



# F-SERIES RFI SUPPRESSION FOR SINGLE PHASE POWER REGULATORS

**F-RFI**

X10229

## INTRODUCTION

Phase-angle power controllers generate Radio Frequency Interference (RFI) during each half-cycle of the mains waveform when the power is switched on. In sensitive applications this interference, or interaction with other equipment, must be suppressed to comply with the Electromagnetic Compatibility Regulations 1992 (SI 1992 No.2372). Appropriate suppression may be achieved by the addition of a series choke and capacitor network incorporated in a filter module. The F-type series filter modules have been manufactured to complement the UAL range of phase angle power controllers.

## INSTALLATION

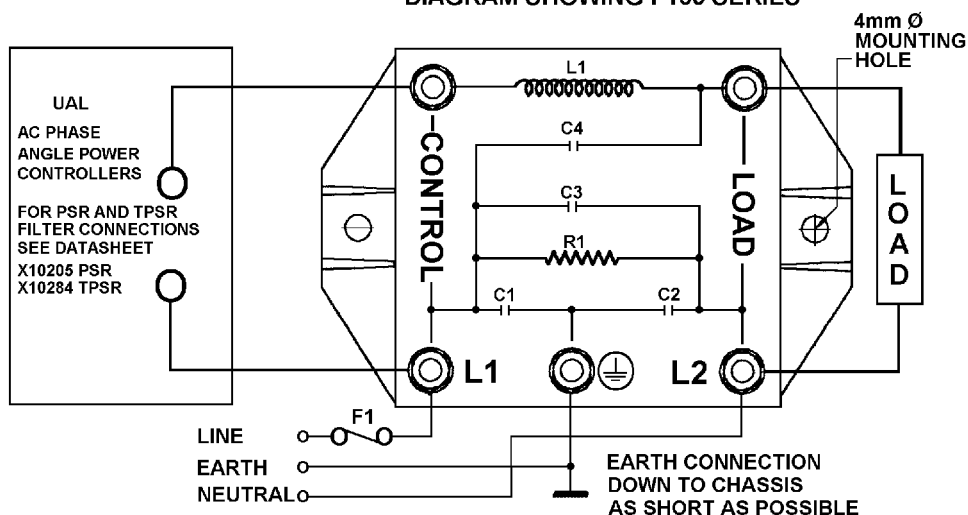
**FUSING**  
SEMICONDUCTOR FUSE (F1)  
OR CONTACT BREAKER  
RATED AT LINE CURRENT

RoHS Compliant  
Directive  
2002/95/EC

**WARNING LIVE TERMINALS**  
**THIS UNIT MUST BE EARTHED**

## CONNECTIONS

DIAGRAM SHOWING F165 SERIES





## SAFETY REQUIREMENTS

### ADVICE SHEET

**SRA**

X10255

#### **INTRODUCTION**

The objective of this leaflet is to provide information to ensure that the safety of the person(s) installing or maintaining the equipment is not jeopardised and its location and method of installation does not endanger others, during or after installation.

Customers should be aware of the Health and Safety at Work Act 1974 (HSW 1974) and the EC "Provision and Use of Work Equipment Regulations 1992" (PUWER), both available from the Health and Safety Executive (HSE) publications, within the UK.

#### **INSTALLATION**

##### **CE Directives**

These are European regulations which are appropriate to our industry. They affect the equipment emissions and immunity to Radio Frequency Interference (RFI) and various elements of safety for electrical equipment.

The European Community (EC) 'CE' Directives that mainly concern *United Automation Limited (UAL)* are the Low Voltage Directive (**LVD**) and the Electromagnetic Compliance Directive (**EMC**). With further reference to appropriate European Harmonised Standards, the Company opted for the self certification method of assessment to address the wide range and variety of products supplied by *United Automation Limited*.

A Declaration of Conformity may be supplied with the product or supplied on request.

##### **Cooling Requirements**

*United Automation Limited* manufacture and use a wide range of discrete power semiconductors, which under load conditions, may generate excessive heat. We therefore recommend some form of cooling, or additional cooling for high power rated products.

The use of an additional heatsink (this could be a conductive panel) suitably attached or mounted with the unit, will help to dissipate heat away from the device(s). An alternative or additional method would be forced air cooling (using a fan), helping the natural convection of air flow over an existing heatsink within the unit.

The equipment's environment and its initial ambient temperature also need to be considered, as this could have an adverse effect to the overall operating conditions.

##### **Fusing**

We recommend that semiconductor (fast acting to BS88 [IEC 269] ) type fuses or circuit breakers (Semiconductor - MCB) should be used for unit and/or device protection. The appropriate maximum load current should be known to select the required SCR fuse or MCB, but must not exceed the equipment rating. The  $I^2 t$  ( $A^2 s$ ) rating of the selected fuse, must be less than that of the equipment so as to protect the equipment's discrete device. Further appropriate fusing may be required for protection of the unit supply using standard fuse links and holders. Failure to address these requirements and use incorrectly selected fuses, may cause the equipment to fail.

##### **Earthing**

The protective conductor terminal of the equipment must be utilised at all times and bonded to a 'good' Earth (ground). The earth bonding (strapping) leads of any combined equipment should be as short as possible and be substantial (i.e. at least rated higher than the equipment's load). For further information refer to BS7671 (*see MAINTENANCE below*) Following these simple guidelines will ensure optimum use of any appropriate filter circuits which may be required.

##### **Insulation (overvoltage category) and Protection of electric shock Classification of Equipment**

All equipment, unless otherwise stated, is rated to CLASS II Insulation (overvoltage category) and CLASS I Protection category. For specific insulation test voltage ratings, see Equipment Datasheet.

#### **MAINTENANCE**

Electronic equipment has few mechanical moving parts and is therefore, inherently, very reliable. Before any servicing is carried out, reference should be made to appropriate installation instructions, drawings and labelling which may come with the equipment. Personnel should switch off the unit supply before accessing or removing a safety cover and be aware of 'hazardous live' parts.

We recommend that installation and maintenance of all *United Automation Limited* equipment should be done with reference to the current edition of the I.E.E. wiring regulations (BS7671), by suitably qualified/trained personnel. The regulations contain important requirements regarding safety of electrical equipment within the UK (For International Standards refer to I.E.C Directive IEC 950).



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# INTERACTION CAUSES AND REMEDIES

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## INTERACTION

A sudden current change within a conductor generates Radio Frequency Interference (RFI). Thus, unsuppressed Phase Angle thyristor or triac power systems inherently generate RFI, rising to maximum at mid-phase angle. High impedance Phase Angle controlled thyristor trigger circuits can be considered as sensitive receivers of any generated RFI.

These two characteristics of adjacent Phase Angle controlled systems can cause interaction (also called Cross-talk or Tracking), unless the following procedures are used.

Zero Voltage Switching (ZVS) control removes this problem and should always be first choice in multi-thyristor systems for resistive loads.

Both Phase Angle and Burst Firing control are detailed further on page 2.

## INTERACTION REMEDIES IN PHASE-ANGLE CONTROL SYSTEMS

In sensitive applications, interference must be suppressed to comply with Electromagnetic Compatibility Regulations 1992 (SI 1992 No. 2372), this includes emissions and immunity standards, to prevent and protect against interaction with other components. This may be achieved by the addition of a series, parallel combination filter network.

The following guidelines are important aspects for correct circuit layout, to help eliminate interaction problems in power application circuits:-

Run both leads of each power circuit as a twisted pair and when practical, avoid close proximity to other RFI transmitting or receiving components. Earth leads should be rated higher than the maximum power of the circuit and kept as short as possible.

Ideally, to achieve the above, keep the widest possible spacing between phase angle firing controlled circuits and other large power carrying conductors.

Any high impedance signal/control wires should be kept as short as possible, preferably twisted, shielded and separate from power cables.

Avoid wires encircling magnetic components (e.g. Transformers).

A series inductance fitted in the supply line will limit  $di/dt$  at thyristor switch-on and consequent transmitted output, reducing the risk of interaction ( See RFI Data Sheet).

Interaction is a whole system phenomena resulting from the nature of phase-angle thyristor control and will almost always be eliminated by some or all of the above steps.

## RFI FILTERS

A 'type' filter would normally be required because of the function of Phase Angle control firing of Power circuits, to reduce the RFI to an acceptable level of EMC emission standards. These standards are identified on the appropriate Declaration of Conformity, to address the 'CE' marking of products. Particular attention should be paid to 'good earth bonding' and current selection for the F1-series 'type' filters which incorporates a series choke, to achieve maximum choke efficiency.

*see also RFI Datasheets for connections and available type filters.*

The performance of any thyristor system and its suitability for a particular application depends on the type of control circuit used. The main types, characteristics and features of both Phase Angle and Burst Firing circuits, showing the waveforms and probable sources of RFI, are detailed below:-

### PHASE ANGLE TYPES

(e.g. CSR, QVR and PSR family)

These are universally applicable and are often more economical but are susceptible to RFI caused interaction between systems.

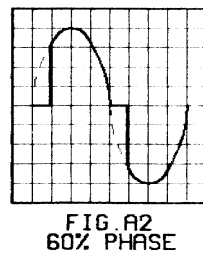
### ZVS, BURST FIRING TYPES

(e.g. BVR, ZVT family)

These are virtually free from RFI problems but are only suitable for resistive loads.

#### PHASE ANGLE

Graphs show load voltage against time on 1/50 second repeating time base at 30% and 60% throughput. Output is a chopped sine wave allowing more power through as conduction angle is increased.

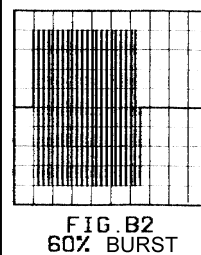
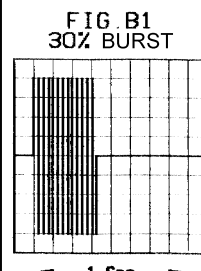


#### GENERATION OF RFI

The step function of current creates a wide range of radio frequencies and is the main source of RFI.

#### BURST FIRE

Graphs show load voltage against time on 1 second repeating pattern time base at 30% and 60% throughput. Output is block bursts of complete sine waves, switched on and off at zero voltage mains crossover. More power is allowed through as ON to OFF ratio is increased.



#### INHIBITION OF RFI

No step function as current is only switched on at zero voltage, therefore the RFI problem is eliminated.

### PHASE ANGLE FIRING FEATURES

In each mains half cycle the duration of thyristor conduction is determined by the firing instant, relative to mains polarity changeover. Once switched on, the driven thyristors conduct power to the load until the end of each applied half cycle, resulting in a chopped sine wave output. A ramp and pedestal input circuit, allowing variation of firing phase angle by DC signal, enables more power through to the load with increasing conduction angle. Advantages of phase angle firing include: Operation with all types of loads including inductive, soft start, current limit facility and stepless quick response.

### BURST FIRE FIRING FEATURES

Using Zero Volts Switching (ZVS) burst firing, the alternative form of triggering, gives interference free AC power control. This circuit inhibits RFI by switching 'on' and 'off' at zero volts mains crossover, in repeating time periods (typically one second). The number of complete mains sine waves are varied in its ON/OFF ratio, or duty cycle, linearly by the control signal level. The burst firing circuit provides trigger pulses coincident with mains zero polarity change-over, ensuring only complete half cycles are passed through to the resistive loads. This prevents step changes in load current, and thus virtually no RFI is produced. UAL Burst Firing Circuits are available and suitable for 2,3,4 or 6 wire load connections (see 'Stacks' Product Technical Datasheets). Stability against temperature and supply voltage variations is exceptionally good.



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