

**3**  
YEARS  
WARRANTY

ROHS  
COMPLIANT

REACH  
COMPLIANT



Railway



Automation



Datacom



IPC



Industry



Measurement



Telecom



Automobile



Boat



Charger



Medical



PV



**3000 VAC**  
Reinforced  
Insulation

**10:1**  
Ultra-Wide  
Input  
Range

**HOLD UP**

**NO**  
Min. Load  
Required

Primary  
**PULSE**  
OUTPUT

REMOTE  
**ON**  
OFF

**OCP**

**OTP**

**OVP**

**SCP**

**UVP**  
Adjustable

### PART NUMBER STRUCTURE

| HAE150      | - | 72                  | S               | 05   | U           | A                                 | - | P                                      | TH  |
|-------------|---|---------------------|-----------------|--|-------------|-----------------------------------|---|--|---|
| Series Name |   | Input Voltage (VDC) | Output Quantity | Output Voltage (VDC)                                       | Input Range | Pin Connection Option             |   | Ctrl and Pin Options                   | Assembly Option                               |
|             |   | 72:16~160           | S:Single        | 05:5<br>12:12<br>15:15<br>24:24<br>28:28<br>48:48<br>53:53 | 10:1        | A: A type (Standard)<br>B: B type |   | □: Negative logic<br>P: Positive logic | □: None<br>Through hole type<br>TH: No thread |

**TECHNICAL SPECIFICATION** All specifications are typical at nominal input, full load and 25°C unless otherwise noted

| Model Number     | Input Range | Output Voltage | Output Current @Full Load | Input Current @ No Load | Efficiency | Maximum Capacitor Load |
|------------------|-------------|----------------|---------------------------|-------------------------|------------|------------------------|
|                  | VDC         | VDC            | A                         | mA                      | %          | μF                     |
| HAE150-72S05UA/B | 16 ~ 160    | 5              | 30                        | 33                      | 90.5       | 45000                  |
| HAE150-72S12UA/B | 16 ~ 160    | 12             | 12.5                      | 16                      | 92.5       | 8000                   |
| HAE150-72S15UA/B | 16 ~ 160    | 15             | 10                        | 26                      | 91.5       | 5000                   |
| HAE150-72S24UA/B | 16 ~ 160    | 24             | 6.3                       | 30                      | 89.5       | 2000                   |
| HAE150-72S28UA/B | 16 ~ 160    | 28             | 5.4                       | 32                      | 89         | 1470                   |
| HAE150-72S48UA/B | 16 ~ 160    | 48             | 3.2                       | 23                      | 92         | 470                    |
| HAE150-72S53UA/B | 16 ~ 160    | 53             | 2.9                       | 30                      | 91.5       | 390                    |

| INPUT SPECIFICATIONS          |                             |                           |           |      |      |                     |        |
|-------------------------------|-----------------------------|---------------------------|-----------|------|------|---------------------|--------|
| Parameter                     | Conditions                  |                           |           | Min. | Typ. | Max.                | Unit   |
| Operating input voltage range | 72Vin(nom)                  |                           |           | 16   | 72   | 160                 | VDC    |
| Start up voltage              | UVLO external resistor open |                           |           |      |      | 16                  | VDC    |
| Shutdown voltage              | UVLO external resistor open |                           |           | 10   | 11   | 12                  | VDC    |
| Start up time                 | Constant resistive load     |                           |           |      | 350  |                     | ms     |
|                               | Power up                    |                           |           |      | 350  |                     |        |
|                               | Remote ON/OFF               |                           |           |      |      |                     |        |
| Input Transient voltage       | 100 mS, max.                |                           |           | 12   |      |                     | VDC    |
| Input surge voltage           | 1 second, max.              |                           |           |      |      | 185                 | VDC    |
| Input filter                  |                             |                           |           |      |      |                     | C type |
| Remote ON/OFF                 | Referred to -Vin pin        | Negative logic (Standard) | DC-DC ON  |      |      | Short or 0 ~ 1.2VDC |        |
|                               |                             | Positive logic (Option)   | DC-DC OFF |      |      | Open or 3 ~ 12VDC   |        |
|                               |                             |                           | DC-DC ON  |      |      | Open or 3 ~ 12VDC   |        |
|                               |                             |                           | DC-DC OFF |      |      | Short or 0 ~ 1.2VDC |        |
|                               |                             | Input current of Ctrl pin |           | -0.5 |      | 1                   | mA     |
|                               |                             | Remote off input current  |           |      | 15   |                     | mA     |

| OUTPUT SPECIFICATIONS            |  |  |  |                                 |      |       |       |
|----------------------------------|--|--|--|---------------------------------|------|-------|-------|
| Parameter                        | Conditions   |  |  | Min.                            | Typ. | Max.  | Unit  |
| Voltage accuracy                 |  |  |  | -1.0                            |      | +1.0  | %     |
| Line regulation                  | Low Line to High Line at Full Load   |  |  | -0.2                            |      | +0.2  | %     |
| Load regulation                  | No Load to Full Load   |  |  | -0.1                            |      | +0.1  | %     |
| Voltage adjustability            | Single output  |  |  | -20                             |      | +10   | %     |
| Remote sense                     | % of Vout(nom).<br>If remote sense is not being used, SENSE pins should connect to corresponding polarity Vout pins. |  |  |                                 |      | 10    | %     |
| Ripple and noise                 | Measured by 20MHz bandwidth  |  |  |                                 |      |       |       |
|                                  | With a 22μF/25V X7R MLCC and a 22μF/25V POS-CAP  |  |  | 5Vout                           | 75   |       |       |
|                                  | With a 22μF/25V X7R MLCC and a 22μF/25V POS-CAP  |  |  | 12Vout, 15Vout                  | 150  |       | mVp-p |
|                                  | With a 4.7μF/50V X7R MLCC  |  |  | 24Vout, 28Vout                  | 200  |       |       |
|                                  | With a 1μF/100V X7R MLCC   |  |  | 48Vout, 53Vout                  | 300  |       |       |
| Temperature coefficient          |  |  |  | -0.02                           |      | +0.02 | %/°C  |
| Transient response recovery time | 25% load step change   |  |  |                                 | 250  |       | μs    |
| Over voltage protection          | % of Vout(nom); Hiccup mode  |  |  | 115                             |      | 130   | %     |
| Over load protection             | % of Iout rated; Hiccup mode   |  |  | 120                             |      | 150   | %     |
| Short circuit protection         |  |  |  | Continuous, automatics recovery |      |       |       |

| GENERAL SPECIFICATIONS       |                                 |   |                                       |      |      |                      |
|------------------------------|---------------------------------|---|---------------------------------------|------|------|----------------------|
| Parameter                    | Conditions                      |   | Min.                                  | Typ. | Max. | Unit                 |
| Isolation voltage            | 1 minute(Reinforced insulation) | Input to Output<br>Input (Output) to Base-Plate | 3000<br>1500                          |      |      | VAC                  |
| Isolation resistance         | 500VDC                          |   | 1                                     |      |      | GΩ                   |
| Isolation capacitance        |                                 |   |                                       | 1000 |      | pF                   |
| Switching frequency          |                                 |   | 207                                   | 230  | 253  | kHz                  |
| Safety approvals (Pending)   |                                 |   |                                       |      |      | IEC /UL/ EN62368-1   |
| Standard approvals (Pending) | Railway                         |   |                                       |      |      | EN50155<br>EN45545-2 |
| Case material                |                                 |   | Aluminum base-plate with plastic case |      |      |                      |
| Potting material             |                                 |   | Silicone (UL94 V-0)                   |      |      |                      |
| Weight                       |                                 |   | 113g (3.99oz)                         |      |      |                      |
| MTBF                         | MIL-HDBK-217F, Full load        |   | 3.093 x 10 <sup>5</sup> hrs           |      |      |                      |

| ENVIRONMENTAL SPECIFICATIONS     |   |               |      |            |      |                       |
|----------------------------------|---|---------------|------|------------|------|-----------------------|
| Parameter                        | Conditions  |               | Min. | Typ.       | Max. | Unit                  |
| Operating base-plate temperature |   | With derating | -40  |            | +105 | °C                    |
| Maximum case temperature         |   |               |      |            | 105  | °C                    |
| Over temperature protection      |   |               |      | 110        |      | °C                    |
| Storage temperature range        |   |               | -55  |            | +125 | °C                    |
| Thermal impedance                | Module without assembly option<br>Only mount on the iron base-plate |               |      | 6.1<br>2.8 |      | °C/W                  |
| Thermal shock                    |   |               |      |            |      | MIL-STD-810F          |
| Shock                            |   |               |      |            |      | EN61373, MIL-STD-810F |
| Vibration                        |   |               |      |            |      | EN61373, MIL-STD-810F |
| Relative humidity                |   |               |      |            |      | 5% to 95% RH          |

| EMC SPECIFICATIONS             |                      |   |                  |
|--------------------------------|----------------------|---|------------------|
| Parameter                      | Conditions           |   | Level            |
| EMI                            | EN55032, EN50121-3-2 | With external components                                  | Class A, Class B |
| EMS                            | EN55024, EN50121-3-2 |   |                  |
| ESD                            | EN61000-4-2          | Air ± 8kV and Contact ± 6kV                               | Perf. Criteria A |
| Radiated immunity              | EN61000-4-3          | 20 V/m  | Perf. Criteria A |
| Fast transient                 | EN61000-4-4          | ± 2kV   | Perf. Criteria A |
| Surge                          | EN61000-4-5          | With external components<br>EN55024:±2kV and EN50155:±2kV | Perf. Criteria A |
| Conducted immunity             | EN61000-4-6          | With external components<br>10 Vr.m.s                     | Perf. Criteria A |
| Power frequency magnetic field | EN61000-4-8          | 100A/m continuous; 1000A/m 1 second                       | Perf. Criteria A |

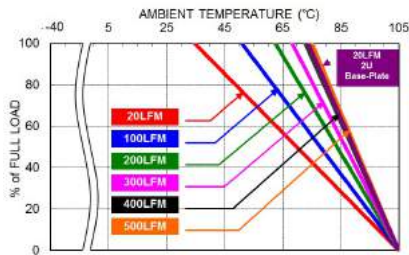
**Note:**

1. BASE-PLATE GROUNDING: When connect four screw bolts to shield plane, the EMI could be reduced.

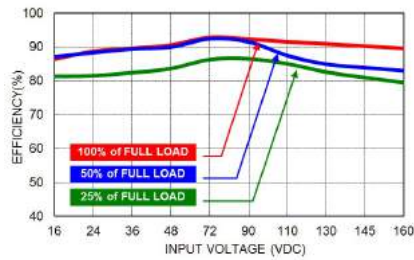
**CAUTION:**

1. This power module is not internally fused. An input line fuse must always be used.
2. The BUS pin is for hold-up time function, and it only can be connected to capacitor and the components that P-DUKE advised, please do not connect to load and use for any other purpose.
3. A Cbus must always be used. (Cbus:Nippon Chemi-con KXJ series, 150µF/200V)

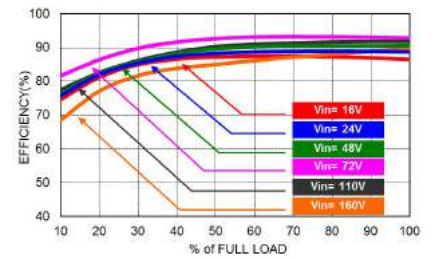
## CHARACTERISTIC CURVE



HAE150-72S12UA Derating Curve  
(See Thermal Considerations)



HAE150-72S12UA Efficiency vs. Input Voltage



HAE150-72S12UA Efficiency vs. Output Load

## FUSE CONSIDERATION

This power module is not internally fused. An input line fuse must always be used.

This encapsulated power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of sophisticated power architecture.

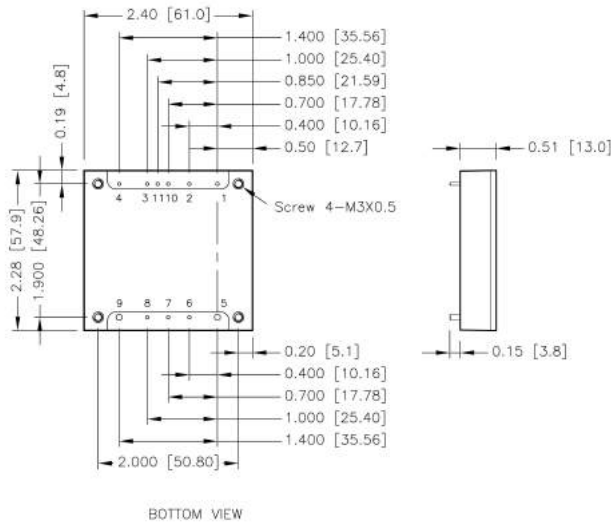
To maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse.

The input line fuse suggest as below :

| Location          | Fuse Rating (A) | Fuse Type   |
|-------------------|-----------------|-------------|
| Input Line        | 15              | Fast-Acting |
| BUS Line (Option) | 3               | Fast-Acting |

The table based on the information provided in this data sheet on inrush energy and maximum DC input current at low Vin.

## MECHANICAL DRAWING



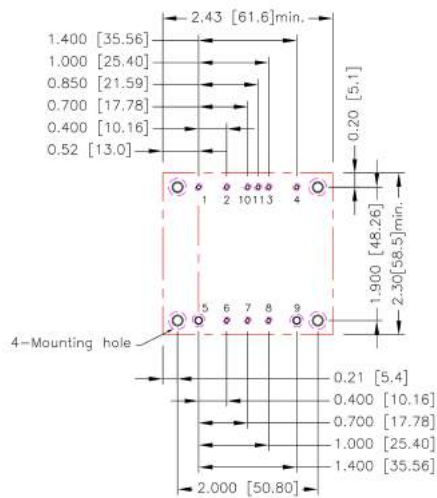
■ The screw locked torque: MAX 3.5kgf-cm/0.34N-m

## PIN CONNECTION

| PIN | A-TYPE    | B-TYPE    | DIAMETER  |
|-----|-----------|-----------|-----------|
| 1   | -Vin      | -Vin      | 0.04 Inch |
| 2   | BUS       | BUS       | 0.04 Inch |
| 3   | Ctrl      | UVLO      | 0.04 Inch |
| 4   | +Vin      | +Vin      | 0.04 Inch |
| 5   | -Vout     | -Vout     | 0.08 Inch |
| 6   | -Sense    | -Sense    | 0.04 Inch |
| 7   | Trim      | Trim      | 0.04 Inch |
| 8   | +Sense    | +Sense    | 0.04 Inch |
| 9   | +Vout     | +Vout     | 0.08 Inch |
| 10  | UVLO      | Ctrl      | 0.04 Inch |
| 11  | Pulse Out | Pulse Out | 0.04 Inch |

- All dimensions in inch [mm]
- Tolerance :x.xxx±0.02 [x.x±0.5]  
x.xxx±0.010 [x.xx±0.25]
- Pin dimension tolerance ±0.004 [0.10]

## RECOMMENDED PAD LAYOUT



- All dimensions in inch[mm]  
 Pad size(lead free recommended)  
 Through hole 1.2.3.4.6.7.8.10.11:Φ0.051[1.30]  
 Through hole 5.9:Φ0.091[2.30]  
 Through hole of mounting:Φ0.126[3.20]  
 Top view pad 1.2.3.4.6.7.8.10.11:Φ0.064[1.63]  
 Top view pad 5.9:Φ0.113[2.88]  
 Top view pad of mounting:Φ0.157[4.00]  
 Bottom view pad 1.2.3.4.6.7.8.10.11:Φ0.102[2.60]  
 Bottom view pad 5.9:Φ0.181[4.60]  
 Bottom view pad of mounting:Φ0.252[6.40]

## THERMAL CONSIDERATIONS

The power module operates in a variety of thermal environments.

However, sufficient cooling should be provided to help ensure reliable operation of the unit.

Heat is removed by conduction, convection, and radiation to the surrounding Environment.

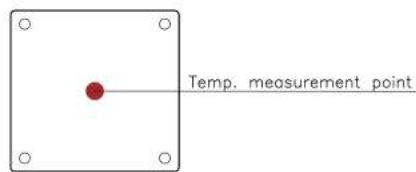
Proper cooling can be verified by measuring the point as the figure below.

The temperature at this location should not exceed "Maximum case temperature".

When Operating, adequate cooling must be provided to maintain the test point temperature at or below "Maximum case temperature".

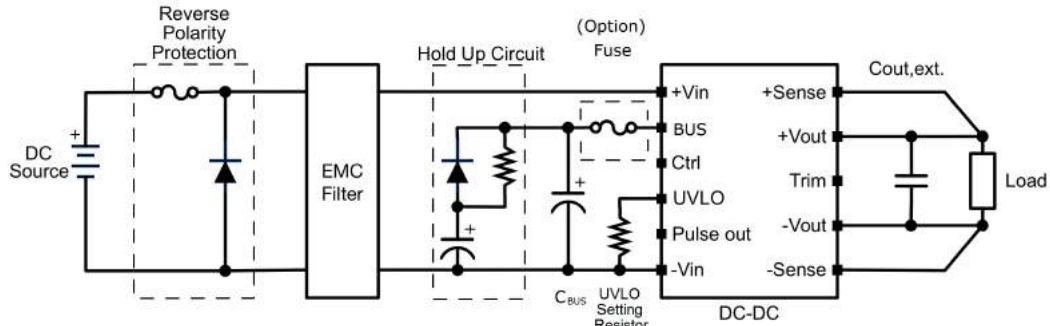
You can limit this Temperature to a lower value for extremely high reliability.

- Thermal test condition with vertical direction by natural convection (20LFM).
- The iron base-plate dimension is 19" X 3.5" X 0.063" (The height is EIA standard 2U).



BASE PLATE

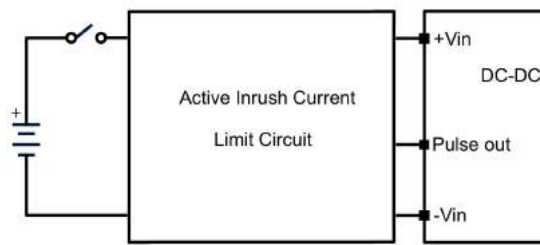
**TYPICAL APPLICATION**



Typical Connection

■ Pulse Out

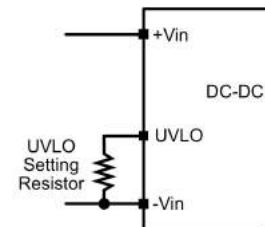
This pin generates voltage pulse with fixed frequency. It provides the function that could achieve inrush current limit with external circuit. If Pulse Out pin is not to be used, please left this pin floating.



■ UVLO

This series product has ultra wide input range. It could cover many kind of nominal input voltage in one module. In order to preventing incorrect operating under different input system, it offers UVLO adjustment by connecting a resistor to set UVLO threshold.

$$V_{in,on} = \left( \frac{451.23}{R_{UVLO} + 3} + 15.18 \right) V \quad V_{in,off} = \left( \frac{448.5}{R_{UVLO} + 3} + 10.80 \right) V$$

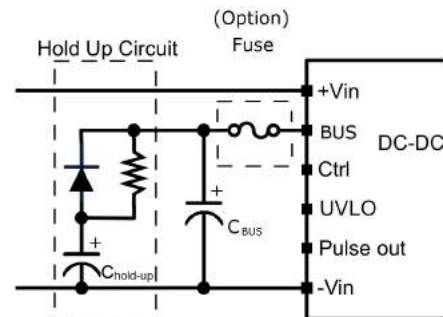


UVLO Setting

| Nominal Vin           | (V)  | 24   | 36   | 48   | 72   | 96   | 110  |
|-----------------------|------|------|------|------|------|------|------|
| Start-up Voltage      | (V)  | 15.0 | 21.6 | 28.8 | 43.2 | 57.6 | 66.0 |
| Shutdown Voltage      | (V)  | 11.0 | 17.2 | 24.3 | 38.7 | 53.0 | 61.3 |
| UVLO Setting Resistor | (kΩ) | Open | 67.2 | 30.2 | 13.1 | 7.64 | 5.88 |

■ Hold Up Time

Generally, connecting a large number of hold up capacitors on input are necessary to get long duration of hold up time. The external circuit connected to BUS pin provides energy that stored in C<sub>hold-up</sub> when input voltage shutdown. That extends duration of hold up time with less capacitance so that reduce the number of capacitors.



Hold Up Function

## OUTPUT VOLTAGE ADJUSTMENT

Output voltage is adjustable for 10% trim up or -20% trim down of nominal output voltage by connecting an external resistor between the Trim pin and either the +Sense or -Sense pins.

With an external resistor between the Trim and -Sense pin, the output voltage set point decreases.

With an external resistor between the Trim and +Sense pin, the output voltage set point increases.

Maximum output deviation is +10% inclusive of remote sense.

The external Trim resistor needs to be at least 1/8W of rated power.

### Trim Up Equation

$$R_U = \left( \frac{V_{OUT}(100 + \Delta\%)}{1.225\Delta\%} - \frac{100 + 2\Delta\%}{\Delta\%} \right) k\Omega$$

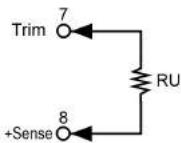
### Trim Down Equation

$$R_D = \left( \frac{100}{\Delta\%} - 2 \right) k\Omega$$

### EXTERNAL OUTPUT TRIMMING

Output can be externally trimmed by using the method shown below.

Trim-up



#### 72S05UA/B

| $\Delta V$ (%)   | 1       | 2       | 3       | 4      | 5      | 6      | 7      | 8      | 9      | 10     |
|------------------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|
| Vout (V)         | 5.05    | 5.10    | 5.15    | 5.20   | 5.25   | 5.30   | 5.35   | 5.40   | 5.45   | 5.50   |
| RU (k $\Omega$ ) | 310.245 | 156.163 | 104.803 | 79.122 | 63.714 | 53.442 | 46.105 | 40.602 | 36.322 | 32.898 |

#### 72S12UA/B

| $\Delta V$ (%)   | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10     |
|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| Vout (V)         | 12.12   | 12.24   | 12.36   | 12.48   | 12.60   | 12.72   | 12.84   | 12.96   | 13.08   | 13.20  |
| RU (k $\Omega$ ) | 887.388 | 447.592 | 300.993 | 227.694 | 183.714 | 154.395 | 133.452 | 117.745 | 105.528 | 95.755 |

#### 72S15UA/B

| $\Delta V$ (%)   | 1        | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      |
|------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Vout (V)         | 15.15    | 15.30   | 15.45   | 15.60   | 15.75   | 15.90   | 16.05   | 16.20   | 16.35   | 16.50   |
| RU (k $\Omega$ ) | 1134.735 | 572.490 | 385.075 | 291.367 | 235.143 | 197.660 | 170.886 | 150.806 | 135.188 | 122.694 |

#### 72S24UA/B

| $\Delta V$ (%)   | 1        | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      |
|------------------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Vout (V)         | 24.24    | 24.48   | 24.72   | 24.96   | 25.20   | 25.44   | 25.68   | 25.92   | 26.16   | 26.40   |
| RU (k $\Omega$ ) | 1876.776 | 947.184 | 637.320 | 482.388 | 389.429 | 327.456 | 283.190 | 249.990 | 224.168 | 203.510 |

#### 72S28UA/B

| $\Delta V$ (%)   | 1        | 2        | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      |
|------------------|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|
| Vout (V)         | 28.28    | 28.56    | 28.84   | 29.12   | 29.40   | 29.68   | 29.96   | 30.24   | 30.52   | 30.80   |
| RU (k $\Omega$ ) | 2206.571 | 1113.714 | 749.429 | 567.286 | 458.000 | 385.143 | 333.102 | 294.071 | 263.714 | 239.429 |

#### 72S48UA/B

| $\Delta V$ (%)   | 1        | 2        | 3        | 4       | 5       | 6       | 7       | 8       | 9       | 10      |
|------------------|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|
| Vout (V)         | 48.48    | 48.96    | 49.44    | 49.92   | 50.40   | 50.88   | 51.36   | 51.84   | 52.32   | 52.80   |
| RU (k $\Omega$ ) | 3855.551 | 1946.367 | 1309.973 | 991.776 | 800.857 | 673.578 | 582.665 | 514.480 | 461.447 | 419.020 |

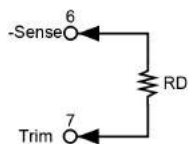
#### 72S53UA/B

| $\Delta V$ (%)   | 1        | 2        | 3        | 4        | 5       | 6        | 7       | 8       | 9     | 10    |
|------------------|----------|----------|----------|----------|---------|----------|---------|---------|-------|-------|
| Vout (V)         | 53.53    | 54.06    | 54.59    | 55.12    | 55.65   | 56.18    | 56.71   | 57.24   | 57.77 | 58.30 |
| RU (k $\Omega$ ) | 4267.769 | 2154.531 | 1450.109 | 1097.898 | 886.571 | 745.6871 | 645.055 | 569.582 |       |       |



**OUTPUT VOLTAGE ADJUSTMENT (CONTINUED)**

Trim-down



72S□□UA/B

|                  |        |        |        |        |        |        |        |        |       |       |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|
| $\Delta V$ (%)   | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9     | 10    |
| RD (k $\Omega$ ) | 98.000 | 48.000 | 31.333 | 23.000 | 18.000 | 14.667 | 12.286 | 10.500 | 9.111 | 8.000 |
| $\Delta V$ (%)   | 11     | 12     | 13     | 14     | 15     | 16     | 17     | 18     | 19    | 20    |
| RD (k $\Omega$ ) | 7.091  | 6.333  | 5.692  | 5.143  | 4.667  | 4.250  | 3.882  | 3.556  | 3.263 | 3.000 |