This user’s guide explains how to quickly obtain the push-pull converter performance results with the SN6501 evaluation module (EVM). This EVM provides five push-pull converters for various input-to-output voltage conversions utilizing regulated and non-regulated outputs. All push-pull converters use low-power, center-tapped transformers from Wurth-Electronics/Midcom whose designs have been optimized in form-factor, turns ratio, and saturation product to operate in combination with the SN6501 transformer driver. Table 1 lists the push-pull converter configurations with their associated transformers and Figure 3 shows the EVM schematic.

Table 1. Push-pull Converters Provided on the SN6501 EVM

<table>
<thead>
<tr>
<th>Converter Configuration</th>
<th>Application VIN : VOUT</th>
<th>LDO</th>
<th>Xfmr No.</th>
<th>Turns Ratio</th>
<th>V-T (Vµs)</th>
<th>Performance Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.3 V : 3.3 V</td>
<td>No</td>
<td>T1</td>
<td>1.0:1.1</td>
<td>7</td>
<td>Figure 6 and Figure 7</td>
</tr>
<tr>
<td>2</td>
<td>5 V : 5 V</td>
<td></td>
<td>T2</td>
<td>1.0:1.1</td>
<td></td>
<td>Figure 8 and Figure 9</td>
</tr>
<tr>
<td>3</td>
<td>3.3 V : 5 V</td>
<td></td>
<td>T3</td>
<td>1.0:1.7</td>
<td>11</td>
<td>Figure 10 and Figure 11</td>
</tr>
<tr>
<td>4</td>
<td>3.3 V : 5 V</td>
<td>Yes</td>
<td>T4</td>
<td>1.0:2.0</td>
<td></td>
<td>Figure 12 and Figure 13</td>
</tr>
<tr>
<td>5a</td>
<td>3.3 V : 3.3 V</td>
<td>Yes</td>
<td>T5</td>
<td>1.0:1.3</td>
<td></td>
<td>Figure 14 and Figure 15</td>
</tr>
<tr>
<td>5b</td>
<td>5 V : 5 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Figure 16 and Figure 17</td>
</tr>
</tbody>
</table>

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9 Efficiency Versus Load Current Vin = 5 V, Vout = 5 V ....................................................................................... 7
10 Output Voltage Versus Load Current Vin = 3.3 V, Vout = 5 V ................................................................. 7
11 Efficiency Versus Load Current Vin = 3.3 V, Vout = 5 V ................................................................................ 7
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17 Efficiency Versus Load Current Vin = 5 V, Vout = 5 V ................................................................................... 8
1 Performance Measurements

Figure 1 shows the principle measurement set-up when using discrete volt and amp meters. Note: Sense lines have been used to prevent efficiency losses due to \( I^2R \) heating.

![Measurement Set-Up Diagram]

**Figure 1. Measurement Set-Up for Measuring Output Voltage and Efficiency as a Function of Load Current**

The nominal input voltage \( V_I \) of 3.3 V or 5 V, depending on the push-pull converter configuration, is applied to the input terminal block, while measuring the input current \( I_I \). The output voltage \( V_O \), taken from the output and ground test pins TPX, is recorded as a function of the load current \( I_L \), which is adjusted with the load resistor \( R_L \) that connects to the output terminal block. While the above measurement principle applies to all push-pull converters, the 5th converter providing two regulated outputs allows for only one linear regulator (LDO) to be active while the other one must be disabled. Thus, for a 3.3 Vin-to-3.3 Vout or a 5 Vin-to-5 Vout configuration, apply the jumper settings as shown in Figure 2.

![Jumper Settings Diagram]

**Figure 2. Jumper Settings**
Figure 3. SN6501 EVM Schematic
Figure 4. Top Layer (Left) and Layer 2 (Right)
Figure 5. Layer 3 (Left) and Bottom Layer (Right)
## 1.1 Bill Of Materials

<table>
<thead>
<tr>
<th>DESIGNATOR</th>
<th>VALUE</th>
<th>DESCRIPTION</th>
<th>PACKAGE</th>
<th>MFR</th>
<th>PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C4, C8, C10, C15</td>
<td>1μF, 10%, 10V, X5R</td>
<td>Capacitor</td>
<td>0402</td>
<td>Taiyo Yuden</td>
<td>LMK105BJ105KV-F</td>
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<tr>
<td>C2, C3, C5, C6, C7, C9, C11, C12, C14, C16</td>
<td>1μF, 10%, 16V, X7R</td>
<td>Capacitor</td>
<td>0603</td>
<td>TDK</td>
<td>C1608X7R1C105K</td>
</tr>
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<td>C13, C17, C18</td>
<td>4.7μF, 10%, 6.3V, X5R</td>
<td>Capacitor</td>
<td>0603</td>
<td>TDK</td>
<td>C1608X5R0J475K/0.80</td>
</tr>
<tr>
<td>D1, D2, D3, D4, D5, D6, D7, D8, D9, D10</td>
<td>MBR0520L</td>
<td>Rectifier Diode</td>
<td>SOD-123</td>
<td>ON-Semi</td>
<td>MBR0520LT1G</td>
</tr>
<tr>
<td>U1, U2, U3, U4, U6</td>
<td>SN6501</td>
<td>Transformer Driver</td>
<td>DBV</td>
<td>TI</td>
<td>SN6501DBV</td>
</tr>
<tr>
<td>U7</td>
<td>TPS76333</td>
<td>3.3 V, 3% LDO</td>
<td>DBV</td>
<td>TI</td>
<td>TPS76333DBVR</td>
</tr>
<tr>
<td>U5, U8</td>
<td>TPS76350</td>
<td>5 V, 3% LDO</td>
<td>DBV</td>
<td>TI</td>
<td>TPS76350DBVR</td>
</tr>
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<td>T1</td>
<td>1:1.1, 7Vμs</td>
<td>Transformer</td>
<td>6.73 x 7.14 x 4.06 mm</td>
<td>Wurth Electronics/Midcom</td>
<td>760390011</td>
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<td>T2</td>
<td>1:1.1, 11Vμs</td>
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<td></td>
<td></td>
<td>760390012</td>
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<tr>
<td>T3</td>
<td>1:1.7, 11Vμs</td>
<td></td>
<td></td>
<td></td>
<td>760390013</td>
</tr>
<tr>
<td>T4</td>
<td>1:2.0, 11Vμs</td>
<td></td>
<td></td>
<td></td>
<td>760390015</td>
</tr>
<tr>
<td>T5</td>
<td>1:1.3, 11Vμs</td>
<td></td>
<td></td>
<td></td>
<td>760390014</td>
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<td>TP1, TP3, TP5, TP7, TP9</td>
<td>Test Loop - Black</td>
<td>Test Point</td>
<td>0.04</td>
<td>Keystone Electronics</td>
<td>5001</td>
</tr>
<tr>
<td>TP2, TP4, TP6, TP8, TP10</td>
<td>Test Loop - Blue</td>
<td>Test Point</td>
<td>0.04</td>
<td>Components Corporation</td>
<td>TP-105-40-06</td>
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<tr>
<td>JMP1, JMP2</td>
<td>1 x 3 Jumper</td>
<td>Jumper</td>
<td>0.1&quot;</td>
<td>Samtec</td>
<td>HTSW-150-07-G-S</td>
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<tr>
<td>TB1 to TB11</td>
<td>2-pin female</td>
<td>Terminal Block</td>
<td>2.54 cm</td>
<td>Phoenix Contact</td>
<td>1725656</td>
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</table>
1.2 Performance Characteristics (Push-Pull Converters with Non-Regulated Outputs)

Figure 6 through Figure 11 show performance characteristics for push-pull converters with non-regulated outputs.

- **Figure 6. Output Voltage Versus Load Current**
  - Vin = 3.3 V, Vout = 3.3 V

- **Figure 7. Efficiency Versus Load Current**
  - Vin = 3.3 V, Vout = 3.3 V

- **Figure 8. Output Voltage Versus Load Current**
  - Vin = 5 V, Vout = 5 V

- **Figure 9. Efficiency Versus Load Current**
  - Vin = 5 V, Vout = 5 V

- **Figure 10. Output Voltage Versus Load Current**
  - Vin = 3.3 V, Vout = 5 V

- **Figure 11. Efficiency Versus Load Current**
  - Vin = 3.3 V, Vout = 5 V
1.2.1 Performance Characteristics (Push-Pull Converters with Regulated Outputs)

Figure 12 through Figure 17 show performance characteristics for push-pull converters with regulated outputs.

**Figure 12. Output Voltage Versus Load Current**
Vin = 3.3 V, Vout = 5 V

**Figure 13. Efficiency Versus Load Current**
Vin = 3.3 V, Vout = 5 V

**Figure 14. Output Voltage Versus Load Current**
Vin = 3.3 V, Vout = 3.3 V

**Figure 15. Efficiency Versus Load Current**
Vin = 3.3 V, Vout = 3.3 V

**Figure 16. Output Voltage Versus Load Current**
Vin = 5 V, Vout = 5 V

**Figure 17. Efficiency Versus Load Current**
Vin = 5 V, Vout = 5 V
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\textbf{Caution}

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This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.
FCC Interference Statement for Class B EVM devices
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant
This Class A or B digital apparatus complies with Canadian ICES-003.
Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

Concerning EVMs including radio transmitters
This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas
Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.
Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l’autorité de l’utilisateur pour actionner l’équipement.

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Le présent appareil est conforme aux CNR d’Industrie Canada applicables aux appareils radio exempts de licence. L’exploitation est autorisée aux deux conditions suivantes : (1) l’appareil ne doit pas produire de brouillage, et (2) l’utilisateur de l’appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d’en compromettre le fonctionnement.

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Conformément à la réglementation d’Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d’un type et d’un gain maximal (ou inférieur) approuvé pour l’émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l’intention des autres utilisateurs, il faut choisir le type d’antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l’intensité nécessaire à l’établissement d’une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d’antenne énumérés dans le manuel d’usage et ayant un gain admissible maximal et l’impédance requise pour chaque type d’antenne. Les types d’antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l’exploitation de l’émetteur.
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This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,

2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or

3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

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2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.

3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.

4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User’s Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User’s Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, “Claims”) arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

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