

**3A 150KHz 40V Buck DC to DC Converter****HS2596****Features**

- Wide 4.5V to 40V Input Voltage Range
- 3.3V, 5V, 12V, and adjustable versions
- Output Adjustable from 1.23V to 37V
- Maximum Duty Cycle 100%
- Minimum Drop Out 1.5V
- Fixed 150KHz Switching Frequency
- 3A Constant Output Current Capability
- Internal Optimize Power Transistor
- High efficiency
- Excellent line and load regulation
- TTL shutdown capability
- ON/OFF pin with hysteresis function
- Built in thermal shutdown function
- Built in current limit function
- Built in second current limit function
- Available in TO-220, TO-263 packages

**Applications**

- LCD Monitor and LCD TV
- Digital Photo Frame
- Set-up Box
- ADSL Modem
- Telecom / Networking Equipment

**General Description**

The HS2596 is a 150 KHz fixed frequency PWM buck (step-down) DC/DC converter, capable of driving a 3A load with high efficiency, low ripple and excellent line and load regulation. Requiring a minimum number of external components, the regulator is simple to use and include internal frequency compensation and a fixed-frequency oscillator.

The PWM control circuit is able to adjust the duty ratio linearly from 0 to 100%. An enable function, an over current protection function is built inside. When second current limit function happens, the operation frequency will be reduced from 150KHz to 50KHz. An internal compensation block is built in to minimize external component count.

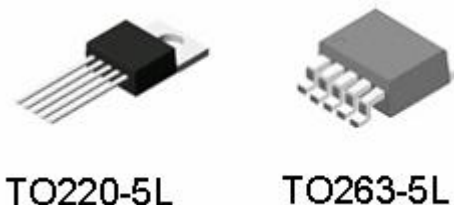


Figure1. Package Type of HS2596

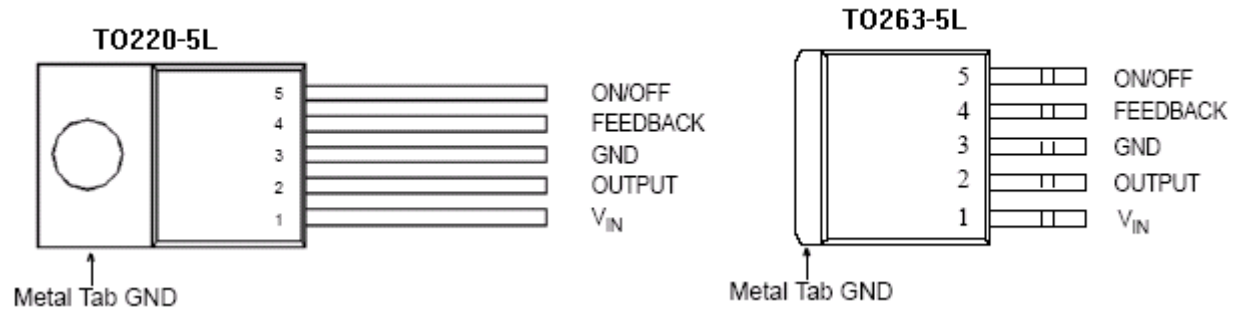
**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Pin Configurations**


Figure2. Pin Configuration of HS2596 (Top View)

Table 1 Pin Description

| Pin Number | Pin Name | Description                                                                                                                                                                                                    |
|------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1          | VIN      | Supply Voltage Input Pin. HS2596 operates from a 4.5V to 40V DC voltage. Bypass Vin to GND with a suitably large capacitor to eliminate noise on the input.                                                    |
| 2          | OUTPUT   | Power Switch Output Pin (SW). Output is the switch node that supplies power to the output.                                                                                                                     |
| 3          | GND      | Ground Pin. Care must be taken in layout. This pin should be placed outside of the Schottky Diode to output capacitor ground path to prevent switching current spikes from inducing voltage noise into HS2596. |
| 4          | FEEDBACK | Feedback Pin (FB). Through an external resistor divider network, Feedback senses the output voltage and regulates it. The feedback threshold voltage is 1.23V.                                                 |
| 5          | ON/OFF   | Enable Pin. Drive ON/OFF pin low to turn on the device, drive it high to turn it off. Floating is default low.                                                                                                 |

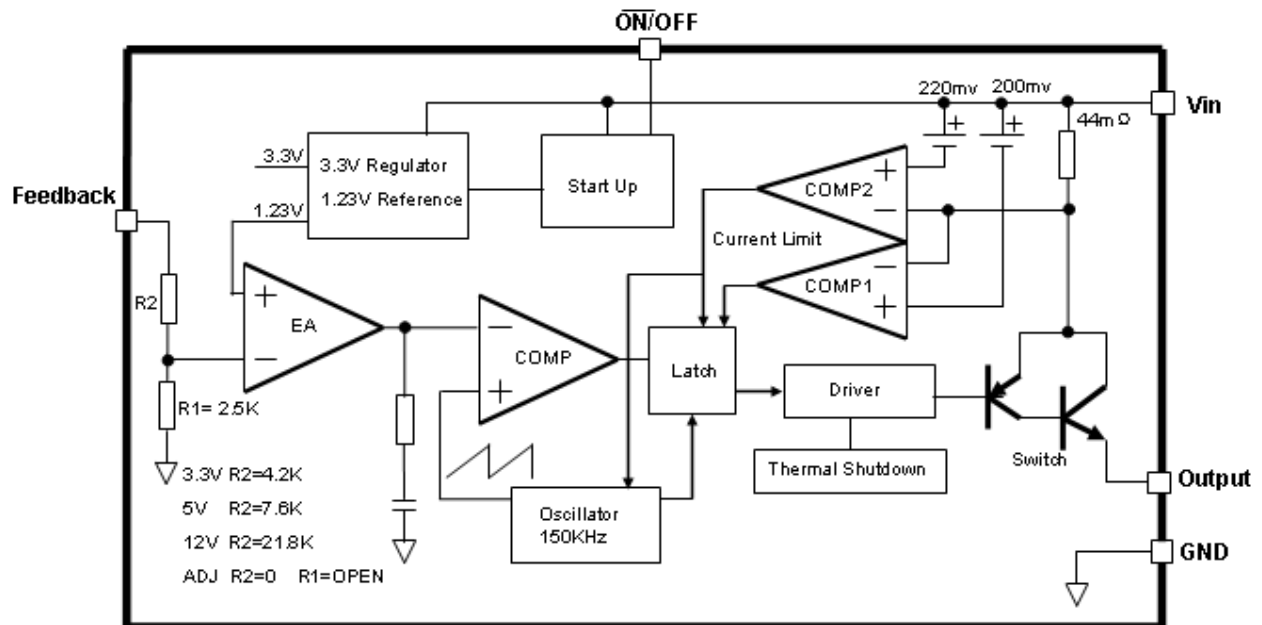
**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Function Block**


Figure3. Function Block Diagram of HS2596

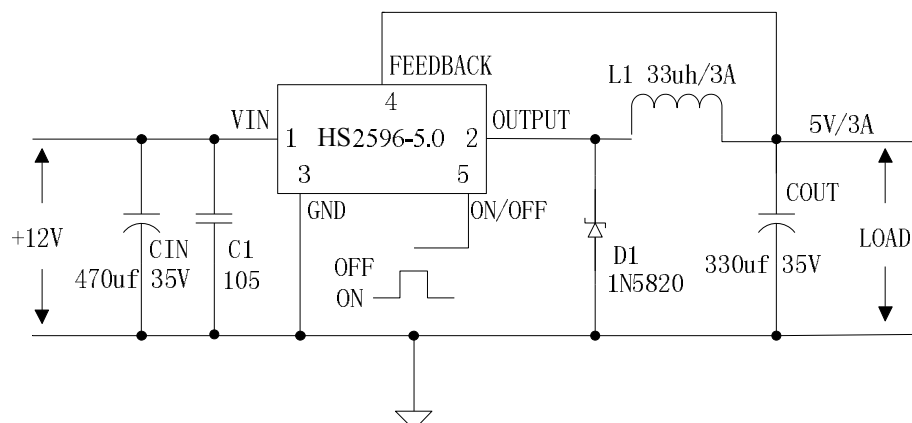
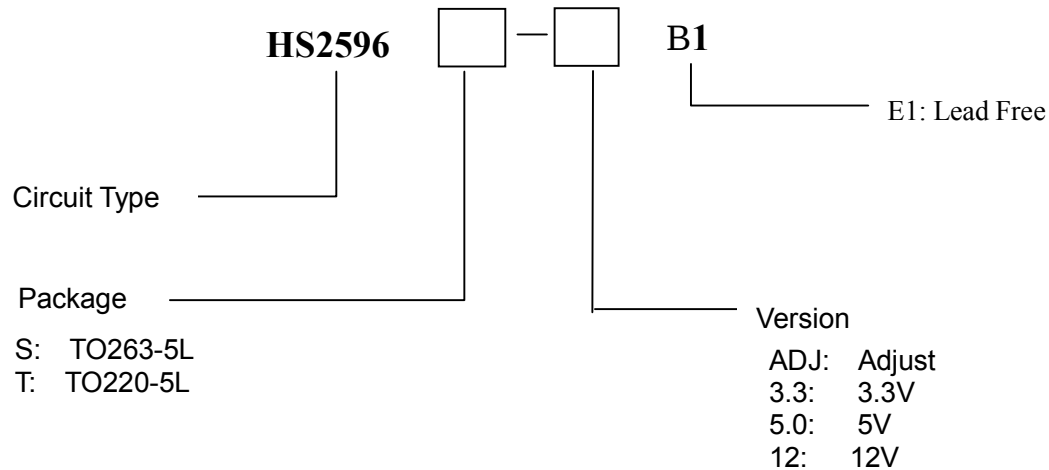
**Typical Application Circuit**


Figure4. HS2596 Typical Application Circuit 12V-5V/3A

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Ordering Information**


| Package  | Temperature Range | Marking ID    | Packing Type Supplied As |
|----------|-------------------|---------------|--------------------------|
|          |                   | Lead Free     |                          |
| TO220-5L | -40°C ~ 85°C      | HS2596T-ADJB1 | Tube                     |
|          |                   | HS2596T-3.3B1 | Tube                     |
|          |                   | HS2596T-5.0B1 | Tube                     |
|          |                   | HS2596T-12B1  | Tube                     |
| TO263-5L | -40°C ~ 85°C      | HS2596S-ADJB1 | 800 Units on Tape & Reel |
|          |                   | HS2596S-3.3B1 | 800 Units on Tape & Reel |
|          |                   | HS2596S-5.0B1 | 800 Units on Tape & Reel |
|          |                   | HS2596S-12B1  | 800 Units on Tape & Reel |

HS Pb-free products, as designated with “B1” suffix in the par number, are RoHS compliant.

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Absolute Maximum Ratings (Note1)**

| Parameter                                                                          | Symbol       | Value              | Unit |
|------------------------------------------------------------------------------------|--------------|--------------------|------|
| Input Voltage                                                                      | $V_{in}$     | -0.3 to 45         | V    |
| Feedback Pin Voltage                                                               | $V_{FB}$     | -0.3 to $V_{in}$   | V    |
| ON/OFF Pin Voltage                                                                 | $V_{ON/OFF}$ | -0.3 to $V_{in}$   | V    |
| Output Switch Pin Voltage                                                          | $V_{Output}$ | -0.3 to $V_{in}$   | V    |
| Power Dissipation                                                                  | $P_D$        | Internally limited | mW   |
| Thermal Resistance (TO220 & TO263)<br>(Junction to Ambient, No Heatsink, Free Air) | $R_{JA}$     | 30                 | °C/W |
| Operating Junction Temperature                                                     | $T_J$        | -40 to 125         | °C   |
| Storage Temperature                                                                | $T_{STG}$    | -65 to 150         | °C   |
| Lead Temperature (Soldering, 10 sec)                                               | $T_{LEAD}$   | 260                | °C   |
| ESD (HBM)                                                                          |              | 2000               | V    |

**Note1:** Stresses greater than those listed under Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**HS2596-3.3 Electrical Characteristics**
 $T_a = 25^{\circ}\text{C}$ ; unless otherwise specified.

| Symbol                                        | Parameter      | Test Condition                         | Min.  | Typ. | Max.  | Unit |
|-----------------------------------------------|----------------|----------------------------------------|-------|------|-------|------|
| <i>System parameters test circuit figure6</i> |                |                                        |       |      |       |      |
| VOUT                                          | Output Voltage | Vin = 4.75V to 40V<br>Iload=0.2A to 3A | 3.168 | 3.3  | 3.432 | V    |
| Efficiency                                    | $\eta$         | Vin=12V , Vout=3.3V<br>Iout=3A         | -     | 73   | -     | %    |

**HS2596-5.0 Electrical Characteristics**
 $T_a = 25^{\circ}\text{C}$ ; unless otherwise specified.

| Symbol                                        | Parameter      | Test Condition                      | Min. | Typ. | Max. | Unit |
|-----------------------------------------------|----------------|-------------------------------------|------|------|------|------|
| <i>System parameters test circuit figure7</i> |                |                                     |      |      |      |      |
| VOUT                                          | Output Voltage | Vin = 7V to 40V<br>Iload=0.2A to 3A | 4.8  | 5    | 5.2  | V    |
| Efficiency                                    | $\eta$         | Vin=12V , Vout=5V<br>Iout=3A        | -    | 80   | -    | %    |

**HS2596-12 Electrical Characteristics**
 $T_a = 25^{\circ}\text{C}$ ; unless otherwise specified.

| Symbol                                        | Parameter      | Test Condition                       | Min.  | Typ. | Max.  | Unit |
|-----------------------------------------------|----------------|--------------------------------------|-------|------|-------|------|
| <i>System parameters test circuit figure8</i> |                |                                      |       |      |       |      |
| VOUT                                          | Output Voltage | Vin = 15V to 40V<br>Iload=0.2A to 3A | 11.52 | 12   | 12.48 | V    |
| Efficiency                                    | $\eta$         | Vin=25V , Vout=12V<br>Iout=3A        | -     | 90   | -     | %    |

**HS2596-ADJ Electrical Characteristics**
 $T_a = 25^{\circ}\text{C}$ ; unless otherwise specified.

| Symbol                                        | Parameter      | Test Condition                        | Min.  | Typ. | Max.  | Unit |
|-----------------------------------------------|----------------|---------------------------------------|-------|------|-------|------|
| <i>System parameters test circuit figure9</i> |                |                                       |       |      |       |      |
| VOUT                                          | Output Voltage | Vin = 4.5V to 40V<br>Iload=0.2A to 3A | 1.193 | 1.23 | 1.267 | V    |
| Efficiency                                    | $\eta$         | Vin=12V , Vout=3V<br>Iout=3A          | -     | 73   | -     | %    |

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Electrical Characteristics (DC Parameters)**

$V_{in} = 12V$  for the 3.3V, 5V, and Adjustable versions and  $V_{in} = 24V$  for the 12V version,  $GND = 0V$ ,  $V_{in}$  &  $GND$  parallel connect a 220uF/50V capacitor;  $I_{out} = 500mA$ ,  $T_a = 25^\circ C$ ; the others floating unless otherwise specified.

| Parameters                       | Symbol       | Test Condition                             | Min. | Typ.       | Max. | Unit |
|----------------------------------|--------------|--------------------------------------------|------|------------|------|------|
| Input operation voltage          | $V_{in}$     |                                            | 4.5  |            | 40   | V    |
| Shutdown Supply Current          | $I_{STBY}$   | $V_{ON/OFF} = 5V$                          |      | 80         | 200  | uA   |
| Quiescent Supply Current         | $I_q$        | $V_{ON/OFF} = 0V$ ,<br>$V_{FB} = V_{in}$   |      | 2          | 10   | mA   |
| Oscillator Frequency             | $F_{osc}$    |                                            | 127  | 150        | 173  | KhZ  |
| Switch Current Limit             | $I_L$        | $V_{FB} = 0$                               | 3.6  | 4.8        | 6.9  | A    |
| ON/OFF Pin Threshold             | $V_{ON/OFF}$ | High (Regulator OFF)<br>Low (Regulator ON) |      | 1.4<br>0.8 |      | V    |
| ON/OFF Pin Input Leakage Current | $I_H$        | $V_{ON/OFF} = 2.5V$ (OFF)                  |      | 5          | 15   | uA   |
|                                  | $I_L$        | $V_{ON/OFF} = 0.5V$ (ON)                   |      | 0.2        | 5    | uA   |
| Output Saturation Voltage        | $V_{CE}$     | $V_{FB} = 0V$<br>$I_{out} = 3A$            |      | 1.3        | 1.5  | V    |
| Max. Duty Cycle                  | $D_{MAX}$    | $V_{FB} = 0V$                              |      | 100        |      | %    |

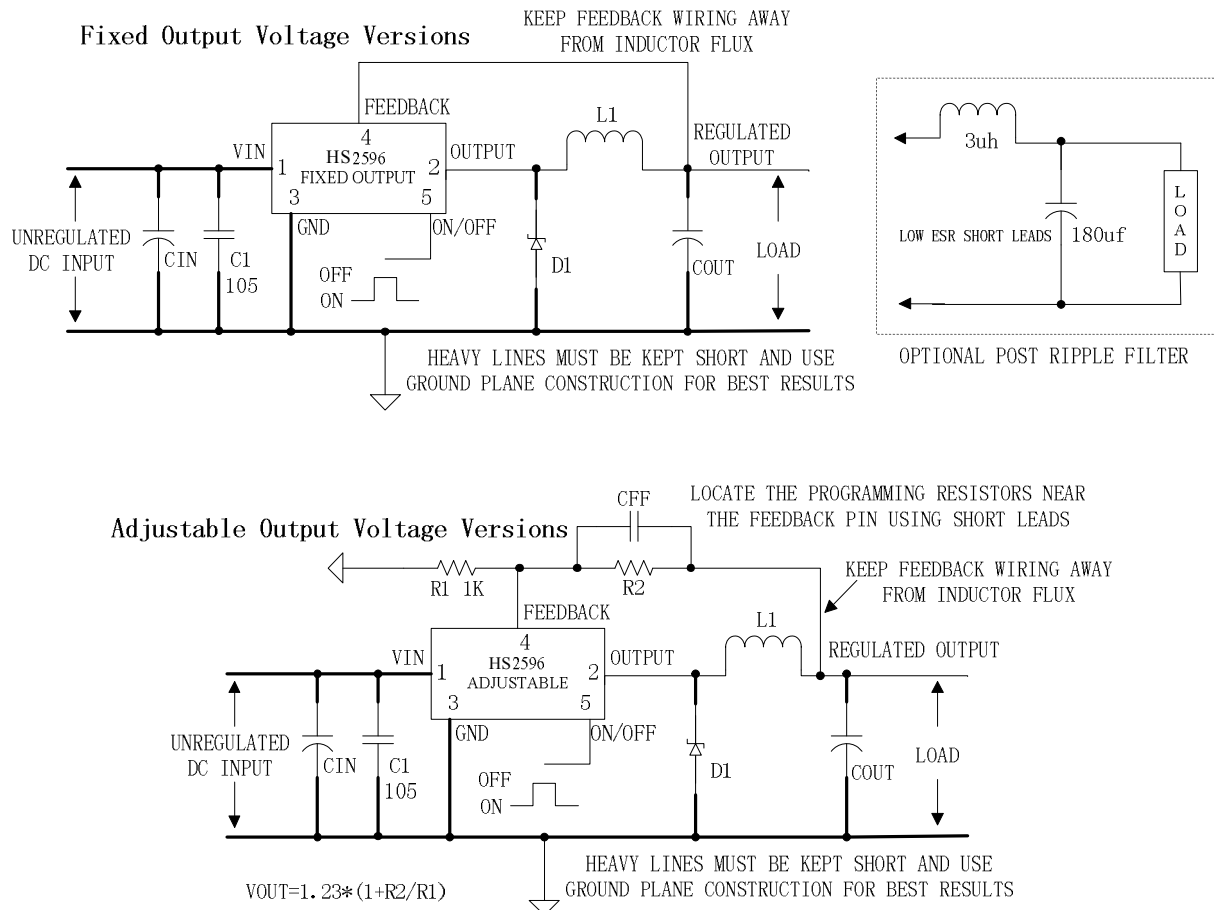
**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Test Circuit and Layout guidelines**


Figure5. Standard Test Circuits and Layout Guides

Select R1 to be approximately 1K, use a 1% resistor for best stability.

C1 and CFF are optional; in order to increase stability and reduce the input power line noise, CIN and C1 must be placed near to PIN1 and PIN3;

For output voltages greater than approximately 10V, an additional capacitor CFF is required. The compensation capacitor is typically between 100 pf and 33 nf, and is wired in parallel with the output voltage setting resistor, R2. It provides additional stability for high output voltage, low input-output voltages, and/or very low ESR output capacitors, such as solid tantalum capacitors.  $CFF = 1/(31 * 1000 * R2)$ ; This capacitor type can be ceramic, plastic, silver mica, etc. (Because of the unstable characteristics of ceramic capacitors made with Z5U material, they are not recommended.)

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**HS2596 Series Buck Regulator Design Procedure (Fixed Output)**

| Conditions               |                        |                          | Inductor<br>(L1)   | Output Capacitor (COUT)           |                                 |                             |                                  |
|--------------------------|------------------------|--------------------------|--------------------|-----------------------------------|---------------------------------|-----------------------------|----------------------------------|
|                          |                        |                          |                    | Through Hole Electrolytic         |                                 | Surface Mount Tantalum      |                                  |
| Output<br>Voltage<br>(V) | Load<br>Current<br>(A) | Max Input<br>Voltage (V) | Inductance<br>(uh) | Panasonic<br>HFQ Series<br>(uf/V) | Nichicon<br>PL Series<br>(uf/V) | AVX TPS<br>Series<br>(uf/V) | Sprague<br>595D Series<br>(uf/V) |
| 3.3                      | 3                      | 5                        | 22                 | 470/25                            | 560/16                          | 330/6.3                     | 390/6.3                          |
|                          |                        | 7                        | 22                 | 560/35                            | 560/35                          | 330/6.3                     | 390/6.3                          |
|                          |                        | 10                       | 22                 | 680/35                            | 680/35                          | 330/6.3                     | 390/6.3                          |
|                          |                        | 40                       | 33                 | 560/35                            | 470/35                          | 330/6.3                     | 390/6.3                          |
|                          | 2                      | 6                        | 22                 | 470/25                            | 470/35                          | 330/6.3                     | 390/6.3                          |
|                          |                        | 10                       | 33                 | 330/35                            | 330/35                          | 330/6.3                     | 390/6.3                          |
|                          |                        | 40                       | 47                 | 330/35                            | 270/50                          | 220/10                      | 330/10                           |
| 5                        | 3                      | 8                        | 22                 | 470/25                            | 560/16                          | 220/10                      | 330/10                           |
|                          |                        | 10                       | 22                 | 560/25                            | 560/25                          | 220/10                      | 330/10                           |
|                          |                        | 15                       | 33                 | 330/35                            | 330/35                          | 220/10                      | 330/10                           |
|                          |                        | 40                       | 47                 | 330/35                            | 270/35                          | 220/10                      | 330/10                           |
|                          | 2                      | 9                        | 22                 | 470/25                            | 560/16                          | 220/10                      | 330/10                           |
|                          |                        | 20                       | 68                 | 180/35                            | 180/35                          | 100/10                      | 270/10                           |
|                          |                        | 40                       | 68                 | 180/35                            | 180/35                          | 100/10                      | 270/10                           |
| 12                       | 3                      | 15                       | 22                 | 470/25                            | 470/25                          | 100/16                      | 180/16                           |
|                          |                        | 18                       | 33                 | 330/25                            | 330/25                          | 100/16                      | 180/16                           |
|                          |                        | 30                       | 68                 | 180/25                            | 180/25                          | 100/16                      | 120/20                           |
|                          |                        | 40                       | 68                 | 180/35                            | 180/25                          | 100/16                      | 120/20                           |
|                          | 2                      | 15                       | 33                 | 330/25                            | 330/25                          | 100/16                      | 180/16                           |
|                          |                        | 20                       | 68                 | 180/25                            | 180/25                          | 100/16                      | 120/20                           |
|                          |                        | 40                       | 150                | 82/25                             | 82/25                           | 68/20                       | 68/25                            |

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**HS2596 Series Buck Regulator Design Procedure (Adjustable Output)**

| Output Voltage (V) | Through Hole Output Electrolytic |                           |                       | Surface Mount Output Capacitor |                            |                       |
|--------------------|----------------------------------|---------------------------|-----------------------|--------------------------------|----------------------------|-----------------------|
|                    | Panasonic HFQ Series (uf/V)      | Nichicon PL Series (uf/V) | Feedforward Capacitor | AVX TPS Series (uf/V)          | Sprague 595D Series (uf/V) | Feedforward Capacitor |
| 2                  | 820/35                           | 820/35                    | 33nf                  | 330/6.3                        | 470/4                      | 33nf                  |
| 4                  | 560/35                           | 470/35                    | 10nf                  | 330/6.3                        | 390/6.3                    | 10nf                  |
| 6                  | 470/25                           | 470/35                    | 3.3nf                 | 220/10                         | 330/10                     | 3.3nf                 |
| 9                  | 330/25                           | 330/25                    | 1.5nf                 | 100/16                         | 180/16                     | 1.5nf                 |
| 12                 | 330/25                           | 330/25                    | 1nf                   | 100/16                         | 180/16                     | 1nf                   |
| 15                 | 220/25                           | 220/35                    | 680pf                 | 68/20                          | 120/20                     | 680pf                 |
| 24                 | 220/35                           | 150/35                    | 560pf                 | 33/25                          | 33/25                      | 220pf                 |
| 28                 | 100/50                           | 100/50                    | 390pf                 | 10/35                          | 15/50                      | 220pf                 |

**Schottky Diode Selection Table**

| Current | Surface Mount | Through Hole | VR (The same as system maximum input voltage) |        |        |        |        |
|---------|---------------|--------------|-----------------------------------------------|--------|--------|--------|--------|
|         |               |              | 20V                                           | 30V    | 40V    | 50V    | 60V    |
| 1A      |               | ✓            | 1N5817                                        | 1N5818 | 1N5819 |        |        |
| 3A      |               | ✓            | 1N5820                                        | 1N5821 | 1N5822 |        |        |
|         |               | ✓            | MBR320                                        | MBR330 | MBR340 | MBR350 | MBR360 |
|         | ✓             |              | SK32                                          | SK33   | SK34   | SK35   | SK36   |
|         | ✓             |              |                                               | 30WQ03 | 30WQ04 | 30WQ05 |        |
|         |               | ✓            |                                               | 31DQ03 | 31DQ04 | 31DQ05 |        |
|         |               | ✓            | SR302                                         | SR303  | SR304  | SR305  | SR306  |
| 5A      |               | ✓            | 1N5823                                        | 1N5824 | 1N5825 |        |        |
|         |               | ✓            | SR502                                         | SR503  | SR504  | SR505  | SR506  |
|         |               | ✓            | SB520                                         | SB530  | SB540  | SB550  | SB560  |
|         | ✓             |              |                                               | 50WQ03 | 50WQ04 | 50WQ05 |        |

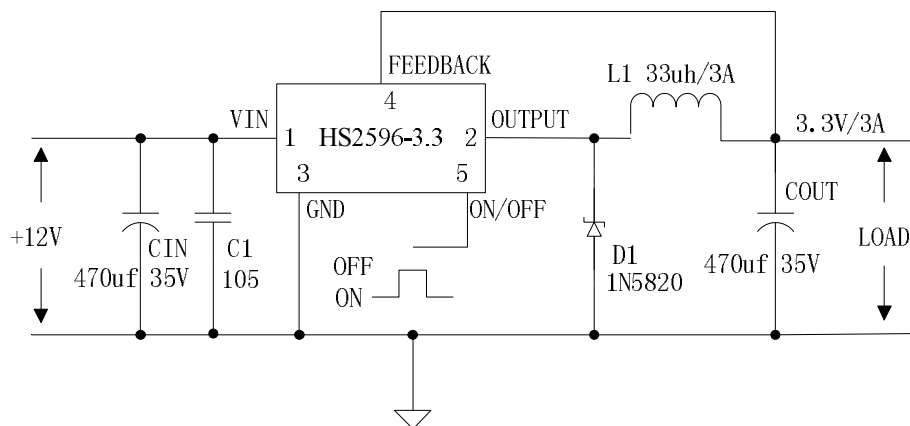
**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Typical System Application for 3.3V Version**


Figure6. HS2596-3.3 System Parameters Test Circuit

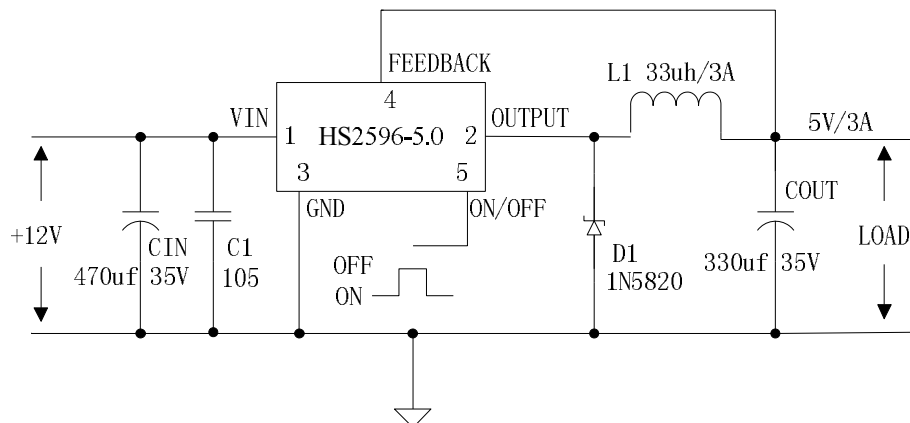
**Typical System Application for 5V Version**


Figure7. HS2596-5.0 System Parameters Test Circuit

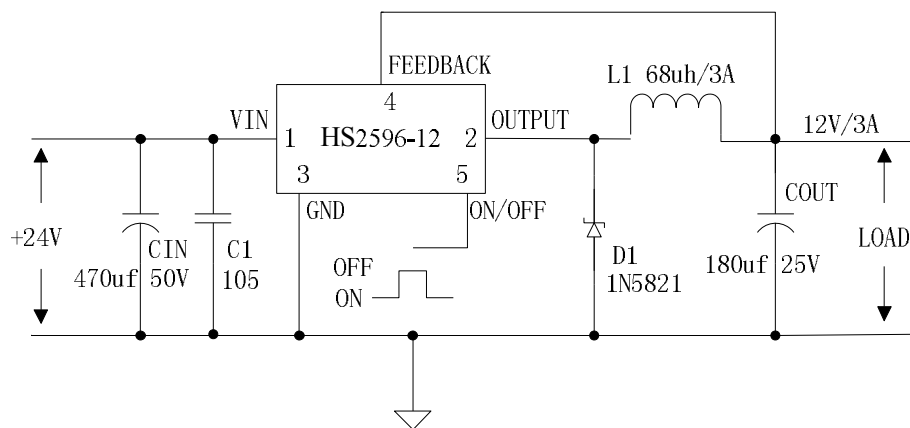
**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Typical System Application for 12V Version**


Figure8. HS2596-12 System Parameters Test Circuit

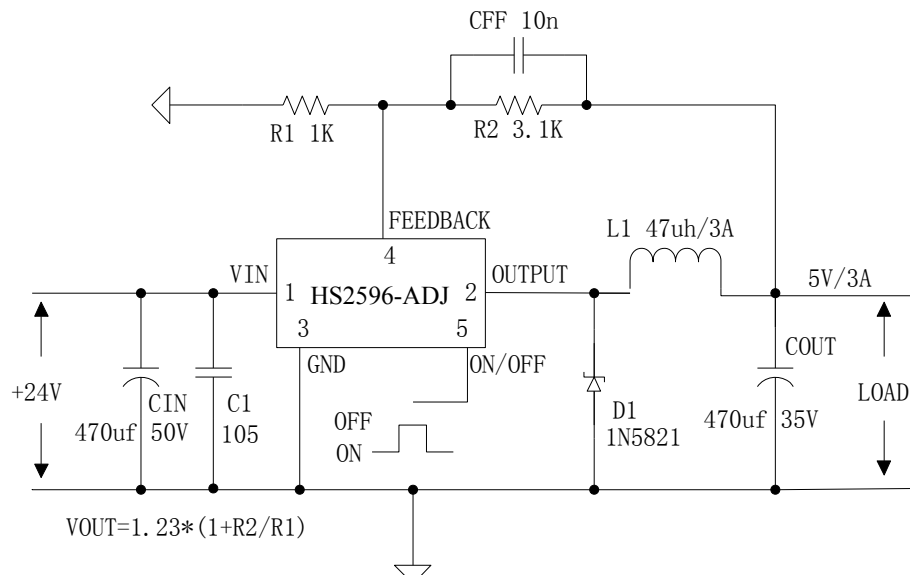
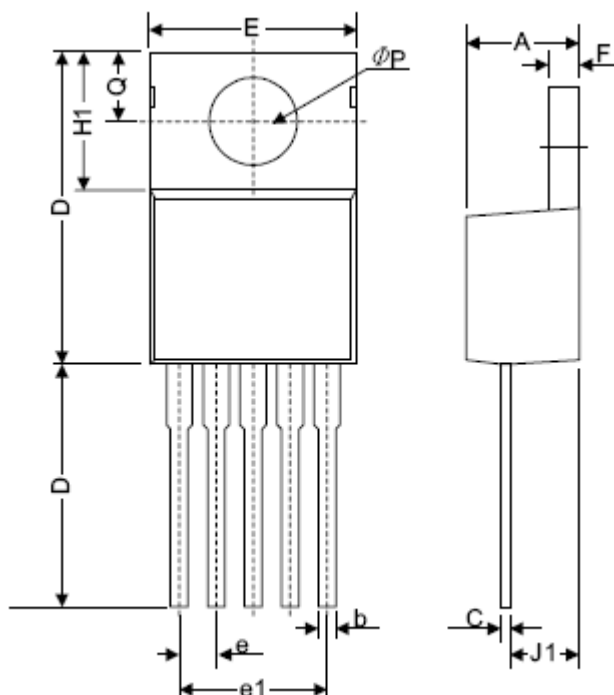
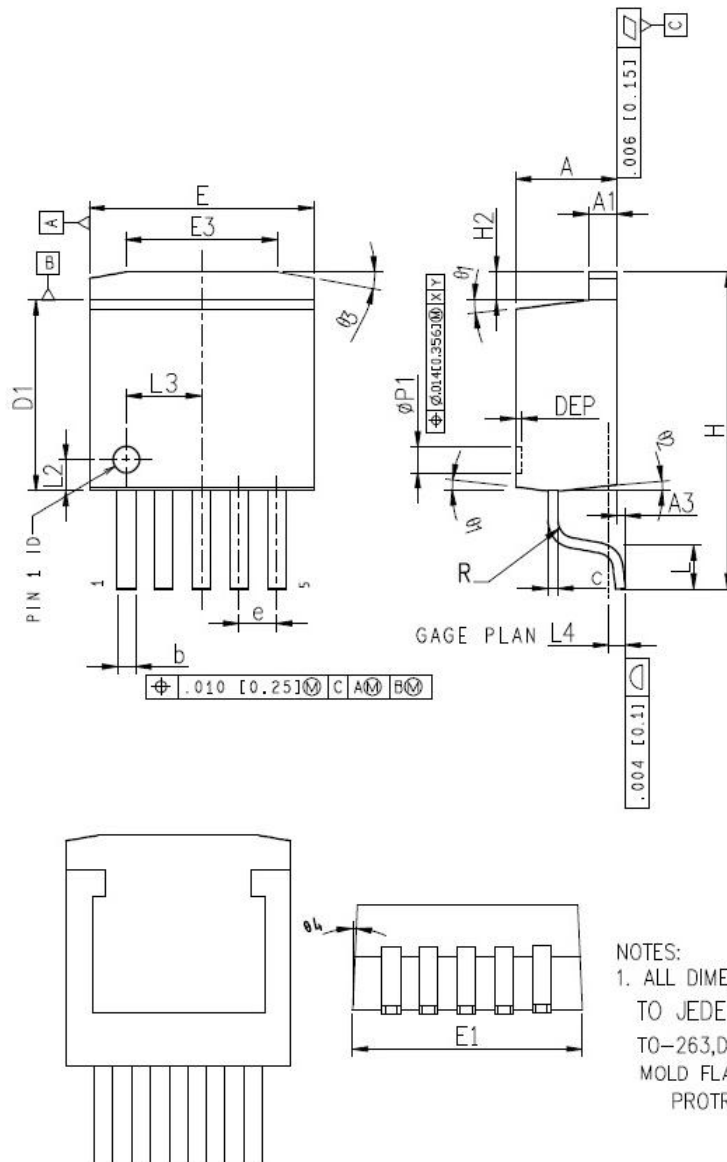
**Typical System Application for ADJ Version**


Figure9. HS2596-ADJ System Parameters Test Circuit

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Package Information**
**(1) TO220-5L**


| Symbol   | Dimensions In Millimeters |       | Dimensions In Inches |       |
|----------|---------------------------|-------|----------------------|-------|
|          | Min.                      | Max.  | Min.                 | Max.  |
| A        | 4.06                      | 4.83  | 0.160                | 0.190 |
| b        | 0.76                      | 1.02  | 0.030                | 0.040 |
| C        | 0.36                      | 0.64  | 0.014                | 0.025 |
| D        | 14.22                     | 15.49 | 0.560                | 0.610 |
| E        | 9.78                      | 10.54 | 0.385                | 0.415 |
| e        | 1.57                      | 1.85  | 0.062                | 0.073 |
| e(1)     | 6.68                      | 6.93  | 0.263                | 0.273 |
| F        | 1.14                      | 1.40  | 0.045                | 0.055 |
| H(1)     | 5.46                      | 6.86  | 0.215                | 0.270 |
| J(1)     | 2.29                      | 3.18  | 0.090                | 0.125 |
| L        | 13.21                     | 14.73 | 0.520                | 0.580 |
| $\phi P$ | 3.68                      | 3.94  | 0.145                | 0.155 |
| Q        | 2.54                      | 2.92  | 0.100                | 0.115 |

**3A 150KHz 40V Buck DC to DC Converter**
**HS2596**
**Package Information**
**(2) TO263-5L**


| COMMON DIMENSIONS |         |       |       |          |       |       |
|-------------------|---------|-------|-------|----------|-------|-------|
| SYMBOL            | MIN     | NDM   | MAX   | MIN      | NDM   | MAX   |
| A                 | 4.45    | 4.57  | 4.70  | 0.175    | 0.180 | 0.185 |
| A1                | 1.22    | 1.27  | 1.32  | 0.048    | 0.050 | 0.052 |
| A3                | 0       | -     | 0.15  | 0.000    | -     | 0.006 |
| b                 | 0.71    | -     | 0.97  | 0.028    | -     | 0.038 |
| c                 | 0.38    | -     | 0.76  | 0.015    | -     | 0.030 |
| D1                | 8.38    | 8.70  | 8.89  | 0.330    | 0.343 | 0.350 |
| E                 | 9.91    | 10.16 | 10.39 | 0.390    | 0.400 | 0.410 |
| E1                | 10.03   | 10.16 | 10.54 | 0.395    | 0.400 | 0.415 |
| E3                | 6.61    | 6.86  | 7.11  | 0.260    | 0.270 | 0.280 |
| e                 | 1.70BSC |       |       | 0.067BSC |       |       |
| H                 | -       | -     | 14.35 | -        | -     | 0.565 |
| H2                | -       | -     | 1.27  | -        | -     | 0.050 |
| L                 | -       | 1.98  | -     | -        | 0.078 | -     |
| L2                | 1.47REF |       |       | 0.058REF |       |       |
| L3                | 3.40REF |       |       | 0.134REF |       |       |
| L4                | -       | 0.76  | -     | -        | 0.030 | -     |
| φp1               | 1.07    | 1.20  | 1.32  | 0.042    | 0.047 | 0.052 |
| R                 | -       | -     | 0.76  | -        | -     | 0.030 |
| θ1                | -       | 7°    | -     | -        | 7°    | -     |
| θ2                | -       | 3°    | -     | -        | 3°    | -     |
| θ3                | 7°      | 10°   | 13°   | 7°       | 10°   | 13°   |
| θ4                | -       | 3°    | -     | -        | 3°    | -     |
| DEP               | 0.10    | 0.18  | 0.25  | 0.004    | 0.007 | 0.010 |

NOTES:  
1. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-263, DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.