

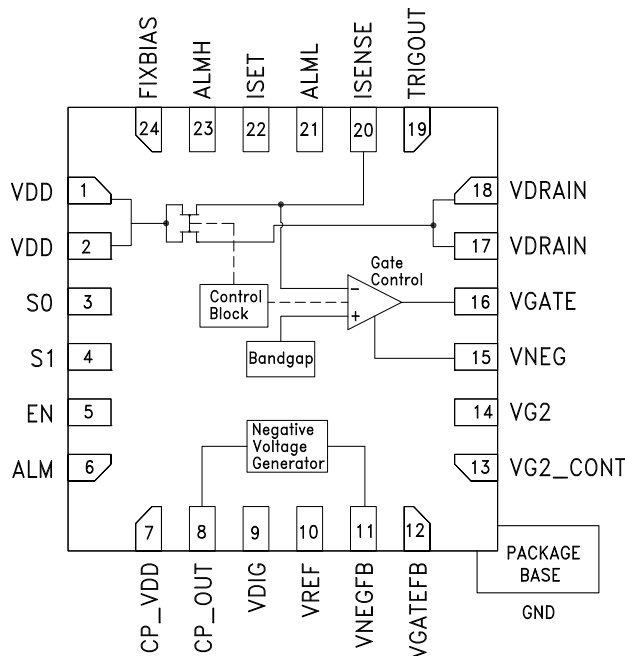
Typical Applications

- Microwave Radio & VSAT
- Military & Space
- Test Instrumentation
- Fiber Optic Modulator Driver Biasing
- CATV Laser Driver Biasing
- Cellular Base Station
- Wireless Infrastructure Equipment

Features

- Automatic Gate voltage adjustment (No Calibration required)
- Supply Voltage (5V to 16.5V)
- Bias both Enhancement or Depletion type devices
 - Adjustable Drain Current up to 1.6 A
- Sink or source gate current
- Internal negative voltage generation
 - Can be disabled to use external negative rail
- Fast Enable/Disable
- Trigger-out Output for Daisy Chain
- Power-Up and Power-Down Sequencing
- Over/Under Current Alarm with built-in hysteresis
- 24 Lead 4mmx4mm QFN Package: 16mm²

Functional Diagram



General Description

HMC980LP4E is an active bias controller that can automatically adjust the gate voltage of an external amplifier to achieve constant bias current. With an integrated controller, HMC980LP4E achieves safe power on/off, disable/enable and automatic supply sequencing ensuring the safety of the external amplifier. It can be used to bias any enhancement and depletion type amplifier operating in Class-A regime with drain voltages (VDRAIN) from 5V to 16.5V and drain currents (IDRAIN) up to 1.6 A, offering a complete biasing solution.

HMC980LP4E achieves excellent bias stability over supply, temperature and process variations, and eliminates the required calibration procedures usually employed to prevent RF performance degradation due to such variations.

The HMC980LP4E is housed in an RoHS compliant 4x4 mm QFN leadless package with an exposed backside pad to improve thermal characteristics.

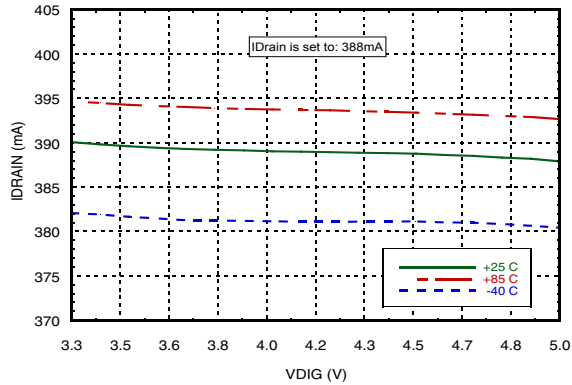

**ACTIVE BIAS CONTROLLER
HIGH CURRENT**

Electrical Specifications, $T_A = +25^\circ\text{C}$, $V_{DD}=12\text{V}$, $V_{DIG}= 3.3\text{V}$, Depletion Master
Unless Otherwise Noted

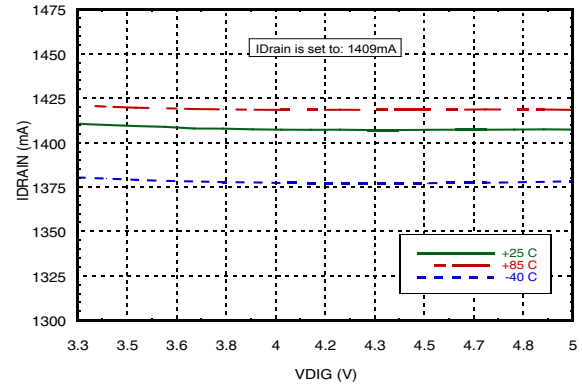
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Units |
|---|-------------------|--|-----------|----------|---------|-------|
| Supply Voltage | Vdd | | 5 | | 16.5 | V |
| VDD Quiescent Current | IDD | VDD = 5V | EN = VDIG | 19 | | mA |
| | | | EN = GND | 7.5 | | mA |
| | | VDD = 12V | EN = VDIG | 20 | | mA |
| | | | EN = GND | 9 | | mA |
| VDIG Quiescent Current | IDIG | VDIG= 3.3 V | | 3.5 | | mA |
| | | VDIG= 5 V | | 6.5 | | mA |
| Charge Pump Oscillator Frequency | FOSC | | | 300 | | kHz |
| Voltage Reference | VREF | | | 1.44 | | V |
| Enable Input Threshold | ENTHRS | Vinlow | | | 1 | V |
| | | Vinhigh | 1.4 | | | V |
| S0, S1 Input Threshold | SWTHRS | Vinlow | | | 1 | V |
| | | Vinhigh | 1.4 | | | V |
| VDRAIN Characteristics | | | | | | |
| DRAIN Current Adjustment Range | IDRAIN | S1=S0=GND | 0.05 | | 0.3 | A |
| | | S1=GND, S0=VDIG | 0.3 | | 0.6 | A |
| | | S1=VDIG, S0=GND | 0.6 | | 1.2 | A |
| | | S1=VDIG, S0=VDIG | 1.2 | | 1.6 | A |
| DRAIN Current Change Over Digital Voltage | Δ IDRAIN/V | VDRAIN set to 12V, IDRAIN set to 400 mA | | 0.4 | | %/V |
| DRAIN Current Change Over Temperature | | | | 0.023 | | %/C |
| DRAIN Range | VDRAIN | | 5 | | 16.5 | V |
| VDRAIN Change Over Temperature | Δ VDRAIN | VDRAIN set to 12V, IDRAIN set to 400 mA | | 0.02 | | %/C |
| VNEG Characteristics | | | | | | |
| Negative Voltage Output | VNEG | | | -2.46 | | V |
| VNEG Current Sink | INEG | | 0 | | 60 | mA |
| VGATE Characteristics | | | | | | |
| GATE Current Supply | IG | | -4 | | 4 | mA |
| VGATE Low Level | VG_MIN | | | VNEG | | V |
| VGATE High Level | VG_MAX | | | VNEG+4.5 | | V |
| VG2 Characteristics | | | | | | |
| VG2 Current Supply | IG2 | VG2<2V | -0.1 | | 0.1 | mA |
| | | 6V>VG2>2V | -1 | | 1 | mA |
| | | VG2>6V | -5 | | 5 | mA |
| VG2 Adjustment Range | VG2 | | 1 | | VDD-1.3 | V |
| VDIG Characteristics | | | | | | |
| Adjustment Range | VDIG | | 3.3 | | 5 | V |
| VDIG Quiescent Current | IDIG | VDD= 12V, VDIG=EN =3.3 V | | 3.5 | | mA |
| SW Characteristics | | | | | | |
| Internal Switch Resistance | RDS_ON | S1=S0=GND | | 2.8 | | Ohm |
| | | S1=GND, S0=VDIG | | 1.55 | | Ohm |
| | | S1=VDIG, S0=GND | | 0.85 | | Ohm |
| | | S1=VDIG, S0=VDIG | | 0.7 | | Ohm |

ACTIVE BIAS CONTROLLER HIGH CURRENT

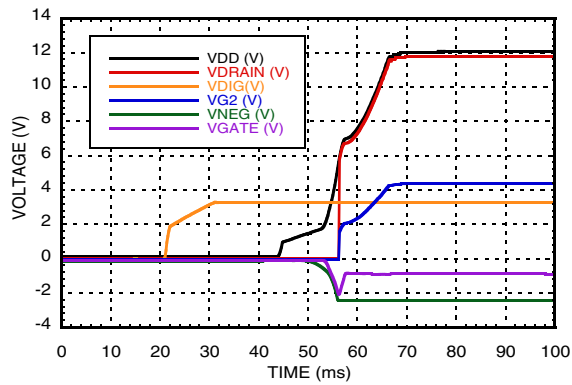
Bias Current Accuracy^[1]



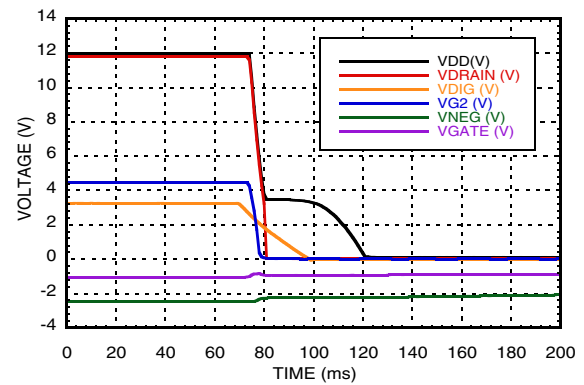
Bias Current Accuracy^[2]



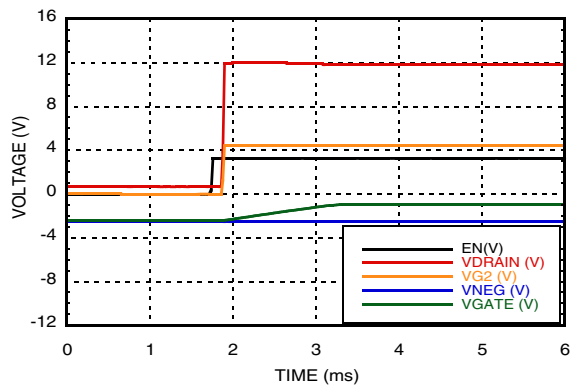
Power Up Waveform



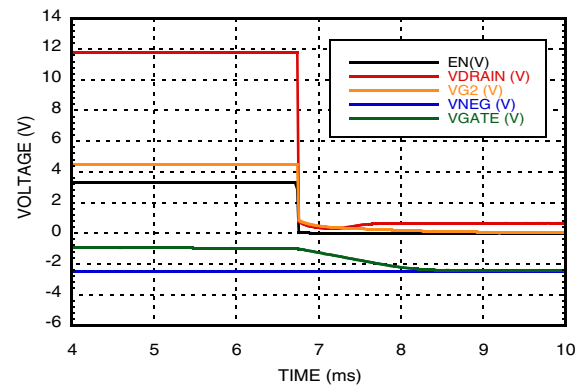
Shutdown Waveform



Enable Waveform



Disable Waveform



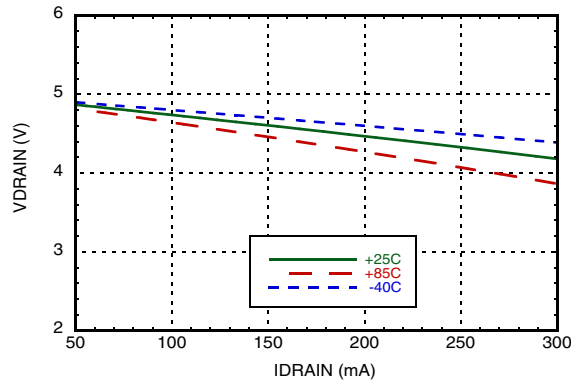
[1] HMC637LP5 is used as external amplifier

[2] HMC591LP5 is used as external amplifier

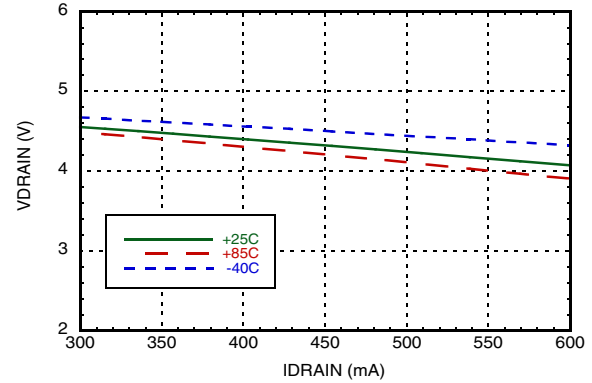


ACTIVE BIAS CONTROLLER HIGH CURRENT

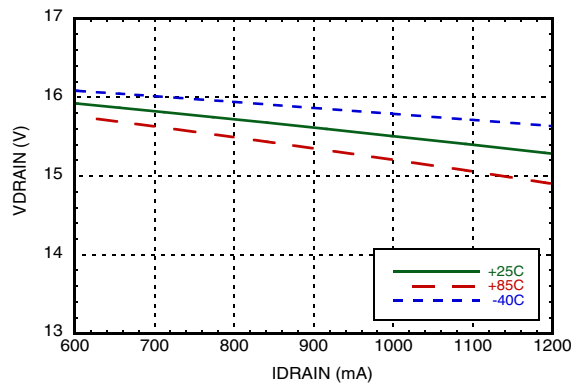
**Load Regulation @ VDD=5V, VDIG=3.3V,
SW0=GND, SW1=GND**



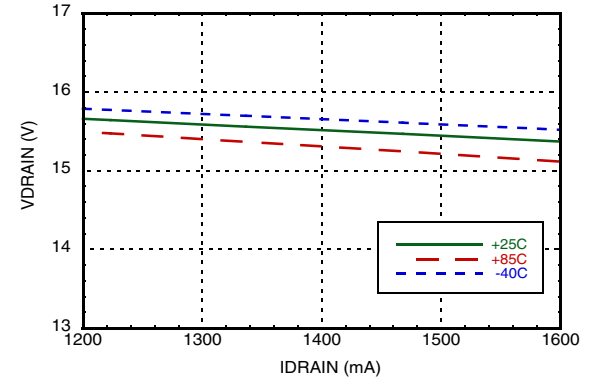
**Load Regulation @ VDD=5V, VDIG=3.3V,
SW0=3.3V, SW1=GND**



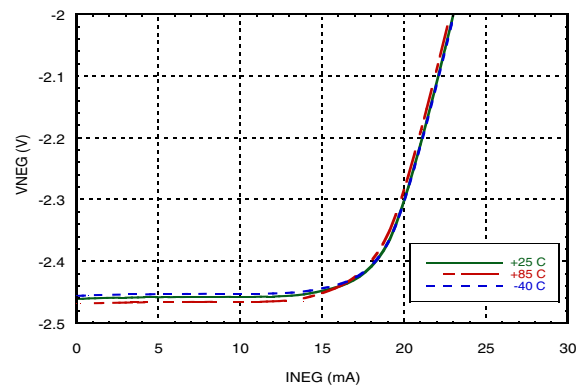
**Load Regulation @ VDD=16.5V,
VDIG=5.0V, SW0=GND, SW1=VDIG**



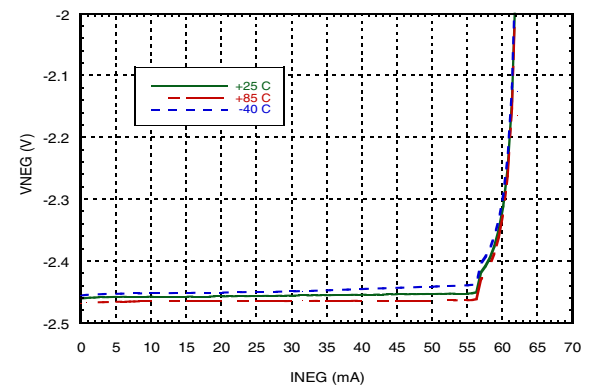
**Load Regulation @ VDD=16.5V,
VDIG=5.0V, SW0=VDIG, SW1=VDIG**



VNEG Load Regulation @ VDD=5V



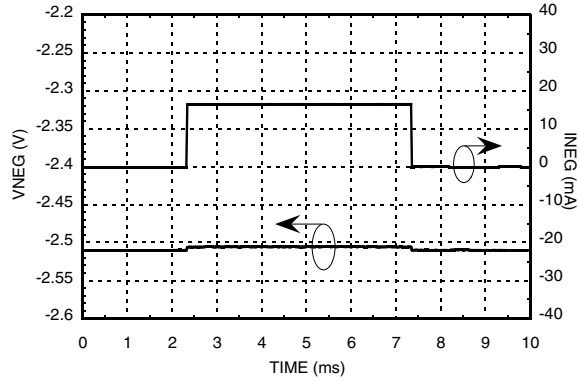
VNEG Load Regulation @ VDD=16.5V



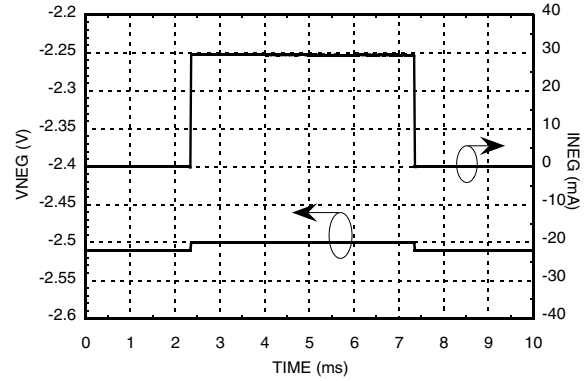


**ACTIVE BIAS CONTROLLER
HIGH CURRENT**

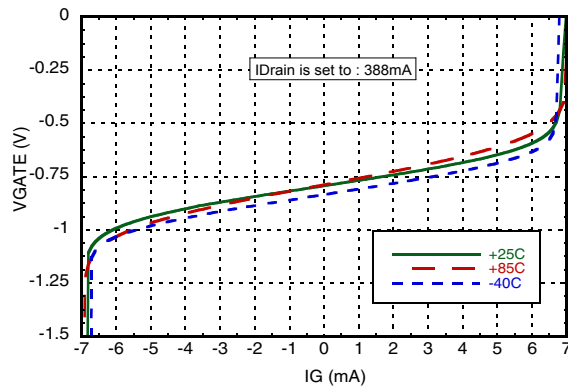
VNEG Load Transient VDD=5V



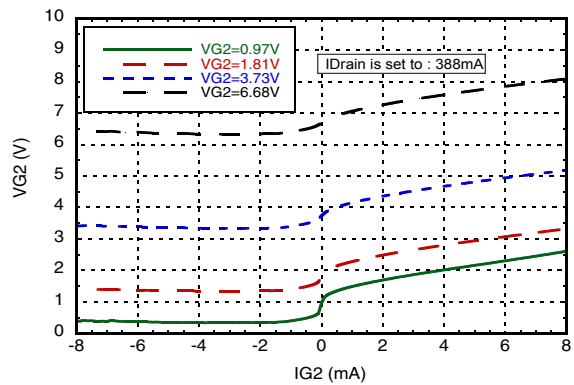
VNEG Load Transient VDD=16.5V



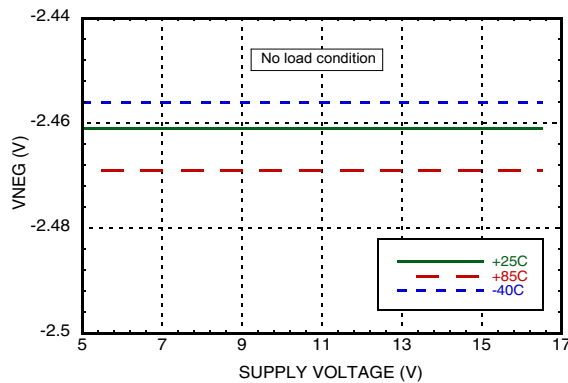
VGATE Load Regulation @ VDD=12V [1]



VG2 Load Regulation @ VDD=12V [2]



VNEG Line Regulation vs. Supply Voltage



[1] HMC637LP5 is used as external amplifier

[2] HMC637LP5 is used as external amplifier



ACTIVE BIAS CONTROLLER HIGH CURRENT

Absolute Maximum Ratings

| | |
|---|----------------------|
| VDD | 18V |
| S0, S1, EN, ALM, VREF, VNEGFB, VGATEFB, TRIG_OUT, ISENSE, ALML, ISET, ALMH, FIXBIAS | -0.5V to VDIG + 0.5V |
| CP_VDD | VDD-0.5V to VDD+0.5V |
| CP_OUT, VG2_CONT, VG2, VDRAIN | -0.5V to VDD + 0.5V |
| VDIG | 5.5V |
| VNEG | -4V to GND |
| VGATE | VNEG to GND |
| Junction Temperature | 125 °C |
| Continuous Pdiss (T = 85 °C) (Derate 94.79 mW/°C above 85 °C) | 3.8 Watt |

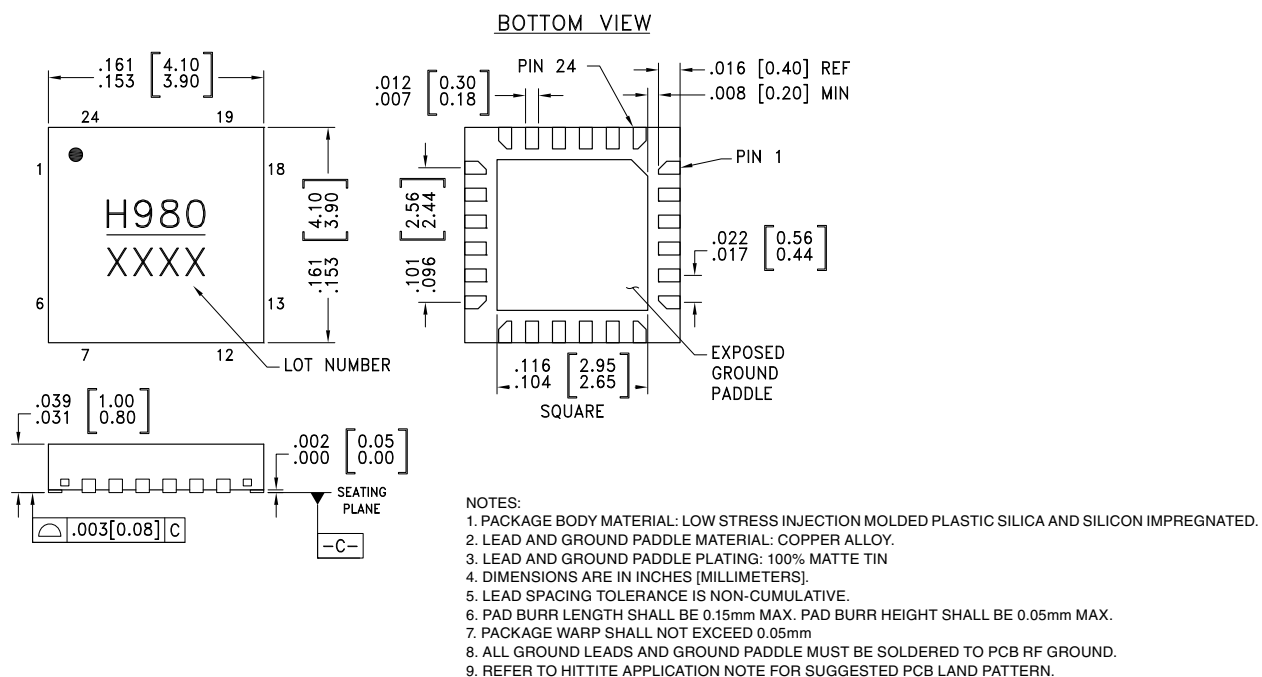
| | |
|---|----------------|
| Thermal Resistance (R _{TH}) (Junction to package bottom) | 10.6 °C/W |
| Storage Temperature | -65 to +150 °C |
| Operating Temperature | -40 to +85 °C |
| ESD Sensitivity (HBM) | Class 1A |

Note that there are two different voltage domains on HMC980LP4E; a high voltage domain V_{dd}, and a low voltage domain VDIG. Take necessary precautions not to violate ABS MAX ratings of each subdomains.



**ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS**

Outline Drawing



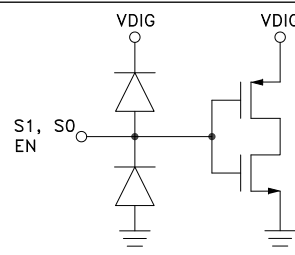
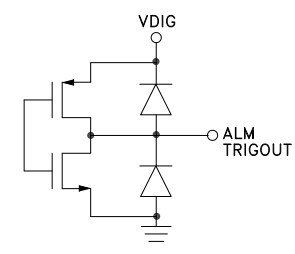
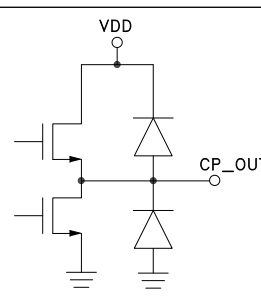
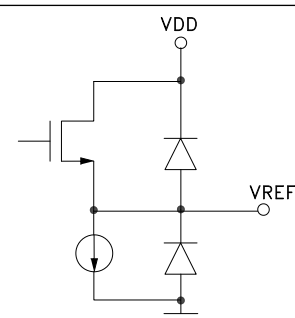
Package Information

| Part Number | Package Body Material | Lead Finish | MSL Rating | Package Marking ^[1] |
|-------------|--|---------------|---------------------|--------------------------------|
| HMC980LP4E | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 ^[2] | H980 XXXX |

[1] 4-Digit lot number XXXX

[2] Max peak reflow temperature of 260 °C


**ACTIVE BIAS CONTROLLER
HIGH CURRENT**
Pin Descriptions

| Pin Number | Function | Description | Interface Schematic |
|------------|----------|--|---|
| 1,2 | VDD | Bias supply Pin. Connect supply voltage to this pin with appropriate filtering. | |
| 3,4 | S0,S1 | Control pins for internal switch resistance. If left floating, default to HIGH. Refer to Table-1 in Application Notes for recommended settings |  |
| 5 | EN | Enable pin. Bias control loop is enabled when Ven is HIGH(VDIG). If left floating, Ven defaults to HIGH (enabled). | |
| 6 | ALM | Over/under current alarm. Provides an active high signal (VDIG) if the quiescent bias exceed the upper threshold or drops below the lower threshold. |  |
| 19 | TRIGOUT | Trigger out signal. Generates a HIGH (3.3V) signal when the active bias system stabilizes. This signal can be used to trigger next device (ENABLE) if more than one HMC980LP4E is used in a daisy chain. | |
| 7 | CP_VDD | Bias supply for negative voltage generator. Connect supply voltage with appropriate filtering. CP_VDD supply voltage should be same as VDD | |
| 8 | CP_OUT | Negative voltage generator charge pump output. Negative voltage generator requires a flying capacitor, a reservoir capacitor and two diodes to operate. |  |
| 9 | VDIG | 3.3V-5V Digital Bias supply Pin. Connect supply voltage to this pin with appropriate filtering.. | |
| 10 | VREF | 1.44V reference voltage. |  |



ACTIVE BIAS CONTROLLER HIGH CURRENT

Pin Descriptions (Continued)

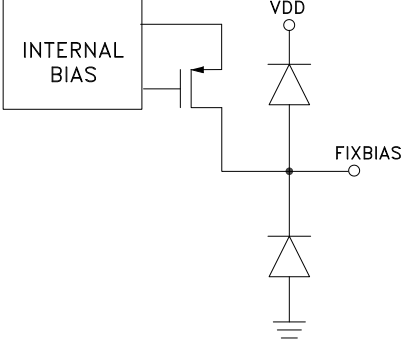
| Pin Number | Function | Description | Interface Schematic |
|------------|----------|---|---------------------|
| 11 | VNEGFB | Feedback (Control) pin for Negative Voltage Generator Charge Pump. Float to activate the negative voltage generator / Short to GND to disable the negative voltage generator. | |
| 12 | VGATEFB | Control pin for VGATEFB. Float VGATEFB when a depletion mode transistor is biased. Selects the mode of operation along with VNEGFB pin. | |
| 13 | VG2_CONT | Control voltage of the second gate pin VG2. Use a resistor divider between VDD and GND to set the voltage. VG2 is typically 1.3V lower than the VG2CONT | |
| 14 | VG2 | Second gate control. | |
| 15 | VNEG | Negative input to the chip. Should be supplied with CPOUT when negative voltage generator is enabled, or connect to external VSS when negative voltage generator is enabled. Defaults to -2.5V. If a value different than -2.5V required, please contact factory. | |
| 16 | VGATE | Gate Control pin for external amplifier. Connect to the gate (base) of the external amplifier. In order to guarantee stability, a 2.2µF capacitor should be connected between the gate (base) terminal of the external amplifier and GND as close to the amplifier as possible. | |
| 17, 18 | VDRAIN | Drain voltage. Should be connected to the supply terminal of the external amplifier. A minimum 10 nF capacitor has to be placed close to the external amplifier to improve load regulation. | |



Pin Descriptions (Continued)

| Pin Number | Function | Description | Interface Schematic |
|------------|----------|--|---------------------|
| 20 | ISENSE | Drain current adjustment pin. To adjust the bias current of the external amplifier connect a resistor (Rsense) from ISENSE pin to GND according to eqn(2) on page 13-15. A high precision resistor (e.g. 0.5%, ±25 ppm TCR) is recommended for good bias accuracy. | |
| 21 | ALML | A high precision resistor (e.g. 0.5%, ±25 ppm TCR) to GND is recommended for good bias accuracy. The value of the resistor sets the threshold value for under current alarm. If alarm feature is not used ALML can be shorted to ISet. | |
| 22 | ISET | A high precision resistor (e.g. 0.5%, ±25 ppm TCR) between ALML and ISet is recommended for good bias accuracy. The total external resistance from ISet pin to GND should always be equal to 5 kΩ. | |
| 23 | ALMH | A high precision resistor (e.g. 0.5%, ±25 ppm TCR) to ISet pin is recommended for good bias accuracy. The value of the resistor sets the threshold. If alarm feature is not used ALMH can be shorted to ISet. | |

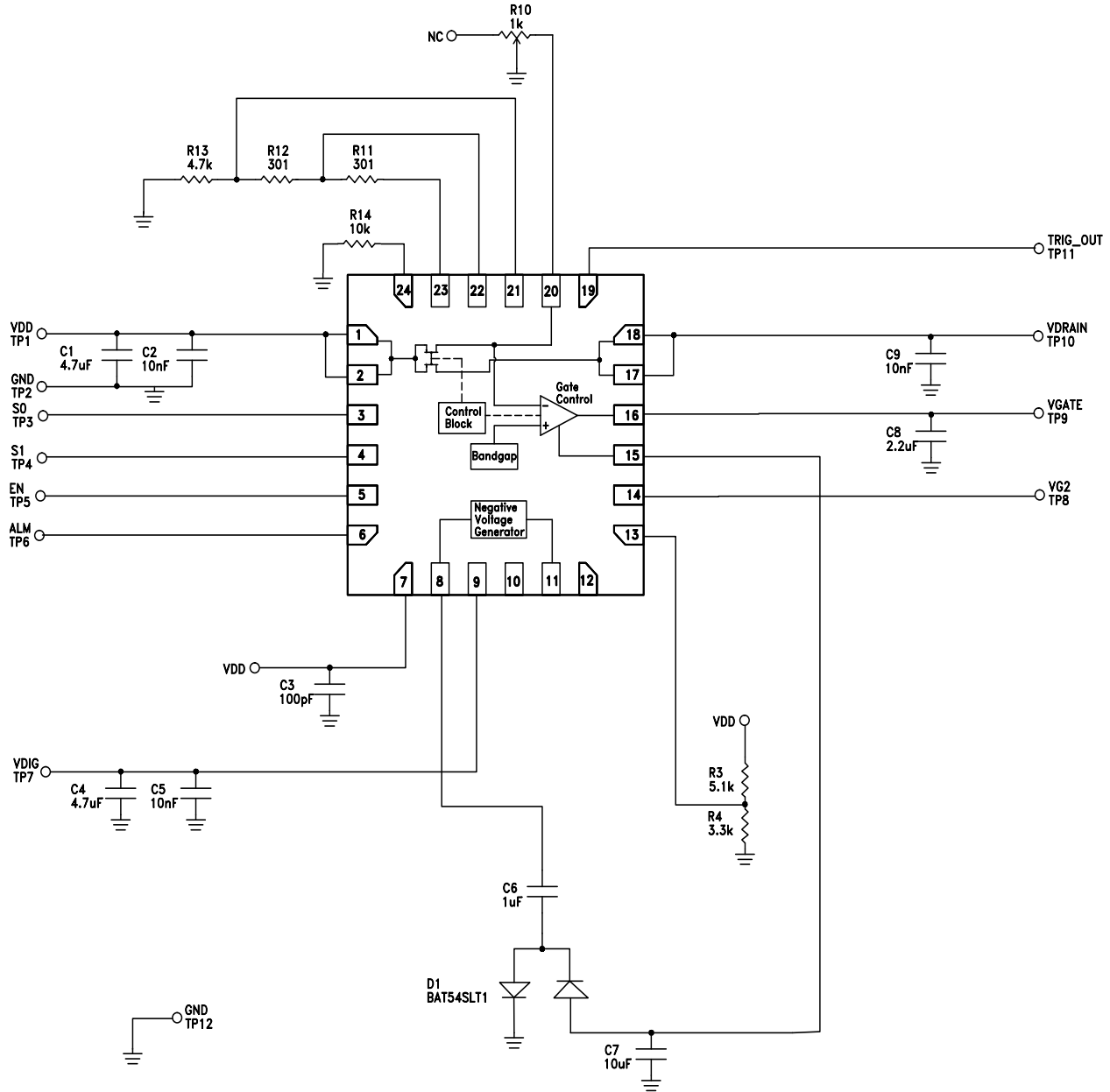


| Pin Number | Function | Description | Interface Schematic |
|------------|----------|--|---|
| 24 | FIXBIAS | A high precision (e.g. 0.5%, ± 25 ppm TCR) 10K resistor to ground is recommended for good bias accuracy. |  |



ACTIVE BIAS CONTROLLER HIGH CURRENT

Evaluation Board Circuit



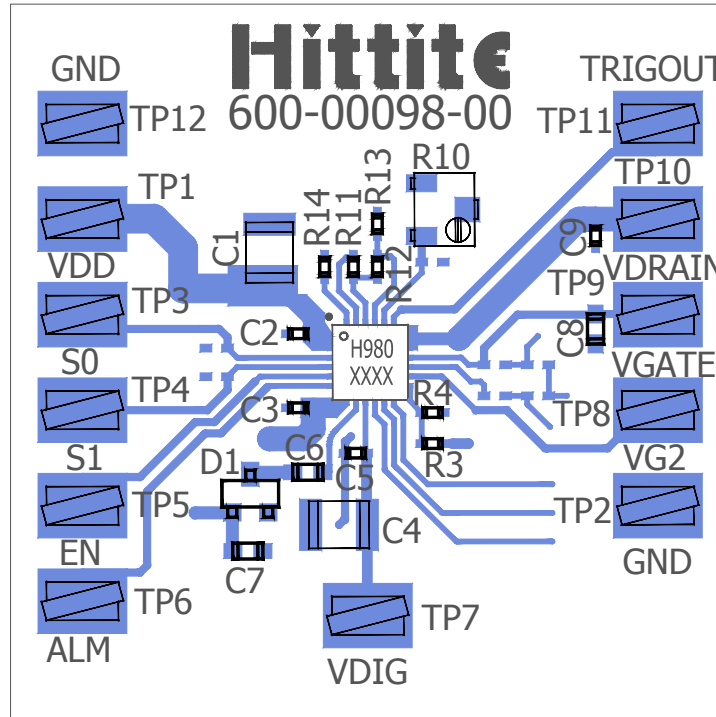
Notes:

- [1] A variable resistor is assembled on R10 slot to adjust bias current for evaluating various different amplifiers without soldering.



**ACTIVE BIAS CONTROLLER
HIGH CURRENT**

Evaluation PCB



List of Materials for Evaluation PCB EVAL01-HMC980LP4E [1]

| Item | Description |
|------------|---|
| TP1-12 | Test Point |
| C1, C4 | 4.7 μ F Capacitor, 1210 Pkg. |
| C2, C5, C9 | 10 nF Capacitor, 0402 Pkg. |
| C3 | 100 pF Capacitor, 0402 Pkg. |
| C6 | 1 μ F Capacitor, 0603 Pkg. |
| C7 | 10 μ F Capacitor, 0603 Pkg. |
| C8 | 2.2 μ F Capacitor, X5R Pkg. |
| D1 | Dual Series Schottky Barrier Diode, BAT54SLT1 |
| R3 | 5.1k Ohm Resistor, 0402 Pkg |
| R4 | 3.3k Ohm Resistor, 0402 Pkg. |
| R10 | Trim Potentiometer |
| R11, R12 | 301 Ohm Resistor, 0402 Pkg. |
| R13 | 4.7k Ohm Resistor, 0402 Pkg. |
| R14 | 10k Ohm Resistor, 0402 Pkg. |
| U1 | HMC980LP4E Switch Type ABC-High Current Version-1 |
| PCB [2] | EVAL01-HMC980LP4E Evaluation PCB |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: FR4



Application Notes

Detailed Description

All amplifiers require stable quiescent current to operate at their specifications. Many amplifiers in the market require external biasing to achieve stable quiescent current. HMC980LP4E is a fully integrated biasing solution for such amplifiers. With an internal feedback, the automatic gate voltage control achieves constant quiescent bias through the amplifier under bias, independent of temperature and amplifier threshold variations. The quiescent current is adjusted with a resistor connected externally. The HMC980LP4E employs an integrated control circuitry to manage safe power-up and power-down sequencing of the targeted amplifier. The HMC980LP4E can provide auto-bias solution to virtually any amplifier in the market (both enhancement and depletion type) with a quiescent current of up to 1.6A and a supply voltage of up to 16.5V.

The HMC980LP4E has an integrated negative voltage generator to create negative voltages required to drive depletion mode amplifiers. If an external negative supply is already available or an enhancement mode device is targeted, the negative voltage generator can be disabled.

The HMC980LP4E achieves excellent bias stability over supply and temperature variations. The gate control can both sink and source current (± 4 mA) which is required to compensate for charging gate current of the amplifier over input power variations. The HMC980LP4E also generates a second gate voltage VG2. VG2 can be adjusted through a resistor divider connected to VDD for the amplifiers which require second gate voltage.

The HMC980LP4E ensures safety of the external amplifier during turn on/off by automatically adjusting the sequence of VDRAIN, VGATE and VG2 outputs.

The HMC980LP4E has a built-in over-under current alarm feature. If a fault condition arises (either under or over current) an alarm signal is generated (ALM, active HIGH). The current alarm signal provided in HMC980LP4E does not affect the operation of the controller. It is included for monitoring purposes where a system level protection can be implemented with external control circuitry.

The HMC980LP4E employs S0, S1 pins to control RDS_ON resistance of the internal switch between VDD and VDRAIN. Refer to the section under the "Supply and Drain Voltage" section for details.

The HMC980LP4E has a built-in self protection feature to protect itself against short circuit conditions at the VDRAIN output. The HMC980LP4E has also a built-in VNEG fault protection feature to protect both itself and the amplifier under bias against short circuit conditions at the VNEG pin.

Digital Power Supply (VDIG)

The HMC980LP4E requires an external low voltage bias rail (3.3V to 5.0V). VDIG powers the internal logic circuitry. VDIG draws an average of 3.5 mA from a 3.3V. VDIG can accept voltages up to 5.0V.

Supply and Drain Voltage (VDD and VDRAIN)

The VDD supply to the HMC980LP4E is directly connected to the VDRAIN output through an internal MOSFET switch. This internal MOSFET is controlled through power-up sequencing which ensures that no voltage is applied to the drain of the external amplifier until the gate voltage is pulled down to VNEG (ensuring external amplifier is pinched-off). The VDRAIN output of the HMC980LP4E should be connected to the drain (collector) of the amplifier under bias for the active bias control feedback and power-up/down sequencing to operate properly.



**ACTIVE BIAS CONTROLLER
HIGH CURRENT**

There will be a voltage drop from VDD to VDRAIN due to finite RDS_ON resistance of the internal switch. To compensate for this voltage drop choose the VDD value as shown in equation (1).

$$VDD = VDRAIN + IDRAIN \times RDS_ON \quad (1)$$

where VDRAIN is the supply voltage of the external amplifier and IDRAIN is the desired constant bias current through the external amplifier.

Note that RDS_ON resistance of the internal FET switch can be adjusted through S0, S1 pins based on the DRAIN current requirement as shown in table-1. RDS_ON is typically equal to 0.7 Ohm when S0 and S1 are pulled up to VDIG, and is typically equal to 2.8 Ohm when S0 and S1 are pulled down to GND. If S0 and S1 pins are left floating, it is pulled up to VDIG through an internal weak pull-up. Recommended settings for the S0 and S1 positions are given in Table-1. Not using the HMC980LP4E in the recommended settings may increase the power dissipation of the part and the part-to-part variation.

Table 1. Recommended Current Range Configuration

| Current Range (A) | Condition | RD_ON Value (Ohm) |
|-------------------|------------------|-------------------|
| 0.05 to 0.3 | S1=S0=GND | 2.8 |
| 0.3 to 0.6 | S1=GND, S0=VDIG | 1.55 |
| 0.6 to 1.2 | S1=VDIG, S0=GND | 0.85 |
| 1.2 to 1.6 | S1=VDIG, S0=VDIG | 0.7 |

Negative Voltage Generator (VNEGOUT)

The HMC980LP4E has internal regulated charge pump circuitry to generate the negative voltage (VNEGOUT) required for depletion mode devices. The HMC980LP4E generates -2.5V at the VNEGOUT output in default configuration. It requires two diodes and two capacitors connected externally as shown in the sample application schematics. It can be disabled through the VGATEFB and VNEGFB pins, if an enhancement device is targeted or a negative supply is already available in the system. In this configuration, simply connect the available negative supply to the VNEG pin. See Table-2 for the operation mode selection. The HMC980LP4E is designed to reject the ripple on the VNEGOUT pin by isolating VNEGOUT from the VGATE. Thus, switching noise of the charge-pump is effectively isolated from the external amplifier.

Enable/Disable (EN)

The active bias control loop is enabled when EN is pulled up to VDIG, and it is disabled when it is pulled down to GND. If EN is left floating HMC980LP4E is enabled through an internal weak pull-up. Note that VNEG operation is independent of EN condition. EN signal controls the operation of only VGATE, VG2 and VDRAIN outputs. When EN pulled down to GND, the HMC980LP4E discharges VDRAIN and VG2 down to GND and it pulls the VGATE down to VNEG. When EN pulled high to VDIG, HMC980LP4E enables, VDRAIN and VG2, and enables the bias control loop to automatically adjust the VGATE voltage. Please see the “Active Bias Control Loop” section for detailed explanation and refer to the Enable and Disable waveforms for transient characteristics.

Active Bias Control Loop

The HMC980LP4E regulates the bias current (IDRAIN) of the amplifier under bias through VGATE output connected to the gate of the external amplifier. In this closed loop operation the current passing through the amplifier under bias is sampled and is used to automatically adjust VGATE to achieve constant quiescent bias through the external amplifier.



ACTIVE BIAS CONTROLLER HIGH CURRENT

The HMC980LP4E continuously adjusts VGATE voltage to achieve constant DRAIN current over any supply, temperature, process variations and threshold drifts due to aging. The part-to-part, temperature, and supply variation of the HMC980LP4E is excellent. Thus, by using an accurate sense resistor connected to the ISENSE pin, expensive calibration procedures in high volume production could be avoided.

The gate control of the HMC980LP4E is designed to both sink and source current in to the gate of the targeted amplifier (at least ± 4 mA). This unique feature is important to achieve nearly constant quiescent bias through the amplifier under varying gate current at different input power values.

The bias current passing through the external amplifier can be adjusted with RSENSE, where RSENSE is the R10 connected from ISENSE to GND. Use the relation given in equation (2) to set the desired bias current through the external amplifier.

$$IDRAIN = 150 / R_{sense} \text{ (A)} \quad (2)$$

VG2 Voltage Adjustment

The HMC980LP4E generates a second gate voltage (VG2). VG2 can be adjusted through a resistor divider connected to VG2_CONT for the amplifiers which require second gate voltage. Eqn. (3) gives the formula to adjust VG2:

$$VG2(V) = VDD * R4 / (R3 + R4) - 1.3 \quad (3)$$

For instance, choosing 5.1k Ohm as R3 and 3.3k Ohm as R4 sets VG2 voltage to 3.4V when VDD=12V. For improved accuracy, choose resistor values below 5k Ohm on R3.

Self Protection Feature

Due to the small resistance of the internal switch FET between VDD and VDRAIN, a large amount of current may flow through the HMC980LP4E. HMC980LP4E limits the maximum current to self protect itself under such fault conditions, by turning off VDRAIN and VGATE.

The HMC980LP4E will remain in this protection mode until a full power-cycle or enable/disable cycle is applied.

VNEG Fault Detection Feature

In depletion mode operation VNEG is continuously monitored against short circuit fault to GND. If VNEG rises above a preset value (typically -0.6V) the system and the external amplifier are disabled by pulling VDRAIN and VG2 to GND and VGATE to VNEG. The system will stay in this stand-by mode until short fault at VNEG is fixed.

Over/Under Current Alarm

The HMC980LP4E provides over and under current alarm indicator ALM (pin#6) signal. The ALM is pulled up to VDIG when the IDRAIN current exceeds $\pm 6\%$ (With the given R11, R12, and R13 values in application circuit) of IDRAIN regulation target value as shown in Figure 1. The alarm threshold level is user adjustable through R11, R12, and R13 according to the following equations:

$$\text{Over current ALM Threshold} = I_{\text{octh}} = IDRAIN (1 + R11 / (R12 + R13)),$$

$$\text{Under current ALM Threshold} = I_{\text{ucth}} = IDRAIN (1 - R12 / (R12 + R13)),$$

where R12+R13 should always be equal to 5 k Ω (%1 accuracy)

Threshold values possess a small built-in hysteresis. The condition of ALM signal does not effect the operation of HMC980LP4E. It is provided only for monitoring purposes.



**ACTIVE BIAS CONTROLLER
HIGH CURRENT**

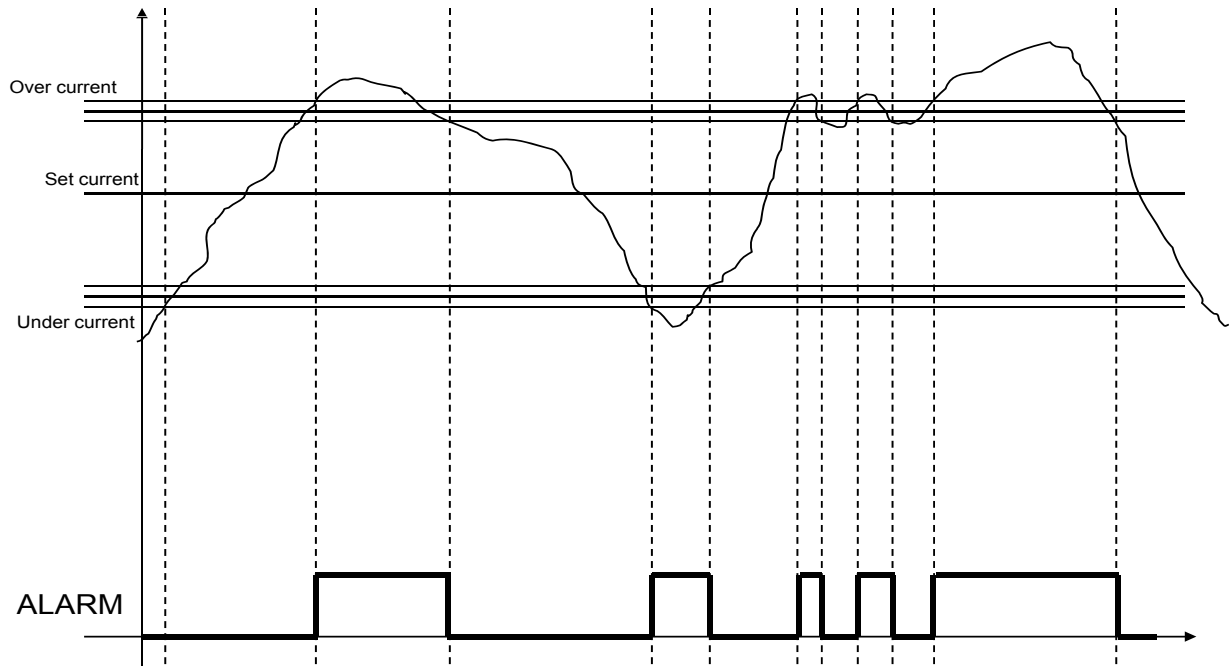


Figure 1. Current Alarm Behavior

Power-up and Enable Sequencing

To ensure the safety of the external amplifier, the HMC980LP4E provides an automatic power-up sequence for enabling the active bias control loop. During start-up VDRAIN and VG2 are kept at GND while VGATE is taken to the most negative supply available (VGATE=VNEG). This ensures that external amplifier is completely pinched-off before VDRAIN is applied. When EN signal is received, VDRAIN is applied and the active bias loop is enabled. After the VDRAIN is applied, VG2 is generated. The power-up sequence is completed by increasing the VGATE linearly until the set IDRAIN value is reached.

For power-down and disabling, the same sequencing is applied in the reverse order.

Daisy-Chain Operation

HMC980LP4E produces a trigger out signal (TRIGOUT pin#19) when the quiescent current is in regulation. This trigger signal can be used to enable additional HMC980LP4E chips in a chain of amplifiers. The triggering sequence can be routed in any way, from input to output, or from output to input depending on the use. Figure-2 shows a sample use of three HMC980LP4Es in an amplification chain. Please note that, only one of the HMC980LP4E (in master mode) is used to generate the negative voltage and the remaining HMC980LP4E (in slave mode) is set to receive external negative voltage (which is provided from the master depletion mode HMC980LP4E). Generating negative voltage from a single HMC980LP4E reduces the number of the components in the system, and decreases the over all current consumption.

Please note that, to ensure proper start-up, the system enable signal should be applied to the depletion master mode device that has the negative voltage generator.



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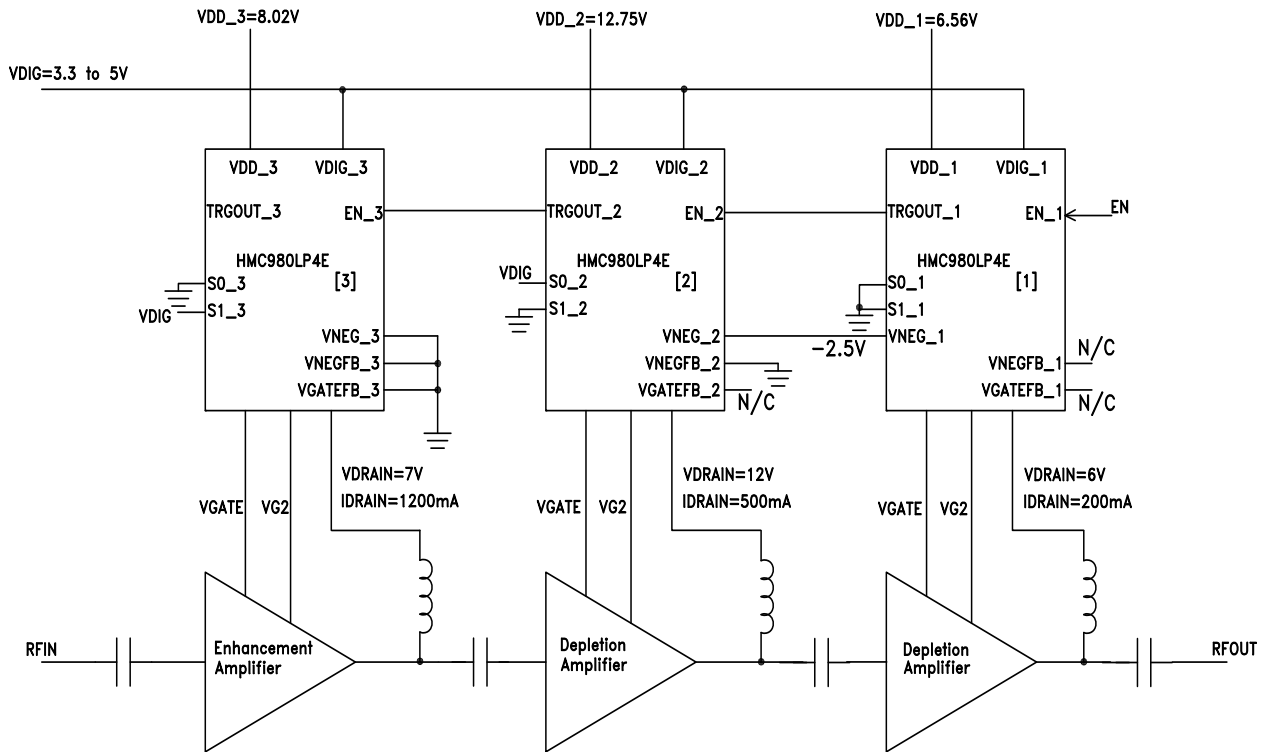


Figure 2. Daisy Chain Operation

Operation Modes

HMC980LP4E can be configured to bias both enhancement and depletion mode external amplifiers. The mode of operation can be selected by setting two pins (VNEGFB, VGATEFB) as tabulated in Table-2. The connection to the VNEGIN should be adjusted accordingly.

In order not to bias external amplifier in a wrong region, please make sure that the correct mode of operation is selected before powering up the HMC980LP4E.

The HMC980LP4E does not allow the internal negative voltage generator to work if an enhancement mode is selected. Therefore, if VNEGFB is left floating while VGATEFB is grounded, HMC980LP4E will stay in standby mode.

Please note that in depletion slave mode the external negative voltage should be between -2.3V to -3.5V for HMC980LP4E to operate. If your application requires negative voltages outside this range please contact Hittite application support.

Table 2. Mode Selection

| | VNEGFB | VGATEFB | VNEGIN | Description |
|----------------------------------|--------|---------|---------------------------|---|
| MODE1 (Depletion/Master Mode) | FLOAT | FLOAT | Connected to VNEGOUT | Depletion mode transistor. Internal negative voltage generator is active and generates -2.5V. Sample application schematic given shown in Fig.3a. |
| MODE2 (Depletion/Slave Mode) | GND | FLOAT | Connected to External VSS | Depletion mode transistor. Internal negative voltage generator is disabled. An external negative voltage less than -2.3V should be connected to VNEGIN. Sample application schematic given shown in Fig.3b. |
| --- | FLOAT | GND | N/A | Not allowed. HMC980LP4E stays in standby. |
| MODE3 (Enhancement Mode) | GND | GND | Connected to GND | Enhancement mode transistor. Internal negative voltage generator is disabled. Sample application schematic given shown in Fig.3c. |

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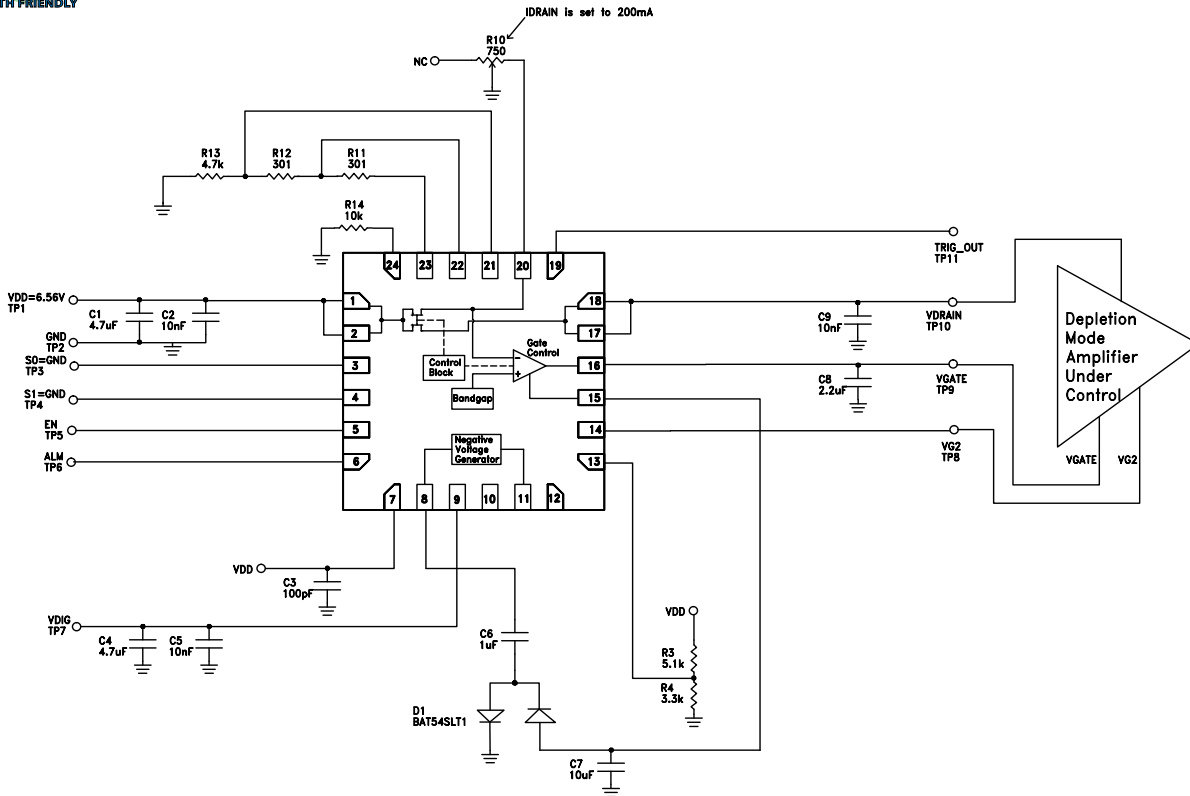


Figure 3a. Depletion/Master Mode Amplifier Typical Application Circuit (Mode 1)

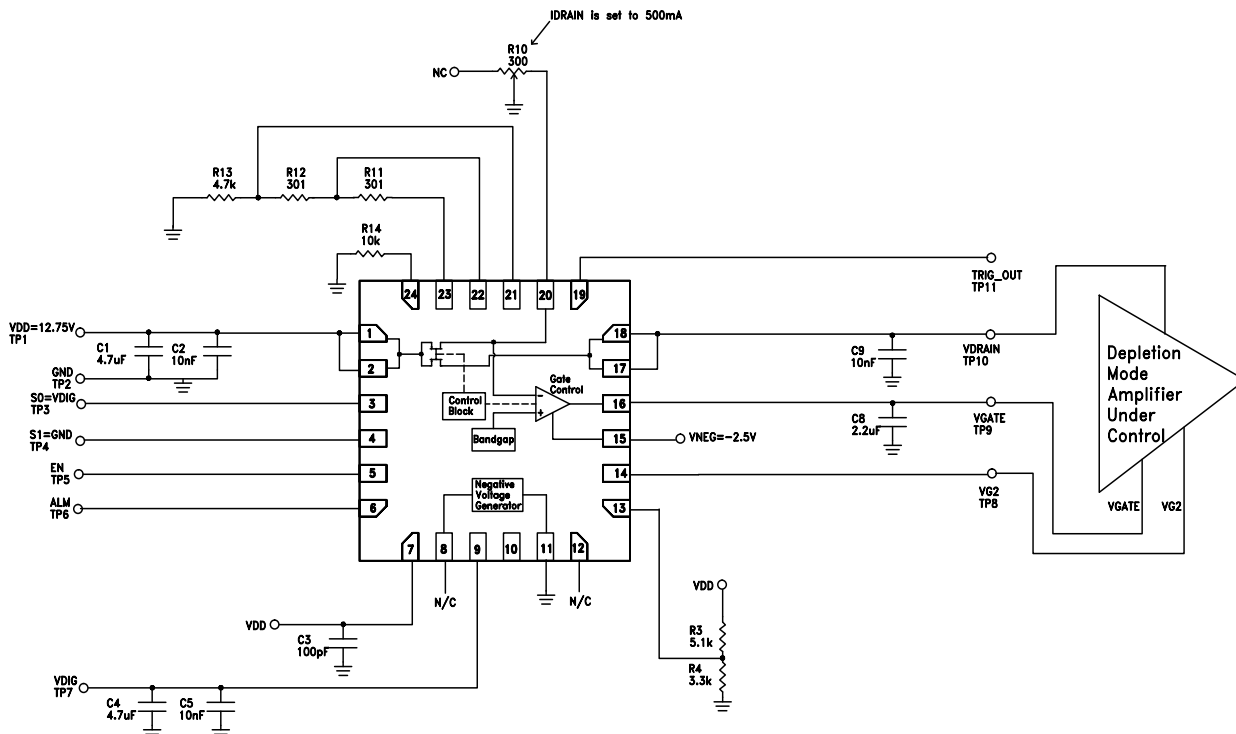


Figure 3b. Depletion/Slave Mode Amplifier Typical Application Circuit (Mode 2)

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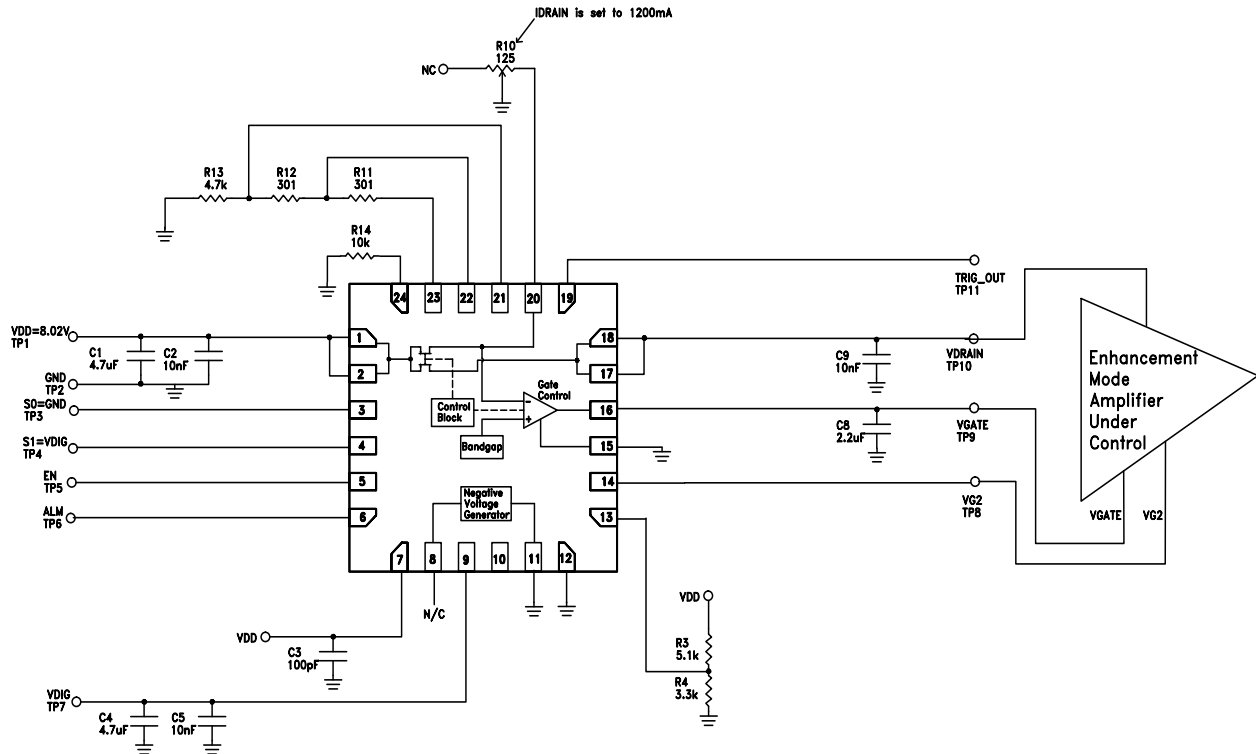


Figure 3c. Enhancement Mode Amplifier Typical Application Circuit (Mode 3)

For biasing Hittite amplifiers compatible with HMC980LP4E refer to the Table 3, where values of the external components are provided on typical application circuit shown in Figure 3a.

Table 3 - List of Bias Settings for Various Hittite Amplifiers

| Hittite Part Number | VDRAIN (V) | VDD (V) | IDRAIN (mA) | RSENSE (kOhm) | R4 (kOhm) | R3 (kOhm) | VG2 (V) | S1 | S0 |
|----------------------------------|------------|---------|-------------|---------------|-----------|-----------|---------|-----|-----|
| Gain Blocks & Drivers | | | | | | | | | |
| HMC-AUH256 | 5 | 5.83 | 295 | 0.508 | open | open | - | GND | GND |
| LNAs | | | | | | | | | |
| HMC-ALH435 | 5 | 5.08 | 30 | 5.000 | 6.13 | 5 | 1.5 | GND | GND |
| HMC-ALH444 | 5 | 5.15 | 55 | 2.727 | 5.95 | 5 | 1.5 | GND | GND |
| HMC490 | 5 | 5.56 | 200 | 0.750 | open | open | - | GND | GND |
| HMC490LP5 | 5 | 5.56 | 200 | 0.750 | open | open | - | GND | GND |
| HMC594 | 6 | 6.28 | 100 | 1.500 | open | open | - | GND | GND |
| HMC594LC3B | 6 | 6.28 | 100 | 1.500 | open | open | - | GND | GND |
| HMC609 | 6 | 6.48 | 170 | 0.882 | open | open | - | GND | GND |
| HMC609LC4 | 6 | 6.48 | 170 | 0.882 | open | open | - | GND | GND |
| HMC753LP4E | 5 | 5.15 | 55 | 2.727 | 5.95 | 5 | 1.5 | GND | GND |
| Linear & Power | | | | | | | | | |
| HMC-ABH209 | 5 | 5.22 | 80 | 1.875 | open | open | - | GND | GND |
| HMC-ABH264 | 5 | 5.34 | 120 | 1.250 | open | open | - | GND | GND |
| HMC442 | 5 | 5.24 | 85 | 1.765 | open | open | - | GND | GND |
| HMC442LC3B | 5 | 5.24 | 84 | 1.786 | open | open | - | GND | GND |


**ACTIVE BIAS CONTROLLER
HIGH CURRENT**
Table 3 - List of Bias Settings for Various Hittite Amplifiers (Continued)

| Hittite Part Number | VDRAIN (V) | VDD (V) | IDRAIN (mA) | RSENSE (kOhm) | R4 (kOhm) | R3 (kOhm) | VG2 (V) | S1 | S0 |
|-------------------------------|------------|---------|-------------|---------------|-----------|-----------|---------|------|------|
| HMC442LM1 | 5 | 5.24 | 85 | 1.765 | open | open | - | GND | GND |
| HMC499 | 5 | 5.56 | 200 | 0.750 | open | open | - | GND | GND |
| HMC499LC4 | 5 | 5.56 | 200 | 0.750 | open | open | - | GND | GND |
| HMC-ABH241 | 5 | 5.62 | 220 | 0.682 | open | open | - | GND | GND |
| HMC-APH403 | 5 | 5.74 | 475 | 0.316 | open | open | - | GND | VDIG |
| HMC-APH460 | 5 | 5.77 | 900 | 0.167 | open | open | - | VDIG | GND |
| HMC-APH462 | 5 | 6.22 | 1440 | 0.104 | open | open | - | VDIG | GND |
| HMC-APH473 | 5 | 5.92 | 1080 | 0.139 | open | open | - | VDIG | GND |
| HMC-APH478 | 5 | 5.77 | 900 | 0.167 | open | open | - | VDIG | GND |
| HMC-APH510 | 5 | 5.99 | 640 | 0.234 | open | open | - | GND | VDIG |
| HMC-APH518 | 5 | 5.81 | 950 | 0.158 | open | open | - | VDIG | GND |
| HMC-APH596 | 5 | 6.12 | 400 | 0.375 | open | open | - | GND | GND |
| HMC-APH608 | 5 | 5.81 | 950 | 0.158 | open | open | - | VDIG | GND |
| HMC486 | 7 | 8.11 | 1300 | 0.115 | open | open | - | VDIG | GND |
| HMC486LP5 / HMC486LP5E | 7 | 8.11 | 1300 | 0.115 | open | open | - | VDIG | GND |
| HMC487LP5 / HMC487LP5E | 7 | 8.11 | 1300 | 0.115 | open | open | - | VDIG | GND |
| HMC489LP5 / HMC489LP5E | 7 | 8.11 | 1300 | 0.115 | open | open | - | VDIG | GND |
| HMC498 | 5 | 5.70 | 250 | 0.600 | open | open | - | GND | GND |
| HMC498LC4 | 5 | 5.70 | 250 | 0.600 | open | open | - | GND | GND |
| HMC590 | 7 | 7.70 | 820 | 0.183 | open | open | - | VDIG | GND |
| HMC590LP5 / HMC590LP5E | 7 | 7.70 | 820 | 0.183 | open | open | - | VDIG | GND |
| HMC591 | 7 | 8.14 | 1340 | 0.112 | open | open | - | VDIG | GND |
| HMC591LP5 / HMC591LP5E | 7 | 8.14 | 1340 | 0.112 | open | open | - | VDIG | GND |
| HMC592 | 7 | 8.16 | 750 | 0.200 | open | open | - | GND | VDIG |
| HMC608LC4 | 5 | 5.87 | 310 | 0.484 | open | open | - | GND | GND |
| HMC693 | 5 | 6.24 | 800 | 0.188 | open | open | - | GND | VDIG |
| HMC756 | 7 | 8.22 | 790 | 0.190 | open | open | - | GND | VDIG |
| HMC757 | 7 | 8.11 | 395 | 0.380 | open | open | - | GND | GND |
| HMC757LP4E | 5 | 6.12 | 400 | 0.375 | open | open | - | GND | GND |
| HMC863 | 6 | 7.05 | 375 | 0.400 | open | open | - | GND | GND |
| HMC863LP4E | 6 | 7.05 | 375 | 0.400 | open | open | - | GND | GND |
| HMC864 | 6 | 7.16 | 750 | 0.200 | open | open | - | GND | VDIG |
| HMC906 | 6 | 7.02 | 1200 | 0.125 | open | open | - | VDIG | GND |
| HMC943LP5E | 5.5 | 6.52 | 1200 | 0.125 | open | open | - | VDIG | GND |
| HMC949 | 7 | 8.02 | 1200 | 0.125 | open | open | - | VDIG | GND |
| HMC965LP5E | 6 | 7.02 | 1200 | 0.125 | open | open | - | VDIG | GND |
| HMC968 | 6 | 6.77 | 900 | 0.167 | open | open | - | VDIG | GND |
| HMC969 | 6 | 6.77 | 900 | 0.167 | open | open | - | VDIG | GND |
| Wideband (Distributed) | | | | | | | | | |
| HMC-AUH232 | 5 | 5.50 | 180 | 0.833 | 5.18 | 5 | 1.5 | GND | GND |
| HMC-AUH249 | 5 | 5.56 | 200 | 0.750 | 5.07 | 5 | 1.5 | GND | GND |
| HMC-AUH312 | 8 | 8.17 | 60 | 2.500 | 3.06 | 5 | 1.8 | GND | GND |

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**ACTIVE BIAS CONTROLLER
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Table 3 - List of Bias Settings for Various Hittite Amplifiers (Continued)

| Hittite Part Number | VDRAIN (V) | VDD (V) | IDRAIN (mA) | RSENSE (kOhm) | R4 (kOhm) | R3 (kOhm) | VG2 (V) | S1 | S0 |
|--|------------|---------|-------------|---------------|-----------|-----------|---------|-----|-----|
| HMC460 | 8 | 8.17 | 60 | 2.500 | open | open | - | GND | GND |
| HMC460LC5 | 8 | 8.21 | 75 | 2.000 | open | open | - | GND | GND |
| HMC463 | 5 | 5.17 | 60 | 2.500 | open | open | - | GND | GND |
| HMC463LH250 | 5 | 5.17 | 60 | 2.500 | open | open | - | GND | GND |
| HMC463LP5 | 5 | 5.17 | 60 | 2.500 | open | open | - | GND | GND |
| HMC465 | 8 | 8.45 | 160 | 0.938 | 2.48 | 5 | 1.5 | GND | GND |
| HMC465LP5 | 8 | 8.45 | 160 | 0.938 | 2.48 | 5 | 1.5 | GND | GND |
| HMC562 | 8 | 8.22 | 80 | 1.875 | open | open | - | GND | GND |
| HMC633 | 5 | 5.50 | 180 | 0.833 | open | open | - | GND | GND |
| HMC633LC4 | 5 | 5.50 | 180 | 0.833 | open | open | - | GND | GND |
| HMC634 | 5 | 5.50 | 180 | 0.833 | open | open | - | GND | GND |
| HMC634LC4 | 5 | 5.50 | 180 | 0.833 | open | open | - | GND | GND |
| HMC-930 | 10 | 10.49 | 175 | 0.857 | 4.22 | 5 | 3.5 | GND | GND |
| HMC-459 | 8 | 8.81 | 290 | 0.517 | 4.77 | 5 | 3 | GND | GND |
| HMC-464 | 8 | 8.81 | 290 | 0.517 | 4.77 | 5 | 3 | GND | GND |
| HMC464LP5 / HMC464LP5E | 8 | 8.81 | 290 | 0.517 | 4.77 | 5 | 3 | GND | GND |
| HMC559 | 10 | 11.12 | 400 | 0.375 | 4.55 | 5 | 4 | GND | GND |
| HMC619 | 12 | 12.84 | 300 | 0.500 | 4.82 | 5 | 5 | GND | GND |
| HMC619LP5 / HMC619LP5E | 12 | 12.84 | 300 | 0.500 | 4.82 | 5 | 5 | GND | GND |
| HMC635 | 5 | 5.78 | 280 | 0.536 | open | open | - | GND | GND |
| HMC635LC4 | 5 | 5.78 | 280 | 0.536 | open | open | - | GND | GND |
| HMC637 | 12 | 13.12 | 400 | 0.375 | 6.27 | 5 | 6 | GND | GND |
| HMC637LP5 / HMC637LP5E | 12 | 13.12 | 400 | 0.375 | 4.62 | 5 | 5 | GND | GND |
| HMC659 | 8 | 8.84 | 300 | 0.500 | 4.74 | 5 | 3 | GND | GND |
| HMC659LC5 | 8 | 8.84 | 300 | 0.500 | 4.74 | 5 | 3 | GND | GND |
| HMC797 | 10 | 11.12 | 400 | 0.375 | 3.80 | 5 | 3.5 | GND | GND |
| HMC797LP5E | 10 | 11.12 | 400 | 0.375 | 3.80 | 5 | 3.5 | GND | GND |
| Microwave & Optical Drivers | | | | | | | | | |
| HMC870LC5 | 7 | 7.46 | 165 | 0.909 | open | open | - | GND | GND |
| HMC871LC5 | 8 | 8.21 | 75 | 2.000 | open | open | - | GND | GND |



Notes:



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Телефон: 8 (812) 309 58 32 (многоканальный)

Факс: 8 (812) 320-02-42

Электронная почта: org@eplast1.ru

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.