

**HYBRID - HIGH RELIABILITY  
RADIATION HARDENED  
DC-DC CONVERTERS**

**ARH28XXS SERIES**  
**28V Input, Single Output**

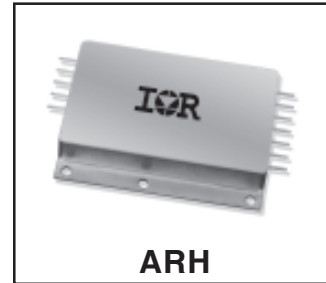
**Description**

The ARH Series of DC-DC converters has been designed specifically for use in the hostile environments. The high level of radiation tolerance inherent in the ARH design is the result of extensive research, thorough analysis and testing and of careful component specification. Designed to supplement the triple output configuration provided by the ART series, the ARH circuit topology is the follow-on to the successful ART design and incorporates many of the design features characterizing that product line. Capable of uniform high performance over long term exposures in radiation intense environments, this series expands the standard for distributed power systems demanding high performance and reliability in the harsh environments.

The ARH converters are hermetically sealed in a rugged, low profile package utilizing copper core input and output pins to minimize resistive DC losses. Long-term hermeticity is assured through use of parallel seam welded lid attachment along with rugged ceramic pin-to-package seal. Axial orientation of the leads facilitates preferred bulkhead mounting placing the converter on the principal heat-dissipating surface.

Manufactured in a facility fully qualified to MIL-PRF-38534, these converters are fabricated utilizing DLA Land and Maritime qualified processes. For available screening options, refer to device screening table in the data sheet.

Variations in electrical, mechanical and screening specifications can be accommodated. Contact IR San Jose for special requirements.



**Features**

- Total Dose > 100 krad (Si), 2:1 Margin
- SEE Hardened to LET up to 83 MeV.cm<sup>2</sup>/mg
- Derated per MIL-STD-975 & MIL-STD-1547
- Output Power to 30 Watts
- Regulates to No-Load
- 18 to 50 Volt Input Range
- Input Undervoltage Lockout
- Fully Characterized from -55°C to +125°C
- Continuous Short Circuit Protection
- 12.8 W/in<sup>3</sup> Output Power Density
- True Hermetic Package
- External Inhibit Port
- Externally Synchronizable
- Fault Tolerant Design
- Available with Outputs from 2.5V to 15V
- Overload Protection
- Standard Microcircuit Drawings Available

**Specifications**

| Absolute Maximum Ratings |                      | Recommended Operating Conditions |  |
|--------------------------|----------------------|----------------------------------|--|
| Input Voltage range      | -0.5V to +80VDC      | Input Voltage range              | +18V to +60VDC<br>+18V to +50V for full derating to MIL-STD-1547 |
| Soldering temperature    | 300°C for 10 seconds | Output Power                     | 0 to 30W   |
| Storage case temperature | -65°C to +135°C      | Operating case temperature       | -55°C to +125°C  |
|                          |                      |                                  | -55°C to +85°C for full derating to MIL-STD-975                  |

**Electrical Performance**  $-55^{\circ}\text{C} \leq T_{\text{CASE}} \leq +125^{\circ}\text{C}$ ,  $V_{\text{IN}} = 28\text{V} \pm 5\%$ ,  $C_{\text{L}} = 0$  unless otherwise specified.

| Parameter   | Symbol             | Test Conditions   | Limit MIN  | Limit MAX  | Units                    |
|---|--------------------|---|--|--|--------------------------|
| Output voltage accuracy<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S                   | $V_{\text{OUT}}$   | $P_{\text{OUT}} = 30\text{ W}$ , $T_{\text{C}} = +25^{\circ}\text{C}$   | 2.487<br>3.283<br>4.975<br>5.174<br>11.940<br>14.925 | 2.513<br>3.317<br>5.025<br>5.226<br>12.060<br>15.075 | Vdc                      |
| Output power  | $P_{\text{OUT}}$   | 18 Vdc < $V_{\text{IN}}$ < 50Vdc  | 0  | 30   | W                        |
| Output current<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S                            | $I_{\text{OUT}}$   | 18 Vdc < $V_{\text{IN}}$ < 50Vdc  | 0<br>0<br>0<br>0<br>0<br>0                           | 12000<br>9090<br>6000<br>5770<br>2500<br>2000        | mAdc                     |
| Line regulation Note 3  | $VR_{\text{LINE}}$ | 18 Vdc < $V_{\text{IN}}$ < 50Vdc, $0 < I_{\text{OUT}} < I_{\text{MAX}}$ | -1.0   | +1.0   | %                        |
| Load regulation Note 4  | $VR_{\text{LOAD}}$ | 18 Vdc < $V_{\text{IN}}$ < 50Vdc, $0 < I_{\text{OUT}} < I_{\text{MAX}}$ | -2.0   | +2.0   | %                        |
| Total regulation  | VR                 | All conditions of Line, Load, Temperature, Radiation and End of Life    | -4.0   | +4.0   | %                        |
| No-load input current   | $I_{\text{IN}}$    | $I_{\text{OUT}} = 0$ (Pin 3 open)                                       | —  | 100  | mA                       |
|   |                    | inhibited (Pin 3 shorted to pin 2)                                      | —  | 8.0  |                          |
| Output ripple and noise voltage<br>Note 5<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S | $VR_{\text{RIP}}$  | 18 Vdc < $V_{\text{IN}}$ < 50Vdc, $I_{\text{OUT}} = I_{\text{MAX}}$     |  | 30<br>30<br>40<br>40<br>50<br>50                     | $\text{mV}_{\text{p,p}}$ |

For Notes to Specifications, refer to page 4

**Electrical Performance**  $-55^{\circ}\text{C} \leq T_{\text{CASE}} \leq +125^{\circ}\text{C}$ ,  $V_{\text{IN}} = 28\text{V} \pm 5\%$ ,  $C_{\text{L}} = 0$  unless otherwise specified. (Continued)

| Parameter   | Symbol           | Test Conditions  | Limit MIN                                    | Limit MAX                              | Units  |
|---|------------------|--|--|--|--|
| Input ripple current Note 5   | $I_{\text{RIP}}$ | $18\text{ Vdc} < V_{\text{IN}} < 50\text{Vdc}$ , $I_{\text{OUT}} = I_{\text{MAX}}$ |  | 100                                    | $\text{mA}_{\text{p.p}}$                     |
| Switching frequency   | $F_{\text{S}}$   | Synchronization input open. (pin 6)  | 225  | 275                                    | KHz  |
| Efficiency<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S  | Eff              | $I_{\text{OUT}} = I_{\text{MAX}}$ , $T_{\text{C}} = +25^{\circ}\text{C}$           | 72<br>75<br>76<br>76<br>80<br>80             |  | %  |
| Enable Input<br>open circuit voltage<br>drive current (sink)<br>voltage range   |                  |  | 3.0<br>-0.5                                  | 5.0<br>100<br>50                       | V<br>$\mu\text{A}$<br>V                      |
| Synchronization Input<br>frequency range<br>pulse high level<br>pulse low level<br>pulse rise time<br>pulse duty cycle            |                  | External clock signal on Sync. input (pin 4)                                       | 225<br>3.5<br>-0.5<br>40<br>20               | 310<br>10<br>0.25<br>80                | KHz<br>V<br>V<br>$\text{V}/\mu\text{s}$<br>% |
| Synchronization Output<br>pulse high level  |                  | Signal compatible with Synchronization Input                                       | 3.7  | 4.3                                    | V  |
| Power dissipation, Short circuit<br>ARH2802R5S<br>ARH2803R3S & ARH2805S<br>All Others   | $P_{\text{D}}$   | Short circuit on output  |  | 10<br>12<br>9.5                        | W  |
| Output response to step load changes<br>Note 8<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S      | $V_{\text{TLD}}$ | 50% Load $\leftrightarrow$ 100% load   | -200<br>-200<br>-200<br>-200<br>-300<br>-350 | 200<br>200<br>200<br>200<br>300<br>350 | $\text{mV}_{\text{PK}}$                      |
| Recovery time from step load changes<br>Notes 8, 9<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S  | $T_{\text{TLD}}$ | 50% Load $\leftrightarrow$ 100% load   |  | 200<br>200<br>200<br>200<br>200<br>200 | $\mu\text{s}$                                |
| Output response to step line changes<br>Notes 7, 10<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S | $V_{\text{TLN}}$ | $I_{\text{OUT}} = I_{\text{MAX}}$ , $V_{\text{IN}} = 18\text{ V}$ to/from 50 V     | -180<br>-180<br>-250<br>-250<br>-450<br>-900 | 180<br>180<br>250<br>250<br>450<br>900 | $\text{mV}_{\text{PK}}$                      |

For Notes to Specifications, refer to page 4

**Electrical Performance**  $-55^{\circ}\text{C} \leq T_{\text{CASE}} \leq +125^{\circ}\text{C}$ ,  $V_{\text{IN}} = 28\text{V} \pm 5\%$ ,  $C_L = 0$  unless otherwise specified. (Continued)

| Parameter  | Symbol           | Test Conditions  | Limit MIN | Limit MAX                                  | Units                        |
|--|------------------|--|-----------|--|------------------------------|
| Recovery time from step line changes<br>Notes 7, 9, 10<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S | $T_{\text{TLN}}$ | $I_{\text{OUT}} = I_{\text{MAX}}$ , $V_{\text{IN}} = 18\text{ V}$ to/from 50 V       |           | 600<br>600<br>700<br>700<br>320<br>400     | $\mu\text{s}$                |
| Turn on overshoot  | $V_{\text{OS}}$  | $I_{\text{OUT}} = 10\%$ or $100\%$ of $I_{\text{MAX}}$                               |           | 5.0  | $\%V_{\text{out}}$           |
| Turn on delay Note 11  | $T_{\text{DLY}}$ | $I_{\text{OUT}} = 10\%$ or $100\%$ of $I_{\text{MAX}}$                               | 2.0       | 20   | ms                           |
| Capacitive load Notes 6, 7<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S                             | CL               | No effect on DC performance  |           | 1200<br>1200<br>1000<br>1000<br>180<br>120 | $\mu\text{F}$                |
| Isolation  | ISO              | 500VDC Input to Output or any pin to case  | 100       |  | $\text{M}\Omega$             |
| Recovery from a short circuit  | $V_r$            | Output shorted, then open into max rated load current. $V_{\text{in}} = 28\text{ V}$ |           | 10   | $\%$ of Rated Output Voltage |
| Overload Trip Current  | Ovld             | Maximum current at specified output voltage  | 105       | 135  | $\%$ of Max Output Current   |

Notes to Specifications Tables

- Operation outside absolute maximum/minimum limits may cause permanent damage to the device. Extended operation at the limits may permanently degrade performance and affect reliability.
- Device performance specified in Electrical Performance table is guaranteed when operated within recommended limits. Operation outside recommended limits is not specified.
- Parameter measured from 28V to 18V or to 50V while load remains fixed at 10%, 50% and 100% of  $I_{\text{max}}$ .
- Parameter measured from 50% to 10% or 100% of maximum load conditions while line remains fixed at 18, 28 or 50 volts.
- Guaranteed for a bandwidth of DC to 20 MHz. Tested using a 20 KHz to 2.0 MHz bandwidth.
- A capacitive load of any value from 0 to the specified maximum is permitted without compromise to DC performance. A capacitive load in excess of the maximum limit may interfere with the proper operation of the converter's short circuit protection, causing erratic behavior during turn on.
- Parameter is tested as part of design characterization or after design or process changes. Thereafter, parameters shall be guaranteed to the limits specified in the table.
- Load transient rate of change,  $di/dt \leq 2.0\text{ A}/\mu\text{s}$ .
- Recovery time is measured from the initiation of the transient to where  $V_{\text{OUT}}$  has returned to within  $\pm 1\%$  of its steady state value.
- Line transient rate of change,  $dv/dt \leq 50\text{ V}/\mu\text{s}$ .
- Turn on delay time is for either a step application of input power or a logical low to high transition on the enable pin (pin 3) while power is present at the input.

**Group A Tests**  $V_{IN} = 28V$ ,  $C_L = 0$  unless otherwise specified.

| Test   | Symbol    | Test Conditions  | Group A Subgroups  | Limit MIN  | Limit MAX  | Units                     |
|--|-----------|--|--------------------|--|--|---------------------------|
| Output voltage accuracy<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S  | $V_{OUT}$ | $I_{OUT} = I_{MAX}$ , $T_C = 25^\circ C$                                 | 1                  | 2.487<br>3.283<br>4.975<br>5.174<br>11.940<br>14.925 | 2.513<br>3.317<br>5.025<br>5.226<br>12.060<br>15.075 | V                         |
| Output power Note 1  | $P_{OUT}$ | $V_{IN} = 18 V, 28V, 50 V$   | 1, 2, 3            | 0  | 30   | W                         |
| Output current Note 1<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S    | $I_{OUT}$ | $V_{IN} = 18 V, 28V, 50 V$   | 1, 2, 3            | 0<br>0<br>0<br>0<br>0<br>0                           | 12000<br>9090<br>6000<br>5770<br>2500<br>2000        | mA                        |
| Output regulation Note 4<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S | VR        | $I_{OUT} = 10\%, 50\%, 100\%$ of $I_{MAX}$<br>$V_{IN} = 18 V, 28V, 50 V$ | 1, 2, 3            | 2.425<br>3.201<br>4.850<br>5.044<br>11.640<br>14.550 | 2.575<br>3.399<br>5.150<br>5.356<br>12.360<br>15.450 | V                         |
| No Load Input Current  | $I_{IN}$  | $I_{OUT} = 0$ , Pin 3 open<br>Pin 3 shorted to pin 2 (disabled)          | 1, 2, 3<br>1, 2, 3 |  | 100<br>8.0   | mA                        |
| Output ripple Note 2<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S     | $V_{RIP}$ | $V_{IN} = 18 V, 28V, 50 V$<br>$I_{OUT} = I_{MAX}$                        | 1, 2, 3            |  | 30<br>30<br>40<br>40<br>50<br>50                     | mV <sub>p,p</sub>         |
| Switching frequency  | $F_S$     | Synchronization pin (pin 6) open   | 4, 5, 6            | 225  | 275  | KHz                       |
| Input ripple Note 2  | $I_{RIP}$ | $V_{IN} = 18 V, 28V, 50 V$<br>$I_{OUT} = I_{MAX}$                        | 1, 2, 3            |  | 100  | mA <sub>p,p</sub>         |
| Recovery from a short circuit  | Vr        | Output shorted, then open into max rated load current. $V_{in} = 28 V$   |                    |  | 5.0  | % of Rated Output Voltage |
| Overload Trip Current  | Ovld      | Maximum current at specified output voltage                              | 1, 2, 3            | 105  | 135  | % of Max Output Current   |

For Notes to Group A Tests, refer to page 6

**ARH28XXS Series**  
**28V Input, Single Output**

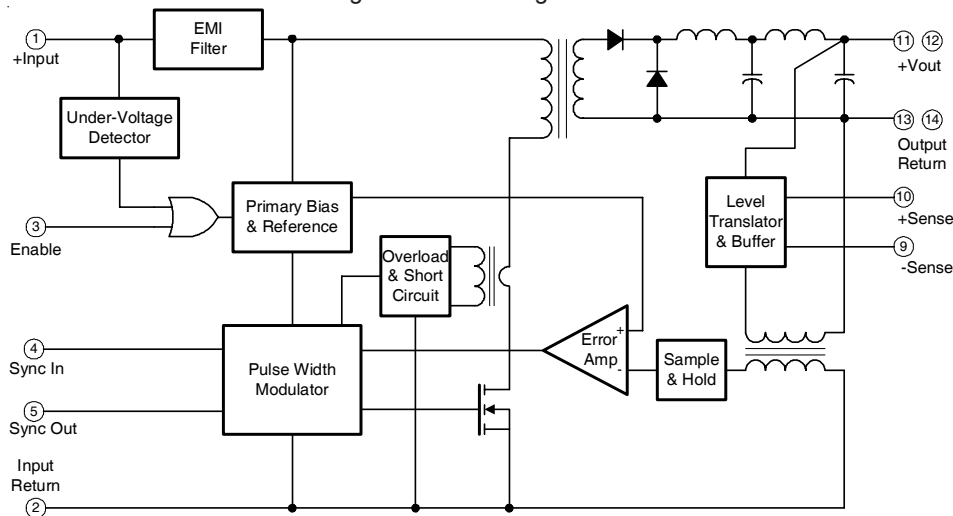
**Group A Tests**  $V_{IN} = 28V$ ,  $C_L = 0$  unless otherwise specified. (continued)

| Test   | Symbol    | Test Conditions   | Group A Subgroups                 | Limit MIN  | Limit MAX                              | Units            |
|--|-----------|---|-----------------------------------|--|--|------------------|
| Efficiency<br><br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S<br><br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S | Eff       | $I_{OUT} = I_{MAX}$                                       | 1<br><br><br><br><br><br><br>2, 3 | 72<br>75<br>76<br>76<br>80<br>80<br><br>68<br>68<br>72<br>72<br>78<br>78 |  | %                |
| Power dissipation,<br>Short circuit<br>ARH2802R5S<br>ARH2803R3S & ARH2805<br>All Others  | $P_D$     | Short circuit across output                               | 1, 2, 3                           |  | 10<br>12<br>9.5                        | W                |
| Output response to step load changes Note 5<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S  | $V_{TL}$  | 50% Load to/from 100% load                                | 4, 5, 6                           | -200<br>-200<br>-200<br>-200<br>-300<br>-350                             | 200<br>200<br>200<br>200<br>300<br>350 | mV <sub>PK</sub> |
| Recovery from step load changes Notes 5, 6<br>ARH2802R5S<br>ARH2803R3S<br>ARH2805S<br>ARH2805R2S<br>ARH2812S<br>ARH2815S   | $T_{TL}$  | 50% Load to/from 100% load                                | 4, 5, 6                           |  | 200<br>200<br>200<br>200<br>200<br>200 | $\mu$ s          |
| Turn on overshoot  | $V_{OS}$  | $I_{OUT} = 10\%$ and 100%                                 | 4, 5, 6                           |  | 5.0                                    | % $V_{OUT}$      |
| Turn on delay Note 7   | $T_{DLY}$ | $I_{OUT} =$ minimum and full rated                        | 4, 5, 6                           | 2.0  | 20                                     | ms               |
| Isolation  | ISO       | 500VDC Input to output or any pin to case (except pin 12) | 1                                 | 100  |  | M $\Omega$       |

Notes to Specifications Tables

1. Parameter verified during dynamic load regulation tests.
2. Guaranteed for DC to 20 MHz bandwidth. Test conducted using a 20 KHz to 2.0MHz bandwidth.
3. Deleted .
4. Output is measured for all combinations of line and load. Only the minimum and maximum readings for the output are recorded.
5. Load step transition time is 10 $\mu$ s.
6. Recovery time is measured from the initiation of the transient to where  $V_{OUT}$  has returned to within  $\pm 1\%$  of its steady state value.
7. Turn on delay time is tested by application of a logical low on high transition on the enable pin (pin 3) with power present at the input.
8. Subgroups 1 and 4 are performed at +25°C, subgroups 2 and 5 at +85°C and subgroups 3 and 6 at -55°C.

Figure I. Block Diagram



## Circuit Operation and Application Information

The ARH28XXS series of converters have been designed using a single ended forward switched mode converter topology. (Refer to Figure I.) Single ended topologies enjoy certain advantages in radiation hardened designs in that they eliminate the possibility of simultaneous turn on of both switching elements during a radiation induced upset. In addition, single ended topologies are not subject to transformer saturation problems often associated with double ended implementations.

The design incorporates a two-stage LC input filter to attenuate input ripple current. A low overhead linear bias regulator provides both a bias voltage for the converter primary control logic and a stable, well-regulated reference for the error amplifier. Output control is realized using a wide band discrete pulse width modulator control circuit incorporating a unique non-linear ramp generator circuit. This circuit helps stabilize loop gain over variations in line voltage for superior output transient response. Nominal conversion frequency has been selected as 250 KHz to maximize efficiency and minimize magnetic element size.

Output voltages are sensed and fed back to the controller using a patented magnetic feedback circuit. This circuit is designed to be relatively insensitive to variations in temperature, aging, radiation and manufacturing tolerances making it particularly well suited to radiation hardened designs. The control logic has been designed to use only radiation tolerant components, and current paths include series resistances to limit photocurrents.

Other key circuit design features include output short circuit and overload protection, input undervoltage lockout and an external synchronization input port, permitting operation at an externally set clock rate. Alternately, a synchronization output is provided to lock frequencies with another converter when using more than one converter in a system.

## Thermal Considerations

The ARH series of converters is capable of providing relatively high output power from a package of modest volume. The power density exhibited by these devices is obtained by combining high circuit efficiency with effective methods of heat removal from the die junctions. Good design practices have effectively addressed this requirement inside the device. However when operating at maximum loads, heat generated at the die junctions depends upon minimally restricted thermal conduction from the base plate for that heat to be carried away. To maintain case temperature at or below the specified maximum of 125°C, this heat can be transferred by attachment of the ARH28XXS to an appropriate heat dissipater held in intimate contact with the converter base-plate.

Effectiveness of this heat transfer is dependent on the intimacy of the baseplate to heatsink interface. It is therefore suggested that a heat-transferring medium possessing good thermal conductivity be inserted between the baseplate and heatsink. A material utilized at the factory during testing and burn-in processes is sold under the

## ARH28XXS Series 28V Input, Single Output

International  
**IR** Rectifier

trade name of Sil-Pad<sup>®</sup> 400<sup>1</sup>. This particular product is an insulator but electrically conductive versions are also available. Use of these materials assures optimum surface contact with the heat dissipater by compensating for minor surface variations. While other available types of heat conducting materials and thermal compounds provide similar effectiveness, these alternatives are often less convenient and are sometimes messy to use.

A conservative aid to estimating the total heat sink surface area (A<sub>HEAT SINK</sub>) required to set the maximum case temperature rise (DT) above ambient temperature is given by the following expression:

$$A_{\text{HEAT SINK}} \approx \left\{ \frac{\Delta T}{80P^{0.85}} \right\}^{-1.43} - 5.94$$

where

$\Delta T$  = Case temperature rise above ambient

$$P = \text{Device dissipation in Watts} = P_{\text{out}} \left\{ \frac{1}{\text{Eff}} - 1 \right\}$$

As an example, assume that it is desired to maintain the case temperature of an ARH2815S at +65°C or less while operating in an open area whose ambient temperature does not exceed +35°C; then

$$\Delta T = 65 - 35 = 35^\circ\text{C}.$$

From the Specification Table, the worst case full load efficiency for this device is 80%; therefore the maximum power dissipation at full load is given by

$$P = 30 \cdot \left\{ \frac{1}{.80} - 1 \right\} = 30 \cdot (0.25) = 7.5\text{W}$$

and the required heat sink area is

$$A_{\text{HEAT SINK}} = \left\{ \frac{35}{80 \cdot 7.5^{0.85}} \right\}^{-1.43} - 5.94 = 31.8 \text{ in}^2$$

Thus, a total heat sink surface area (including fins, if any) of approximately 32 in<sup>2</sup> in this example, would limit case rise to 35°C above ambient. A flat aluminum plate, 0.25" thick and of approximate dimension 4" by 4" (16 in<sup>2</sup> per side) would suffice for this application in a still air environment. Note that to meet the criteria, both sides of the plate require unrestricted exposure to the ambient air. The user should remember that when operating in the vacuum of space, this method does not apply and all heat must be conducted away from the attaching surface.

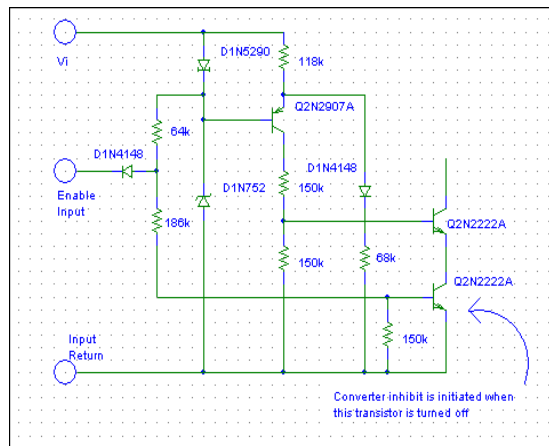
<sup>1</sup>Sil-Pad is a registered Trade Mark of Bergquist, Minneapolis, MN

### Inhibiting Converter Output

As an alternative to application and removal of the DC voltage at the input, the user can control the converter output by providing an input referenced, TTL compatible, logic signal to the enable pin 3. This port is internally pulled "high" so that when not used, an open connection on the pin permits normal converter operation. When inhibited outputs are desired, a logical "low" on this port will shut the converter down. An open collector device capable of sinking at least 100  $\mu\text{A}$  connected to enable pin 3 will work well in this application.

A benefit of utilization of the enable input is that following an initial charge of the input capacitor, subsequent turn-on commands will induce no uncontrolled current inrush.

Figure II. Enable Input Equivalent Circuit



### Synchronization

When using multiple converters, system requirements may dictate operating several converters at a common system frequency. To accommodate this requirement, the ARH28XXS type converter provides a synchronization input port.

The sync input port permits synchronization of an ARH converter to any compatible external frequency source operating in the band of 225 to 310 KHz. In the event of failure of an external synchronization source, the converter will revert to its own internally set frequency. When external synchronization is not desired, the sync in port may be left open (unconnected) permitting the converter to operate at its own internally set frequency.



When an external frequency source is not available, an internal clock signal is provided through appropriate buffering at the sync out port. This port can drive a minimum of 3 ARH sync in ports thereby allowing all to operate at the same clock frequency.

### Output Short Circuit Protection

Protection against accidental short circuits on the output is provided in the ARH28XXS converter. This protection is implemented by sensing primary switching current and reducing the switching pulse widths when a short occurs. The output current is therefore limited to a maximum value, which protects the converter. Under this condition the internal power dissipation is nearly the same as for maximum loading.

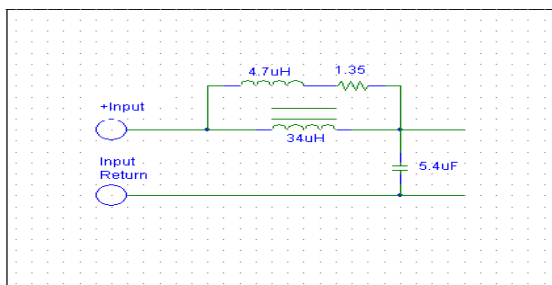
### Input Undervoltage Protection

A minimum voltage is required at the input of the converter to initiate operation. This voltage is set to a nominal value of 16.8 volts. To preclude the possibility of noise or other voltage variations at the input falsely initiating and halting converter operation, a hysteresis of approximately 1.0 volts is incorporated into this circuit. The converter is guaranteed to operate at 18 Volts input under all specified conditions.

### Input Filter

To attenuate input ripple current, the ARH28XXS series converters incorporate a two-stage LC input filter illustrated in Figure III following. The elements of this filter comprise the dominant input load impedance characteristic, and therefore determine the nature of the current inrush at turn-on.

Figure III. Input Filter



### EMI Filtering

Although the internal filtering provided at both input and output terminals of the ARH series converters is sufficient for most applications, some critical applications may require additional filtering in order to accommodate particular system requirements.

While the internal input filter maintains input ripple current below 50 mA<sub>p-p</sub>, an external filter can be applied to further attenuate this ripple to a level below the CE03 limits imposed by MIL-STD-461. International Rectifier currently supplies such a filter housed in a complementary package. The catalog number of this part is ARF461.

### Output Noise

When attempting noise measurement at the output of switching converters, measurement techniques employed can have a significant influence on results during these tests. Any noise measurements should be undertaken only with test leads dressed as close to the device output pins as is physically possible. Probe ground leads should be kept to a minimum (<< 1") length to minimize the influence of parasitic impedances on results.

**Radiation Performance**

The radiation tolerance characteristics inherent in the ARH28XXS converters are a result of a carefully planned ground-up design program with specific radiation design goals. Identification of the general circuit topology, a fundamental task in the design effort, was followed by selection of appropriate elements from a list of devices for which extensive radiation effects data was available. By imposing sufficiently large margins on those electrical parameters showing the worst case degrading effects of radiation, designers were able to select appropriate elements for incorporation into the circuit. Existing radiation data was utilized for input to PSPICE and RadSPICE in the generation of circuit performance verification analyses. Thus, electrical performance capability under all environmental conditions including radiation was well understood before first application of power to the inputs.

A principal design goal was achieving a converter topology that, because of large design margins, had radiation performance essentially independent of radiation induced element-lot performance variations. Where such margins cannot be assured, element lots are either selected following RLAT characterization as radiation hard devices or, purchased as radiation hard devices so that realization of the design goals are maintained.

The following table specifies guaranteed minimum radiation exposure levels tolerated while maintaining specification limits.

**Radiation Specification Tcase = 25°C**

| Test  | Conditions   | Min         | Typ | Unit                    |
|---|--|-------------|-----|-------------------------|
| Total Ionizing Dose (2.:1 Margin)             | MIL-STD-883, Method 1019.4<br>Operating bias applied during exposure | 100         |     | Krads(Si)               |
| Dose Rate<br>Temporary Saturation<br>Survival | MIL-STD-883, Method 1021   | 1E8<br>1E11 |     | Rads(Si)/sec            |
| Heavy Ions<br>(Single Event Effects)          | BNL Dual Van de Graf Generator                                       | 83          |     | MeV•cm <sup>2</sup> /mg |

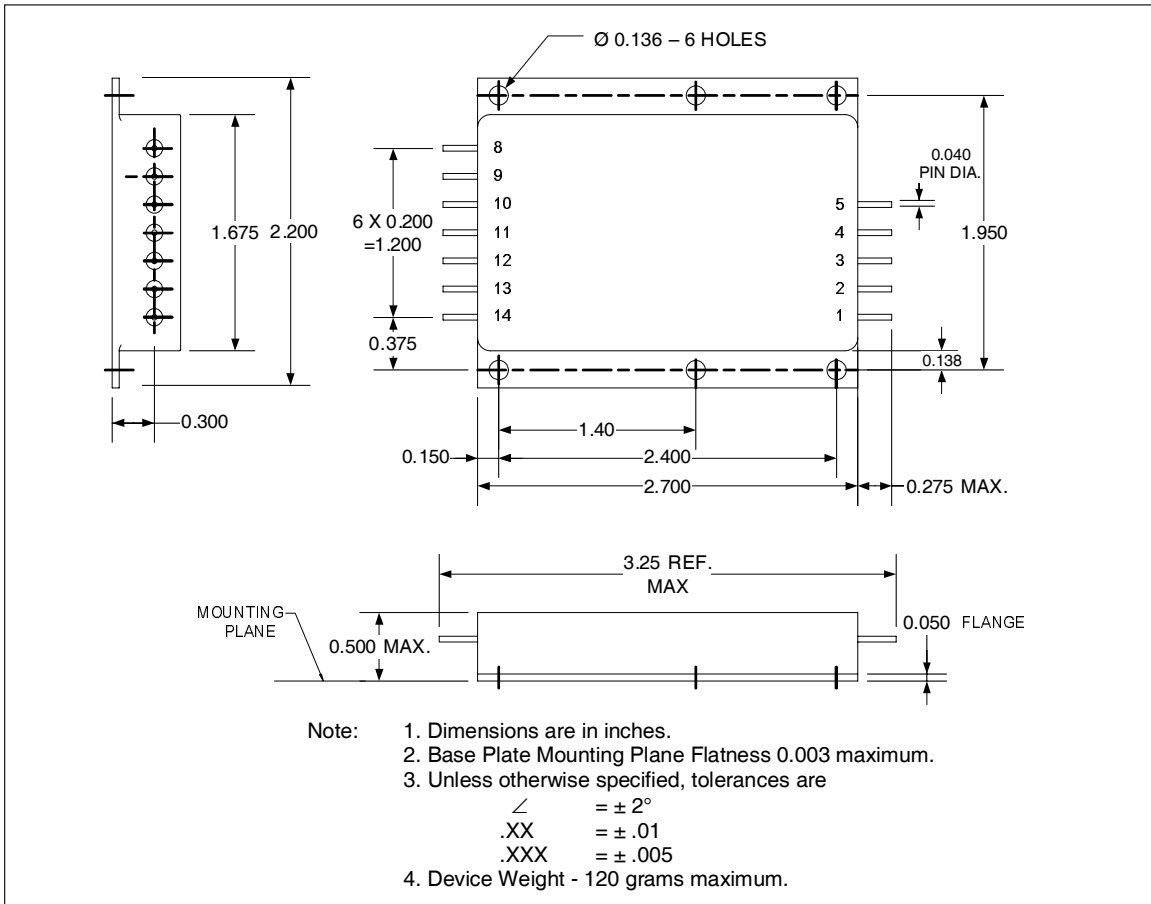
International Rectifier currently does not have a DLA Land and Maritime certified Radiation Hardness Assurance Program.

**Standard Quality Conformance Inspections on ARH28XXS Series (Flight Screened)**

| Inspection | Application                                      | Samples   |
|------------|--|-----------|
| Group A    | Part of screening on each unit                   | 100%      |
| Group B    | Each inspection lot                              | * 5 units |
| Group C    | First inspection lot or following Class 1 change | 10 units  |
| Group D    | In line (Part of element evaluation)             | 3 units   |

\* Group B quantity for option 2 End of Line QCI. No Group B samples required for Option 1, In-line.

**Mechanical Outline**



**Pin Designation**

| Pin # | Designation   |
|-------|---------------|
| 1     | + Input       |
| 2     | Input Return  |
| 3     | Enable        |
| 4     | Sync In       |
| 5     | Sync Out      |
| 8     | Chassis       |
| 9     | -Sense        |
| 10    | +Sense        |
| 11    | +V Output     |
| 12    | +V Output     |
| 13    | Output Return |
| 14    | Output Return |

**Standard Microcircuit Drawing Equivalence Table**

| Standard Microcircuit Drawing Number | IR Standard Part Number |
|--------------------------------------|-------------------------|
| 5962-04232                           | ARH2805S                |
| 5962-04233                           | ARH2803R3S              |

**ARH28XXS Series**  
**28V Input, Single Output**

International  
**IR** Rectifier

**Device Screening**

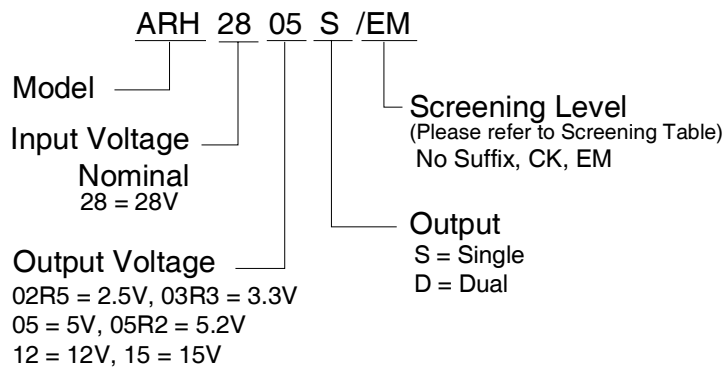
| Requirement                     | MIL-STD-883 Method               | No Suffix ②                        | CK ②                               | EM                     |
|---------------------------------|----------------------------------|------------------------------------|------------------------------------|------------------------|
| Temperature Range               | —                                | -55°C to +85°C                     | -55°C to +85°C                     | -55°C to +85°C         |
| Element Evaluation              | MIL-PRF-38534                    | Class K                            | Class K                            | N/A                    |
| Non-Destructive Bond Pull       | 2023                             | Yes                                | Yes                                | N/A                    |
| Internal Visual                 | 2017                             | Yes                                | Yes                                | ①                      |
| Temperature Cycle               | 1010                             | Cond C                             | Cond C                             | Cond C                 |
| Constant Acceleration           | 2001, Y1 Axis                    | 3000 Gs                            | 3000 Gs                            | 3000 Gs                |
| PIND                            | 2020                             | Cond A                             | Cond A                             | N/A                    |
| Burn-In                         | 1015                             | 320 hrs @ 125°C<br>( 2 x 160 hrs ) | 320 hrs @ 125°C<br>( 2 x 160 hrs ) | 48 hrs @ 125°C         |
| Final Electrical<br>( Group A ) | MIL-PRF-38534<br>& Specification | -55°C, +25°C,<br>+85°C             | -55°C, +25°C,<br>+85°C             | -55°C, +25°C,<br>+85°C |
| PDA                             | MIL-PRF-38534                    | 2%                                 | 2%                                 | N/A                    |
| Seal, Fine and Gross            | 1014                             | Cond A, C                          | Cond A, C                          | Cond A                 |
| Radiographic                    | 2012                             | Yes                                | Yes                                | N/A                    |
| External Visual                 | 2009                             | Yes                                | Yes                                | ①                      |

Notes:

- ① Best commercial practice.
- ② CK is DLA class K compliant without radiation performance. No Suffix is a radiation rated device but not available as a DLA qualified SMD per MIL-PRF-38534.

International Rectifier currently does not have a DLA certified Radiation Hardness Assurance Program.

**Part Numbering**



International  
**IR** Rectifier

**WORLD HEADQUARTERS:** 101 N, Sepulveda Blvd., El Segundo, California 90245, USA Tel: (310) 252-7105  
**IR SAN JOSE:** 2520 Junction Avenue, San Jose, California 95134, USA Tel: (408) 434-5000

Visit us at [www.irf.com](http://www.irf.com) for sales contact information.

Data and specifications subject to change without notice. 06/2013