

**HIGH RELIABILITY  
RADIATION HARDENED  
LOW POWER  
DC-DC CONVERTER****28V Input, Dual Output****Description**

The ARE Series of DC-DC converters are low power radiation hardened, high reliability devices designed for radiation environments such as those encountered by geostationary earth orbit satellites, deep space probes and communication systems. Features include small size, high efficiency, low weight and a high tolerance to total ionizing dose, single event effects and environmental stresses such as temperature extremes, mechanical shock, and vibration. All components are fully de-rated to meet the requirements of MIL-STD-975, MIL-STD-1547 and NASA EEE-INST-002. Extensive documentation including Radiation Susceptibility, Thermal Analysis, Stress Analysis and MTBF are available

The ARE Series converters incorporate a fixed frequency flyback topology with magnetic feedback and an internal EMI filter utilizing large multilayer ceramic capacitors processed per MIL-PRF-49470 for improved reliability. All models include an external inhibit port. They are encased in a hermetic 1.20" x 1.20" x 0.31" AISi package and weigh less than 15 grams. The package utilizes rugged ceramic feed-through copper core pins and is hermetically sealed using laser welding.

Environmental screening includes temperature cycling, constant acceleration, fine and gross leak, and burn-in as specified by MIL-PRF-38534 for class K hybrids.

Non-flight versions of the ARE Series converters are available for system development purposes. Variations in electrical specifications and screening to meet custom requirements can be accommodated.

**Features**

- Total Dose Guaranteed to 100 kRads(Si)
- SEE with LET up to 64 MeV.cm<sup>2</sup>/mg
- Low Weight < 15 grams
- Magnetically Coupled Feedback
- 18V to 50V DC Input Range
- Up to 5W Output Power
- Dual Output Models Include ±5, ±12 and ±15V
- Low Quiescent Current
- High Efficiency - to 80%
- -55°C to +85°C Operating Temperature Range
- 100MΩ @ 100V DC Isolation
- Under-Voltage Lockout
- Short Circuit and Overload Protection
- External Inhibit
- Output Adjustment

**Applications**

- Geostationary Earth Orbit Satellites (GEO)
- Deep Space Satellites / Probes
- Strategic Weapons and Communication System

## Circuit Description

The ARE Series converters utilize a flyback topology with a nominal switching frequency of 400 kHz. Electrical isolation and tight output regulation are achieved through the use of a magnetically coupled feedback.

Output current is limited under any load fault condition to approximately 160% of rated. The converter will resume normal operation when the load current is reduced below the current limit point. This protects the converter from both overload and short circuit conditions. There are no latching elements included in the load fault protection circuits to eliminate the possibility of falsely triggering the protection circuits during single event radiation exposure.

An under-voltage lockout circuit prohibits the converter from operating when the line voltage is too low to maintain the output voltage. The converter will not start until the line voltage rises to approximately 17 volts and will shut down when the input voltage drops below 16 volts. The one volt of hysteresis reduces the possibility of line noise interfering with the converter's start-up and shut down circuitry.

An external inhibit port is provided to control converter operation. The converter's operation is inhibited when this pin is pulled low. It is intended to be driven by an open collector device. The pin may be left open for normal operation and has a nominal open circuit voltage of about 13V.

## Design Methodology

The ARE Series was developed using a proven conservative design methodology, which includes selecting radiation tolerant, and established reliability components and fully de-rating to the requirements of MIL-STD-975, MIL-STD-1547, and NASA EE-INST-002. Conservative de-rating of the radiation-hardened power MOSFET virtually eliminates the possibility of SEGR and SEB. A magnetic feedback circuit is utilized instead of opto-couplers to minimize temperature, radiation and aging sensitivity. PSPICE was used extensively to predict and optimize circuit performance for both beginning and end-of-life. Thorough design analyses include Radiation Susceptibility, Worst Case, Stress, Thermal, Failure Modes and Effects (FMEA) and Reliability (MTBF).

## Specifications

Absolute Maximum Ratings		Recommended Operating Conditions	
Input Voltage	-0.5V <sub>DC</sub> to +60V <sub>DC</sub>	Input Voltage	+18V <sub>DC</sub> to +50V <sub>DC</sub>
Output power	Internally limited	Output power	0 to Max. Rated
Lead Temperature	+300°C for 10 seconds		
Operating temperature	-55°C to +125°C	Operating temperature	-55°C to +85°C
Storage temperature	-55°C to +135°C	Operating temperature <sup>1</sup>	-55°C to +70°C

<sup>1</sup> Meets de-rating per MIL-STD-975, MIL-STD-1547, NASA EEE-INST-002 when V<sub>IN</sub> nominal is 28V and V<sub>IN</sub> worst case is 50V. (Note 13)

## Electrical Performance Characteristics: BOL (Beginning of Life)

Parameter	Group A Subgroup	Conditions -55°C ≤ T <sub>C</sub> ≤ +85°C V <sub>IN</sub> = 28V DC ± 5%, C <sub>L</sub> = 0uF unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Input voltage (V <sub>IN</sub> )			18	28	50	V
Output voltage (V <sub>OUT</sub> ) ARE2805D ARE2812D ARE2815D	1,2,3 1,2,3 1,2,3	I <sub>OUT</sub> = 100% rated load Note 4	±4.95 ±11.88 ±14.85	±5.00 ±12.00 ±15.00	±5.05 ±12.12 ±15.15	V
Output power (P <sub>OUT</sub> )	1,2,3	V <sub>IN</sub> = 18, 28, 50 Volts, Note 2	0		5.0	W
Output current (I <sub>OUT</sub> ) ARE2805D ARE2812D ARE2815D	1,2,3	V <sub>IN</sub> = 18, 28, 50 Volts, Note 2 Either Output, Note 3 Either Output, Note 3 Either Output, Note 3	0 0 0		0.8 0.33 0.27	A
Line regulation (VR <sub>LINE</sub> ) (Measured +V <sub>OUT</sub> to -V <sub>OUT</sub> )	1, 4	V <sub>IN</sub> = 18, 28, 50 Volts I <sub>OUT</sub> = 0, 50%, 100% rated, Note 4	-0.50		0.50	%
Load regulation (VR <sub>LOAD</sub> ) (Measured +V <sub>OUT</sub> to -V <sub>OUT</sub> )	1,2,3 4,5,6	I <sub>OUT</sub> = 0, 50%, 100% rated, Note 4 V <sub>IN</sub> = 18, 28, 50 Volts	-1.0		1.0	%
Total regulation (Line & Load) (Measured +V <sub>OUT</sub> to -V <sub>OUT</sub> )	1,2,3	V <sub>IN</sub> = 18, 28, 50 Volts I <sub>OUT</sub> = 0, 50%, 100% rated, Note 14	-1.0		1.0	%
Cross regulation (VR <sub>CROSS</sub> ) ARE2805D ARE2812D ARE2815D	1,2,3	Duals only, Note 5 V <sub>IN</sub> = 18, 28, 50 Volts	-8.0 -5.0 -3.0		8.0 5.0 3.0	%
Input current (I <sub>IN</sub> )	1,2,3	I <sub>OUT</sub> = 0, Pin 4 open Pin 4 shorted to Pin 2			20 5.0	mA
Switching frequency (F <sub>S</sub> )	1,2,3		350	400	450	kHz
Output ripple (V <sub>RIP</sub> ) ARE2805D ARE2812D ARE2815D	1,2,3	V <sub>IN</sub> = 18, 28, 50 Volts I <sub>OUT</sub> = 100% rated load Notes 4, 6			50 80 80	mVp-p
Efficiency (E <sub>FF</sub> ) ARE2805D ARE2812D ARE2815D	1,2,3	I <sub>OUT</sub> = 100% rated load Note 4	71 76 76	75 79 79		%

For Notes to Electrical Performance Characteristics, refer to page 4

**Electrical Performance Characteristics (continued)**

Parameter	Group A Subgroup	Conditions -55°C ≤ T <sub>C</sub> ≤ +85°C V <sub>IN</sub> = 28V DC ± 5%, C <sub>L</sub> = 0μF unless otherwise specified	Limits			Unit
			Min	Nom	Max	
Enable input (inhibit function) Open circuit voltage Drive current (sink) Voltage range	1,2,3	Note 1	11		14 800 50	V μA V
Current limit point Expressed as a percentage of full rated load current	1,2,3	V <sub>OUT</sub> = 90% of Nominal, Note 4	120		200	%
Power dissipation, load fault (P <sub>D</sub> )	1,2,3	Short Circuit, Overload, Note 8			3.0	W
Output response to step load changes (V <sub>TLD</sub> )	4,5,6	Half load to/ from Full load, Notes 4, 9	-300		300	mVpk
Recovery time, step load changes (T <sub>TLD</sub> )	4,5,6	Half load to/from Full load, Notes 4, 9,10			200	ms
Output response to step line changes (V <sub>TLN</sub> )	4,5,6	18V to/from 50V I <sub>OUT</sub> =100% rated load, Notes 1, 4,11	-300		300	mVpk
Recovery time, step line changes (T <sub>TLN</sub> )	4,5,6	18V to/from 50V I <sub>OUT</sub> =100% rated load, Notes 4,10,11			200	ms
Turn-on response Overshoot (V <sub>OS</sub> ) Turn-on Delay (T <sub>DLY</sub> )	4,5,6	No load, Full load Notes 4,12	1.5		500 10	mV ms
Capacitive load (C <sub>L</sub> ) ARE2805D ARE2812D ARE2815D	1	I <sub>OUT</sub> = 100% rated load No effect on DC performance Notes 1, 4, 7			300 90 60	μF
Line rejection	1	I <sub>OUT</sub> = 100% rated load DC to 50 kHz, Notes 1, 4		50		dB
Isolation	1	Input to Output or Any Pin to Case except Pin 1, test @ 100VDC	100			MΩ
Device weight					15	g
MTBF		MIL-HDBK-217F2, SF, 35°C	1.5 x 10 <sup>6</sup>			Hours

**Notes: Electrical Performance Characteristics**

- Parameter is tested as part of design characterization or after design changes. Thereafter, parameter shall be guaranteed to the limits specified.
- Parameter verified during line and load regulation tests.
- Output load current must be distributed such that at least 20% of the total load current is being provided by one of the outputs.
- Load current split equally between outputs on dual output models.
- Cross regulation is measured with 20% rated load on output under test while changing the load on the other output from 20% to 80% of rated.
- Guaranteed for a D.C. to 20 MHz bandwidth. Tested using a 20 kHz to 10 MHz bandwidth.
- Capacitive load may be any value from 0 to the maximum limit without compromising dc performance.
- Overload power dissipation is defined as the device power dissipation with the load set such that V<sub>OUT</sub> = 90% of nominal.
- Load step transition time ≥ 10 μs.
- Recovery time is measured from the initiation of the transient to where V<sub>OUT</sub> has returned to within ±1% of its steady state value.
- Line step transition time ≥ 100 μs.
- Turn-on delay time from either a step application of input power or a logic low to a logic high transition on the inhibit pin (Pin 4) to the point where V<sub>OUT</sub> = 90% of nominal.
- For ceramic capacitors with voltage stress less than 10V, derating requirements require minimum 100V rated capacitors. The product will use capacitors with a minimum rating of 16V.
- Total regulation is ± 3% for End-of-Life.

**Radiation Performance Characteristics**

Test	Conditions	Min	Typ	Max	Unit
Total Ionizing Dose (TID) (Gamma)	Operating bias applied during exposure, Half Rated Load, $V_{IN} = 28V$ $T_C = +25^{\circ}C$ , 50 Rads/s	100		150	kRads(Si)
Single Event Effects (SEE) SEU, SEL, SEGR, SEB - Note 1	Heavy Ions (LET) Operating bias applied during exposure, Full Rated Load, $V_{IN} = 18V, 28V, 50V$ - Note 2	58	61	64	MeV.cm <sup>2</sup> /mg

**Notes:**

- Output perturbation is less than + 5% / -10% of nominal output voltage.
- Beam condition: LET = 61±5% MeV.cm<sup>2</sup>/mg

**ARE Series Output Voltage Adjustment:**

Output of ARE series can be adjusted to be greater or less than the nominal output voltage with an external resistor. However, the ranges of the output voltages are limited depending on the model as specified in Table 1. An approximate value of the resistor can be determined using the following formula.

**For Dual Output Model:  $Radj = [A - (B \times 2Vout)] / [(C \times 2Vout) - D]$**

Where:

**Radj** is the value of the external resistor in ohms and is connected as specified in Table 1. Power rating of the resistor shall be  $\geq 0.125W$ . A Metal film resistor with temperature coefficient  $\alpha$  of  $\leq \pm 50$  ppm and tolerance of  $\geq 1\%$  is recommended. However, the final selection is dependent on specific design requirements.

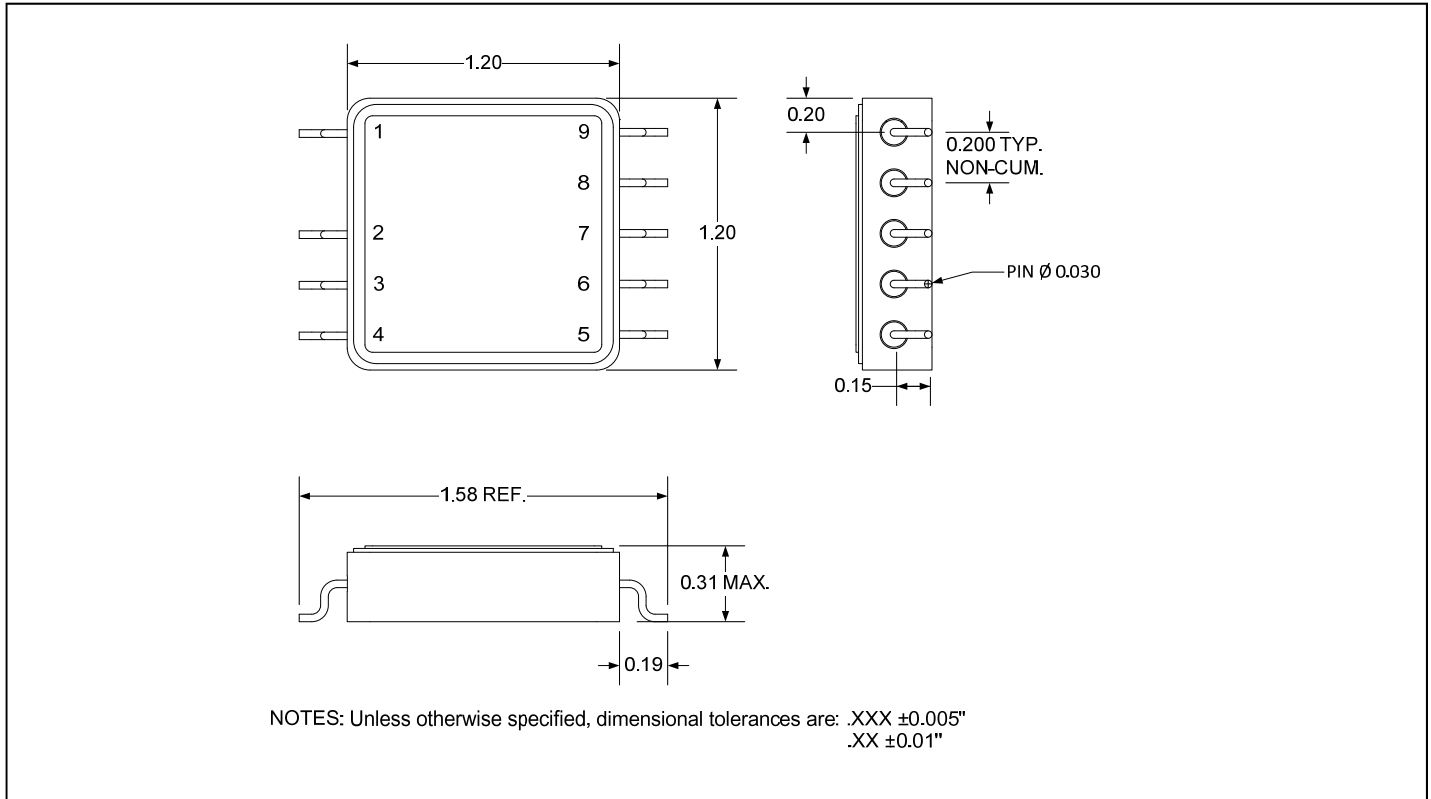
**Vout** is the desired output voltage in volts.

**A, B, C, and D** are unique constants depending on the model as shown in Table 1.

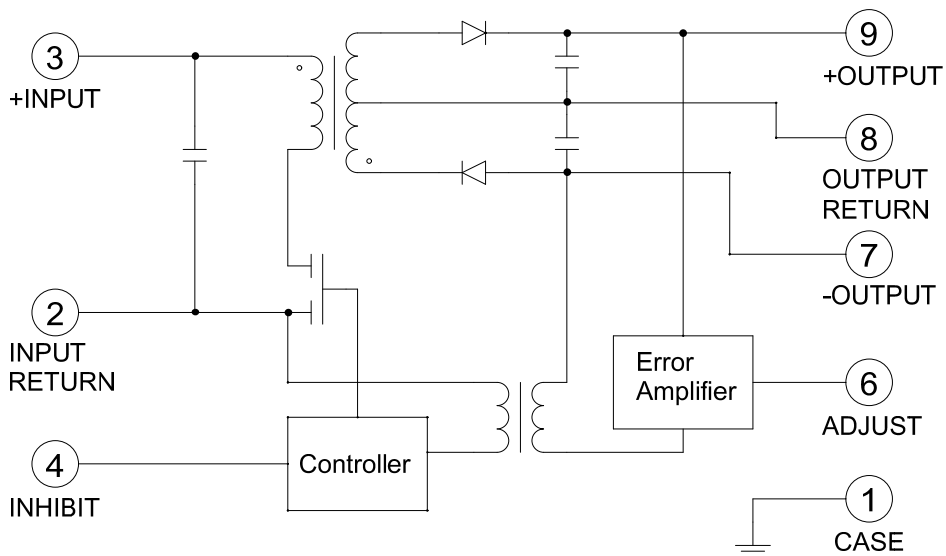
**Table 1: Dual Output Voltage Ranges, Constants and Resistor connection by Model**

Model	Output Voltage Range	Radj connection between	A	B	C	D
ARE2805D	5.0 to 5.5	Pin 6 & Pin 7	3.8E+9	300.0E+6	10.0E+3	100.0E+3
	4.5 to 5.0	Pin 6 & Pin 5	1.5E+9	240.0E+6	4.0E+3	40.0E+3
ARE2812D	12.0 to 13.2	Pin 6 & Pin 7	9.4E+9	300.0E+6	10.0E+3	240.0E+3
	10.8 to 12.0	Pin 6 & Pin 5	3.7E+9	464.0E+6	4.0E+3	96.0E+3
ARE2815D	15.0 to 16.5	Pin 6 & Pin 7	11.8E+9	300.0E+6	10.0E+3	300.0E+3
	13.5 to 15.0	Pin 6 & Pin 5	4.7E+9	560.0E+6	4.0E+3	120.0E+3

**Mechanical Outline**



**Block Diagram**



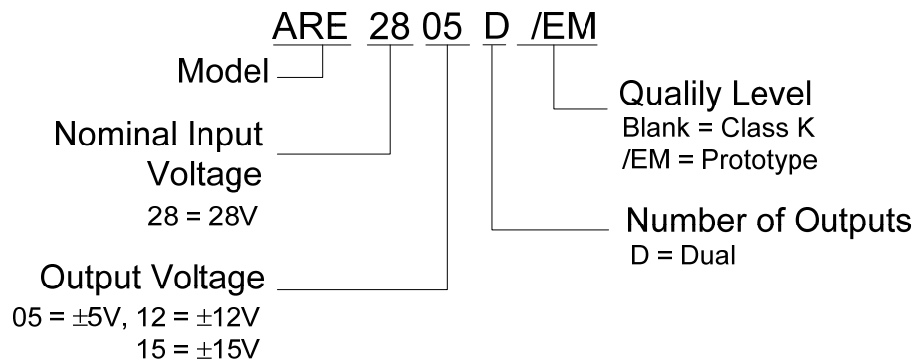
**Pin Designation**

Pin #	Designation	Pin #	Designation
1	Case Ground	6	Adjust
2	Input Return	7	- Output
3	+ Input	8	Output Return
4	Inhibit	9	+ Output
5	NC		

**Device Screening**

Requirement	Method	/EM Conditions	Flight Conditions
Element Evaluation	MIL-PRF-883, Method 2023		X
Nondestructive Bond Pull	MIL-STD-883, Method 2023		X
Internal Visual	MIL-STD-883, Method 2017		X
Temperature Cycling	MIL-STD-883, Method 1010		C
Constant Acceleration	MIL-STD-883, Method 2001 (2K-g)		A, Y1 axis only
Electrical	In accordance with device specification		X
Burn-in (2 x 160 hours)	MIL-STD-883, Method 1015	48 Hours	320 Hours
Final Electrical (Group A)	In accordance with device specification	X	X
Seal Fine Leak Gross Leak	MIL-STD-883, Method 1014		A1 C
Radiographic	MIL-STD-883, Method 2012		X
External Visual	MIL-STD-883, Method 2009	X	X

**Part Numbering**



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The information given in this document shall be in no event regarded as guarantee of conditions or characteristic. The data contained herein is a characterization of the component based on internal standards and is intended to demonstrate and provide guidance for typical part performance. It will require further evaluation, qualification and analysis to determine suitability in the application environment to confirm compliance to your system requirements.

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