APPLICATION NOTE

Application Note AN-1204

Application Note, explaining the overload/short circuit power dissipation, Remote Sense and output filtering of ARE28XXS/D

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1 PREFACE

The ARE28XXS/D, shortly referred to as ARE28 series, are Radiation Hardened converters with 5W output power. They are designed with goals of simplicity, performance, reliability and compactness. This Application Note explains the overload/short circuit behavior and resultant power dissipation so that the customer understands how to properly design the heat sink for such abnormal conditions. Other sections of this Application Note explain Remote Sense and how to enhance output filtering such that it is possible to achieve output ripple at or below 5 mV p-p.

2 BACKGROUND

Application of ARE28XXS-D converters will be in satellites and deep space probes. For such space applications, heat dissipation is only through convection. Hence it is essential that for all operating conditions, including severe overload and short circuit, design of heat dissipation subsystems built for space should comply with established and accepted standards. Coupled with this consideration is the MTBF, which degrades with rise in case temperature of ARE28XXS-D converter.

It is prudent to use a heat sink, such as an aluminum plate, for mounting the ARE28XXS-D so that the case temperature can be reduced. This is especially true for those customers, who want higher MTBF and also envisage over load and/or short circuit conditions during the operating life.

3 DESIGN CONSIDERATIONS

First and foremost, one has to study the Thermal Analysis of ARE28XXS-D. It provides very useful information about following:

(a) Power dissipated in each die of power semiconductor and resistor when ARE28XXS-D is operating at full load. This is very useful for determining power dissipation in die of Rad Hard MOSFET and Schottky Rectifiers, which are main power dissipating active components.
(b) Estimated rise in temperature of die of those components.
(c) Different layers of the thick Film Hybrid and their respective thermal resistance to facilitate computation of allowable power dissipation for a given case temperature.
(d) Thus allowing study of worst case scenario when overload takes place.

3.1 Over Load Behavior

Overload power dissipation is defined as the device power dissipation with the load set such that VOUT = 90% of nominal.

At factory the overload trip point is laser trimmed to a value around 175% of the full load current rating of the converter. However, due to component variations and considering worst case scenario, Data Sheet indicates 200% as the maximum overload. Group C results of many finished ARE28XXS-D converters show the actual measured values of overload setting below 175%.

As per the embodied design, ARE28XXS-D follows sequence of events internally taking place:

a) When external load (circuit) tries to draw more current than the full load rating of ARE28XXS-D, its output voltage goes down to 90%, while the output current proportionately increases, thus keeping output power constant. But if overload keeps increasing, the converter's output voltage further goes down. Under severe/dead short circuit, the converter maintains only a low voltage value to keep power dissipation within converter to 3 W or below.
b) Upon removal of output short circuit or overload, the converter resumes normal operation. Thus, it is a fail-safe design, giving utmost reliability under severest external conditions. The actual measurement of output voltage and output current of ARE2805S is depicted graphically in Figure (1) to get complete picture of this protection feature.

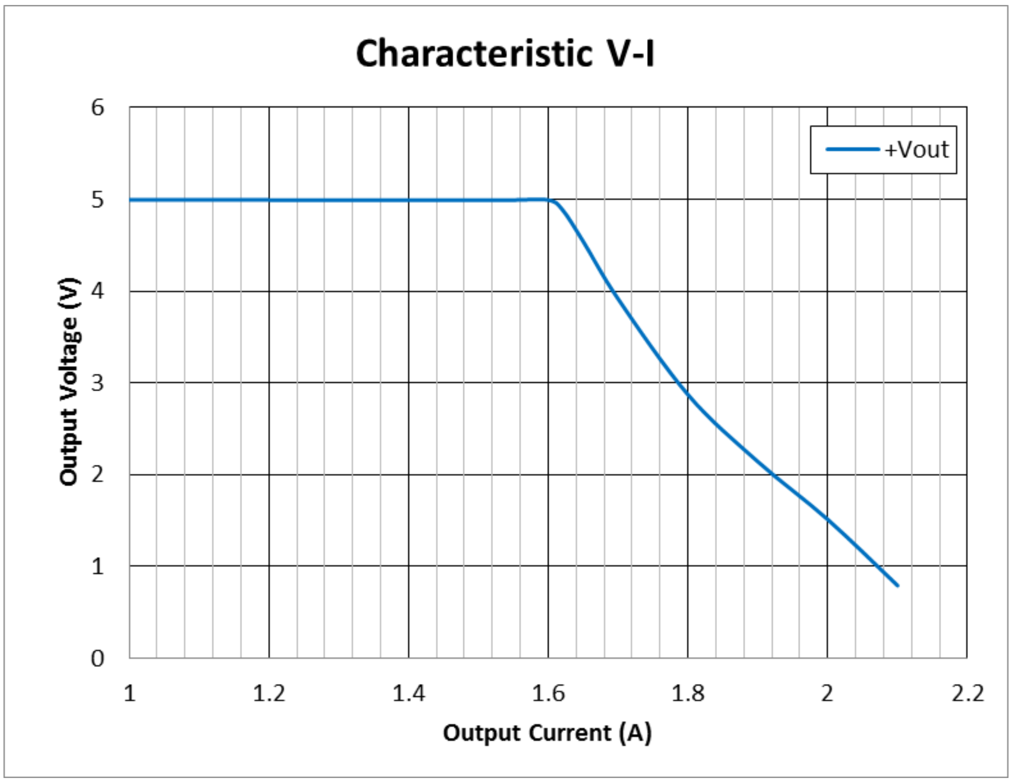

Figure (1) Output Current vs Output voltage during short circuit (ARE2805S)

3.2 Design of Heat Sink

Under sustained short circuit or severe overload, dissipation of 3 watts inside ARE28XXS-D can cause its case temperature to rise. An optimally designed heat sink can help maintain the case temperature to a safe value. This is recommended for space applications to achieve higher MTBF under all possible worst case operating conditions.

For satellites and space borne payloads, criteria for choosing such a heat sink involve size and weight restrictions also. So highest acceptable temperature rise should be used for working backwards to design a heat sink.

For example, let us assume we have 35°C in space environment and we accept a temperature rise of 25°C above this and thus design a heat sink to maintain case temperature of 60°C. Same methodology can be followed for any other allowable temperature rise or any other acceptable size and weight of heat sink. This is, because heat can be transferred only by conduction and radiation in space

The Thermal Analysis of ARE28XXS-D goes into great details about power dissipation and likely temperature rise of each power semiconductor die used in the converter, stating margins between its rated dissipation and actual designed-in dissipation. As can be appreciated, this margin is sufficient for guaranteeing reliable performance during its lifetime.

4 REMOTE SENSE:

The remote sense feature helps maintain output voltage regulation at the load by correcting for the voltage drop along the conductors that connect the load to the converter's output. This feature is available only on single output model (ARE28XXS). To use this feature connect ±Sense pins directly to the load. One can use thinner gauge wires for this connection, but it is recommended that these wires be twisted. Alternatively one can use a shielded cable with the shield being connected to case of the converter, which can be grounded as shown in Figure (2)

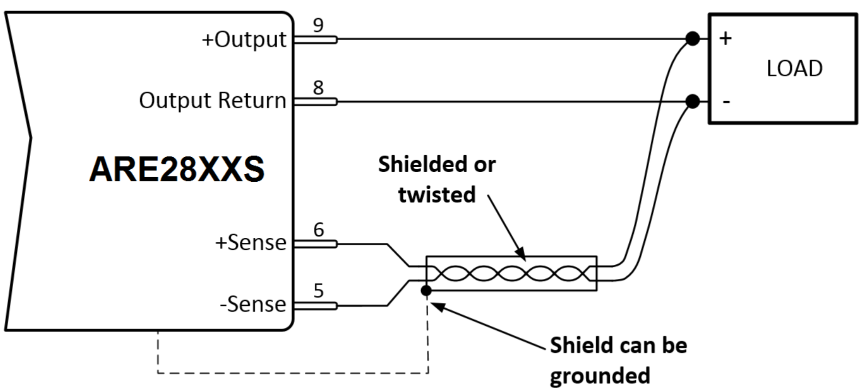

Figure (2) Remote sense feature-single model

If user decides not to make use of the Remote sense feature, it is imperative that +Sense pin be connected to +Output and –Sense pin be connected to –Output. This is shown in Figure (3).

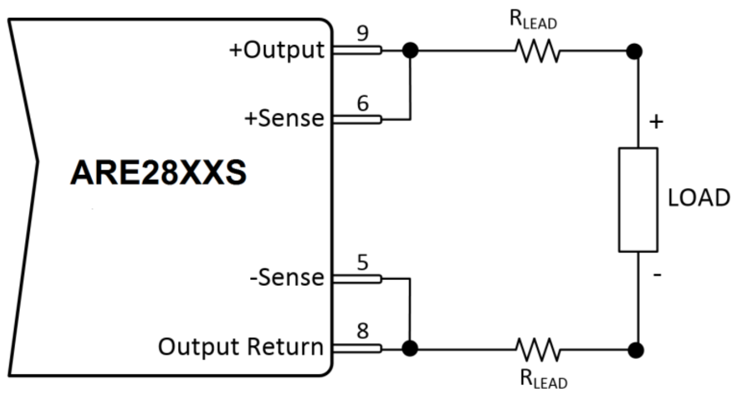

Figure (3) Converter without Remote sense-single model

5 OUTPUT FILTERING

The Data Sheet of ARE28XXS-D states maximum values of output ripple guaranteed in 20 MHz bandwidth at full load. However, if for some application, lower values of output ripple are a must, then external filtering becomes necessary.

5.1 Measuring Output Ripple of ARE28XXS-D

ARE28XXS-D converter's output ripple should be measured per prescribed procedure to get reliable values. Figure (4) presents the proposed setup to properly measure the output ripple at full load.

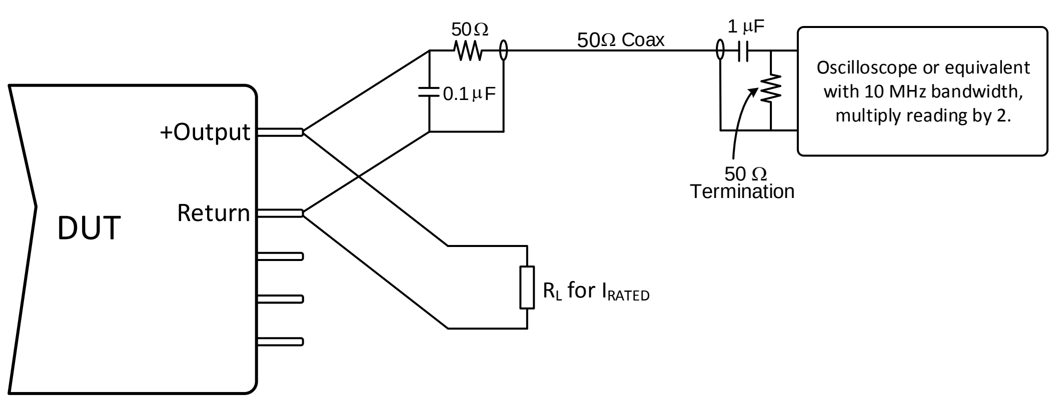

Figure (4) Output Ripple voltage setup for ARE28XXS-D

Because of the high frequency content of this ripple, special measurement techniques must be employed so that correct measurements are obtained. On a 200 MHz or 500 MHz (or higher) oscilloscope, one should limit the bandwidth to 20 MHz for this measurement so that all significant harmonics of the ripple spikes are included.

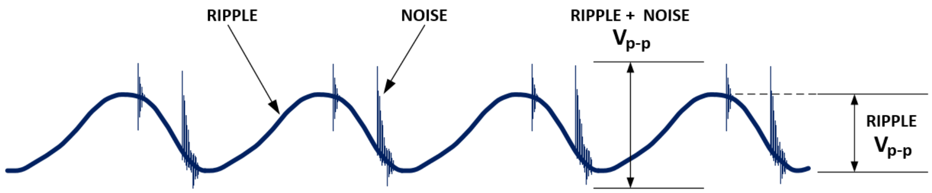

Figure (5) Typical output ripple waveform

The actual ripple voltage measurement must be carefully made in order not to induce error voltages in the test equipment. Therefore, the conventional ground clip on an oscilloscope as shown in Figure (6) should never be used in this type of measurement. This clip, when placed in a field of radiated high frequency energy, acts as an antenna or inductive pickup loop, creating an extraneous voltage that is not part of the output noise of the converter. Figure (7) displays a proper method to use the oscilloscope probe to measure the output voltage ripple of the ARE28XXS-D converters.

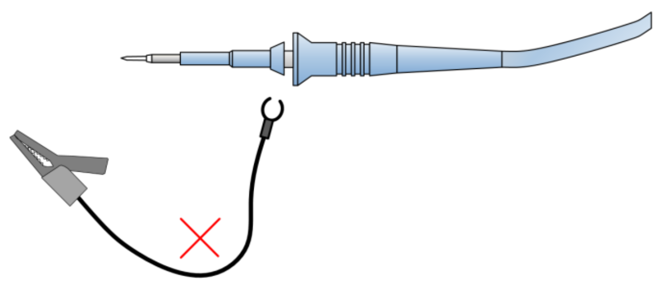

Figure (6) Oscilloscope probe without ground clip

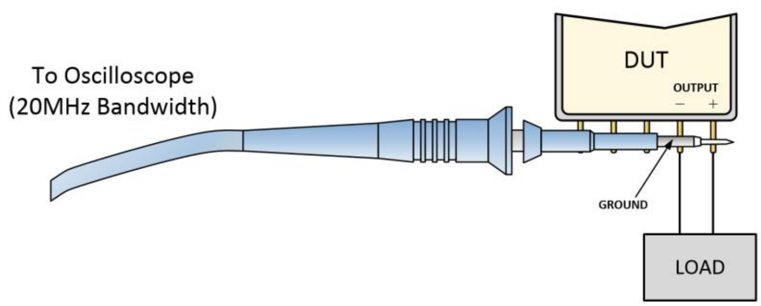

Figure (7) Proper method to use the oscilloscope probe

5.2 External Filters

For noisy input power, it is recommended to use the EMI filter AF28461.

If lower output ripple than what is specified in the Data Sheet is required, an external filter can be used.

The recommended designs of such filters are given below:

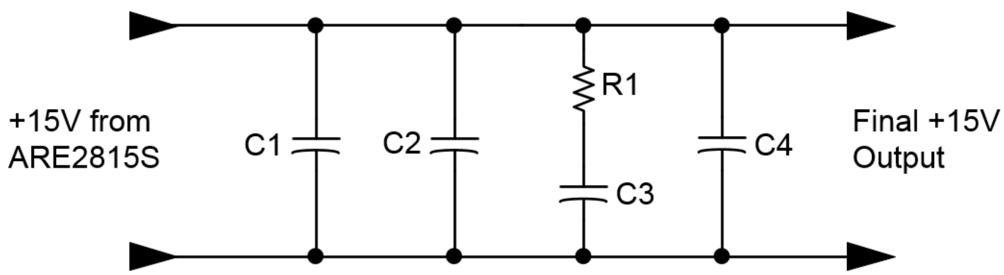

Figure (8) Recommended external filter for ARE2812S and ARE2815S

Where:

C1 = 33 µF, 35V, Tantalum space qualified capacitor.
Used AVX Type TAJV336M035KNJ for prototype
C2 = 0.1 µF, 35V, Ceramic X7R space qualified capacitor
C3 = 0.47 µF, 35V, Ceramic X7R space qualified capacitor
C4 = 33 µF, 35V, Tantalum space qualified capacitor
Used AVX Type TAJV336M035KNJ for prototype
R1 = 3.3 Ohm, non-inductive space qualified resistor

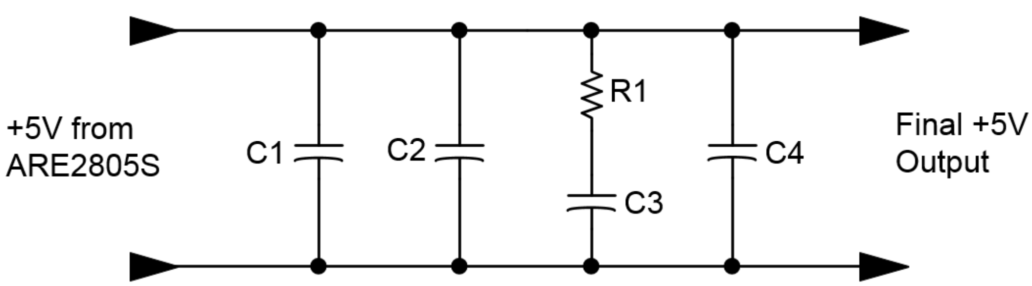

Figure (9) Recommended external filter for ARE2805S

Where:

C1 = 100 µF, 16V, Tantalum space qualified capacitor
Used AVX Type TAJC107M016KNJ for prototype.
C2 = 0.1 µF, 35V, Ceramic X7R space qualified capacitor
C3 = 0.47µF, 35V, Ceramic X7R space qualified capacitor
C4 = 100 µF, 16V, Tantalum space qualified capacitor
Used AVX Type TAJC107M016KNJ for prototype.
R1 = 3.3 Ohm, non-inductive space qualified resistor

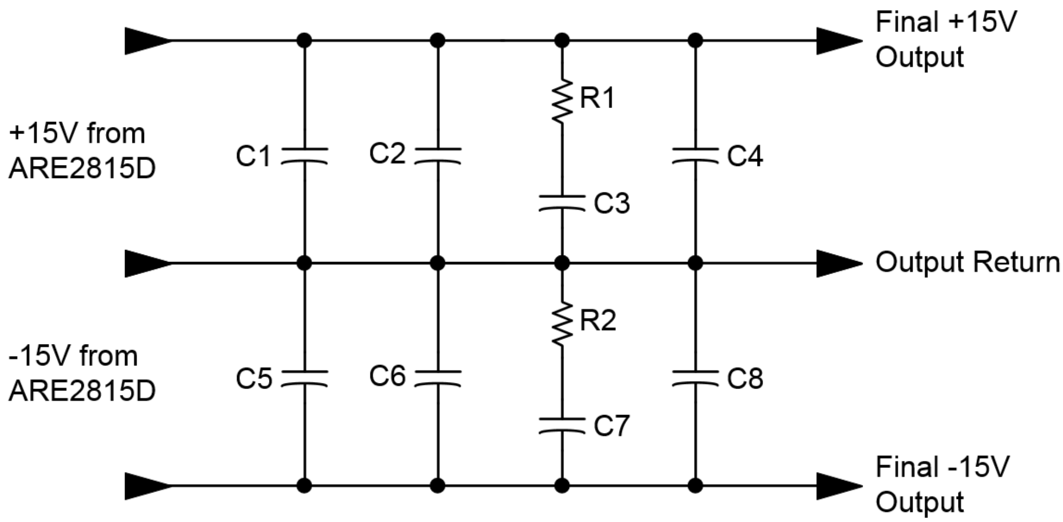

Figure (10) Recommended external filter for ARE2812D and ARE2815D

Where:

C1 = 33 µF, 35V, Tantalum space qualified capacitor
Used AVX Type TAJV336M035KNJ for prototype.
C2 = 0.1µF, 35V, Ceramic X7R space qualified capacitor
C3 = 0.47µF, 35V, Ceramic X7R space qualified capacitor
C4 = 33 µF, 35V, Tantalum space qualified capacitor
Used AVX Type TAJV336M035KNJ for prototype.
R1 = 3.3 Ohm, non-inductive space qualified resistor

6 OUTPUT RIPPLE MEASUREMENT WITH EXTERNAL FILTER

Just to confirm the performance of the above external filters to be connected after outputs, filters were designed & built using two layer PCBs and tried out with ARE2805S and ARE2815D.

The ARE2805S was operated at full load and output ripple was measured as shown in Figure (11). As can be seen and appreciated peak to peak ripple measured on ARE2805S was 3.55 mV, thus proving the filter design.

Likewise, Figure (12) shows output ripple of ARE2815D after using external filter of Figure (10). On the ARE2815D the peak to peak output ripple measured was below 5 mV on both outputs +15V and -15V, while both are carrying full load currents.

In order to test stability of ARE28XXS-D, while using Remote Sense and also the external filters, tests were conducted. The dynamic performance, while using external filters was recorded and proved that the converter remained stable under all operating modes. Figure (13) shows the step load transient response of the ARE2805S model. The output voltage transient is below 50 mV (1% of the output voltage) and the recovery time is well within 200 µs.
A complete test fixture was prepared to test ARE28XXS-D with and without external filter. This is shown in Figure (14)

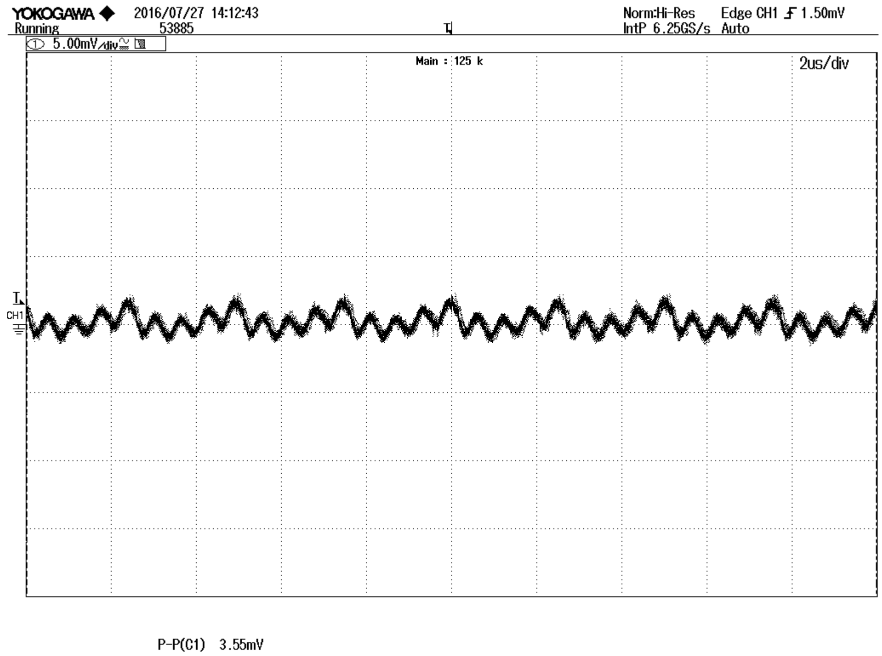

Figure (11) Output ripple of ARE2805S after external filter
Vin=28V @ 100% rated load (25°C)
5.0mV/div, 2µs/div. Ripple = 3.55mVp-p

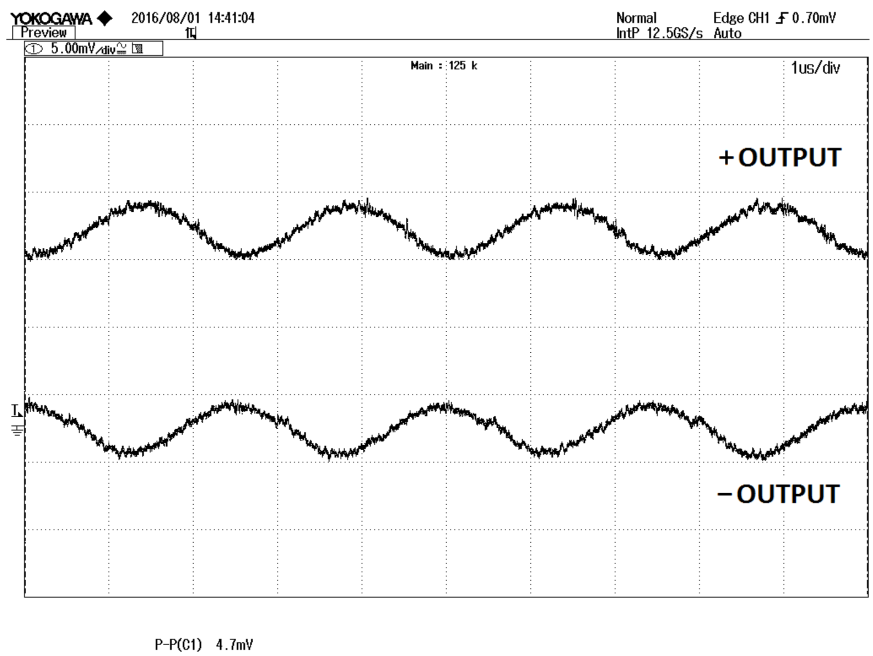

Figure (12) Output ripple of ARE2815D after external filter
Vin=28V @ 100% rated load (25°C)
5.0mV/div, 1µs/div. Ripple = 4.7mVp-p

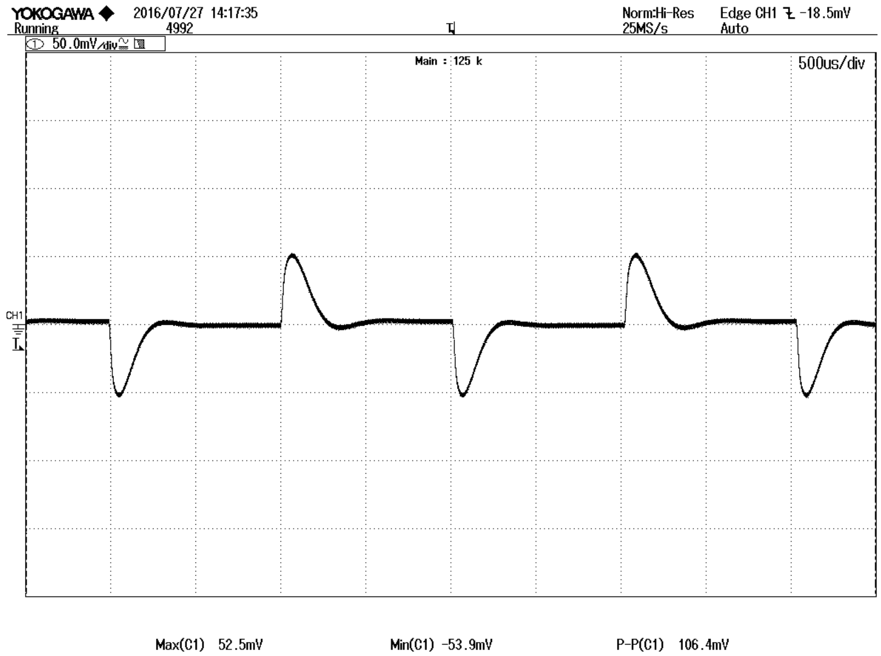

Figure (13) Dynamic performance of ARE2805S converter half load to/from full load
50.0mV/div, 500µs/div. transient=+52.5mV/-53.9mV

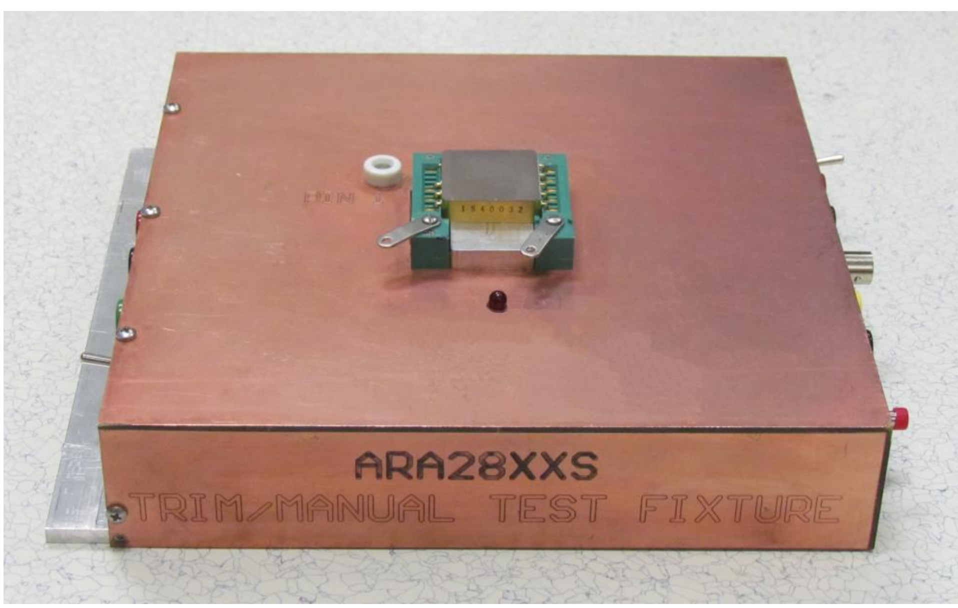

Figure (14) ARA/ARE Fixture used to test ARE28XXS-D with and without external filter

7 LAYOUT AND CONNECTION OF THE ARE28XXS-D

It is recommended to connect the input power and the load to the ARE28XXS-D converter with as short wires as possible for best results. It is recommended that TEFLON coated stranded copper wires of correct AWG gauge be employed to meet current capacity and insulation requirements for high reliability. Input Positive and Return wires can be twisted and likewise output Positive and Return wires can be twisted. If shielded wires are employed, shields can be connected to input return for input wires. Likewise, shield can be connected to output return for connections to load. The case of the ARE28XXS-D converter can be grounded (i.e. earthed).

8 CONCLUSION

The Rad Hard ARE28XXS-D converters have been well designed and thoroughly tested products destined for use on satellites and variety of critical space missions, where size and weight are real constraints, but reliability and long life can't be compromised. This Application Note is prepared with objectives to help designers and product planners for such critical missions by providing insight into four aspects of their use:

1. Systematic explanation of the overload and short circuit behavior
2. Remote Sense Operation
3. Enhancing Output filtering by use of an external filter.
4. Checking and ensuring full stable performance while using external filters in conjunction with Remote Sense facility.