring dimming compatibility between products is to test the combination as installed. Variations between a test setup and installed application may deliver performance discrepancies and result in dissatisfaction.

6 Test Procedure - LED lamp, Transformer and Dimmer

The associated test matrix of omni-directional LED lamps, directional MR16 retrofit lamps, ELV electronic and magnetic transformer combinations have been assessed for performance characteristics on a range of typical dimmers supplied common in the market. See Attachment A.

The compatibility tests have been conducted with one of each representative device.

The results and performance have been recorded on the matrix.

Combinations of product demonstrating satisfactory dimming performance are assumed to be a realistic indicator of compatibility when installed in a typical application. However, as detailed in the previous explanatory notes external variables in real world applications may vary performance due to a number of factors that cannot be replicated in a testing procedure.

Providing a matrix, chart or electronic app to inform consumers and electricians of the likelihood of product compatibility would be advantageous, however the results indicated should be qualified as “Guidance Only”.

7 Inrush Current

Lamp inrush current on switching LEDs has become an item of concern throughout the lighting industry.

For an LED, inrush current refers to the input current flow to the driver electronics due to the charging of capacitors. This current flow during the initial start-up process is of short duration but can be quite high in magnitude depending on system and component specification. The inrush current and duration differs from LED driver to LED driver, manufacturer to manufacturer and from model to model. The short duration current flow is generally much greater than the operating or steady-state current flow of the device.

The inrush current is due to the EMC filter on the input side of the device and the bulk capacitor in the DC power rectification circuit at the LED chip.

If there are a number of LED products on one circuit, the maximum peak inrush current may be additive. However is it not an automatically calculated summation. The total inrush current depends on the impedance of each driver and the line impedance of the circuit and network installation.

The line impedance has a significant effect on the peak and duration of the inrush current. Component type, cable size, length of cable run and other electrical and electronic equipment in the circuit all have an influence to variations in line impedance.

In general, nuisance tripping of circuit breakers and Miniature Circuit Breakers (MCBs) is localised to commercial and industrial applications where there are a higher number of LED or electronic ballasts and cable runs are of greater distance between switch boards and electronic loads. Generally the longer the cable run between switch board and device the higher the line impedance which extends the duration of the inrush current spike. This results in the operation of the circuit protection device due to magnitude of current flow exceeding the preset limits (quantity and duration) of that device which results in the instance of nuisance tripping. Current installation practice in commercial applications is to limit the number of LED Light fixtures to approximately 25 devices on one circuit.

Other contributing variables includes the instance when a switch is closed at the precise time in the wave form shape. If a switch is closed close to the peak of a sine wave the result of the inrush current may be far higher than when the switching occurs close to the zero cross over point of the cycle.

For residential applications the number of LED lamps, switching of smaller loads (i.e. one room at a time) and the shorter cable run distances will not result in instances of tripping of a MCB.

It is considered that the instance of LED lamps causing an increase in nuisance tripping of MCBs in residential applications is highly remote or virtually non-existent.

Test simulations attempting to create an occurrence of nuisance tripping of MCBs due to in rush current did not indicate there to be any increase in risk of future occurrence in residential applications due to the retrofit of LED lamps.

In commercial instances where nuisance tripping has been an issue the situation is effectively death with by limiting the number of devices on a final sub circuit to insure the operating limits of a device have not been exceeded, or in some cases, the type of device can be changed to a type with more suitable operating characteristics better suited to the particular characteristics of that location.

8 Presence and Motion Detectors

The motion detector samples provided for testing were all of the 3 wire type and demonstrated fully compatible operating characters with LED PAR lamps.

It appears that manufactures have voluntarily adopted revisions of motion detector product design from 2 wire to 3 wire circuitry and now supply that form into the market.

However concern exists for legacy type 2 wire product in service across a large number of household locations. Many of the relay contacts in the switching / control systems contained within these devices are designed for low inrush current halogen and incandescent lighting.

These products have not been designed with the consideration of high inrush LED technology.

The higher inrush current of LEDs can cause these products to fail, by welding the relay contacts closed and causing the LED lamp to remain on.

Hence care must be taken that the photocells and occupancy sensors are rated suitably to handle the LED inrush currents, particularly in a retrofit solution.

In addition, if the product contains a photocell control mode the low impedance leakage current through an LED lamp electronics may not be fully isolated. The small amount of current flow through the photocell may be enough to allow the LED lamp to remain on and emit a small quantity of light due to this leakage current flow.

These types of devices typically have an effective operational life of between three and eight years for general residential applications. The life expectancy of the product depends on the quality of manufacture, quality of discreet components within the product and location the product is installed.

Products positioned in severe weather locations that are exposed to extreme variations in temperature and subject to excessive solar radiation demonstrate shorter life expectancy than those located in protected or sheltered areas.

As these products have a relatively high mortality rate and tend to be changed frequently the likely hood is that most motion and presence detectors currently in the market will be upgraded to the widely available versions of 3 wire type in the near future and not present a major concern.

Attachment A – Table 1 – Omni Directional Lamps

Operational Characteristic Performance Legend		Excellent dimming performance and step-less operation when dimming. Dimming range from 100% to < 5%. lamp replicates that of halogen dimming performance.											
		Interim Pass - Acceptable dimming range (to 50% of full lumen output) and continuous (step-less) operation when dimming with near zero perception of lamp flicker or shimmer											
		Pass - Acceptable dimming range (to 30% of full lumen output) and continuous (step-less) operation when dimming with near zero perception of lamp flicker or shimmer											
		Fail - Perceptible (i.e. unacceptable degree of lamp flicker, shimmer or strobe effect demonstrated during operation or when dimming the lamp)											
Table 1- Dimmer Type & Part No.		**Dimmer 1**	**Dimmer 2**	**Dimmer 3**	**Dimmer 4**	**Dimmer 5**	**Dimmer 6**	**Dimmer 7**	**Dimmer 8**	**Dimmer 9**	**Dimmer 10**	**Dimmer 11**	**Dimmer 12**	**Dimmer 13**
Lamp Class	Lamp Description	**Operation Characteristic**												
Omni-Directional 240V Lamps GU10 and ES base	Lamp 1	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 0% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe	Fail - No Dimming Range Severe Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Medium Strobe at 75% setting	Pass / Dimming Range 100% - 50% No Strobe	Pass Dimming Range 100% - 25% No Strobe	Fail / Dimming Range 100% - 0% Strobe at different setting stages	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe
	Lamp 2	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 0% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 100%	Fail - No Dimming Range Severe Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass Dimming Range 100% - 25% No Strobe	Fail / Dimming Range 100% - 0% Strobe at different setting stages	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe
	Lamp 3	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe @ 25% dim stages	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100 - 0% Severe Strobe 50% - 0%	Fail / Dimming Range 100% - 50% Minor Strobe @ 100%	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail / Dimming Range 100 - 50% Severe Strobe between 90% - 50%	Pass / Dimming Range 100% - 50% No Strobe	Pass Dimming Range 100% - 25% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe at all setting stages	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 30% No Strobe
	Lamp 4	Fail / Constant Severe Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100 - 30% Minor Strobe through 100% - 30%	Fail / Dimming Range 100% - 50% Severe Strobe	Fail - No Dimming Range Severe Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Minor Strobe at Intervals	Pass / Dimming Range 100% - 50% No Strobe	Pass Dimming Range 100% - 30% No Strobe	Fail / Dimming Range 100% - 30% Minor Strobe at 75% setting	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe

	Lamp 5	Fail / No Function / No Operation	Fail / Dimming Range 100% - 10% Minor Strobe @ different dim stages	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100 - 0% Minor Strobe 100% - 0%	Pass / Dimming Range 100% - 50% No Strobe	Fail - No Dimming Range Severe Strobe	Pass / Dimming Range 100% - 0% No Strobe	Fail / Dimming Range 100 - 50% Severe Strobe between 90% - 50%	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 0% Minor Strobe at 75% setting	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 10% No Strobe
	Lamp 6	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe @ 25% dim stages	Fail / Dimming Range 100% - 50% Minor Strobe @ 100% Severe Strobe @ 90% No strobe when dimmed lower	Fail / Dimming Range 100 - 50% Minor Strobe through lower range	Fail / Dimming Range 100% - 50% Severe Strobe	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 50% Minor Strobe @ 100%	Fail / Dimming Range 100 - 50% Severe Strobe between @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe @100%	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 50% Minor Strobe at all setting stages	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe
	Lamp 7	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail - No Dimming Range Only 50% output Minor Strobe @ 50%	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range100% - 50% No Strobe	Fail / Dimming Range 100% - 50% No Strobe from 50% - 80% which is full light output. From dimmer setting 80% to 100% less light + strobe@100%	Pass Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100% - 50% Minor Strobe at 75% dim setting	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe

Attachment A – Table 2 – Directional Lamps

Operational Characteristic Performance Legend			Excellent dimming performance and steeples range (dimming) change from 100% to < 5%. Replicates halogen dimming performance.							Performance as per green HOWEVER audible hum from transformer. Subsequent ray trace analysis of the wave form would indicate transient spikes and suspect likely component failure as an outcome				
			Pass - Acceptable dimming range (to 30% of full lumen output) and continuous (step-less) operation when dimming with near zero perception of lamp flicker or shimmer							Fail - Perceptible (i.e. unacceptable degree of lamp flicker, shimmer or strobe effect demonstrated during operation or when dimming the lamp)				
			Interim Pass - Acceptable dimming range (to 50% of full lumen output) and continuous (step-less) operation when dimming with near zero perception of lamp flicker or shimmer							Component failure or extremely high likelihood of failure of either lamp, dimmer or transformer.				
Dimmer Type & Part No.		**Dimmer 1**	**Dimmer 2**	**Dimmer 3**	**Dimmer 4**	**Dimmer 5**	**Dimmer 6**	**Dimmer 7**	**Dimmer 8**	**Dimmer 9**	**Dimmer 10**	**Dimmer 11**	**Dimmer 12**	**Dimmer 13**
Lamp Class	**Transformer Type**	**Operation Characteristic**												
MR16, 7W, 380 lm, GU5.3	Transformer 1	Fail / Constant Severe Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Fail - No Dimming Range Minor Strobe	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100 - 50% Severe Strobe between across all ranges	Fail / Dimming Range 100% - 50% No Strobe from 50% - 80% which is full light output. From dimmer setting 80% to 100% less light + **NO** strobe@100%	Pass Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 2	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 75% No Strobe	Fail / No Dimming Function	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 75% Medium Strobe at 75% setting	Pass / Dimming Range 100% - 50% No Strobe	Pass Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 50% Stepless dim rangenNo Strobe	Pass / Dimming Range 100% - 30% No Strobe

	Transformer 3	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Fail / Dimming Range 100% - 75% Severe Strobe	Fail / No Dimming Function	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 80% - 50% No Strobe	Fail / Dimming Range 100% - 50% No Strobe from 50% - 80% which is full light output. From dimmer setting 80% to 100% less light + **NO** strobe@100%	Pass Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 30% No Strobe
	Transformer 4	Fail / Dimming Range 100% - 50% Constant Severe Strobe THROUGH RANGE	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe / Audible Transformer Hum	Fail / No Dimming Function / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe	Fail / No Dimming Function / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Hum	Pass Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe / Audible T'former hum through range / Excessive Dimmer heating	Fail / Dimming Range 100% - 50% Severe Strobe / Audible T'former hum through range / Excessive Dimmer heating (Dimmer failure within 1 min operation
	Transformer 5	Fail / No Function / No Operation / Stobe at all settings	Pass / Dimming Range 100% - 75% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail / No Dimming Function	Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range100% - 50% No Strobe	Fail / Dimming Range 100% - 20% Minor Strobe @ 20%	Pass Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 20% No Strobe
	Transformer 6	Fail / No Function / No Operation / Strobe at all settings	Pass / Dimming Range 100% - 40% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe	Fail / No Dimming Function	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 30% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 30% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 30% No Strobe / Audible Transformer hum
MR16, 8W, 540 lm, GU5.3	Transformer 1	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% dim stages	Fail / Dimming Range 100% - 10% Minor Strobe @ 10% - 50%	Fail / Dimming Range 100 - 10% Minor Strobe through 100% - 10%	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 10% Minor Strobe between 10 - 50% dim setting	Fail / Dimming Range 100% - 50% Minor Strobe at Intervals	Fail / Dimming Range 100% - 10% Minor Strobe through range 10% - 50%	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible hum in **dimmer**	Fail / Dimming Range 100% - 10% Minor Strobe between 10 - 50% dim setting	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe 50% - 10%

	Transformer 2	Fail / No Function / No Operation	Fail / Dimming Range 100% - 20% Minor Strobe between 20 - 50%	Fail / Dimming Range 100% - 10% Minor Strobe @ 10% - 50%	Fail / Dimming Range 100 - 50% Minor Strobe @ 50% + Audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% - 10%	Fail - No Dimming Range Severe Strobe	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100 - 50% Severe Strobe @ 50% + audible transformer hum	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible hum in transformer	Fail / Dimming Range 100% - 10% Severe Strobe / Audible T'former hum through range	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe upto 50%
	Transformer 3	Fail / No Function / No Operation	Fail / Dimming Range 100% - 20% Minor Strobe between 20 - 50%	Fail / Dimming Range 100% - 10% Minor Strobe @ different range setting	Fail / Dimming Range 100 - 10% Minor Strobe @ 75% + Audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 75% - 100%	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 30% Minor Strobe @ 100% setting	Fail / Dimming Range 100% - 50% Minor Strobe at Intervals + dimmer hum	Fail / Dimming Range 100% - 20% Minor Strobe through 20 - 50% Severe strobe @100%	Fail / Dimming Range 100% - 10% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe + Audible hum from Transformer	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe
	Transformer 4	Fail / Dimming Range 100% - 50% Constant Severe Strobe THROUGH RANGE	Pass / Dimming Range 100% - 50% No Strobe + Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Fail / Dimming Range 100 - 50% Minor Strobe @ 50% + Audible transformer hum	Fail / Dimming Range 100% - 75% Severe Strobe + Audible transformer hum	Fail / No Dimming Function / Audible Transformer hum	Pass / Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 50% Medium Strobe at 75% setting + Audible transformer hum	Fail / Dimming Range 100% - 40% Severe Strobe @ 50% - 100%% + Audible Transformer hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Fail / Dimming Range 100% - 30% Minor Strobe at all ranges + audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe / Audible T'former hum through range	Fail / Dimming Range 100% - 75% Severe Strobe Audible T'former hum through range
	Transformer 5	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% dim stages	Fail / Dimming Range 100% - 50% Minor Strobe @ 75% dim stages	Fail / Dimming Range 100 - 50% Minor Strobe through lower range	Fail / Dimming Range 100% - 30% Severe Strobe @ 50%	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 10% Severe Strobe @ 50%	Pass / Dimming Range100% - 50% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 20% Severe Strobe from 20% - 50%	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe unto 75%	Fail / Dimming Range 100% - 10% Minor Strobe unto 75%
	Transformer 6	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 30% Minor Strobe @ 30% - 75%	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 10% Minor Strobe between 10% - 50%	Pass / Dimming Range100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 75%%	Fail / Dimming Range 100% - 50% Minor Strobe through range	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe

7W LED, 450 lm, GU5.3	Transformer 1		Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe @ 100%	Fail / Dimming Range 100 - 50% Minor Strobe through range	Fail / Dimming Range 100 - 50% Severe Strobe through range		Fail / Dimming Range 100% - 40% Minor Strobe through range	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%% +	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 20% Minor Strobe through range	Pass / Dimming Range 100% - 30% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range
	Transformer 2	Fail / No Function / No Operation	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe through range setting	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range		Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe through range	Pass / Dimming Range 100% - 30% Very Minor Strobe through range 30% - 100%	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe through range
	Transformer 3	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Minor Strobe @ 100% Severe Strobe	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe @ 75% - 100%		Fail / Dimming Range 100% - 50% Minor Strobe @ 100%	Fail / Dimming Range 100% - 75% Medium Strobe at 75% setting + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe @100%	Fail / Dimming Range 100% - 50% Severe Strobe @ different setting + audible dimmer & Transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe at 75% dim setting + Audible hum	Pass / Dimming Range 100% - 50% No Strobe + transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 100%
	Transformer 4	Fail / Dimming Range 100% - 75% Constant Severe Strobe THROUGH RANGE	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% + Audible Hum from 50% - 100%		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Fail / Dimming Range 100% - 50% Minor Strobe Through range + Audible hum	Fail / Dimming Range 100% - 40% Severe Strobe @ 50% - 100%% + Audible Transformer hum	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 40% Minor Strobe between 10 - 50% dim setting + Audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe / Audible T'former hum through range	Fail / Dimming Range 100% - 50% Severe Strobe @ 100% / Audible T'former hum through range / Excessive Dimmer heating (Dimmer failure within 1 min operation
	Transformer 5		Fail / Dimming Range 100% - 20% Minor Strobe through range	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100% - 20% Severe Strobe through range	Fail / Dimming Range 100% - 75% Minor Strobe @ 75%		Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail / Dimming Range 100 - 50% Severe Strobe between @ 50%	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% setting	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe at 100% setting	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 100%

	Transformer 6	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100 - 50% Minor Strobe @ 50% + Audible transformer hum	Fail / Dimming Range 100% - 75% Minor Strobe @ 75% - 100%		Pass / Dimming Range 100% - 75% No Strobe	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Minor Strobe through range + Audible Hum	Pass / Dimming Range 100% - 20% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 75% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe @ 100%
MR16, 7W, 380 lm, GU5.3	Transformer 1		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 40% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 50% No Strobe		Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 80% - 50% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Pass Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Pass Dimming Range 100% - 10% No Strobe
	Transformer 2		Pass / Dimming Range 100% - 40% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100 - 50% Minor Strobe @ 50% & 10% + audible transformer hum	Pass / Dimming Range 100% - 75% No Strobe		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum @ 50% decreasing as dimming range increases to 100%	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe between 10 - 50% + Audible transformer hum	Pass / Dimming Range 100% - 40% No Strobe + Audible Transformer Hum	Pass / Dimming Range 100% - 40% No Strobe
	Transformer 3	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Strobe only @ 100%	Pass / Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% + Audible Hum from 50% - 100%		Pass / Dimming Range 100% - 50% No Strobe		Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%% + Audible hum + severe dimmer heating	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 10% No Strobe + Audible Transformer Hum	Pass / Dimming Range 100% - 10% No Strobe + Audible Transformer Hum	Pass / Dimming Range 100% - 50% No Strobe
	Transformer 4		Pass / Dimming Range 100% - 50% No Strobe + Audible Transformer hum	Pass / Dimming Range 100% - 75% No Strobe + Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 75% No Strobe + Audible Hum		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Pass / Dimming Range 100% - 75% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 75% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 75% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum

	Transformer 5		Fail - reduce lumen output by 25% to 75% - No Strobe - Limited dimming range between of 25% of reduced output	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100 - 50% Severe Strobe @ 50%	Fail / No dimming function		Pass / Dimming Range 100% - 40% No Strobe	Pass / Dimming Range 80% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 40% Lamp pules slowly @ 40%	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 20% No Strobe
	Transformer 6		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 75% Minor Strobe @ 75% - 100%		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 40% Minor Strobe through range + Audible hum	Pass / Dimming Range 100% - 20% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 75% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe
MR16, 5W, 495 lm, GU5.3	Transformer 1		Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 40% Minor Strobe through range setting	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe through range		Fail / Dimming Range 100% - 40% Minor Strobe through range	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Fail / Dimming Range 100% - 10% Minor Strobe through range 10% - 50%	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Severe Strobe	Fail / Dimming Range 100% - 20% Minor Strobe @ 100%	Fail / Dimming Range 100% - 10% Minor Strobe through range
	Transformer 2		Fail / Dimming Range 100% - 10% Minor Strobe @ 10%	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100 - 30% Minor Strobe @ 50% + Audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%		Pass / Dimming Range 100% - 50% No Strobe	Fail - severe strobe as dimming commences. Minor strobe @ 100%	Fail / Dimming Range 100% - 50% Strobe @ 100% which is full light output. Dimming with no strobe below 100%	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe between 10 - 50% + Audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Pass / Dimming Range 100% - 30% No Strobe
	Transformer 3	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail / Dimming Range 100 - 40% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe through range + audible hum		Fail / Dimming Range 100% - 30% Minor Strobe @ 100% setting + Audible transformer hum		Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible hum in transformer	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range

	Transformer 4		Fail / Dimming Range 100% - 50% Minor Strobe @ 100% setting + audible transformer hum. No hum on bridge. i.e. dimmer causes transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Fail / Dimming Range 100 - 50% Minor Strobe through audible hum	Fail / Dimming Range 100% - 50% Severe Strobe + Audible hum		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Fail / Dimming Range 100% - 75% Minor Strobe Through range + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe Through range + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 75%	Fail / Dimming Range 100% - 50% Severe Strobe lower range	Fail / Dimming Range 100% - 50% Severe Strobe @ 100% + Audible hum	Fail / Dimming Range 100% - 40% Severe Strobe @ 100% + Severe Audible hum
	Transformer 5		Fail - reduce lumen output by 25% to 75% - Strobe through lower range - Limited dimming range between of 25% of reduced output	Fail / Dimming Range 100% - 0% Minor Strobe @ 10%	Fail / Dimming Range 100 - 50% Severe Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe through range + delayed dimmer response		Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 75%%	Fail / Dimming Range 100% - 40% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 6		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 30% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe @ lower range		Pass / Dimming Range 100% - 20% No Strobe	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 30% Minor Strobe through range + Audible transformer hum	Pass / Dimming Range 100% - 20% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 20% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 10% No Strobe
MR16, 10.5W, 620 lm, GU5.3	Transformer 1		Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe between 50% - 100%		Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail - No dimming function No strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail / Dimming Range 100% - 40% Severe Strobe through range	Fail / Dimming Range 100% - 10% Severe Strobe between 10 - 50%	Fail / Dimming Range 100% - 50% Minor Strobe @ 100%	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change

	Transformer 2		Fail / Dimming Range 100% - 10% Minor Strobe @ 10%	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer Hum	Fail / Dimming Range 100% - 40% Severe Strobe / Audible Transformer Hum	Fail / Dimming Range 100% - 50% Severe Strobe / Audible Transformer Hum		Fail / Dimming Range 100% - 50% Minor Strobe through range + audible hum	Fail - No dimming function No strobe + audible hum	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 30% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe / Audible T'former hum through range	Fail / Dimming Range 100% - 10% Minor Strobe through range + transformer hum
	Transformer 3	Fail / No Function / No Operation	Fail / Dimming Range 100% - 10% Minor Strobe @ 10%	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%				Fail / Dimming Range 100% - 50% Severe Strobe @ 50% & 100%			Fail / Dimming Range 100% - 20% Severe Strobe from 20% - 50% + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe at all setting stages + Audible Hum	Fail / Dimming Range 100% - 50% Severe Strobe at all setting stages + Audible Hum	Fail / Dimming Range 100% - 20% Minor Strobe up to 75%
	Transformer 4		Pass / Dimming Range 100% - 50% No Strobe + Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum	Fail / Dimming Range 100 - 50% Minor Strobe @ lower range + audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe No dimming		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Pass / Dimming Range 100% - 75% No Strobe + Audible hum	Fail - no dimming sever transformer hum	Pass / Dimming Range 100% - 20% No Strobe	Fail/ Dimming Range 100% - 50% Minor Strobe lower range	Pass / Dimming Range 100% - 75% No Strobe	Fail / No Dimming Range - Severe transformer Hum
	Transformer 5		Fail - reduce lumen output by 25% to 75% - Strobe through lower range - Limited dimming range between of 25% of reduced output	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 75% Minor Strobe @ 75%		Fail / Dimming Range 100% - 50% Minor Strobe through range + audible hum	Fail - No dimming function No strobe	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe between	Fail - No dimming function No strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe lower range
	Transformer 6		Fail / Dimming Range 100% - 20% Minor Strobe @ 20%	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Fail / Dimming Range 100 - 50% Severe Strobe 50%	Fail / Dimming Range 100% - 50% Minor Strobe @ lower range		Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 20% Minor Strobe through range + Audible Hum	Fail / Dimming Range 100% - 50% Severe Strobe at all setting stages + Audible hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum

MR16, 7.8W, 450 lm, 60D, GU5.3	Transformer 1		Fail - No light out put - no operation	Fail / Dimming Range 100% - 40% Minor Strobe @ 40% range setting	Fail / Dimming Range 100 - 50% Minor Strobe through range	Fail - No light out put - no operation. Lamp on at 100% with bridge		Pass / Dimming Range 100% - 40% No Strobe	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe from 20% - 50%	Fail / Dimming Range 100% - 40% Minor Strobe through range	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Pass / Dimming Range 100% - 50% No Strobe
	Transformer 2		Fail / Dimming Range 100% - 50% Minor Strobe @ 50% dim setting	Fail / Dimming Range 100% - 10% Minor Strobe through range setting				Pass / Dimming Range 100% - 10% No Strobe	Fail - No dimming function Minor strobe + audible hum	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe to severe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 40% Minor Strobe / Audible T'former hum through range	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 3	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe @ 25% dim stage	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%		Pass / Dimming Range 100% - 50% No Strobe		Pass / Dimming Range 100% - 10% No Strobe			Fail / Dimming Range 100% - 50% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe at 75% dim setting + Audible hum	Fail / Dimming Range 100% - 50% Minor Strobe at 75% dim setting + Audible hum	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 4		Fail / Dimming Range 100% - 50% Minor Strobe through range + audible hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% dim stage + audible hum	Fail / Dimming Range 100 - 50% Minor Strobe through range. Variable strobe as dimming decrease	Fail / Dimming Range 100% - 50% Severe Strobe through 75% - 100% + audible hum		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Fail / Dimming Range 100% - 75% Minor Strobe Through range + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe through range + Audible hum	Pass Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range + Audible hum	Pass Dimming Range 100% - 75% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range + Audible hum
	Transformer 5		Fail - reduce lumen output by 25% to 75% - Strobe through lower range - Limited dimming range between of 25% of reduced output	Fail / Dimming Range 100% - 10% Minor Strobe @ 10% - 50%	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 20% Severe Strobe @ 50%		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 75% No Strobe + Audible hum	Fail / Dimming Range 100% - 20% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe between 50% to 100%	Fail / Dimming Range 100% - 50% Severe Strobe	Pass / Dimming Range 100% - 10% No Strobe

	Transformer 6		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100 - 50% Severe Strobe @ lower range			Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%%	Fail / Dimming Range 100% - 10% Severe Strobe through range + Audible hum	Fail / Dimming Range 100% - 20% Severe Strobe / Audible T'former hum through range	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe
MR16, 10.5W, 720 lm, GU5.3	Transformer 1		Pass / Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe @ 10% - 30%	Pass / Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Pass / Dimming Range 100% - 30% No Strobe		Pass / Dimming Range 80% - 50% No Strobe	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 10% Severe Strobe between 10 - 30% One flash per second	Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100% - 10% Minor strobe only @ 10%
	Transformer 2		Pass / Dimming Range 100% - 40% No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100 - 40% Minor Strobe through range + Audible transformer hum	Pass / Dimming Range 100% - 50% No Strobe		Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Pass / Dimming Range 100% - 10% No Strobe + Audible Transformer Hum	Pass / Dimming Range 100% - 30% No Strobe + Audible Transformer Hum	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 3	Fail / No Function / No Operation	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100 - 40% Minor Strobe through range + Audible transformer hum			Pass / Dimming Range 100% - 50% No Strobe			Fail / Dimming Range 100% - 10% Severe Strobe between 10 - 30% One flash per second + **nil** transformer heating	Fail / Dimming Range 100% - 10% Severe Strobe between 10 - 50% One flash per second + transformer heating	Pass Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe
	Transformer 4		Pass / Dimming Range 100% - 50% No Strobe + Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum		Fail / Dimming Range 100% - 75% Severe Strobe through range + audible hum		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Pass / Dimming Range 100% - 75% No Strobe + Audible hum	Fail / Dimming Range 100% - 75% Strobe @ 100% + Audible hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Pass / Dimming Range 100% - 40% Stepless dim range No Strobe	Pass / Dimming Range 100% - 75% Stepless dim range No Strobe	Fail / Dimming Range 100% - 75% Strobe @ 100% + Audible hum

	Transformer 5		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100 - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%		Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 75% No Strobe + Audible hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% setting	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe through lower range	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe
	Transformer 6		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Fail / Dimming Range 100 - 20% Minor Strobe through range	Pass / Dimming Range 100% - 50% No Strobe		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%%	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Pass / Dimming Range 100% - 40% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 40% No Strobe
MR16, 8W, 540 lm GU5.3	Transformer 1		Fail / Dimming Range 100% - 50% Minor Strobe through range	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Fail / Dimming Range 100 - 50% Minor Strobe @ 50% and below	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Pass / Dimming Range 100% - 10% No Strobe		Fail / Dimming Range 100 - 50% Severe Strobe between across all ranges	Fail / Dimming Range 100% - 30% Minor Strobe through range	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe	Fail / Dimming Range 100% - 10% Minor strobe only @ 10%
	Transformer 2		Fail / Dimming Range 100% - 10% Minor Strobe through range	Fail / Dimming Range 100% - 10% Minor Strobe @ 10%	Fail / Dimming Range 100 - 40% Minor Strobe through range + Audible transformer hum	Pass / Dimming Range 100% - 50% No Strobe		Pass / Dimming Range 100% - 30% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100% - 10% Minor Strobe through range + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe between 10 - 50% dim setting + Audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe / Audible T'former hum through range	Pass / Dimming Range 100% - 30% No Strobe
	Transformer 3	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe @ 25% dim stage	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100% - 40% Severe Strobe through range + audible hum			Fail / Dimming Range 100% - 10% Minor Strobe between 10% - 50%			Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 0% Minor Strobe at 15% setting + Audible transformer hum	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe

	Transformer 4		Fail / Dimming Range 100% - 50% Minor Strobe through range + Audible hum	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer Hum		Fail / Dimming Range 100% - 50% Severe Strobe through 75% - 100% + audible hum		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Fail / Dimming Range 100% - 90% Medium Strobe + Audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe through range + Severe transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe @ 90% + Audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% 80% + Audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 100% + Audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 100% + Audible transformer hum
	Transformer 5		Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 20% Minor Strobe @ 20% - 50%	Fail / Dimming Range 100 - 20% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%		Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 75% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%%	Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail / Dimming Range 100% - 40% Severe Strobe lower range	Fail / Dimming Range 100% - 10% Minor Strobe lower range
	Transformer 6		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 20% No Strobe =z transformer hum	Pass / Dimming Range 100% - 75% No Strobe		Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 10% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 20% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe
MR16, 6W, 420 lm, GU5.3	Transformer 1		Fail / No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 0% Minor Strobe @ 75% down to 0% Severe strobe 75% - 100%	Fail / No Dimming Range Severe Strobe + audible hum from **LAMP**	Fail - No Dim function - No Strobe - Only 50% lumen output	Fail - No Dimming Range Severe Strobe		Fail - No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail / Dimming Range 100% - 10% Severe Strobe between 10 - 30%	Fail / Dimming Range 100% - 75% Severe Strobe	Fail - No Dimming Range Severe Strobe	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change
	Transformer 2		Fail / No Dimming Range Severe Strobe + audible transformer hum	Fail / No Dimming Range Severe Strobe + audible transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe through range + audible transformer hum	Fail - severe strobe @ 100% + Audible transformer hum. When dimmed lamp sits down. No light out put - no operation. With bridge sever strobe + Audible transformer hum		Fail / Dimming Range 100% - 50% Severe Strobe through range + audible transformer hum	Fail / No Dimming Range Severe Strobe + audible transformer hum	Fail / No Dimming Range Severe Strobe + audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe to severe through range + audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe through range + Audible hum	Fail - No Dimmer function Severe Strobe Transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe through range / Audible T'former hum through range

	Transformer 3	Fail / No Function / No Operation	Fail / No Dimming Range Severe Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe through lower range + audible hum			Fail / Dimming Range 100% - 50% Severe Strobe @ 50%			Fail / No Dimming Range Severe Strobe + transformer hum	Fail / No Dimming Range Severe Strobe + transformer hum	Fail / No Dimming Range Severe Strobe through range + Audible Transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe all range
	Transformer 4		Fail / Dimming Range 100% - 75% Severe Strobe through range + audible hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 100% + audible hum		Fail / No Dimming Range Variable frequency change of Severe Strobe through range		Pass / Dimming Range 100% - 50% No Strobe	Fail - No dimming function No strobe + audible hum	Fail - No dimming function Severe strobe + audible hum	Fail / Dimming Range 100% - 50% Sever Strobe through range + audible hum	Fail / Dimming Range 100% - 20% Severe Strobe through range + audible hum	Fail / Dimming Range 100% - 40% Severe Strobe through range + audible hum	Pass / Dimming Range 100% - 50% No Strobe through range + audible hum
	Transformer 5		Fail / Dimming Range 100% - 75% Severe Strobe through range	Fail / No Dimming Range Severe Strobe	Fail - No dimming function. 100% no strobe. Set dimmer zero lumen output + audible hum	Fail / No dimming function		Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail - No dimming function No strobe + audible hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%%	Fail - No dimming function Strobe + audible hum	Fail - No dimming function Minor strobe	Fail - Severe strobe as dimming changes in frequency of strobe	Fail / No Dimming Range Severe Strobe through range
	Transformer 6		Fail / Dimming Range 100% - 40% Severe Strobe through range	Fail / No Dimming Range Severe Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Fail / No Dimming Range NoStrobe		Fail / Dimming Range 100% - 40% Severe Strobe through range	Fail / No Dimming Range NoStrobe	Fail / Dimming Range 100% - 40% Severe Strobe through range	Fail - No dimming function Strobe + audible hum	Fail - No dimming function No Strobe + audible hum	Fail - Severe strobe as dimming changes in frequency of strobe	Fail - Severe strobe as dimming changes in frequency of strobe
MR16, 7.8W, 36D GU5.3	Transformer 1		Fail - No light out put - no operation	Fail / Dimming Range 100% - 30% Minor Strobe @ 30% - 75%	Fail / Dimming Range 100% - 50% Severe Strobe through range	Fail - No light out put - no operation. Lamp on at 100% with bridge		Fail / Dimming Range 100% - 50% Minor Strobe @ 50%	Fail - No Dimming Range Severe Strobe variable frequency of strobe	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% setting	Fail / Dimming Range 100% - 40% Severe Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe between 50 - 100%	Fail / As dimmer setting changes strobe frequency varies from slower to higher 10% to 100%. No light level change	Pass / Dimming Range 100% - 50% No Strobe
	Transformer 2		Fail / Dimming Range 100% - 50% Minor Strobe @ 50% dim setting	Fail / Dimming Range 100% - 10% Minor Strobe @ 10%	Fail / Dimming Range 100 - 10% Minor Strobe through range + Audible transformer hum	Fail - No light out put - no operation on dimmer. With brings 100% output no strobe no transformer hum		Pass / Dimming Range 100% - 10% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 10% No Strobe	Fail / Dimming Range 100% - 30% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 10% Minor Strobe / Audible T'former hum through range	Pass / Dimming Range 100% - 10% No Strobe

	Transformer 3	Fail / No Function / No Operation	Fail / Dimming Range 100% - 50% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%				Pass / Dimming Range 100% - 10% No Strobe			Fail / Dimming Range 100% - 50% Minor Strobe through range + Audible transformer hum	Fail / Dimming Range 100% - 50% Minor Strobe at 75% dim setting + Audible hum	Fail / Dimming Range 100% - 50% Minor Strobe at 75% dim setting + Audible hum	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 4		Fail / Dimming Range 100% - 50% Minor Strobe through range + audible hum	Fail / Dimming Range 100% - 50% Minor Strobe @ 50% dim stage + audible hum	Fail / Dimming Range 100 - 50% Minor Strobe through range. Variable strobe as dimming decrease	Fail / Dimming Range 100% - 50% Severe Strobe through 75% - 100% + audible hum		Pass / Dimming Range 100% - 50% No Strobe + Audible hum	Fail / Dimming Range 100% - 75% Minor Strobe Through range + Audible hum	Fail / Dimming Range 100% - 50% Severe Strobe through range + Audible hum	Pass Dimming Range 100% - 40% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range + Audible hum	Pass Dimming Range 100% - 75% No Strobe	Fail / Dimming Range 100% - 50% Severe Strobe through range + Audible hum
	Transformer 5		Fail - reduce lumen output by 25% to 75% - Strobe through lower range - Limited dimming range between of 25% of reduced output	Fail / Dimming Range 100% - 10% Minor Strobe @ 10% - 50%	Fail / Dimming Range 100 - 50% Severe Strobe @ 50%	Fail / Dimming Range 100% - 20% Severe Strobe @ 50%		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 75% No Strobe + Audible hum	Fail / Dimming Range 100% - 20% Minor Strobe through range	Fail / Dimming Range 100% - 50% Severe Strobe @ 50%	Fail / Dimming Range 100% - 50% Severe Strobe between 50% to 100%	Fail / Dimming Range 100% - 50% Severe Strobe	Pass / Dimming Range 100% - 10% No Strobe
	Transformer 6		Pass / Dimming Range 100% - 50% No Strobe	Pass / Dimming Range 100% - 20% No Strobe	Fail / Dimming Range 100 - 50% Severe Strobe @ lower range	Fail / Dimming Range 100% - 20% Severe Strobe @ 50%		Pass / Dimming Range 100% - 20% No Strobe	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Fail / Dimming Range 100% - 50% Severe Strobe @ 50% - 100%%	Fail / Dimming Range 100% - 10% Severe Strobe through range + Audible hum	Fail / Dimming Range 100% - 20% Severe Strobe / Audible T'former hum through range	Pass / Dimming Range 100% - 50% No Strobe / Audible Transformer hum	Pass / Dimming Range 100% - 0% Stepless dim range No Strobe

Note: test results are not an assessment of the quality of the individual products selected, rather how a combination of products perform together in the tests carried out for this initial evaluation of the extent to which compatibility issues are present in the market. Further, manufacturers of the specific products tested may not be claiming that the product combinations tested are compatible with each other.