Analysis of Testing Requirements

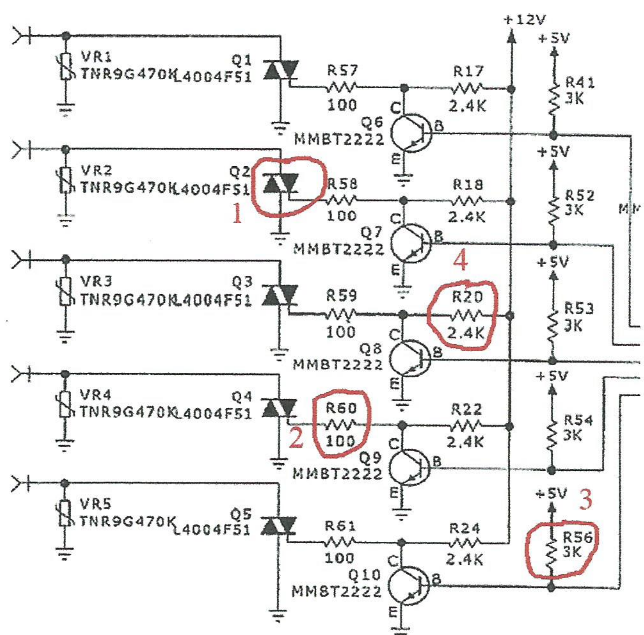
For

ASI/1-6000 and ASI/1-8800

January 20, 2009

This document is prepared in answer to questions regarding the extent to which ASI Controls product listed above should undergo testing to verify appropriate behavior under all operating conditions within the specified range incorporated in ASI Controls literature and documentation.

Upon first exposure to the two products and their current state of development, it became clear that there were a number of variables to be considered when making judgments about testing. These products are in a constant state of revision, from the Printed Circuit Boards (PCB), through component selection, to and including the various Actuators to be coupled to the Controllers themselves. During the following discussion, reference should be made to Figure 1 below.



First, the PCB revisions for the ASIC/1-6000:

1. Revision C-1: A board with the Low-Power Version of the Microprocessor, the so-called 'V-chip', without the 100 Ohm resistors denoted as '2' above, and with the pull-up resistors denoted by '4' above being the value of 1.24Kohms. Since it has previously been determined that the resistors '2', in the figure above, are necessary to proper field behavior with certain actuator

loads, this PCB revision will not be utilized in the future, but is a reference point in the evolution of the current product.

2. Revision C-2: This board has the older, discontinued 'Higher Power' microprocessor installed, the '4' resistors valued at 2.4Kohms and a set of 'intermediate' Triacs, to be discussed in this document below.
3. Revision D-1: A board with the 'V-chip' installed, the 100 Ohm resistors '2' included as in the figure above, original Triacs from all previous product utilized, and with resistors '4' valued at 2.4Kohms.
4. Revision D-2: The same as D-1 board, but with the value of resistors '4' valued at 1.24Kohms. This revision, as D-1 above, has limited usefulness, as one of the on-board interconnecting terminal strips is erroneously rotated 90 degrees from the appropriate position. Note that there are 24 units in house, and will be used as Beta releases to a limited customer set to verify proper functioning in the field. The rotated connector does not cause these boards to be discarded, but represents the final product, less the rotated connector.
5. Revision E: Not yet available, this unit will correct the rotated connector in D-2 above. This unit will also include the 'intermediate' Triacs to be discussed below.

It will be clear from the previous discussion, that there are boards with various versions of Microprocessor, resistors in (or not in) positions '2' and '4', and Triacs of various versions. We will treat each of these separately below.

Next, the Various Motor-driven Actuators in Use.

1. The currently offered Bolimo LMZS, an integrated motor drive included within the housing provided by the vendor to ASI Controls, on which ASI mounts the PCB to create the ASIC/1-6000 product. This unit provides 35 inch-pounds of torque.
2. A proposed offering from Bolimo, the LMB-24 actuator, designed to replace the LMZS with the same enclosure for ASI mounting of the PCB. This unit provides 45 inch-pounds of torque and appears to be the replacement for a soon to be discontinued LMZS.
3. A Bolimo Model LR-24, not offered by ASI Controls, but furnished by customers in the field to be driven to operate motor driven Hot-water Valves. This type of actuator was found to 'lock-up' ASI VAV product last year, finally satisfactorily resolved by the addition of a component to the ASIC/1-6000 PCB. This will be discussed later in this document.
4. A newer Bolimo Model LRB 24-3, also utilized by customers to operate Hot-water Valves. I believe that little or no testing has been done on this product.

Though some of the listed products are furnished by customers in the field, all ASI product must be able to cope with the various electrical characteristics of such devices, up to and including their idio-centric 'noise' behavior.

Finally, the Various versions of Triacs utilized in ASI product.

1. The older version of the Triacs that have been utilized in ASI product for many years and which are now being phased out and replaced with newer technology. This Triac is a four-layer device, with a heat-sink tab integrally connected to the gate lead and is almost always installed vertically to avoid accidental contact of the active tab to adjacent circuitry. The case-type is T0-202.
2. A very similar case type of T0-220, with electrical characteristics and specifications identical to the T0-202, but with the heat-sink tab electrically isolated from the internal circuitry, allowing the tab to be mounted horizontally and soldered to a copper substrate of the PCB.
3. Finally, future ASIC/1-6000 product and all ASIC/1-8800 product will utilize a Surface-Mounted-Carrier (SMC) to be mounted horizontally on all PCB substrates.

It may appear to be an advancement in technology to replace the T0-202 case with the T0-220, however, because of the lack of internal contact of the heat-sink tab to active circuitry, it is essential that the lower rate of heat radiation and conduction of the newer case be taken into consideration during performance testing.

Tracing the Evolution of Revisions of the ASIC/1-6000.

The 3K Resistors: Early last year, the manufacturer of the Microprocessor utilized in the ASIC/1-6000 lowered internal chip power consumption by increasing the value of the internal pull-up resistor of the port outputs. It is not known whether this was an actual resistance change or an internal current-source reduction. The net effect was to lower the amount of current available to drive the transistor bases of Q6 through Q10 in the Figure above. The lower drive current into the base of those transistors, under wide temperature variations, was insufficient to guarantee that the transistors would turn on to a saturation state, such that a maximum of approximately 50 Millivolts would appear from their collector to common. When a higher voltage appeared because of this lack of base drive, the higher collector voltage was applied to the gate of the associated Triac, causing that Triac to stay in the ON condition when it should have turned OFF. This situation was rectified by adding the resistors labeled '3' in the Figure above. The value of 3Kohm was determined to be sufficient to keep the transistors in a saturated state when required to do so.

The 100Ohm Resistors: Later in the last year, we were involved in determining the cause of field experienced 'Lock-up' of the Microprocessor installed in the 6000. With certain actuators connected to the outputs of the controller, occasional, intermittent cases would occur during which the Microprocessor would stop functioning altogether, requiring a power removal and replacement to regain functionality. It was determined that electrical spikes in voltage at the terminals of the controller could result in sufficient current to be forced back from the Triac gate, through the saturated Transistor, collector to base, into the output port of the Microprocessor, causing havoc inside and 'Lock-up'. Since Triacs will turn OFF anywhere during the sinusoidal waveform, occasionally, the OFF command came during high voltage portions of the waveform, causing severe spikes of voltage caused by attempting to stop current rapidly in an inductive load. This was alleviated by inserting a low value resistor in series with the gate of the Triac, resistors '2' in the Figure above. This allowed the power of the spike discharge to be dissipated across the resistor, instead of continuing on through the circuitry and eventually reaching the output port of the Microprocessor. The addition of these resistors has eliminated the problem found in the field with certain actuator types.

The 1.24K/2.4K Resistors: Like any good story there is always a counter-tale. After the addition of the 100Ohm resistors, '2' in the Figure above, and with the acquisition of suitable Temperature Testing Equipment, it was determined that there were very low temperature conditions at which the output Triacs would fail to turn ON completely. That means that one-quadrant of switch would turn ON, but the other quadrant would remain OFF. This occurred at –8degrees C. Consulting the Figure above, it will be noted that a 12 Volt power source will deliver a maximum of 5MA of current into the gate of the associated Triac. At extreme temperatures, this is marginal and occasionally will result in the defective performance noted in testing. By reducing the value to 1.24Kohms, the available gate current is almost doubled to 10MA and this is sufficient to assure the proper behavior of the Triacs at extreme low temperatures.

Where from here?

In each case of the identification of a performance failure, corrective action has been undertaken and proper performance has been demonstrated. After full discussion with members of the ASI Controls Engineering staff, it has been determined that most testing has been adequate for the ASIC/1-6000. However, when the number of variables are considered: Values of resistors and types of Triac cases, it appears that one area that has not been adequately addressed is that of the lower value of the resistors '4' in the Figure above and the 'new technology' Triacs, utilizing the 'isolated' heat-sink tab. **Since the resistor value will provide a higher gate current to the Triac and the 'isolated' heat-sink will not dissipate heat as efficiently, testing at the higher limits of temperature with at least double the expected load currents in the Triacs must be undertaken to fully qualify the ASIC/1-6000 controller**. This should be performed with the PCB loaded as it will be shipped to customers. Of course, it would be wise to test for proper performance over the full temperature range, but the higher end will be the determining factor.

This document has been prepared with the intent to bring the ASIC/1-6000 product to completion. There will be similar attention to testing as applied to the ASIC/1-8800 and that will be left to future consideration.

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