Operation of the HC5513, HC5526 Evaluation Board (HC5513EVAL, HC5526EVAL)

Application Note | September 2000 | AN9537.3

Features

- Includes the Ringing Relay
- Toggle Switch Programming for Logic States
- Convenient Monitoring of $\overline{DET}$ via LED or Banana Jack Output
- Provides Easy Interface of Transhybrid Circuit Using Off Board CODECs Internal Op Amp

Applications

- Solid State Line Interface for Digital and Analog Telephone Line Cards

Functional Description

The HC5513/26EVAL Subscriber Line Interface Circuit (SLIC) evaluation board has provisions for full evaluation of the voice and DC feeding characteristics of the HC5513 and the HC5526 line interface circuit including the ringing function.

SLIC functional control is provided using the toggle switches E0, E1, C1 and C2. Table 2 lists the states of the SLIC, active detector and $\overline{DET}$ output. $\overline{DET}$ is available at both a banana jack for monitoring with test instrumentation as well as an LED for visual verification.

Applying Power to the HC5513/26EVAL

Power Supply Connections

The HC5513/26EVAL requires three external power supplies for operation. The supply voltages are labeled on the HC5513/26EVAL as V_{CC} +5V, V_{EE} -5V and V_{BAT}. The limits for all supply voltages are provided in Table 1. The table also includes the typical current of each supply when the SLIC is in the Active mode and terminated with a 600Ω load.

TABLE 1. POWER SUPPLY INFORMATION

SUPPLY	TYP (V)	TYP (mA)
V_{CC} +5V	+5	11
V_{EE} -5V	-5	1
V_{BAT}, R_{SG} is Open Circuit	-28	27
V_{BAT}, R_{SG} is 21.4kΩ	-48	30

Ground Connections

The HC5513/26EVAL has two separate grounds designated as AGND and BGND. AGND is the analog ground reference for the SLIC. BGND is the battery ground reference, and is to be connected to zero potential. All loop current and longitudinal current flow from this ground. For proper SLIC operation, AGND and BGND must be connected to a common ground, with a potential difference not exceeding ±100mV.

HC5513/26EVAL Board SLIC Controls

The design of the HC5513/26EVAL board incorporates five SPDT switches. Four of the switches control the functional state of the HC5513/26 SLIC and the fifth controls the $\overline{DET}$ output.

Mode Control Switches

The four switches labeled E0, E1, C1 and C2 are used to set the operational mode of the SLIC. Each switch is a Single Pole Double Throw (SPDT) switch.

The two inputs labeled E0 and E1 are enable pins. The two pins labeled C1 and C2 are used to select 1 of 4 operating states of the SLIC. Refer to the HC5513/26 Subscriber Line Interface Circuit electrical data sheet for a full description of the functionality of each pin.

$\overline{DET}$ Select Switch

A switch is provided on the evaluation board to direct the $\overline{DET}$ signal to one of two outputs. With the switch positioned to the right, $\overline{DET}$ will illuminate the LED, when positioned to the left, $\overline{DET}$ may be monitored at the banana jack using an oscilloscope.

Verifying the HC5513/26EVAL Operation

The operation of the HC5513/26EVAL and sample part can be verified by performing five tests. The first four tests require a 600Ω load, an AC voltmeter and an oscilloscope. The last test requires a telephone and a battery backed AC source. All of the tests require three external supplies, one each for V_{CC}, V_{EE} and V_{BAT}.

Verify that the sample HC5513/26 included with the evaluation board is oriented in its socket correctly. Correct orientation is with pin 1 pointing towards tip and ring.

Application Tip: When terminating tip and ring on the HC5513/26EVAL it is handy to assemble terminators using a Pomona MDP dual banana plug connector as the terminating resistor receptacle. Refer to Figure 1 for details

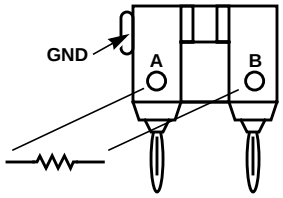

FIGURE 1. TERMINATION ADAPTER

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Using the termination shown in Figure 1 provides an unobtrusive technique for terminating tip and ring while still providing access to both signals using the banana jack feature of the MDP connector. Posts are also available that fit into holes A and B, providing a solderable connection for the terminating resistor.

Power Supply Current Verification

A quick check of evaluation board and the HC5513/26 sample is to measure the currents of each supply voltage. The readings should be similar to the values listed in Table 1. The measurements can be made using a series ammeter on each supply, or power supplies with current displays.

SETUP

1. Connect the power supplies to the HC5513/26EVAL.
2. Set V_{BAT} to -48V.
3. Connect AGND and BNGD to common ground point.
4. Connect RRX pin to common ground point.
5. Terminate HC5513/26 SLIC with 600Ω load.
6. Set the mode switches to E0 = 0, E1 = 1, C1 = 0, C2 = 1.

DISCUSSION

Once setup is complete, apply power to the HC5513/26EVAL and verify the supply currents listed in Table 1. Note that special power supply sequencing is not required for the HC5513/26.

Active Mode Verification

This test will verify that the HC5513/26EVAL can successfully set the HC5513/26 SLIC to Active Mode and that Switch Hook Detect causes $\overline{DET}$ to illuminate the LED.

SETUP

1. Connect the power supplies to the HC5513/26EVAL.
2. Set V_{BAT} to -48V.
3. Connect AGND and BNGD to common ground point.
4. Connect RRX pin to common ground point.
5. Terminate HC5513/26 SLIC with 600Ω load.
6. Set the mode switches to E0 = 0, E1 = 1, C1 = 0, C2 = 1.
7. Position the $\overline{DET}$ select switch to the right.

DISCUSSION

When power is applied to the HC5513/26EVAL, loop current will flow from tip to ring and the LED will illuminate. If the LED does not illuminate, verify the mode control switch settings. Once the LED illuminates, remove the 600Ω termination. This will introduce an open circuit across tip and ring, preventing the flow of loop current and turning off the LED.

VERIFICATION

1. LED is on when tip and ring are terminated with 600Ω.
2. LED is off when tip and ring are open circuit.

Standby Mode Verification

This test will verify that the HC5513/26EVAL can successfully set the HC5513/26 SLIC to Standby Mode and that $\overline{DET}$ can be monitored using the banana jack interface.

SETUP

1. Connect the power supplies to the HC5513/26EVAL.
2. Set V_{BAT} to -48V.
3. Connect AGND and BNGD to common ground point.
4. Connect RRX pin to common ground point.
5. Terminate HC5513/26 SLIC with 600Ω load.
6. Set the mode switches to E0 = 0, E1 = 1, C1 = 1, C2 = 1.
7. Position the $\overline{DET}$ select switch to the left.
8. Connect an oscilloscope or DC voltmeter to the $\overline{DET}$ jack.
9. Monitor the V_{BAT} supply current.

DISCUSSION

When power is applied to the HC5513/26EVAL loop current will flow from tip to ring and the $\overline{DET}$ signal will be near zero volts. Disconnecting the 600Ω termination will prevent the flow of loop current, and cause $\overline{DET}$ to be pulled to V_{CC} rail. In Standby Mode, the V_{BAT} current should be approximately 16.4mA with the 600Ω termination and 0.8mA without the 600Ω termination.

VERIFICATION

1. $\overline{DET}$ is near 0V when terminated with 600Ω.
2. $\overline{DET}$ is near V_{CC} rail when not terminated with 600Ω.
3. V_{BAT} current is near 16.4mA when terminated.
4. V_{BAT} current is near 0.8mA when not terminated.

SLIC Gain Verification

This test will verify that HC5513/26 SLIC is operating properly and that the SLIC is exhibiting unity gain. Unity gain will only exist if the SLIC is properly terminated with 600Ω.

SETUP

1. Connect the power supplies to the HC5513/26EVAL.
2. Set V_{BAT} to -48V.
3. Connect AGND and BNGD to common ground point.
4. Terminate HC5513/26 SLIC with 600Ω load.
5. Set the mode switches to E0 = 0, E1 = 1, C1 = 0, C2 = 1.
6. Connect a sine wave generator to the RRX input.
7. Set the generator for $0.775V_{RMS}$ and 1kHz.
8. Connect an AC voltmeter across tip and ring.

DISCUSSION

When terminated with 600Ω, the SLIC will exhibit unity gain from the RRX input pin to across tip and ring. The unity gain results from the matched impedance that the 600Ω termination represents to the internally synthesized 600Ω of the SLIC. When an open circuit exists, a mismatch occurs and the gain of the SLIC will double.

VERIFICATION

1. Tip to ring AC voltage of $0.775V_{RMS}$ when terminated.
2. Tip to ring AC voltage of $1.55V_{RMS}$ when not terminated.

Ring Trip Detector Verification

This test will verify the ringing function of the HC5513/26EVAL. A telephone and an AC signal source are the only additional hardware required to complete the test.

SETUP

1. Connect the power supplies to the HC5513/26EVAL.
2. Set V_{BAT} to -28V.
3. Connect AGND and BNGD to common ground point.
4. Connect RRX pin to common ground point.
5. Set the mode switches to E0 = 0, E1 = 1, C1 = 1, C2 = 0.
6. Connect the telephone across tip and ring.
7. Connect battery backed AC source to RINGING (V_{BAT} + $90V_{RMS}$) banana jack.
8. Position $\overline{DET}$ select switch to the right (for LED).

DISCUSSION

The 600Ω termination is not necessary for this test since the phone provides this nominal impedance when off-hook. Setting the mode switches as shown above will cause the RINGRLY pin of the HC5513/26 SLIC to energize the relay that is on the evaluation board. The D_T and D_R comparator inputs will sense the flow of DC loop current, causing the Ring Trip comparator to sense when the phone is either on-hook or off-hook. Refer to the HC5513/26 Subscriber Line Interface Circuit electrical data sheet for a full description of the functionality of the Ring Trip Detector.

VERIFICATION

1. Phone starts ringing when power applied to test setup.
2. While ringing and on-hook, $\overline{DET}$ LED is not illuminated.
3. While ringing, going off-hook will illuminate the LED.
4. CAUTION: Short time durations of off-hook should be maintained to protect R_{RT}. In systems, the ring relay is software controlled to turn off milliseconds after off-hook is detected hence limiting power dissipated in R_{RT}.
5. When phone is returned to on-hook, LED will turn off.
6. Configure SLIC in Active mode to stop phone from ringing. Set mode switches to E0 = 0, E1 = 1, C1 = 0, C2 = 1.

Passive Components

The HC5513/26EVAL design incorporates all of the external components necessary for using the HC5513/26 SLIC in normal applications. A brief description of each component is provided below. The components will be grouped by function to provide further insight to the operation of the HC5513/26EVAL board.

Two-Wire Side, Tip and Ring

Relay	Allows injection of ringing signal.
PTC	Provides thermal protection for relay to ground path during extended periods of use. The PTC is not provided with HC5513/26EVAL board.
R_{F1}, R_{F2}	Feed resistors that limit the current into the tip and ring inputs of the HC5513/26 SLIC.
D_1, D_4	Provide transient protection on the tip and ring inputs.
C_{TC}, C_{RC}	Provide immunity against high frequency noise on tip and ring respectively.

The Two-Wire Side components are typical telephony values. Design equations are not used for these components.

Ring Trip Detector

R_1, R_2	Generate a bias voltage from V_{BAT} to drive the R_D pin.
R_3, R_4, R_{RT}	Combine to sense off-hook condition and drive the R_T pin.
C_{RT}	Provides attenuation of the ring signal for stability of D_T pin.

The component values for the Ring Trip detector circuit do not require design equations. For information concerning the functionality of this supervisory function refer to the “Supervisory Function” section of the HC5513/26 data sheet.

Loop Current Detector

R_D	Sets the loop current detect threshold for the HC5513/26 internal comparator function.

The value of R_D programs the loop current detect threshold for the HC5513/26 SLIC. Since the internal comparator has hysteresis, there are two equations that apply to the value of R_D. One equation is for on-hook to off-hook threshold and the other is for off-hook to on-hook threshold. The equations for each condition are as follows:

On-Hook to Off-Hook Threshold

$$R_D = \frac{465}{I_{(\text{ON-HOOK TO OFF-HOOK})}}$$

Off-Hook to On-Hook Threshold

$$R_D = \frac{375}{I_{(\text{OFF-HOOK TO ON-HOOK})}}$$

For details concerning the design equations refer to the “Supervisory Function” section of the HC5513/26 data sheet. As delivered, the HC5513/26EVAL is configured for a loop current detect level of 11.9mA for on-hook to off-hook and 9.6mA for off-hook to on-hook.

Saturation Guard Resistor

R_{SG}	Sets the saturation guard for the HC5513/26 SLIC.

When operating in systems with a -28V battery, R_{SG} needs to be an open circuit. When operating in systems with a -48V battery, R_{SG} needs to be 21.4kΩ as per the following equation:

$$R_{SG} = \frac{5 \bullet 10^5}{(|V_{BAT}| - V_{MARGIN}) \times \left(1 + \frac{(R_{DC1} + R_{DC2})}{600 \bullet R_L}\right) - 16.66V}$$

For details concerning the design equations refer to the “Constant Loop Current (DC) Path” section of the HC5513/26 data sheet. As delivered, the HC5513/26EVAL is configured for a saturation guard of 4V on both the tip side and ring side, resulting in a V_{MARGIN} of 8V for V_{BAT} = -48V (on hook $R_2 = \infty$.

Four-Wire Side, SLIC Impedance Matching

R_T	Sets the synthesized impedance across the tip and ring terminals.
R_{RX}	Performs a voltage to current conversion of the receive signal. Selected to maintain unity gain from 4-wire to 2-wire side when SLIC is terminated with 600Ω.

The values of R_T and R_{RX} have been selected for a 600Ω system. These values can be modified for different impedances. Also, complex impedance matching is possible using these components. For information on impedance matching of the SLIC, refer to the “(AC) 2-Wire Impedance” section of the HC5513/26 data sheet.

Constant Feed Current Programming

R_{DC1}, R_{DC2}	Set the constant feed current that flows from tip to ring when a DC path is present during off-hook conditions. Resistance is split to allow capacitor for filtering (C_{DC}).
C_{DC}	Filter capacitor to attenuate high frequency noise that is fed back from tip and ring.

The constant feed current is programmed using the sum of R_{DC1} and R_{DC2}. The design equation used to set the loop current is shown below.

$$I_L = \frac{2.5V}{R_{DC1} + R_{DC2}} \times 1000$$

For details concerning the design equations for loop current as well as the selection of C_{DC} refer to the “Constant Loop Current (DC) Path” section of the HC5513/26 data sheet. As delivered, the constant feed current is set at 30mA.

Transhybrid Balance

R_{TX}, R_B	Used as part of transhybrid balance circuitry that is located off board.

Transhybrid balance is fully discussed in the “Transhybrid Circuit” section of the HC5513/26 data sheet. As delivered, the HC5513/26EVAL does not include these components.

HC5513/26 SLIC Operating States Logic Truth Table

The logic truth table for controlling the HC5513/26 SLIC using the HC5513EVAL is provided in Table 2. The SLIC has four operating states. The states are Open Circuit, Active, Ringing and Standby. Each state, except Open Circuit, has options available selecting the supervisory signal that drives the $\overline{DET}$ pin. The supervisory signals are Ground Key Detect.

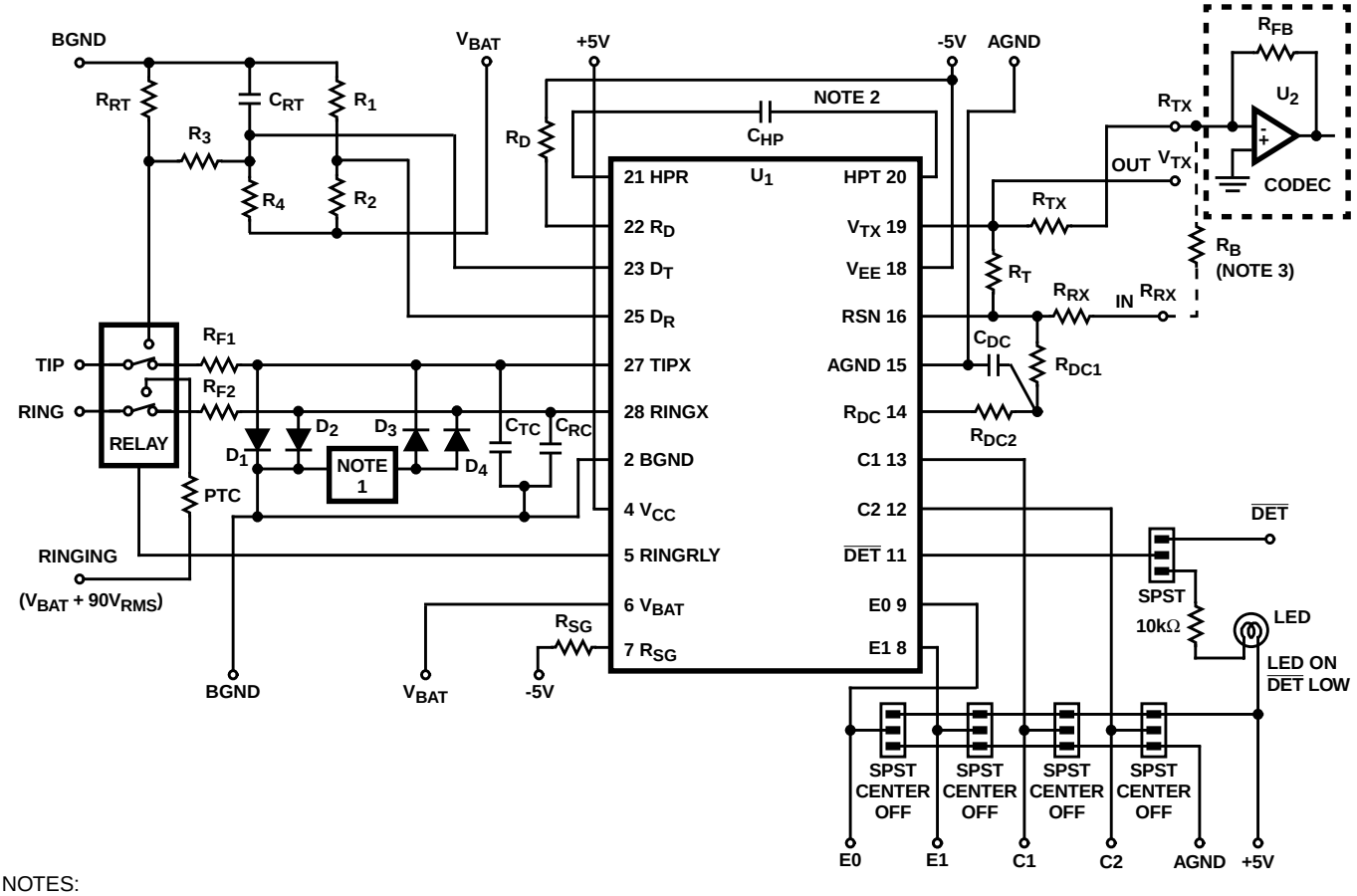
TABLE 2. LOGIC TRUTH TABLE

E0	E1	C1	C2	SLIC OPERATING STATE	ACTIVE DETECTOR	$\overline{DET}$ OUTPUT
0	0	0	0	Open Circuit	No Active Detector	Logic Level High
0	0	0	1	Active	Ground Key Detector	Ground Key Status
0	0	1	0	Ringing	No Active Detector	Logic Level High
0	0	1	1	Standby	Ground Key Detector	Ground Key Status
0	1	0	0	Open Circuit	No Active Detector	Logic Level High
0	1	0	1	Active	Loop Current Detector	Loop Current Status
0	1	1	0	Ringing	Ring Trip Detector	Ring Trip Status
0	1	1	1	Standby	Loop Current Detector	Loop Current Status
1	0	0	0	Open Circuit	No Active Detector	Logic Level High
1	0	0	1	Active	Ground Key Detector	
1	0	1	0	Ringing	No Active Detector	
1	0	1	1	Standby	Ground Key Detector	
1	1	0	0	Open Circuit	No Active Detector	
1	1	0	1	Active	Loop Current Detector	
1	1	1	0	Ringing	Ring Trip Detector	
1	1	1	1	Standby	Loop Current Detector	

TABLE 3. HC5513/26EVAL EVALUATION BOARD PARTS LIST

COMPONENT	VALUE	TOLERANCE	RATING	COMPONENT	VALUE	TOLERANCE	RATING
U1 - SLIC	HC5513/26	N/A	N/A	R_{RT}	150Ω	5%	2W
R_{F1}, R_{F2}	Short	N/A	1/4W	R_{SG}, V_{BAT} = -48V	21.4kΩ	1%	1/4W
R_1, R_3	200kΩ	5%	1/4W	R_{DC1}, R_{DC2}	41.2kΩ	5%	1/4W
R_2	910kΩ	5%	1/4W	C_{DC}	1.5µF	20%	10V
R_4	1.2MΩ	5%	1/4W	C_{HP}	10nF	20%	100V
R_B	Not Installed Reference data sheet for calculation			C_{RT}	0.39µF	20%	100V
R_D	39kΩ	5%	1/4W	C_{TC}, C_{RC}	2200pF	20%	100V
R_{FB}	20.0kΩ	1%	1/4W	D_1 - D_4	Diode with Given Rating		100V, 3A
R_{RX}	300kΩ	1%	1/4W	D_5	1N914	N/A	N/A
R_T	600kΩ	1%	1/4W	PTC	Shorted	N/A	N/A
R_{TX}	20kΩ	1%	1/4W	K_R	2C Contacts, 12V Coil		N/A
R_{LED}	500Ω	10%	1/4W	Textool Socket	228-5523		N/A

HC5513/26EVAL Evaluation Board Schematic Diagram



NOTES:

1. The anodes of D_3 and D_4 may be connected directly to the V_{BAT} supply if the application is exposed to only low energy transients. For harsher environments it is recommended that the anodes of D_3 and D_4 be shorted to ground through a transzorb or surgector (SGT06U13).
2. To meet the specified 25dB 2-wire return loss at 200Hz, C_{HP} needs to be 20nF, 20%, 100V.
3. R_B is required for transhybrid balance when using op amps internal to CODEC. $R_B = R_{TX}$.

FIGURE 2.

HC5513/26EVAL Evaluation Board Layout

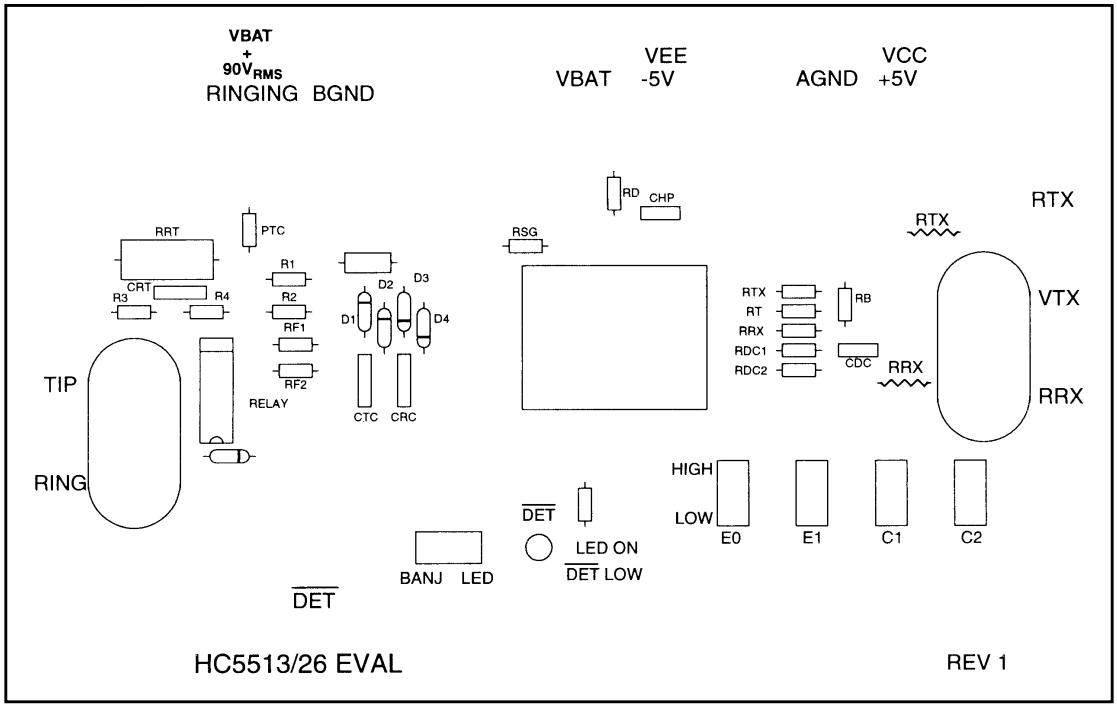


FIGURE 3. SILK SCREEN

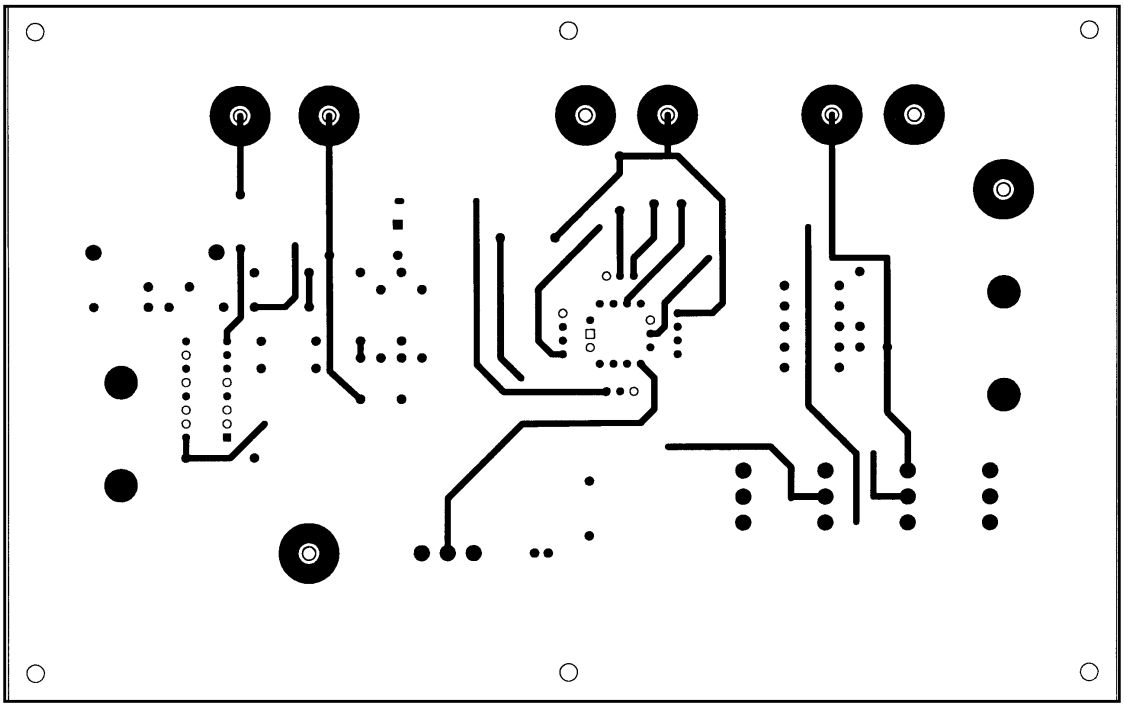


FIGURE 4. TOP SIDE

HC5513/26EVAL Evaluation Board Layout (Continued)

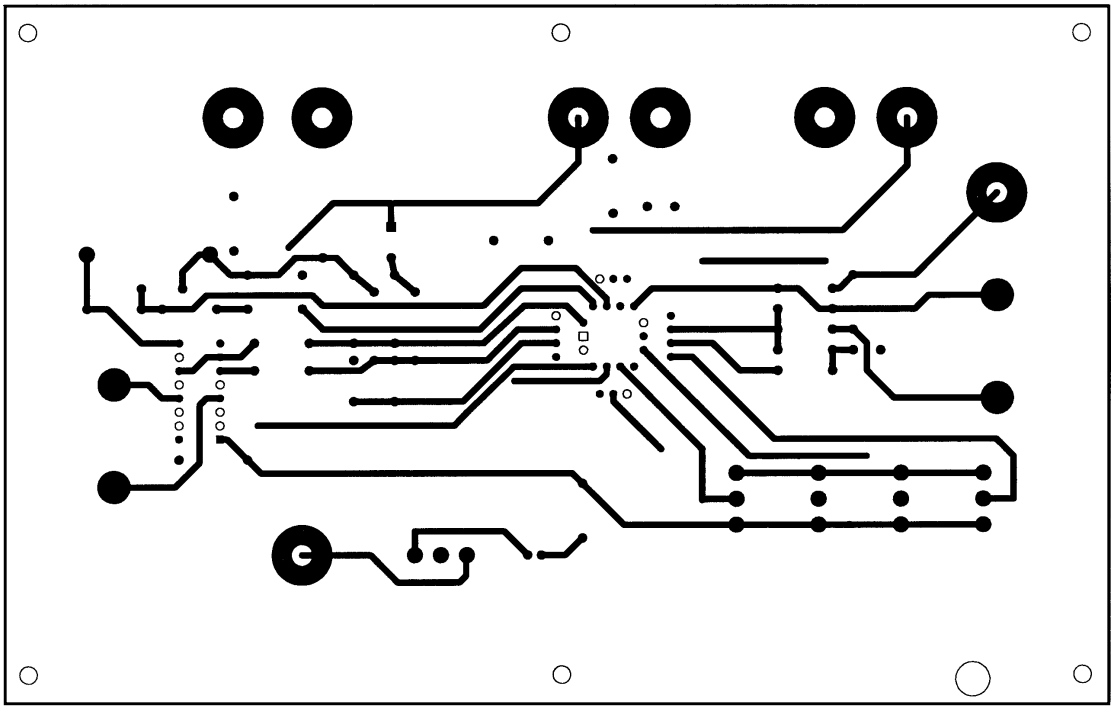


FIGURE 5. BOTTOM SIDE

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