# LMV115 GSM Baseband 30MHz 2.8V Oscillator Buffer

**Check for Samples: LMV115**

## FEATURES

- **(Typical 2.8V Supply; Values Unless Otherwise Specified)**
- **Low Supply Current: 0.3mA**
- **2.5V to 3.3V Supply**
- **AC Coupling Possible Without External Bias Resistors.**
- **Includes Shutdown Function External Oscillator**
- **SC70-6 Pin Package 2.1 x 2mm**
- **Operating Temperature Range −40°C to 85°C**

## APPLICATIONS

- **Cellular Phones**
- **GSM Modules**
- **Oscillator Modules**

## DESCRIPTION

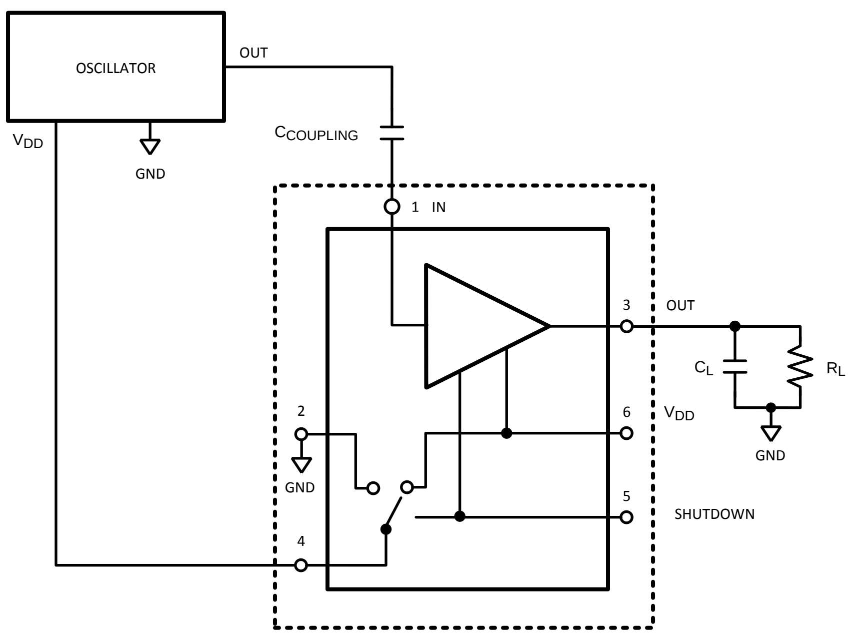
The LMV115 is a 30MHz buffer specially designed to minimize the effects of spurious signals from the base band chip to the oscillator. The buffer also minimizes the influence of varying load resistance and capacitance to the oscillator and increases the drive capability.

The input of the LMV115 is internally biased with two equal resistors to the power supply rails. This allows AC coupling on the input.

The LMV115 offers a shutdown function to optimize current consumption. This shutdown function can also be used to control the supply voltage of an external oscillator. The device is in shutdown mode when the shutdown pin is connected to $V_{DD}$.

The LMV115 comes in SC70-6 package. This space saving product reduces components, improves clock signal and allows ease of placement for the best form factor.

### Schematic Diagram




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[1][2]

| | | |
|---|---|---|
| ESD Tolerance | Human Body Model | 2000V[3] |
| | Machine Model | 150V[4] |
| Supply Voltage ($V^+ – V^-$) | | 3.6V |
| Output Short Circuit to $V^+$ | | See[5][6] |
| Output Short Circuit to $V^-$ | | See[5][6] |
| Storage Temperature Range | | −65°C to +150°C |
| Junction Temperature[7] | | +150°C |
| Mounting Temperature | Infrared or Convection (20 sec.) | 235°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 TI Sales Office/ Distributors for availability and specifications.
(3) Human Body Model (HBM) is 1.5kΩ in series with 100pF.
(4) Machine Model, 0Ω in series with 200pF.
(5) Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C
(6) Infinite Duration; Short circuit test is a momentary test. See Note 7.
(7) The maximum power dissipation is a function of $T_{J(MAX)}$, $\theta_{JA}$ , and $T_A$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / \theta_{JA}$. All numbers apply for packages soldered directly onto a PC board.

## OPERATING RATINGS[1]

| | | |
|---|---|---|
| Supply Voltage ($V^+ – V^-$) | | 2.5V to 3.3V |
| Temperature Range[2][3] | | −40°C to +85°C |
| Package Thermal Resistance[2][3] | SC70-6 | 414°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) The maximum power dissipation is a function of $T_{J(MAX)}$, $\theta_{JA}$ , and $T_A$. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / \theta_{JA}$. All numbers apply for packages soldered directly onto a PC board.
(3) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$ . There is no ensured parametric performance as indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. See APPLICATION SECTION for information on temperature de-rating of this device.

## 2.8V ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified for $T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM} = V^+/2$, shutdown = 0.0V, and $R_L$ = 50kΩ to $V^+/2$, $C_L$ = 5pF to $V^+/2$ and $C_{COUPLING}$ = 1nF.**Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min[1] | Typ[2] | Max[1] | Units |
|---|---|---|---|---|---|---|
| SSBW | Small Signal Bandwidth | $V_{OUT} < 0.5V_{PP}$; −3dB | | 31 | | MHz |
| GFN | Gain Flatness < 0.1dB | f > 50kHz | | 2.8 | | MHz |
| FPBW | Full Power Bandwidth (−3dB) | $V_{OUT} = 1.0V_{PP}$ (+4.5dBm) | | 9 | | MHz |
| **Time Domain Response** | | | | | | |
| $t_r$ | Rise Time | $0.1V_{STEP}$ (10-90%) | | 11 | | ns |
| $t_f$ | Fall Time | | | 11 | | |
| $t_s$ | Settling Time to 0.1% | $0.1V_{STEP}$ | | 95 | | ns |
| OS | Overshoot | $0.1V_{STEP}$ | | 24 | | % |
| SR | Slew Rate | See[3] | | 18 | | V/μs |

(1) All limits are specified by testing or statistical analysis.
(2) Typical Values represent the most likely parametric norm.
(3) Slew rate is the average of the positive and negative slew rate.

## 2.8V ELECTRICAL CHARACTERISTICS (continued)

Unless otherwise specified, all limits specified for $T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM}$ = $V^+/2$, shutdown = 0.0V, and $R_L$ = 50kΩ to $V^+/2$, $C_L$ = 5pF to $V^+/2$ and $C_{COUPLING}$ = 1nF.**Boldface** limits apply at the temperature extremes.

| Symbol | Parameter | Conditions | Min (1) | Typ (2) | Max (1) | Units |
|---|---|---|---|---|---|---|
| **Distortion and Noise Performance** | | | | | | |
| HD2 | 2nd Harmonic Distortion | $V_{OUT}$ = 500mV$_{PP}$; f = 100kHz | | −41 | | dBc |
| HD3 | 3rd Harmonic Distortion | $V_{OUT}$ = 500mV$_{PP}$; f = 100kHz | | −43 | | dBc |
| THD | Total Harmonic Distortion | $V_{OUT}$ = 500mV$_{PP}$; f = 100kHz | | −38 | | dBc |
| $e_n$ | Input-Referred Voltage Noise | f = 1MHz | | 27 | | nV/√Hz |
| Isolation | Output to Input | See also TYPICAL PERFORMANCE CHARACTERISTICS | | >40 | | dB |
| **Static DC Performance** | | | | | | |
| $A_{CL}$ | Small Signal Voltage Gain | $V_{OUT}$ = 100mV$_{PP}$ | 0.90<br>**0.85** | 0.998 | 1.10<br>**1.11** | V/V |
| $V_{OS}$ | Output Offset Voltage | | | 3.5 | 35<br>**55** | mV |
| TC $V_{OS}$ | Temperature Coefficient Output Offset Voltage | See (4) | | 102 | | μV/°C |
| $R_{OUT}$ | Output Resistance | f = 10kHz | | 61 | | Ω |
| | | f = 25MHz | | 330 | | |
| PSRR | Power Supply Rejection Ratio | $V^+$ = 2.8V to $V^+$ = 3.3V | 41<br>**38** | 42 | | dB |
| $I_S$ | Supply Current | No Load; Shutdown = 2.8V | | 0.0 | 2.00 | μA |
| | | No Load; Shutdown = 0V | | 314 | 450<br>**520** | |
| **Miscellaneous Performance** | | | | | | |
| $R_{IN}$ | Input Resistance | Shutdown = 2.8V | | 65 | | kΩ |
| | | Shutdown = 0V | | 64 | | |
| $C_{IN}$ | Input Capacitance | Shutdown = 2.8V | | 1.82 | | pF |
| | | Shutdown = 0V | | 1.50 | | |
| $Z_{IN}$ | Input Impedance | f = 25MHz; Shutdown = 2.8V | | 2.38 | | kΩ |
| | | f = 25MHz; Shutdown = 0V | | 2.47 | | |
| $V_O$ | Output Swing Positive (5) | $R_L$ = 50kΩ to $V^+/2$ | 1.90<br>**1.65** | 2.16 | | V |
| | Output Swing Negative | $R_L$ = 50kΩ to $V^+/2$ | | 1.05 | 1.35<br>**1.30** | |
| $I_O$ | Linear Output Current | No Load; $V_{OUT}$ = $V^+$ − 1.1V (Sourcing) | −90<br>**−35** | −206 | | μA |
| | | No Load; $V_{OUT}$ = $V^-$ + 1.1V (Sinking) | 100<br>**50** | 205 | | |
| $I_{SC}$ | Output Short-Circuit Current (6) | No Load; Sourcing to $V^+/2$ | −90<br>**−35** | −186 | | μA |
| | | No Load; Sinking from $V^+/2$ | 100<br>**50** | 191 | | |
| $R_{ON}$ | Switch in ON Position | | | 21 | 40<br>**45** | Ω |

(4) Average Temperature Coefficient is determined by dividing the change in a parameter at temperature extremes by the total temperature change.
(5) Positive current corresponds to current flowing into the device.
(6) Infinite Duration; Short circuit test is a momentary test. See Note 7 under Absolute Maximum Ratings.

## CONNECTION DIAGRAM

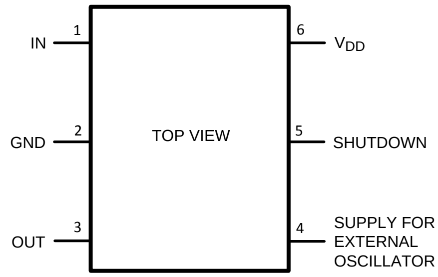



**Figure 1. SC70-6 - Top View**

## TYPICAL PERFORMANCE CHARACTERISTICS

$T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM}$ = $V^+$/2, and $R_L$, $C_L$ is connected to $V^+$/2; Unless otherwise specified.

**Frequency and Phase Response**

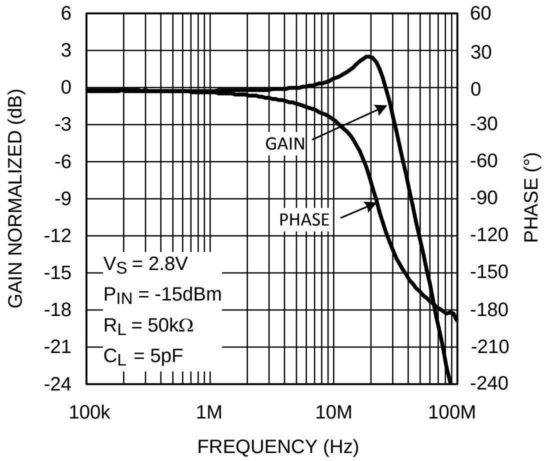



**Figure 2.**

**Frequency Response Over Temperature**

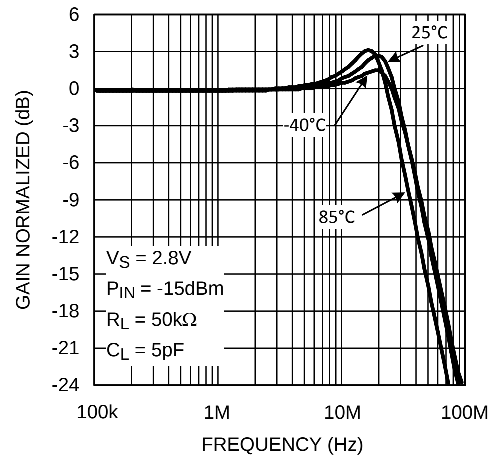



**Figure 3.**

**Phase Response Over Temperature**

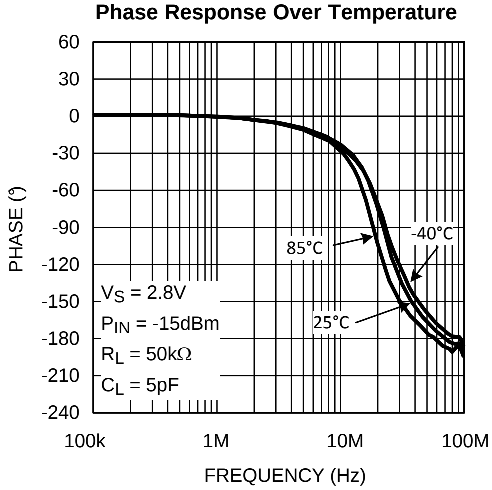



**Figure 4.**

**Gain Flatness 0.1dB**

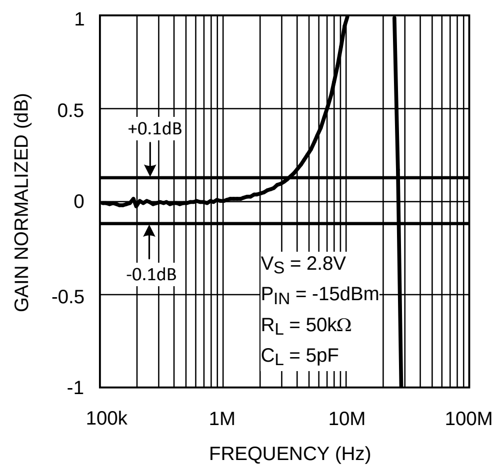



**Figure 5.**

**Full Power Bandwidth**

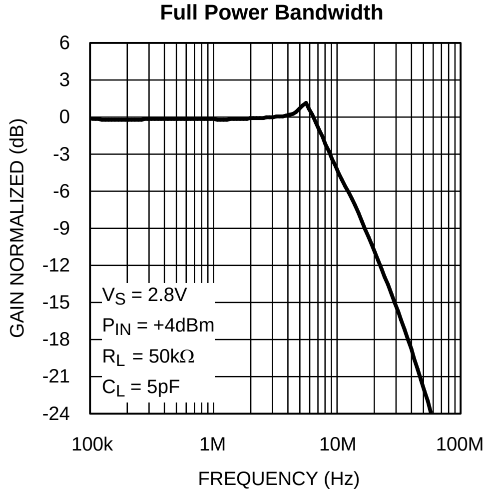



**Figure 6.**

**Transient Response Positive**

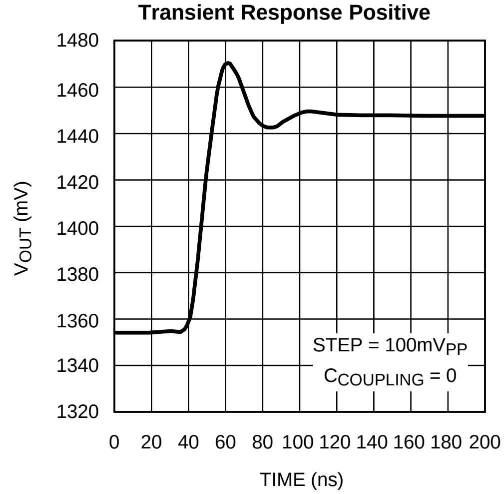



**Figure 7.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM}$ = $V^+$/2, and $R_L$, $C_L$ is connected to $V^+$/2; Unless otherwise specified.

**Transient Response Negative**

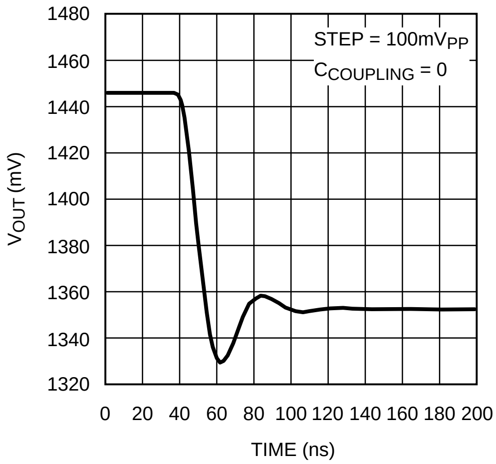



**Figure 8.**

**Harmonic Distortion vs. $V_{OUT}$ @ 100kHz**

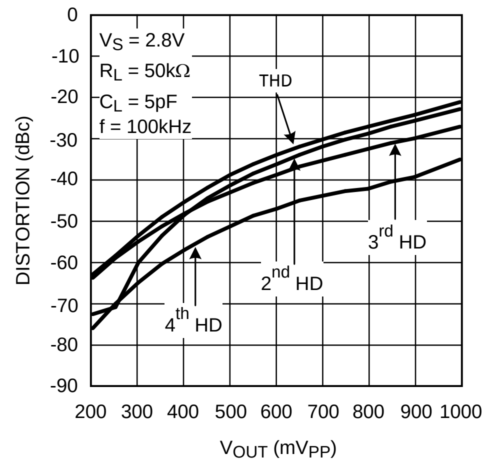



**Figure 9.**

**Harmonic Distortion vs. $V_{OUT}$ @ 500kHz**

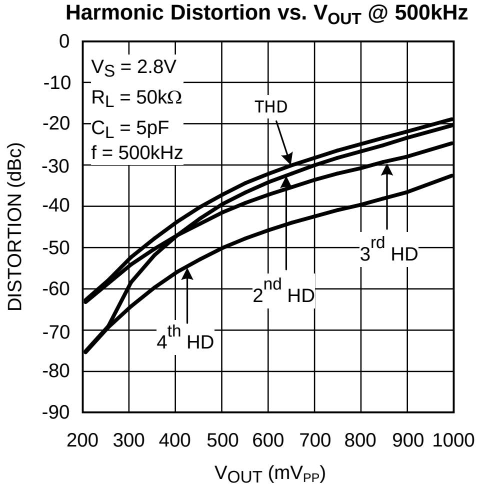



**Figure 10.**

**Harmonic Distortion vs. $V_{OUT}$ @ 1MHz**

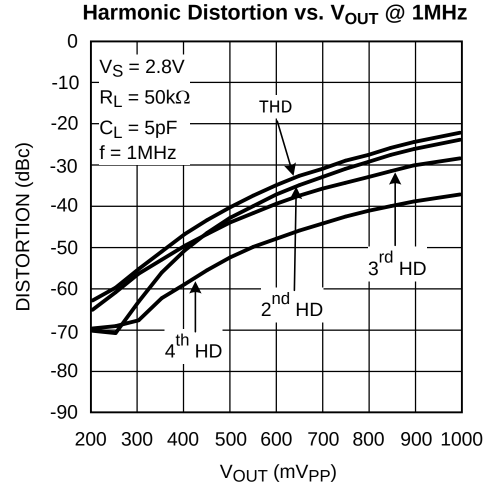



**Figure 11.**

**THD vs. $V_{OUT}$ for Various Frequencies**

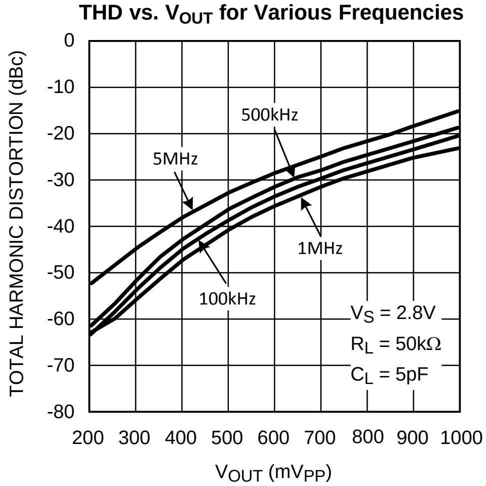



**Figure 12.**

**Voltage Noise**

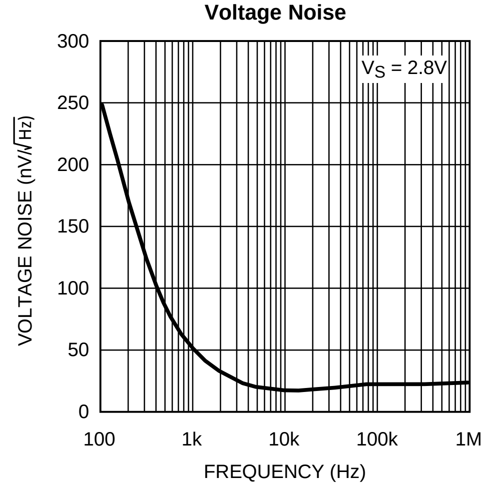



**Figure 13.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM}$ = $V^+$/2, and $R_L$, $C_L$ is connected to $V^+$/2; Unless otherwise specified.

**$R_{OUT}$ vs. Frequency**

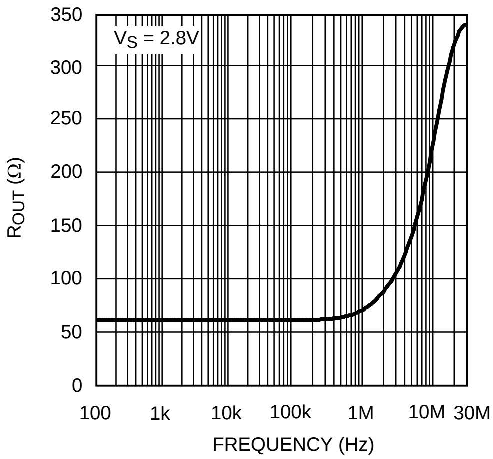



**Figure 14.**

**Input Impedance vs. Frequency**

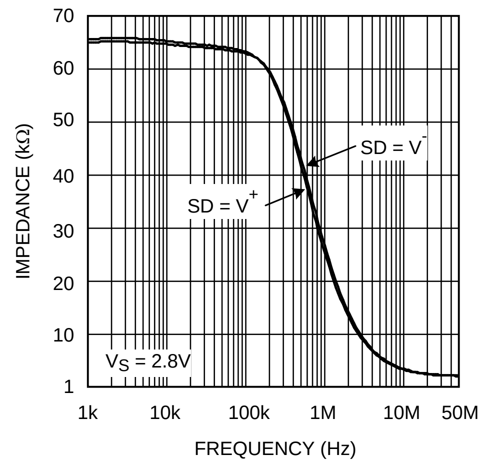



**Figure 15.**

**Isolation Output to Input**

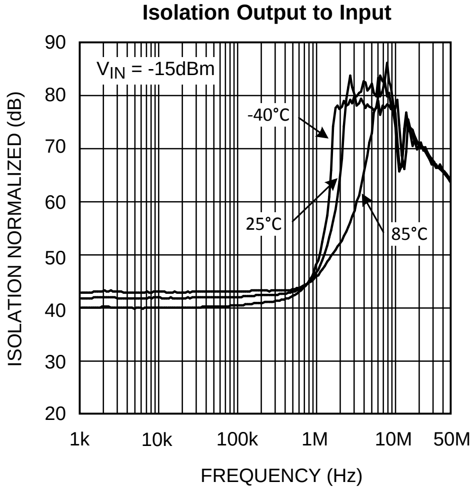



**Figure 16.**

**$V_{OUT}$ vs. $I_{OUT}$ (Sinking)**

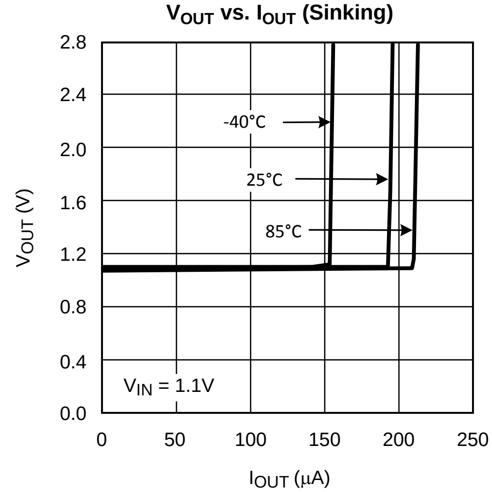



**Figure 17.**

**$V_{OUT}$ vs. $I_{OUT}$ (Sourcing)**

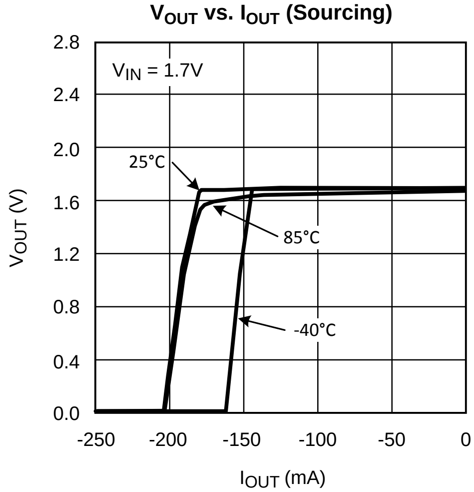



**Figure 18.**

**$I_{SC}$ Sourcing vs. $V_{SUPPLY}$**

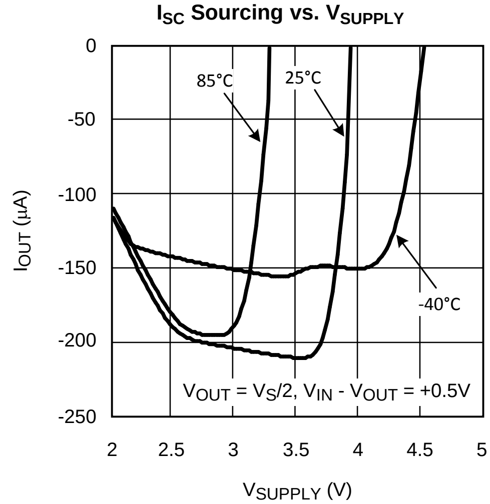



**Figure 19.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM}$ = $V^+$/2, and $R_L$, $C_L$ is connected to $V^+$/2; Unless otherwise specified.

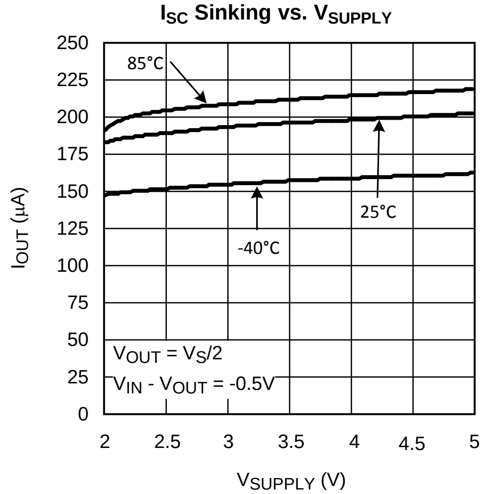



**Figure 20.**

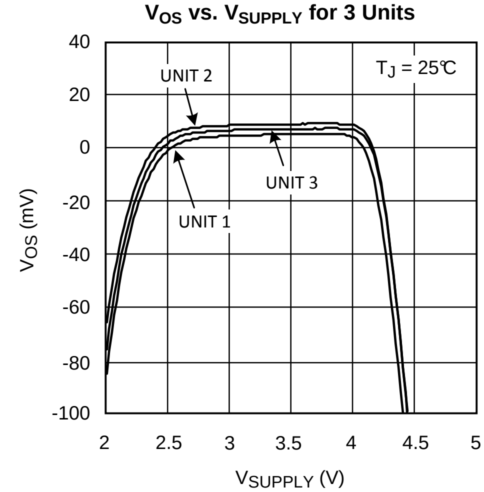



**Figure 21.**

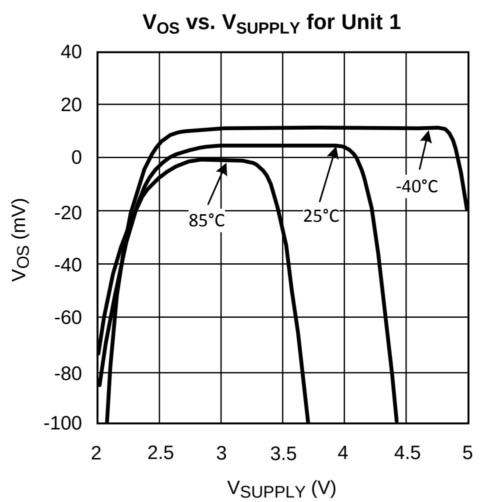



**Figure 22.**

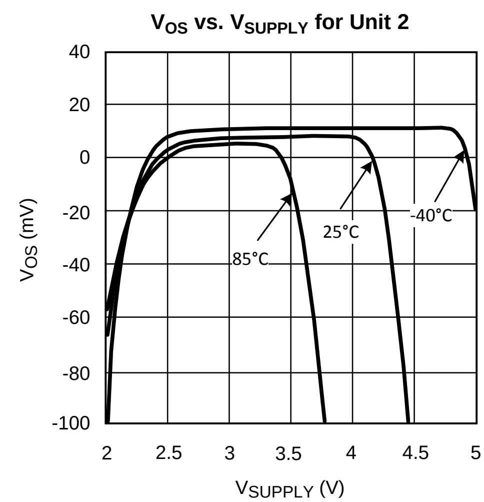



**Figure 23.**

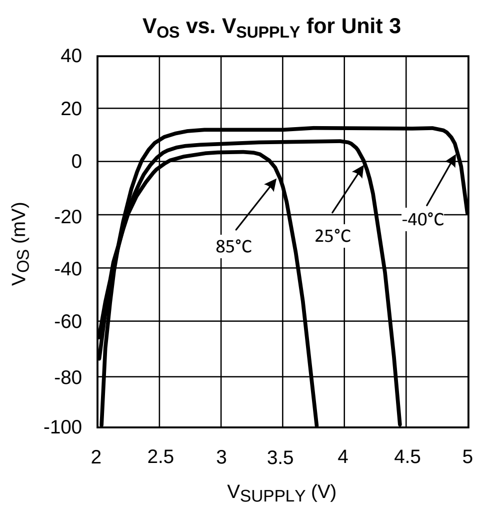



**Figure 24.**

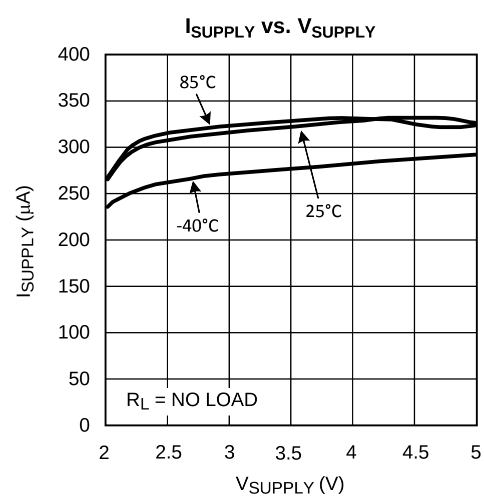



**Figure 25.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_J$ = 25°C, $V^+$ = 2.8V, $V^-$ = 0V, $V_{CM}$ = $V^+$/2, and $R_L$, $C_L$ is connected to $V^+$/2; Unless otherwise specified.

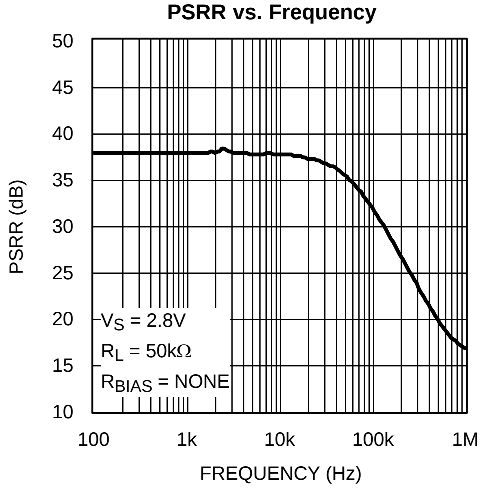



**Figure 26.**

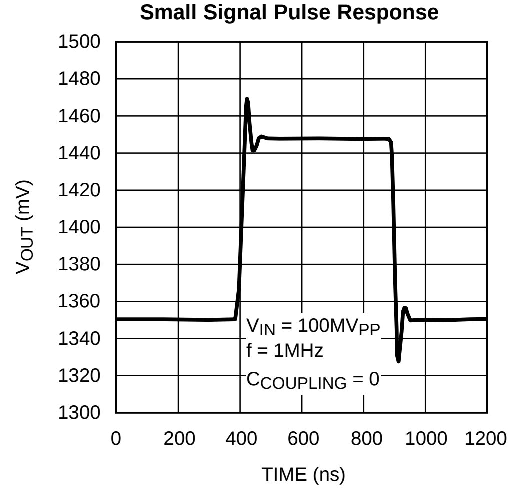



**Figure 27.**

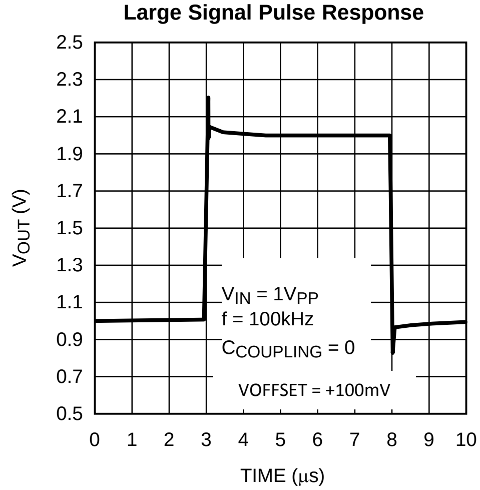



**Figure 28.**

# APPLICATION SECTION

## GENERAL

The LMV115 is specially designed to minimize the effects of spurious signals from the base band chip to the oscillator. Beside this the influence of varying load resistance and capacitance to the oscillator is minimized, while increasing the drive capability. The input of the LMV115 is internally biased with two equal resistors to the power supply rails, and makes AC coupling possible without external bias resistors at the input. The LMV115 has excellent gain phase margin. The LMV115 offers a shutdown pin that can be used to disable the device in order to optimize current consumption and also has a feature to control the supply voltage to an external oscillator. When the shutdown pin is connected to $V_{DD}$ the device is in shutdown mode.

## SWITCHED POWER SUPPLY CONNECTION

The LMV115 features an enable/disable function for an external oscillator by controlling its supply voltage (pin 4). See also the Schematic Diagram on the front page. During normal operating mode, pin 4 is connected to the positive supply rail via an internal switch. The resistance between the positive supply rail and pin 4, $R_{ON}$, is specified in the electrical characterization table. Oscillators with a supply current up to several milliamps can easily be powered from pin 4. During shutdown, pin 4 is switched to the negative supply rail. The simplified schematic for this part of the device is shown in Figure 29

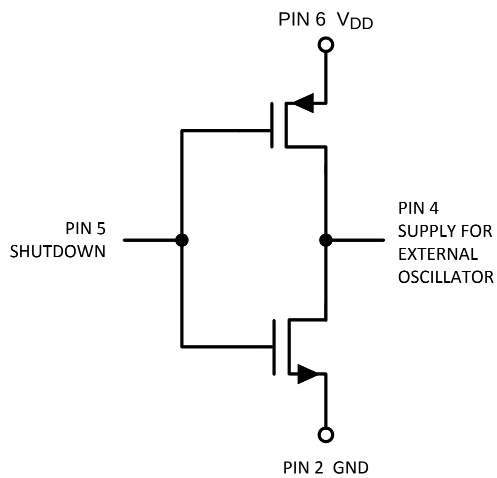



**Figure 29. Supply For External Oscillator**

## INPUT CONFIGURATION

The input of the LMV115 is internally biased at mid-supply by a divider of two equal resistors. With the LMV115 in shutdown mode, the internal resistor connected to the $V_{DD}$ is shortened to the negative power supply rail via a switch. This makes the power consumption in ‘off’ mode almost zero, but causes a small difference for the input impedance between the on and off modes. Both resistors are 110kΩ so the resulting input impedance will be approximately 55kΩ. The input configuration allows AC coupling on the input of the LMV115. A simplified schematic of the input is shown in Figure 30.

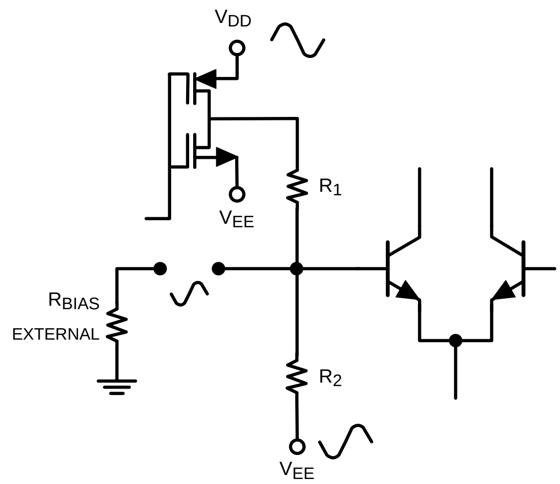



**Figure 30. Dual Supply Mode**

## PSRR

If an AC signal is applied to one of the supply lines, while the input is floating, the signal at the input pin is half the signal at the supply line, causing the same signal at the output of the buffer. This will result in a PSRR of only 6dB (see Figure 30).

In a typical application the input is driven from a low ohmic source that means the disturbance at the supply lines is attenuated by the series resistors of 110k and the source impedance. In case the buffer is connected to a 50Ω source, the resulting suppression will be 20*log $[(R_1 + R_{BIAS})/R_{BIAS}]$ = 67dB for signals at the supply line. The PSRR can also be measured correctly for this type of input by shorten the input to mid-supply. Due to the internal structure it is not recommended to measure with the input connected to ground. To measure correctly the PSRR, two signals are applied to both $V_{DD}$ and $V_{EE}$ but with 180° phase difference (see Figure 30). In this case, both signals are subtracted and there will be no signal at the input. The resulting disturbance at the output is now only caused by the signals at the supply lines.

## INPUT AND OUTPUT LEVEL

Due to the internal loop gain of 1, the output will follow the input. The output voltage cannot swing as close to the supply rail as the input voltage. For linear operation the input voltage swing should not exceed the output voltage swing. The restrictions for the output voltage can be examined by the two curves in Figure 31. The curve $V_{OUT}$ (V) shows the response of the output signal versus the input signal and the curve $V_{OUT} – V_{IN}$ (V) shows the difference between the output and the input signal.

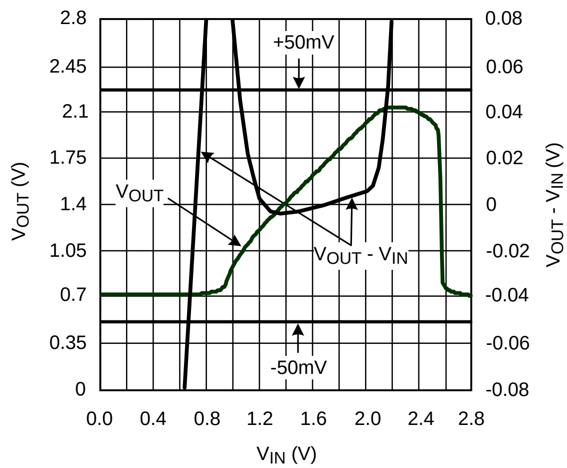



**Figure 31. $V_{OUT}$ – $V_{IN}$**

In Figure 31 the input signal is swept between both supply rails (0V - 2.8V). The linear part of the plot '$V_{OUT}$ vs. $V_{IN}$' covers approximately the voltage range between 1.0V and 2.0V. If a difference of 50mV between output and input is acceptable, the output range is between 1.05V and 2.15V (see curve VOUT - VIN). Alternatively the output voltage swing can be determined by using Figure 32. In the plot 'Gain vs. $V_{IN}$' it can be seen that the gain is flat for input voltages from 1.15V till 2.1V. Outside this range the gain differs from 1. This will introduce distortion of the output signal.

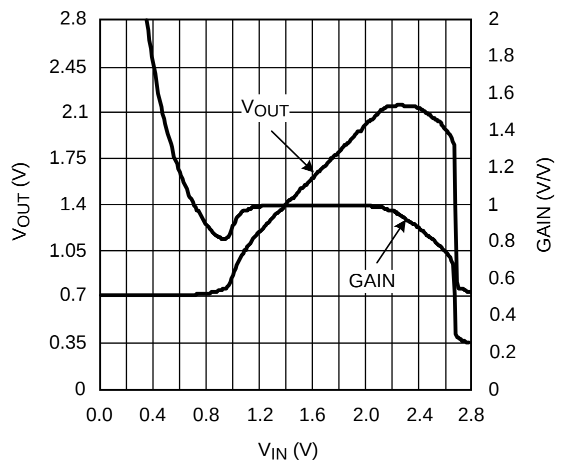



**Figure 32. Gain**

Another point is the DC bias voltage necessary to get the optimum output voltage swing. As discussed above, the output voltage swing can be $1V_{PP}$, but if the two internal bias resistors are used, the DC bias will be 1.4V, which is half of the supply voltage of 2.8V. In this situation the output swing will exceed the lower limit of 1.15V, so it is necessary to introduce a small DC offset of 200mV to make use of the full output swing range of the output stage.

## DRIVING RESISTIVE AND CAPACITIVE LOADS

The maximum output current of the LMV115 is about 200µA which means the output can drive a maximum load of 1V/200µA = 5kΩ. Using lower load resistances will exceed the maximum linear output current. The LMV115 can drive a small capacitive load, but make sure that every capacitor directly connected to the output becomes part of the loop of the buffer and will reduce the gain/phase margin, increasing the instability at higher capacitive values. This will lead to peaking in the frequency response and in extreme situations oscillations can occur. A good practice when driving larger capacitive loads is to include a series resistor to the load capacitor. A to D converters present complex and varying capacitive loads to the buffer. The best value for this isolation resistance is often found by experimentation.

## SHUTDOWN MODE

LMV115 offers a shutdown function that can be used to disable the device and to optimize current consumption. Switching between the normal mode and the shutdown mode requires connecting the shutdown pin either to the negative or the positive supply rail. If directly connected to one of the supply rails, the part is specified in the correct mode. But if the shutdown pin is driven by other output stages, there is a voltage range in which the installed mode is not certainly set and it is recommended not to drive the shutdown pin in this voltage range. As can be seen in Figure 33 this hysteresis varies from 1V to 1.6V. Below 1V the LMV115 is securely 'ON' and above 1.6V securely 'OFF' while using a supply voltage of 2.8V.

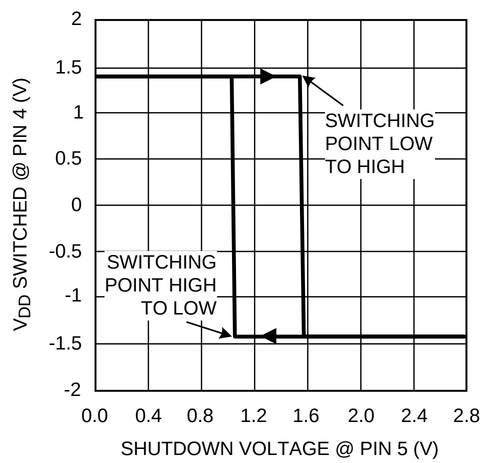



**Figure 33. Hysteresis**

## PRINTED CIRCUIT BOARD LAYOUT AND COMPONENT VALUES SELECTION

For a good high frequency design both the active parts and the passive ones should be suitable for the purpose they are used for. Amplifying high frequencies is possible with standard through-hole components, but for frequencies above several hundreds of MHz the best choice is using surface mount devices. Nowadays designs are often assembled with surface mount devices for the aspect of minimizing space, but this also greatly improves the performance of designs, handling high frequencies. Another important issue is the PCB, which is no longer a simple carrier for all the parts and a medium to interconnect them. The board becomes a real part itself, adding its own high frequency properties to the overall performance of the circuit. It is good practice to have at least one ground plane on a PCB giving a low impedance path for all decoupling and other ground connections. In order to achieve high immunity for unwanted signals from outside, it is important to place the components as flat as possible on the PCB. Be aware that a long lead can act as an inductor, a capacitor or an antenna. A pair of leads can even form a transformer. Careful design of the PCB avoids oscillations or other unwanted behavior. Another important issue is the value of components, which also determines the sensitivity to pick-up unwanted signals. Choose the value of resistors as low as possible, but avoid using values that causes a significant increase in power consumption, while loading inputs or outputs to heavily.

TI suggests the following evaluation board as a guide for high frequency layout and as an aid in device testing and characterization.

| Device | Package | Evaluation Board PN |
|---|---|---|
| LMV115 | SC70-6 | LMV115/117 Eval Board |

This free evaluation board is shipped when a device sample request is placed with TI.

## REVISION HISTORY

| Changes from Revision A (April 2013) to Revision B | Page |
|---|---|
| • Changed layout of National Data Sheet to TI format | 14 |

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