# AN1296
# Application note

## Ring wave tests with ACS108 driving valves and pumps

### Introduction

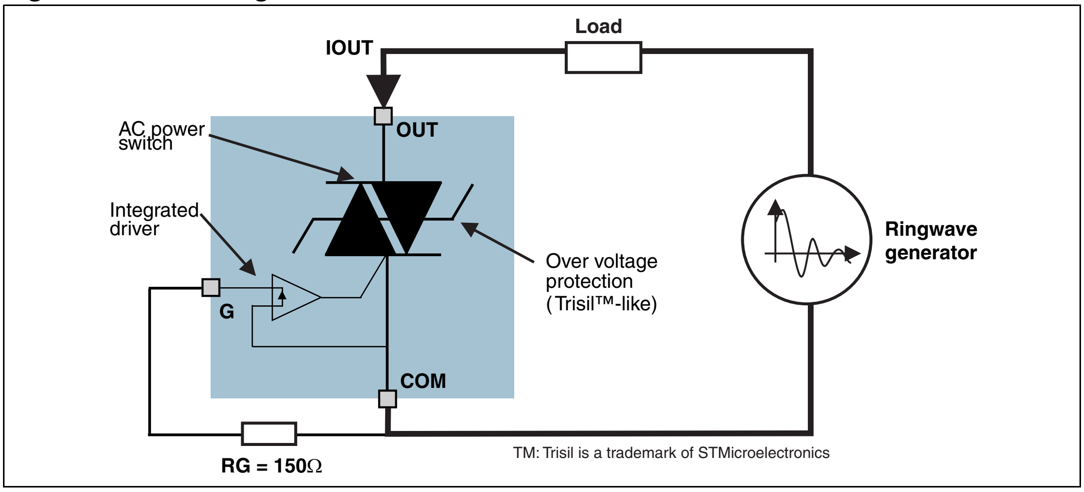
In this application note, test results obtained using ACS108 AC switch devices are presented in order to analyze their behavior when subjected to standard ring wave surges. The behavior of these devices subjected to a 1.2/50 µs impulse wave is specified in the datasheets.

The test procedure is described in the UL858A standard. The only difference with the tests below is that the normalized waveform is applied directly to the semiconductor and the load (refer to *Figure 1*).

No coupling network is used to apply the surges while the system is connected to the mains terminals. The only stress is due to the breakover turn-on current. The current conduction during half mains cycle is not an issue.

The ACSs are not triggered by their gate - they turn on by over voltage when the generator voltage exceeds their clamping level. The surge is then applied across the load and the load current flows through the ACS™ which is in the on state.

**Figure 1. Test diagram**




All the following oscillograms have been produced using the equipment listed below:

- Tektronix TDS754A scope
- Tektronix voltage P6013A probe (1/1000 ratio)
- Eurocraft pulse current transformer (1 V /10 A ratio)Tektronix TCP202 current probe

TM: ACS is a trademark of STMicroelectronics

# 1 Results

Three kinds of loads have been used during the tests.

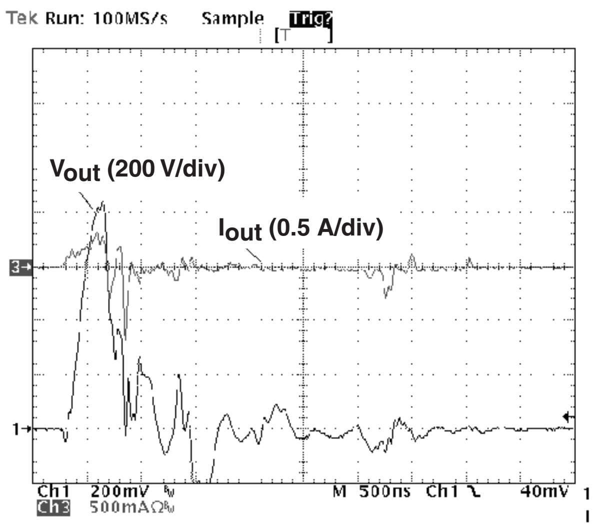
- Valve
- Pump
- Resistor rated at 5 W, 150 Ω

## 1.1 Valve

The valves used were rated for 120 V, 50 mA, 60 Hz operation. Two different types of behavior can appear during ring wave test when using such valves.

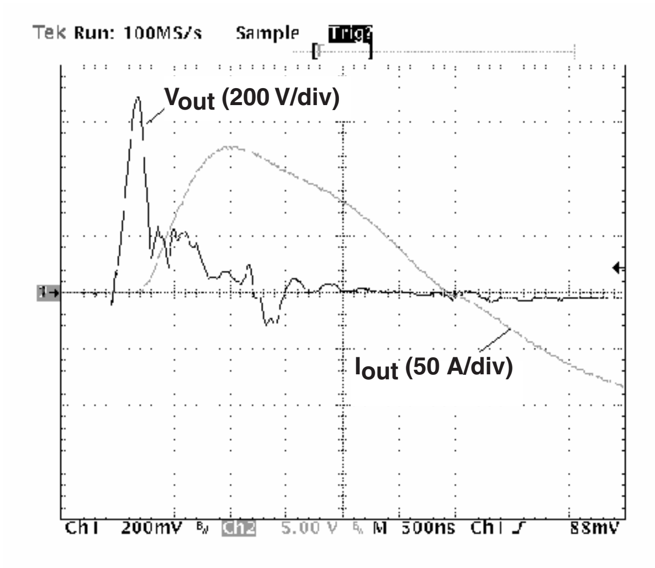
- The valve insulation is sufficient: when the ACS turns on, the current is limited by the load inductor. Only a capacitive current (approximately 250 mA peak, see *Figure 2*) can be seen during the rise of voltage across the switch. Such a turn on is not stressful for the device.

**Figure 2. 3 kV surge with a well insulated valve**



- The valve insulation is not sufficient: in this case, the valve oil winding insulation breaks down when the switch turns on, i.e. when the whole surge voltage is applied across the valve. The load then behaves like a short-circuit. The ACS current is no longer limited and could reach up to 120 A (refer to *Figure 3*). The conduction losses could then be so high that the die silicon could melt or its bonding wires could fuse and cause the destruction of the device package. In practice, as the test is done with the complete equipment including clamping devices or filters, this behavior does not occur.

**Figure 3. 3 kV surge with an insufficiently insulated valve**

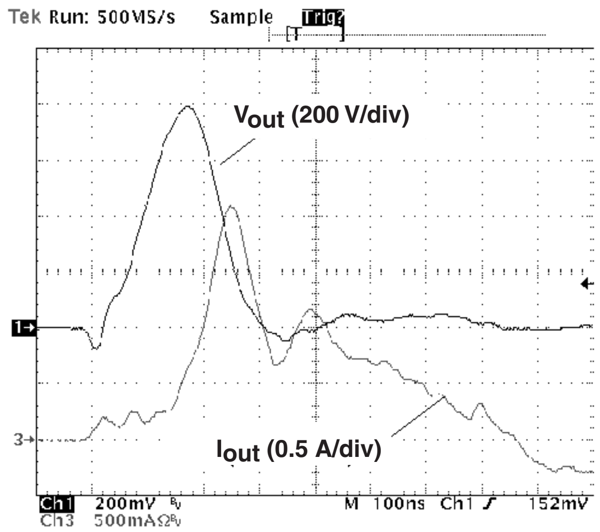


## 1.2 Pump

The pumps which have been tested are rated for 120 V, 700 mA, 60 Hz operation. They withstand the high voltage of the generator up to 6 kV, without flashing.

*Figure 4* shows the behavior of an ACS with this load. During the breakover of the devices, a capacitive current flows through the parasitic capacitor of the load due to the high dV/dt rate applied to it. This current can reach up to 2 A. As the current pulse lasts around 100 ns, there is no thermal issue. ACSs can withstand such a stress without any damage.

**Figure 4. 6 kV test with the pump**

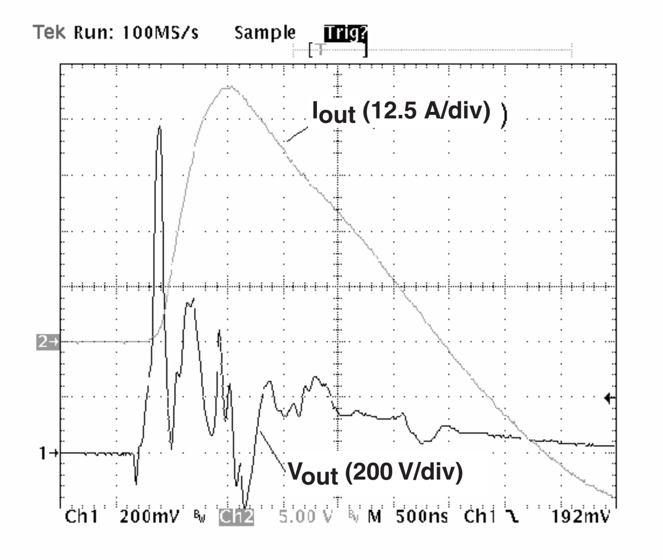


## 1.3 Resistor rated at 5 W, 150 Ω

In order to check the good behavior of ACSs during a ring wave test, whatever the load is, we have performed trials with a 150 Ohm resistor. This value is equivalent to the resistor of a 120 V-10 W light bulb at cold state. The chosen resistors present a serial inductance lower than 3.5 µH. So, as the device turns on in breakover mode, the current rate of increase is not limited by the load. This case seems to be the worst one that can appear in practice for ACS108 products (no inductive and low resistive load).

*Figure 5* shows an oscillogram for a 6 kV surge. The current reaches up to 57 A, with a 130 A/µs slope. Sixty positive surges and sixty negative surges have been applied, as required in the UL858A standard. Tested devices did not present variation of any parameters after the trials.

**Figure 5. 6 kV ring wave test with a 5 W, 150 Ω resistor**



# 2 Conclusion

Ring wave surges, as defined in the UL858A, can be applied on systems including ACSs as long as the loads used are also compatible with the UL858A.

- Valves: 50% of the tested valves sustain the 6 kV surge. In this case, ACSs are compatible with the 100 kHz ring wave defined in the UL858A.
- Pumps: driven by an ACS, it is compatible with the UL858A. These loads can be up to 700 mA. In these case, thermal behavior has to be mastered to keep the junction below maximum junction temperature.
- For a 150 Ω resistor, which seems to be the worst case for the power range of the targeted loads, ACSs also are in line with the UL858A standard without any risk of damage.

ACSs comply with the UL858A when the loads are able to withstand the required level of voltage (6 kV). If not, a spark gap can be implemented by bringing closer the two non-insulated copper tracks where the mains plug is connected. A 3 mm distance will reduce the input over voltages to approximately 3 kV.

# 3 Revision history

Table 1. Document revision history

| Date | Revision | Changes |
|---|---|---|
| Aug-2001 | 1 | Initial release. |
| 23-Apr-2009 | 2 | Reformatted to current standards. Updated for current products. |
| 22-June-2010 | 3 | Updated trademark statements. |