

# LMV710-N/LMV711/LMV715 Low Power, RRIO Operational Amplifiers with High Output Current Drive and Shutdown Option

Check for Samples: [LMV710-N](#), [LMV711-N](#), [LMV715-N](#)

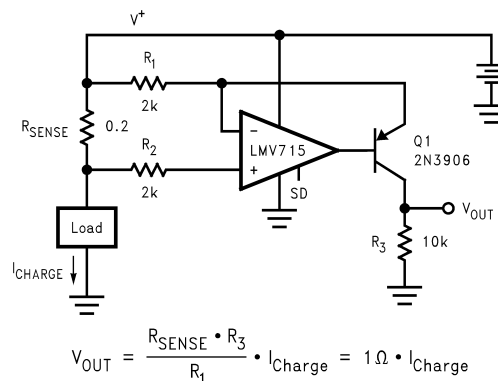
## FEATURES

- (For 5V Supply, Typical Unless Otherwise Noted)
- **Low Offset Voltage 3 mV, Max**
- **Gain-Bandwidth Product 5 MHz, Typ**
- **Slew Rate 5 V/μs, Typ**
- **Space Saving Packages 5-Pin and 6-Pin SOT-23**
- **Turn on Time from Shutdown <10 μs**
- **Industrial Temperature Range –40°C to +85°C**
- **Supply current in Shutdown Mode 0.2 μA, typ**
- **Ensured 2.7V and 5V Performance**
- **Unity Gain Stable**
- **Rail-to-Rail Input and Output**
- **Capable of Driving 600Ω Load**

## APPLICATIONS

- **Wireless Phones**
- **GSM/TDMA/CDMA Power Amp Control**
- **AGC, RF Power Detector**
- **Temperature Compensation**
- **Wireless LAN**
- **Bluetooth**
- **HomeRF**

## Typical Application


**Figure 1. High Side Current Sensing**

## DESCRIPTION

The LMV710-N/LMV711/LMV715 are BiCMOS operational amplifiers with a CMOS input stage. These devices have greater than RR input common mode voltage range, rail-to-rail output and high output current drive. They offer a bandwidth of 5 MHz and a slew rate of 5 V/μs.

On the LMV711/LMV715, a separate shutdown pin can be used to disable the device and reduces the supply current to 0.2 μA (typical). They also feature a turn on time of less than 10 μs. It is an ideal solution for power sensitive applications, such as cellular phone, pager, palm computer, etc. In addition, once the LMV715 is in shutdown the output will be “Tri-stated”.

The LMV710-N is offered in the space saving 5-Pin SOT-23 Tiny package. The LMV711/LMV715 are offered in the space saving 6-Pin SOT-23 Tiny package.

The LMV710-N/LMV711/LMV715 are designed to meet the demands of low power, low cost, and small size required by cellular phones and similar battery powered portable electronics.



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### Absolute Maximum Ratings <sup>(1)(2)</sup>

|   |  |
|---|--|
| ESD Tolerance <sup>(3)</sup>                                |  |
| Machine Model   | 100V   |
| Human Body Model  | 2000V  |
| Differential Input Voltage                                  | ± Supply Voltage                                     |
| Voltage at Input/Output Pin                                 | (V <sup>+</sup> ) + 0.4V<br>(V <sup>-</sup> ) - 0.4V |
| Supply Voltage (V <sup>+</sup> - V <sup>-</sup> )           | 5.5V   |
| Output Short Circuit to V <sup>+</sup>                      | (4)  |
| Output Short Circuit to V <sup>-</sup>                      | (5)  |
| Current at Input Pin  | ± 10 mA  |
| Mounting Temp.  |  |
| Infrared or Convection (20 sec)                             | 235°C  |
| Storage Temperature Range                                   | -65°C to 150°C                                       |
| Junction Temperature (T <sub>JMAX</sub> )<br><sup>(6)</sup> | 150°C  |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) Human body model, 1.5 kΩ in series with 100 pF. Machine model, 0Ω in series with 100 pF.
- (4) Shorting circuit output to V<sup>+</sup> will adversely affect reliability.
- (5) Shorting circuit output to V<sup>-</sup> will adversely affect reliability.
- (6) The maximum power dissipation is a function of T<sub>J(MAX)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any ambient temperature is P<sub>D</sub> = (T<sub>J(MAX)</sub> - T<sub>A</sub>)/θ<sub>JA</sub>. All numbers apply for packages soldered directly into a PC board.

### Operating Ratings <sup>(1)</sup>

|                                       |               |
|---------------------------------------|---------------|
| Supply Voltage                        | 2.7V to 5.0V  |
| Temperature Range                     | -40°C to 85°C |
| Thermal Resistance (θ <sub>JA</sub> ) |               |
| DBV0005A package, 5-Pin SOT-23        | 265 °C/W      |
| DBV0006A package, 6-Pin SOT-23        | 265 °C/W      |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.

## 2.7V Electrical Characteristics

Unless otherwise specified, all limits ensured for T<sub>J</sub> = 25°C. V<sup>+</sup> = 2.7V, V<sup>-</sup> = 0V, V<sub>CM</sub> = 1.35V and R<sub>L</sub> > 1 MΩ. **Boldface** limits apply at the temperature extremes.

| Parameter       |                              | Test Conditions  | Typ <sup>(1)</sup> | Limits <sup>(2)</sup> | Units     |
|-----------------|------------------------------|--|--------------------|-----------------------|-----------|
| V <sub>OS</sub> | Input Offset Voltage         | V <sub>CM</sub> = 0.85V and V <sub>CM</sub> = 1.85V    | 0.4                | 3<br><b>3.2</b>       | mV<br>max |
| I <sub>B</sub>  | Input Bias Current           |  | 4                  |                       | pA        |
| CMRR            | Common Mode Rejection Ratio  | 0 ≤ V <sub>CM</sub> ≤ 2.7V                             | 75                 | 50<br><b>45</b>       | dB<br>min |
| PSRR            | Power Supply Rejection Ratio | 2.7V ≤ V <sup>+</sup> ≤ 5V,<br>V <sub>CM</sub> = 0.85V | 110                | 70<br><b>68</b>       | dB<br>min |
|                 |                              | 2.7V ≤ V <sup>+</sup> ≤ 5V,<br>V <sub>CM</sub> = 1.85V | 95                 | 70<br><b>68</b>       | dB<br>min |

- (1) Typical values represent the most likely parametric norm.
- (2) All limits are specified by testing or statistical analysis.

## 2.7V Electrical Characteristics (continued)

Unless otherwise specified, all limits ensured for  $T_J = 25^\circ\text{C}$ .  $V^+ = 2.7\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = 1.35\text{V}$  and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes.

| Parameter       |   | Test Conditions   | Typ <sup>(1)</sup> | Limits <sup>(2)</sup> | Units                  |
|-----------------|---|---|--------------------|-----------------------|------------------------|
| $V_{\text{CM}}$ | Input Common-Mode Voltage Range                       | For CMRR $\geq 50\text{ dB}$  | -0.3               | -0.2                  | V                      |
|                 |   |   | 3                  | 2.9                   |                        |
| $I_{\text{SC}}$ | Output Short Circuit Current                          | Sourcing<br>$V_O = 0\text{V}$   | 28                 | 15<br><b>12</b>       | mA<br>min              |
|                 |   | Sinking<br>$V_O = 2.7\text{V}$  | 40                 | 25<br><b>22</b>       | mA<br>min              |
| $V_O$           | Output Swing  | $R_L = 10\text{ k}\Omega$ to 1.35V                                    | 2.68               | 2.62<br><b>2.60</b>   | V<br>min               |
|                 |   |   | 0.01               | 0.12<br><b>0.15</b>   | V<br>max               |
|                 |   | $R_L = 600\Omega$ to 1.35V  | 2.55               | 2.52<br><b>2.50</b>   | V<br>min               |
|                 |   |   | 0.05               | 0.23<br><b>0.30</b>   | V<br>max               |
| $V_O$ (SD)      | Output Voltage Level in Shutdown Mode (LMV711 only)   |   | 50                 | 200                   | mV                     |
| $I_O$ (SD)      | Output Leakage Current in Shutdown Mode (LMV715 Only) |   | 1                  |                       | pA                     |
| $C_O$ (SD)      | Output Capacitance in Shutdown Mode (LMV715 Only)     |   | 32                 |                       | pF                     |
| $I_S$           | Supply Current  | On Mode   | 1.22               | 1.7<br><b>1.9</b>     | mA<br>max              |
|                 |   | Shutdown Mode, $V_{\text{SD}} = 0\text{V}$                            | 0.002              | 10                    | $\mu\text{A}$          |
| $A_V$           | Large Signal Voltage                                  | Sourcing<br>$R_L = 10\text{ k}\Omega$<br>$V_O = 1.35\text{V}$ to 2.3V | 115                | 80<br><b>76</b>       | dB<br>min              |
|                 |   | Sinking<br>$R_L = 10\text{ k}\Omega$<br>$V_O = 0.4\text{V}$ to 1.35V  | 113                | 80<br><b>76</b>       | dB<br>min              |
|                 |   | Sourcing<br>$R_L = 600\Omega$<br>$V_O = 1.35\text{V}$ to 2.2V         | 110                | 80<br><b>76</b>       | dB<br>min              |
|                 |   | Sinking<br>$R_L = 600\Omega$<br>$V_O = 0.5\text{V}$ to 1.35V          | 100                | 80<br><b>76</b>       | dB<br>min              |
| SR              | Slew Rate   | <sup>(3)</sup>  | 5                  |                       | V/ $\mu\text{s}$       |
| GBWP            | Gain-Bandwidth Product                                |   | 5                  |                       | MHz                    |
| $\phi_m$        | Phase Margin  |   | 60                 |                       | Deg                    |
| $T_{\text{ON}}$ | Turn-on Time from Shutdown                            |   | <10                |                       | $\mu\text{s}$          |
| $V_{\text{SD}}$ | Shutdown Pin Voltage Range                            | On Mode   | 1.5 to 2.7         | 2.4 to 2.7            | V                      |
|                 |   | Shutdown Mode   | 0 to 1             | 0 to 0.8              | V                      |
| $e_n$           | Input-Referred Voltage Noise                          | $f = 1\text{ kHz}$  | 20                 |                       | nV/ $\sqrt{\text{Hz}}$ |

(3) Number specified is the slower of the positive and negative slew rates.

### 3.2V Electrical Characteristics

Unless otherwise specified, all limits ensured for  $T_J = 25^\circ\text{C}$ .  $V^+ = 3.2\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = 1.6\text{V}$ . **Boldface** limits apply at the temperature extremes.

| Parameter      |              | Test Conditions         | Typ <sup>(1)</sup> | Limit <sup>(2)</sup> | Units    |
|----------------|--------------|-------------------------|--------------------|----------------------|----------|
| V <sub>O</sub> | Output Swing | I <sub>O</sub> = 6.5 mA | 3.0                | 2.95<br><b>2.92</b>  | V<br>min |
|                |              |                         | 0.01               | 0.18<br><b>0.25</b>  | V<br>max |

(1) Typical values represent the most likely parametric norm.

(2) All limits are specified by testing or statistical analysis.

### 5V Electrical Characteristics

Unless otherwise specified, all limits ensured for  $T_J = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = 2.5\text{V}$ , and  $R_L > 1\text{ M}\Omega$ . **Boldface** limits apply at the temperature extremes.

| Parameter           |   | Test Conditions   | Typ <sup>(1)</sup> | Limits <sup>(2)</sup> | Units         |
|---------------------|---|---|--------------------|-----------------------|---------------|
| V <sub>OS</sub>     | Input Offset Voltage                                  | $V_{\text{CM}} = 0.85\text{V}$ and $V_{\text{CM}} = 1.85\text{V}$         | 0.4                | 3<br><b>3.2</b>       | mV<br>max     |
| I <sub>B</sub>      | Input Bias Current                                    |   | 4                  |                       | pA            |
| CMRR                | Common Mode Rejection Ratio                           | $0\text{V} \leq V_{\text{CM}} \leq 5\text{V}$                             | 70                 | 50<br><b>48</b>       | dB<br>min     |
| PSRR                | Power Supply Rejection Ratio                          | $2.7\text{V} \leq V^+ \leq 5\text{V}$ ,<br>$V_{\text{CM}} = 0.85\text{V}$ | 110                | 70<br><b>68</b>       | dB<br>min     |
|                     |   | $2.7\text{V} \leq V^+ \leq 5\text{V}$ ,<br>$V_{\text{CM}} = 1.85\text{V}$ | 95                 | 70<br><b>68</b>       | dB<br>min     |
| V <sub>CM</sub>     | Input Common-Mode Voltage Range                       | For CMRR $\geq 50\text{ dB}$  | -0.3               | -0.2                  | V             |
|                     |   |   | 5.3                | 5.2                   |               |
| I <sub>SC</sub>     | Output Short Circuit Current                          | Sourcing<br>V <sub>O</sub> = 0V   | 35                 | 25<br><b>21</b>       | mA<br>min     |
|                     |   | Sinking<br>V <sub>O</sub> = 5V  | 40                 | 25<br><b>21</b>       | mA<br>min     |
| V <sub>O</sub>      | Output Swing  | R <sub>L</sub> = 10 k $\Omega$ to 2.5V                                    | 4.98               | 4.92<br><b>4.90</b>   | V<br>min      |
|                     |   |   | 0.01               | 0.12<br><b>0.15</b>   | V<br>max      |
|                     |   | R <sub>L</sub> = 600 $\Omega$ to 2.5V                                     | 4.85               | 4.82<br><b>4.80</b>   | V<br>min      |
|                     |   |   | 0.05               | 0.23<br><b>0.3</b>    | V<br>max      |
| V <sub>O</sub> (SD) | Output Voltage Level in Shutdown Mode (LMV711 only)   |   | 50                 | 200                   | mV            |
| I <sub>O</sub> (SD) | Output Leakage Current in Shutdown Mode (LMV715 Only) |   | 1                  |                       | pA            |
| C <sub>O</sub> (SD) | Output Capacitance in shutdown Mode (LMV715 Only)     |   | 32                 |                       | pF            |
| I <sub>S</sub>      | Supply Current  | On Mode   | 1.17               | 1.7<br><b>1.9</b>     | mA<br>max     |
|                     |   | Shutdown Mode   | 0.2                | 10                    | $\mu\text{A}$ |

(1) Typical values represent the most likely parametric norm.

(2) All limits are specified by testing or statistical analysis.

### 5V Electrical Characteristics (continued)

Unless otherwise specified, all limits ensured for  $T_J = 25^\circ\text{C}$ .  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = 2.5\text{V}$ , and  $R_L > 1\text{M}\Omega$ . **Boldface** limits apply at the temperature extremes.

| Parameter       |                              | Test Conditions   | Typ <sup>(1)</sup> | Limits <sup>(2)</sup> | Units     |
|-----------------|------------------------------|---|--------------------|-----------------------|-----------|
| A <sub>V</sub>  | Large Signal Voltage Gain    | Sourcing<br>R <sub>L</sub> = 10 kΩ<br>V <sub>O</sub> = 2.5V to 4.6V | 123                | 80<br><b>76</b>       | dB<br>min |
|                 |                              | Sinking<br>R <sub>L</sub> = 10 kΩ<br>V <sub>O</sub> = 0.4V to 2.5V  | 120                | 80<br><b>76</b>       | dB<br>min |
|                 |                              | Sourcing<br>R <sub>L</sub> = 600Ω<br>V <sub>O</sub> = 2.5V to 4.5V  | 110                | 80<br><b>76</b>       | dB<br>min |
|                 |                              | Sinking<br>R <sub>L</sub> = 600Ω<br>V <sub>O</sub> = 0.5V to 2.5V   | 118                | 80<br><b>76</b>       | dB<br>min |
| SR              | Slew Rate                    | <sup>(3)</sup>  | 5                  |                       | V/μs      |
| GBWP            | Gain-Bandwidth Product       |   | 5                  |                       | MHz       |
| Φ <sub>m</sub>  | Phase Margin                 |   | 60                 |                       | Deg       |
| T <sub>ON</sub> | Turn-on Time from Shutdown   |   | <10                |                       | μs        |
| V <sub>SD</sub> | Shutdown Pin Voltage Range   | On Mode   | 2 to 5             | 2.4 to 5              | V         |
|                 |                              | Shutdown Mode   | 0 to 1.5           | 0 to 0.8              |           |
| e <sub>n</sub>  | Input-Referred Voltage Noise | f = 1 kHz   | 20                 |                       | nV/√Hz    |

(3) Number specified is the slower of the positive and negative slew rates.

### Typical Performance Characteristics

Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .

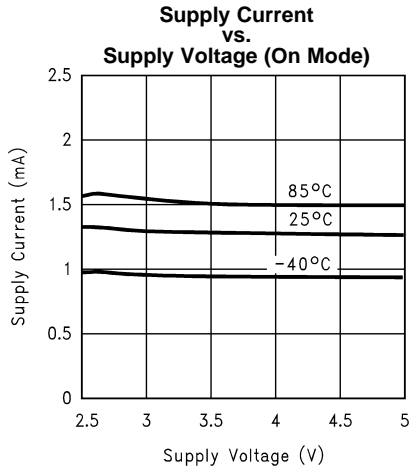


Figure 2.

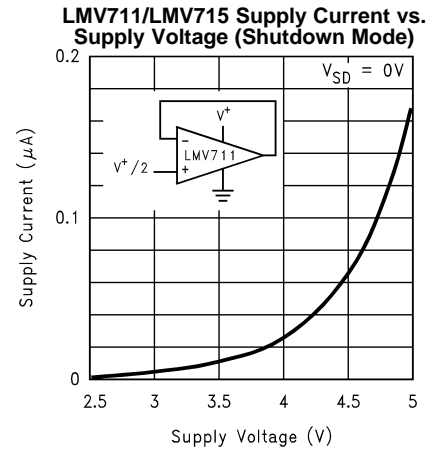


Figure 3.

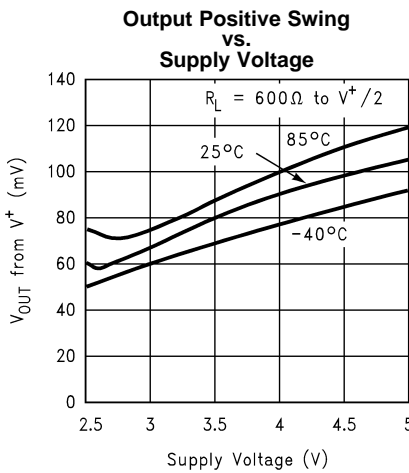


Figure 4.

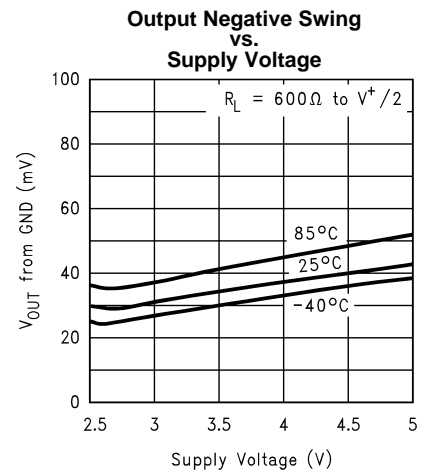


Figure 5.

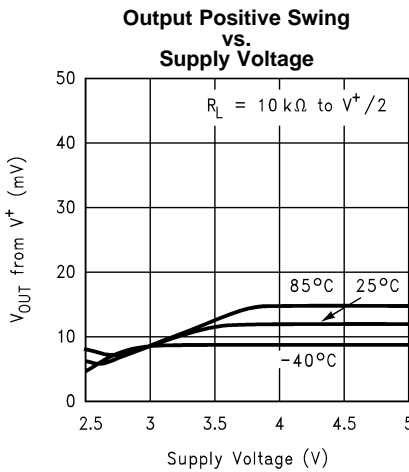


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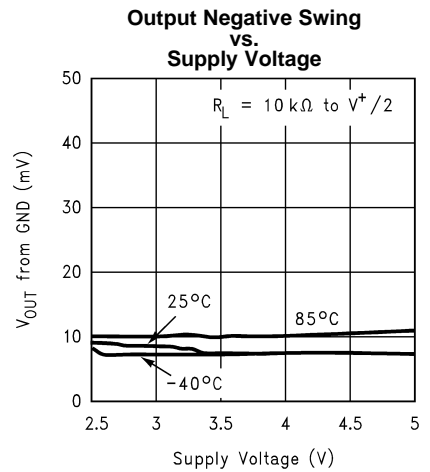
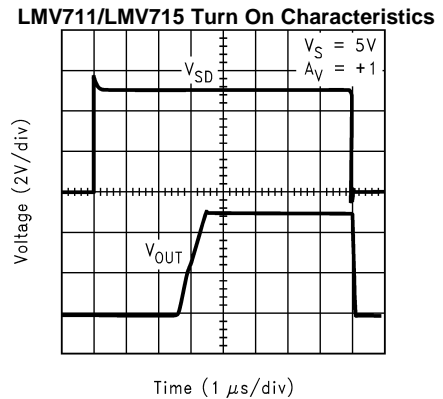
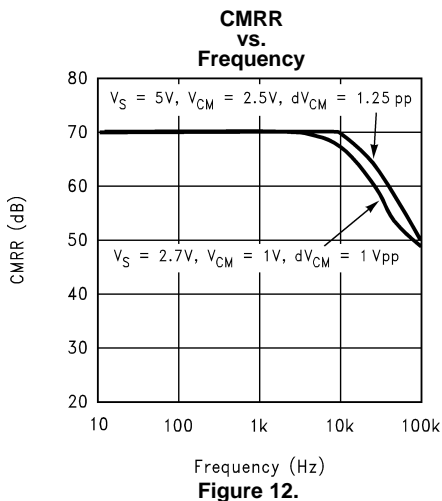
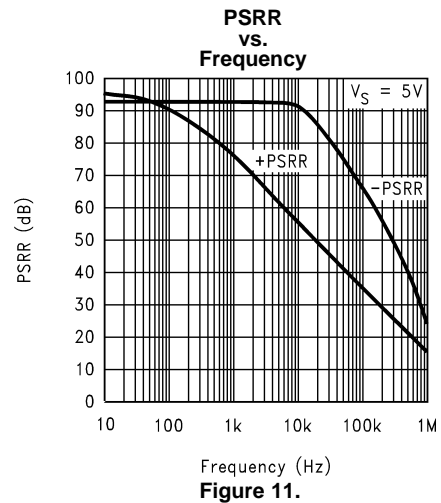
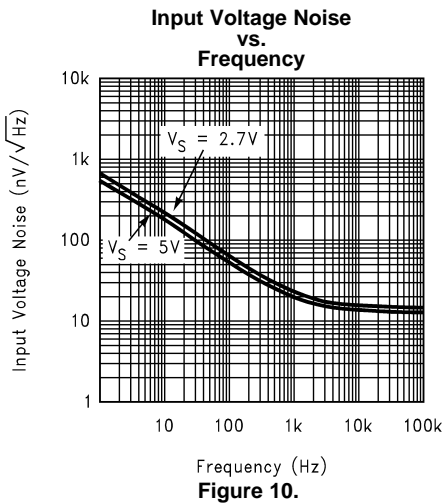
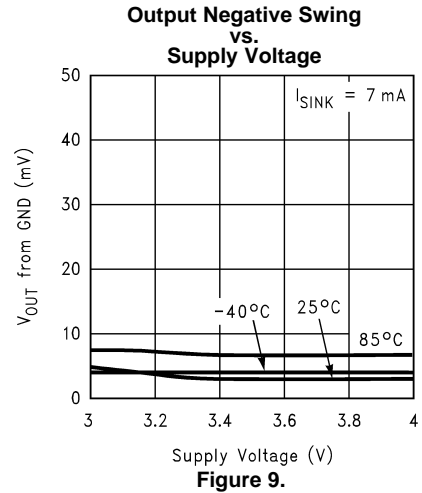
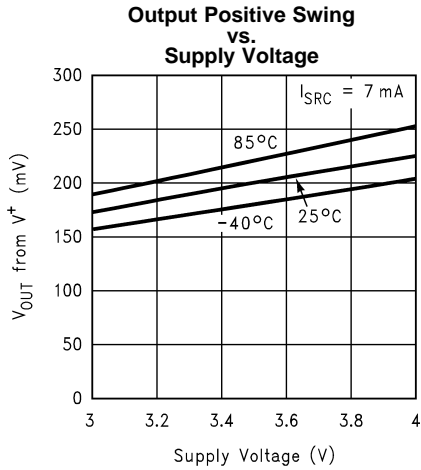


Figure 7.

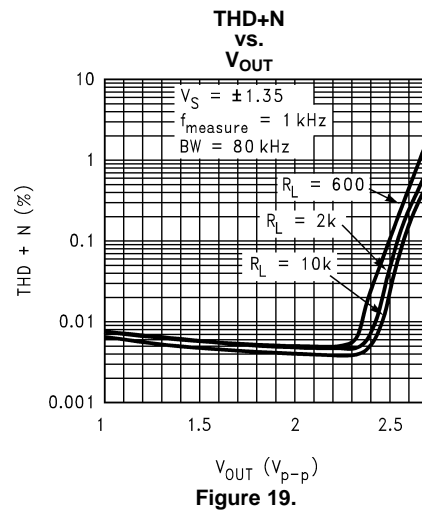
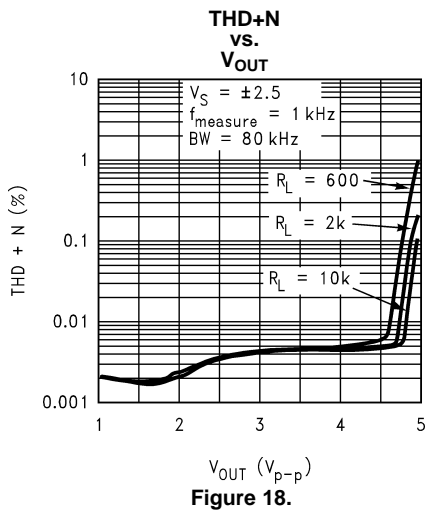
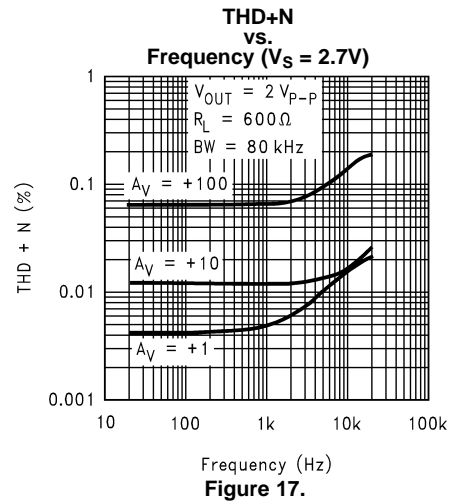
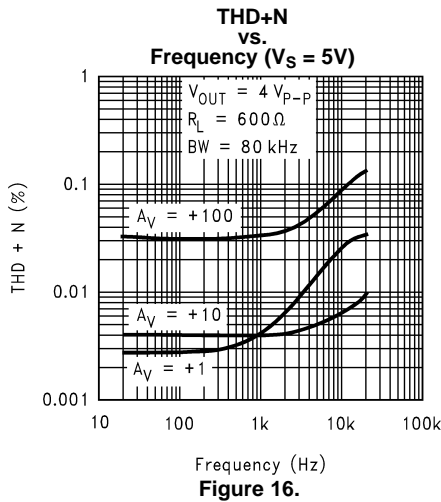
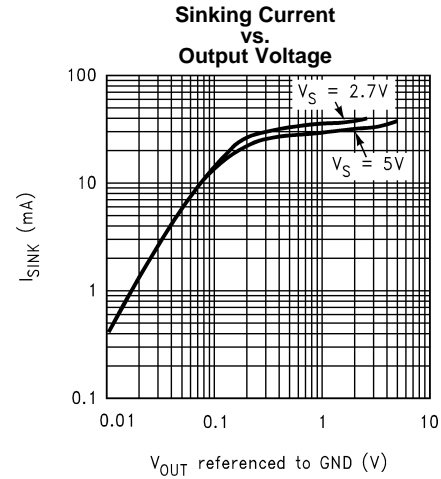
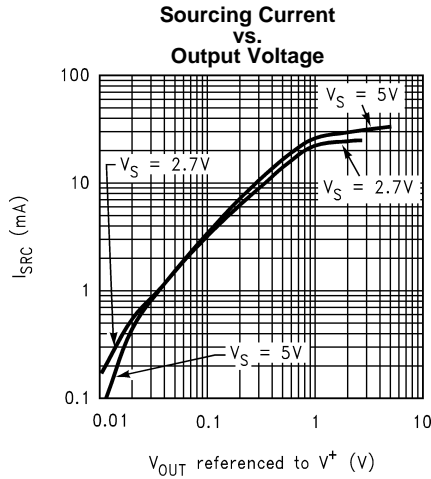
**Typical Performance Characteristics (continued)**

Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .



**Typical Performance Characteristics (continued)**

Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .





Typical Performance Characteristics (continued)

Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .

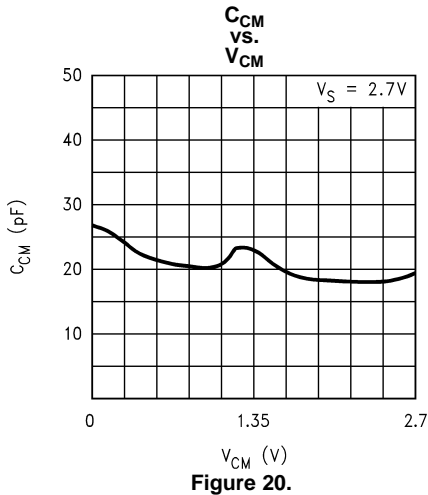


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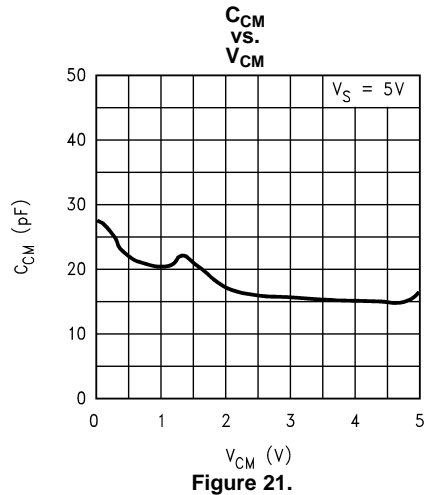


Figure 21.

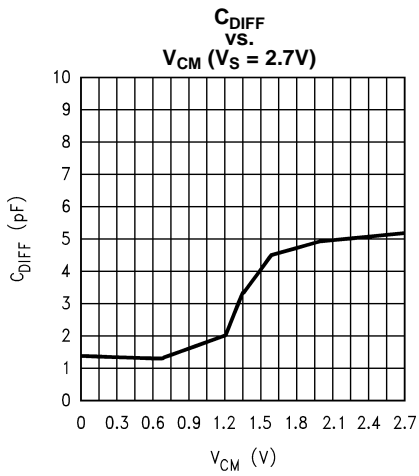


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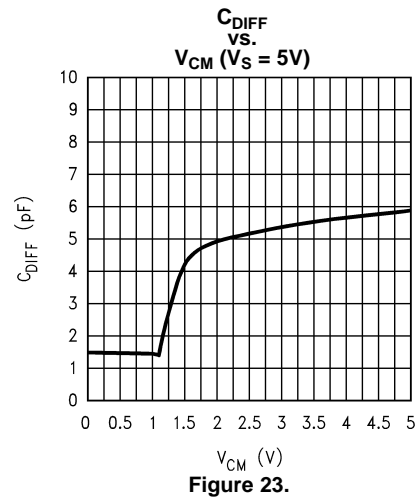


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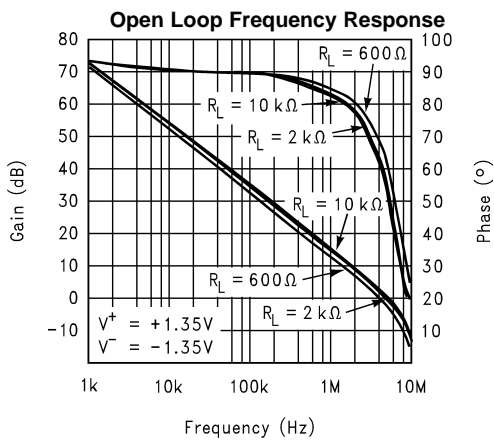


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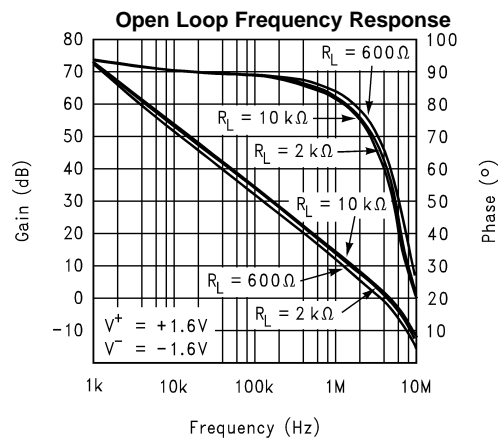


Figure 25.

**Typical Performance Characteristics (continued)**

Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .

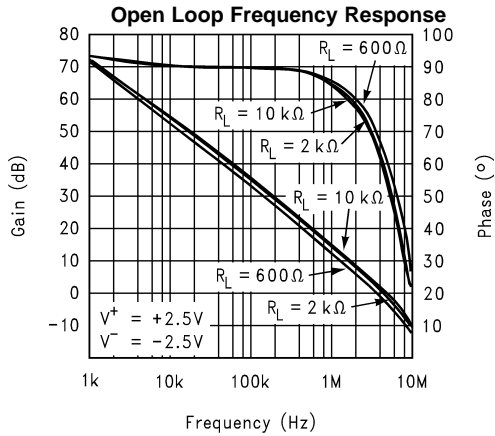


Figure 26.

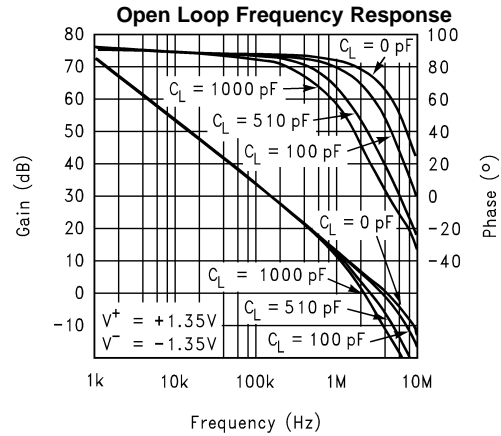


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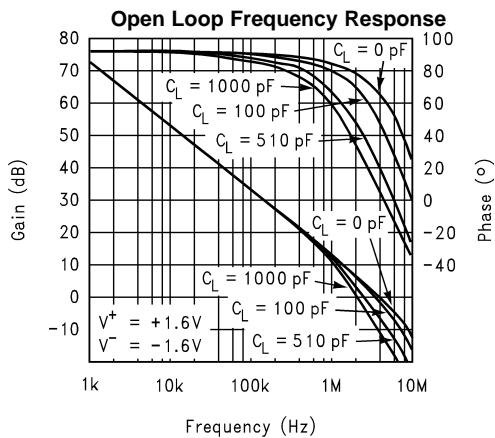


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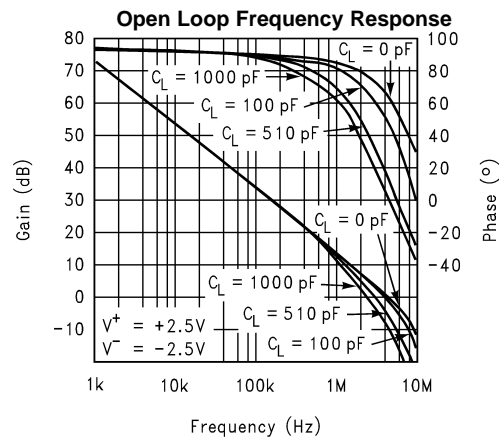


Figure 29.

**Non-Inverting Large Signal Pulse Response**

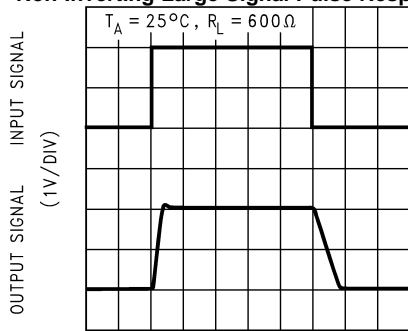


Figure 30.

**Non-Inverting Small Signal Pulse Response**

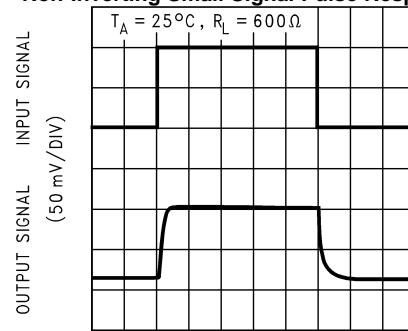
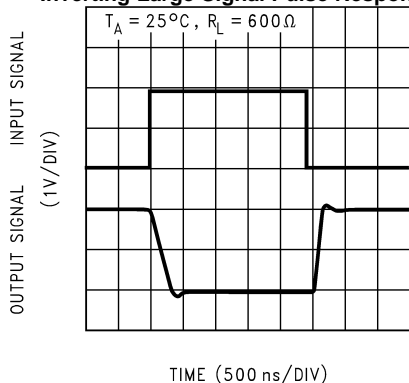


Figure 31.

Typical Performance Characteristics (continued)

Unless otherwise specified,  $V_S = +5V$ , single supply,  $T_A = 25^\circ C$ .

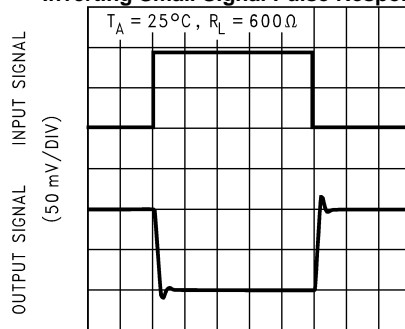
Inverting Large Signal Pulse Response



TIME (500 ns/DIV)

Figure 32.

Inverting Small Signal Pulse Response



TIME (500 ns/DIV)

Figure 33.

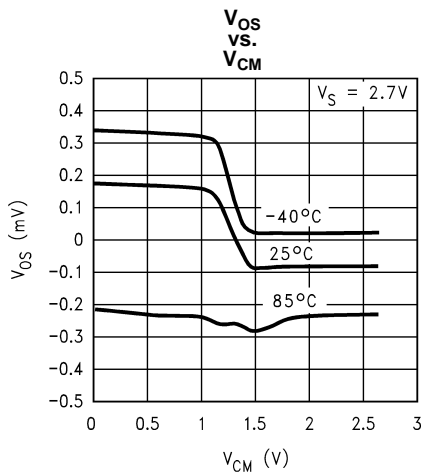


Figure 34.

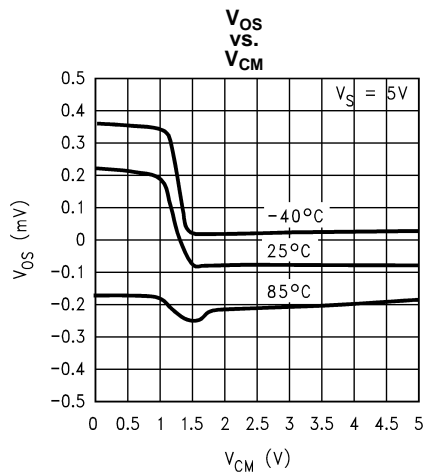


Figure 35.

## APPLICATION INFORMATION

### Supply Bypassing

The application circuits in this datasheet do not show the power supply connections and the associated bypass capacitors for simplification. When the circuits are built, it is always required to have bypass capacitors. Ceramic disc capacitors (0.1  $\mu\text{F}$ ) or solid tantalum (1  $\mu\text{F}$ ) with short leads, and located close to the IC are usually necessary to prevent interstage coupling through the power supply internal impedance. Inadequate bypassing will manifest itself by a low frequency oscillation or by high frequency instabilities. Sometimes, a 10  $\mu\text{F}$  (or larger) capacitor is used to absorb low frequency variations and a smaller 0.1  $\mu\text{F}$  disc is paralleled across it to prevent any high frequency feedback through the power supply lines.

### Shutdown Mode

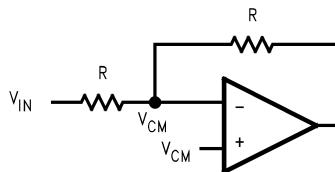
The LMV711/LMV715 have a shutdown pin. To conserve battery life in portable applications, they can be disabled when the shutdown pin voltage is pulled low. For LMV711 during shutdown mode, the output stays at about 50 mV from the lower rail, and the current drawn from the power supply is 0.2  $\mu\text{A}$  (typical). This makes the LMV711 an ideal solution for power sensitive applications. For the LMV715 during shutdown mode, the output will be “Tri-stated”.

The shutdown pin should never be left unconnected. In applications where shutdown operation is not needed and the LMV711 or LMV715 is used, the shutdown pin should be connected to  $V^+$ . Leaving the shutdown pin floating will result in an undefined operation mode and the device may oscillate between shutdown and active modes.

### Rail-to-Rail Input

The rail-to-rail input is achieved by using paralleled PMOS and NMOS differential input stages. (See [Simplified Schematic](#) in this datasheet). When the common mode input voltage changes from ground to the positive rail, the input stage goes through three modes. First, the NMOS pair is cutoff and the PMOS pair is active. At around 1.4V, both PMOS and NMOS pairs operate, and finally the PMOS pair is cutoff and NMOS pair is active. Since both input stages have their own offset voltage ( $V_{OS}$ ), the offset of the amplifier becomes a function of the common-mode input voltage. See curves for  $V_{OS}$  vs.  $V_{CM}$  in [Typical Performance Characteristics](#) section.

As shown in the curve, the  $V_{OS}$  has a crossover point at 1.4V above  $V^-$ . Proper design must be done in both DC and AC coupled applications to avoid problems. For large input signals that include the  $V_{OS}$  crossover point in their dynamic range, it will cause distortion in the output signal. One way to avoid such distortion is to keep the signal away from the crossover point. For example, in a unity gain buffer configuration and with  $V_S = 5\text{V}$ , a 3V peak-to-peak signal center at 2.5V will contain input-crossover distortion. To avoid this, the input signal should be centered at 3.5V instead. Another way to avoid large signal distortion is to use a gain of  $-1$  circuit which avoids any voltage excursions at the input terminals of the amplifier. See [Figure 36](#). In this circuit, the common mode DC voltage ( $V_{CM}$ ) can be set at a level away from the  $V_{OS}$  crossover point.



**Figure 36.**

When the input is a small signal and this small signal falls inside the  $V_{OS}$  transition range, the gain, CMRR and some other parameters will be degraded. To resolve this problem, the small signal should be placed such that it avoids the  $V_{OS}$  crossover point.

To achieve maximum output swing, the output should be biased at mid-supply. This is normally done by biasing the input at mid-supply. But with supply voltage range from 2V to 3.4V, the input of the op amp should not be biased at mid-supply because of the transition of the  $V_{OS}$ . [Figure 37](#) shows an example of how to get away from the  $V_{OS}$  crossover point and maintain a maximum swing with a 2.7V supply. [Figure 38](#) shows the waveforms of  $V_{IN}$  and  $V_{OUT}$ .

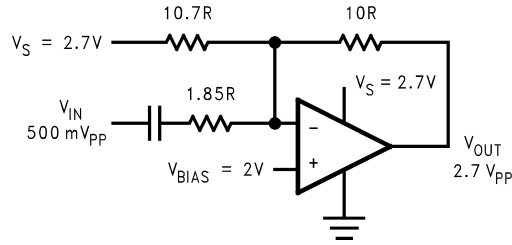


Figure 37.

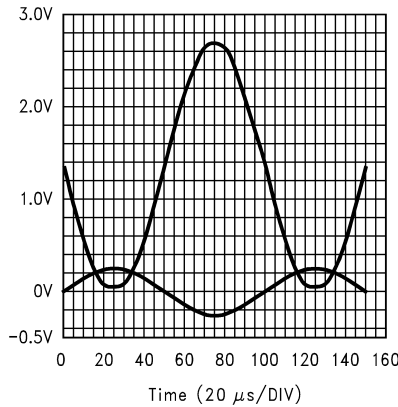


Figure 38.

The inputs can be driven 300 mV beyond the supply rails without causing phase reversal at the output. However, the inputs should not be allowed to exceed the maximum ratings.

### Compensation of Input Capacitance

In the application (Figure 39) where a large feedback resistor is used, the feedback resistor can react with the input capacitance of the op amp and introduce an additional pole to the close loop frequency response.

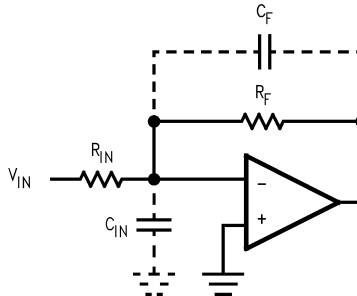


Figure 39. Cancelling the Effect of Input Capacitance

This pole occurs at frequency  $f_p$ , where

$$f_p = \frac{1}{2\pi(R_{IN} \parallel R_F)C_{IN}} \quad (1)$$

Any stray capacitance due to external circuit board layout, any source capacitance from transducer or photodiode connected to the summing node will also be added to the input capacitance. If  $f_p$  is less than or close to the unity-gain bandwidth (5 MHz) of the op amp, the phase margin of the loop is reduced and can cause the system to be unstable.

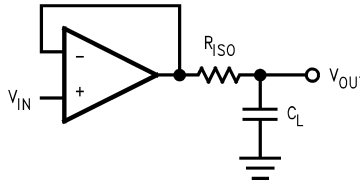
To avoid this problem, make sure that  $f_p$  occurs at least 2 octaves beyond the expected  $-3$  dB frequency corner of the close loop frequency response. If not, a feedback capacitor  $C_F$  can be placed in parallel with  $R_F$  such that

$$\frac{1}{2\pi R_F C_F} = \frac{1}{2\pi (R_{IN} || R_F) (C_F + C_{IN})} \tag{2}$$

The paralleled  $R_F$  and  $C_F$  introduce a zero, which cancels the effect from the pole.

### Capacitive Load Tolerance

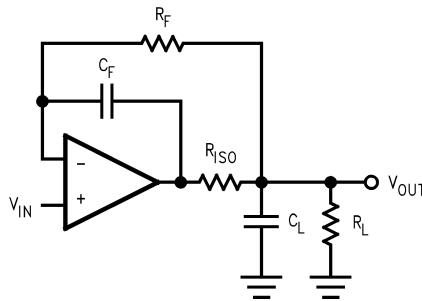
The LMV710-N/LMV711/ LMV715 can directly drive 200 pF in unity-gain without oscillation. The unity-gain follower is the most sensitive configuration to capacitive loading. Direct capacitive loading reduces the phase margin of amplifiers. The combination of the amplifier's output impedance and the capacitive load induces phase lag. This results in either an underdamped pulse response or oscillation. To drive a heavier capacitive load, circuit in [Figure 40](#) can be used.



**Figure 40. Indirectly Driving A Capacitive Load using Resistive Isolation**

In [Figure 40](#), the isolation resistor  $R_{ISO}$  and the load capacitor  $C_L$  form a pole to increase stability by adding more phase margin to the overall system. The desired performance depends on the value of  $R_{ISO}$ . The bigger the  $R_{ISO}$  resistor value, the more stable  $V_{OUT}$  will be. But the DC accuracy is not great when the  $R_{ISO}$  gets bigger. If there were a load resistor in [Figure 40](#), the output would be voltage divided by  $R_{ISO}$  and the load resistor.

The circuit in [Figure 41](#) is an improvement to the one in [Figure 40](#) because it provides DC accuracy as well as AC stability. In this circuit,  $R_F$  provides the DC accuracy by using feed-forward techniques to connect  $V_{IN}$  to  $R_L$ .  $C_F$  and  $R_{ISO}$  serve to counteract the loss of phase margin by feeding the high frequency component of the output signal back to the amplifier's inverting input, thereby preserving phase margin in the overall feedback loop. Increased capacitive drive is possible by increasing the value of  $C_F$ . This in turn will slow down the pulse response.



**Figure 41. Indirectly Driving A Capacitive A Load with DC Accuracy**

### Application Circuits Peak Detector

Peak detectors are used in many applications, such as test equipment, measurement instrumentation, ultrasonic alarm systems, etc. [Figure 42](#) shows the schematic diagram of a peak detector using LMV710-N or LMV711 or LMV715. This peak detector basically consists of a clipper, a parallel RC network, and a voltage follower.

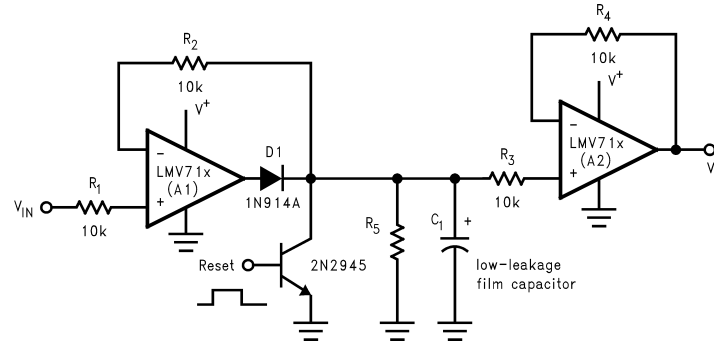


Figure 42. Peak Detector

The capacitor  $C_1$  is first discharged by applying a positive pulse to the reset transistor. When a positive voltage  $V_{IN}$  is applied to the input, the input voltage is higher than the voltage across  $C_1$ . The output of the op amp goes high and forward biases the diode  $D_1$ . The capacitor  $C_1$  is charged to  $V_{IN}$ . When the input becomes less than the current capacitor voltage, the output of the op amp A1 goes low and the diode  $D_1$  is reverse biased. This isolates the  $C_1$  and leaves it with the charge equivalent to the peak of the input voltage. The follower prevents unintentional discharging of  $C_1$  by loading from the following circuit.

$R_5$  and  $C_1$  are properly selected so that the capacitor is charged rapidly to  $V_{IN}$ . During the holding period, the capacitor slowly discharge through  $C_1$ , via leakage of the capacitor and the reverse-biased diode, or op amp bias currents. In any cases the discharging time constant is much larger than the charge time constant. And the capacitor can hold its voltage long enough to minimize the output ripple.

Resistors  $R_2$  and  $R_3$  limit the current into the inverting input of A1 and the non-inverting input of A2 when power is disconnected from the circuit. The discharging current from  $C_1$  during power off may damage the input circuitry of the op amps.

The peak detector can be reset by applying a positive pulse to the reset transistor. The charge on the capacitor is dumped into ground, and the detector is ready for another cycle.

The maximum input voltage to this detector should be less than  $(V^+ - V_D)$ , where  $V_D$  is the forward voltage drop of the diode. Otherwise, the input voltage should be scaled down before applying to the circuit.

### High Side Current Sensing

The high side current sensing circuit (Figure 43) is commonly used in a battery charger to monitor charging current to prevent over-charging. A sense resistor  $R_{SENSE}$  is connected to the battery directly. This system requires an op amp with rail-to-rail input. The LMV710-N/LMV711/LMV715 are ideal for this application because its common mode input range can go beyond the positive rail.

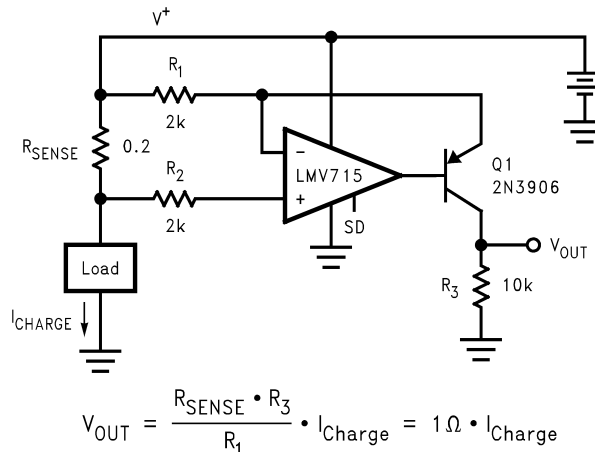


Figure 43. High Side Current Sensing

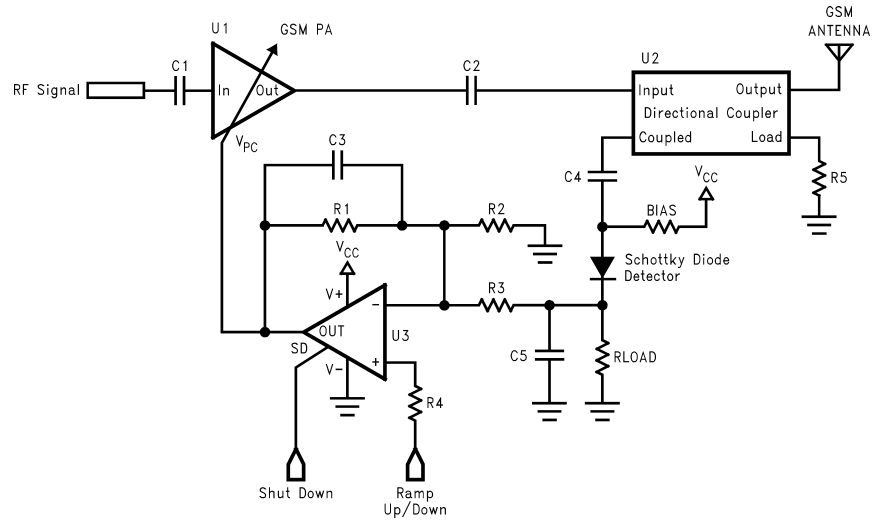


Figure 44. Typical of GSM P.A. Control Loop

### GSM Power Amplifier Control Loop

There are four critical sections in the GSM Power Amplifier Control Loop. The class-C RF power amplifier provides amplification of the RF signal. A directional coupler couples small amount of RF energy from the output of the RF P. A. to an envelope detector diode. The detector diode senses the signal level and rectifies it to a DC level to indicate the signal strength at the antenna. An op amp is used as an error amplifier to process the diode voltage and ramping voltage. This loop control the power amplifier gain via the op amp and forces the detector diode voltage and ramping voltage to be equal. Power control is accomplished by changing the ramping voltage.

The LMV710-N/LMV711/LMV715 are well suited as an error amplifier in this application. The LMV711/LMV715 have an extra shutdown pin to switch the op amp to shutdown mode. In shutdown mode, the LMV711/LMV715 consume very low current. The LMV711 provides a ground voltage to the power amplifier control pin VPC. Therefore, the power amplifier can be turned off to save battery life. The LMV715 output will be “tri-stated” when in shutdown.

### Simplified Schematic

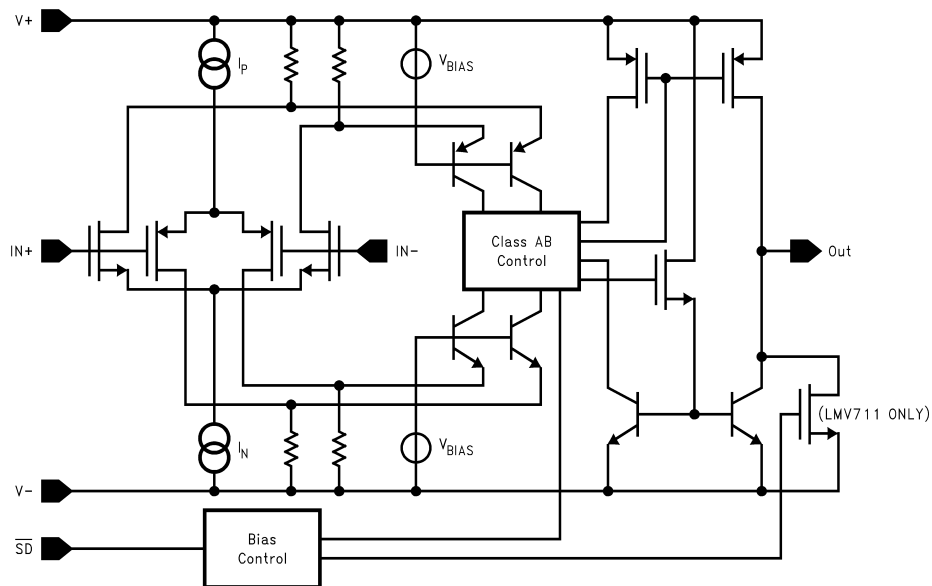
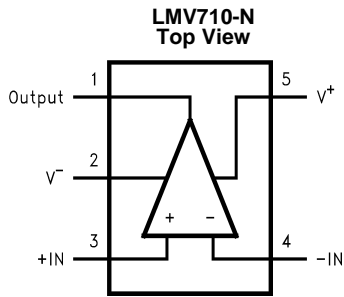


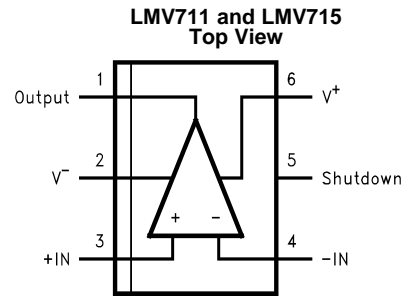
Figure 45. LMV711



**Connection Diagrams**



**Figure 46. 5-Pin SOT-23 Package  
See Package Number DBV0005A**





**Figure 47. 6-Pin SOT-23 Package  
See Package Number DBV0006A**

## REVISION HISTORY

| Changes from Revision I (March 2013) to Revision J         | Page |
|--|------|
| • Changed layout of National Data Sheet to TI format ..... | 17   |

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples   |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|---|
| LMV710M5         | NRND          | SOT-23       | DBV             | 5    | 1000        | TBD                     | Call TI                 | Call TI              | -40 to 85    | A48A                    |   |
| LMV710M5/NOPB    | ACTIVE        | SOT-23       | DBV             | 5    | 1000        | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 85    | A48A                    |  |
| LMV710M5X        | NRND          | SOT-23       | DBV             | 5    | 3000        | TBD                     | Call TI                 | Call TI              | -40 to 85    | A48A                    |   |
| LMV710M5X/NOPB   | ACTIVE        | SOT-23       | DBV             | 5    | 3000        | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 85    | A48A                    |  |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LMV710M5       | SOT-23       | DBV             | 5    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LMV710M5/NOPB  | SOT-23       | DBV             | 5    | 1000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LMV710M5X      | SOT-23       | DBV             | 5    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| LMV710M5X/NOPB | SOT-23       | DBV             | 5    | 3000 | 178.0              | 8.4                | 3.2     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LMV710M5       | SOT-23       | DBV             | 5    | 1000 | 210.0       | 185.0      | 35.0        |
| LMV710M5/NOPB  | SOT-23       | DBV             | 5    | 1000 | 210.0       | 185.0      | 35.0        |
| LMV710M5X      | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |
| LMV710M5X/NOPB | SOT-23       | DBV             | 5    | 3000 | 210.0       | 185.0      | 35.0        |

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - D. Publication IPC-7351 is recommended for alternate designs.
  - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.



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| DLP® Products                | <a href="http://www.dlp.com">www.dlp.com</a>   |
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| Interface                    | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                        | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt                   | <a href="http://power.ti.com">power.ti.com</a>                                       |
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| RFID                         | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
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|                               |  |
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| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
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