HARRIS

HC-5512C

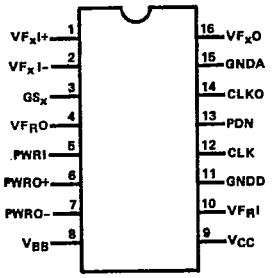
PCM or CVSD Monolithic Filter

FEATURES

- +5V, -5V POWER SUPPLIES
- LOW POWER CONSUMPTION:
  - 45mW (600Ω 0dBm LOAD)
  - 30mW (POWER AMPS DISABLED)
- POWER DOWN MODE: 0.5mW
- 20dB GAIN ADJUST RANGE
- NO EXTERNAL ANTI-ALIASING COMPONENTS
- SIN x/x CORRECTION IN RECEIVE FILTER
- 50/60Hz REJECTION IN TRANSMIT FILTER
- TTL AND CMOS COMPATIBLE LOGIC
- ALL INPUTS PROTECTED AGAINST STATIC DISCHARGE DUE TO HANDLING

PINOUT

DUAL-IN-LINE PACKAGE
TOP VIEW



DESCRIPTION

The HC-5512C filter is a monolithic circuit containing both transmit and receive filters originally designed for PCM CODEC filtering applications in 8kHz sampled systems.

The filter lends itself well as a cost effective replacement of a discrete audio input/output filter for the continuously variable slope delta modulator (CVSD).

The filter is manufactured using double-poly silicon gate CMOS technology. Switched capacitor integrators are used to simulate classical LC ladder filters which exhibit low component sensitivity.

TRANSMIT FILTER STAGE

The transmit filter is a fifth order elliptic low pass filter in series with a fourth order Chebyshev high-pass filter. It provides a flat response in the passband and rejection of signals below 200Hz and above 3.4kHz.

RECEIVE FILTER STAGE

The receive filter is a fifth order elliptic low pass filter designed to reconstruct the voice signal from the decoded/demultiplexed signal which, as a result of the sampling process, is a stairstep signal having the inherent sin x/x frequency response. The receive filter approximates the function required to compensate for the degraded frequency response and restore the flat passband response.

FUNCTIONAL DIAGRAM

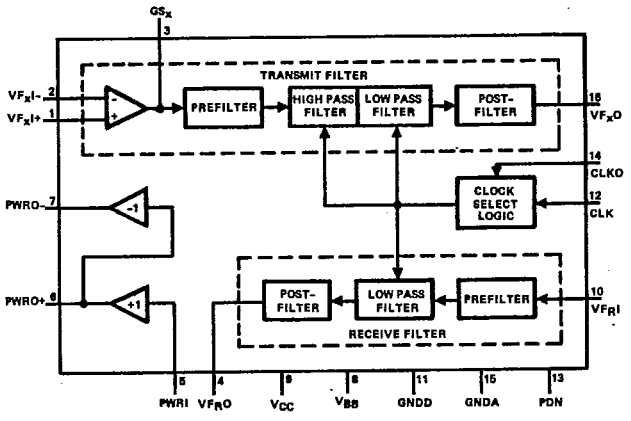


FIGURE 1

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Supply Voltages	±7V
Power Dissipation	1W/Package
Input Voltage	±7V
Output Short-Circuit Duration	Continuous
Operating Temperature Range	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

DC ELECTRICAL CHARACTERISTICS

Unless otherwise noted, T_A = 0°C to 75°C, V_{CC} = 5.0V ±5%, V_{BB} = -5.0V ±5%, clock frequency is 1.544MHz. Typical parameters are specified at T_A = 25°C, V_{CC} = 5.0V, V_{BB} = -5.0V. Digital interface voltages measured with respect to digital ground, GNDD. Analog voltages measured with respect to analog ground, GNDA.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
POWER DISSIPATION						
I_{CC0}	V_{CC} Standby Current	PDN = V_{DD}, Power Down Mode		50	100	µA
I_{BB0}	V_{BB} Standby Current	PDN = V_{DD}, Power Down Mode		50	100	µA
I_{CC1}	V_{CC} Operating Current	PWRI = V_{BB}, Power Amp Inactive		3.0	4.5	mA
I_{BB1}	V_{BB} Operating Current	PWRI = V_{BB}, Power Amp Inactive		3.0	4.5	mA
I_{CC2}	V_{CC} Operating Current	Note 1		4.6	6.4	mA
I_{BB2}	V_{BB} Operating Current	Note 1		4.6	6.4	mA
DIGITAL INTERFACE						
I_{INC}	Input Current, CLK	GNDD ≤ V_{IN} ≤ V_{CC}	-10		10	µA
I_{INP}	Input Current, PDN	GNDD ≤ V_{IN} ≤ V_{CC}	-100			µA
I_{IN0}	Input Current, CLK0	V_{BB} ≤ V_{IN} ≤ V_{CC} - 0.5V	-10		0	µA
V_{IL}	Input Low Voltage, CLK, PDN		0		0.8	V
V_{IH}	Input High Voltage, CLK, PDN		2.2		V_{CC}	V
V_{IL0}	Input Low Voltage, CLK0		V_{BB}		V_{BB}+0.5	V
V_{I10}	Input Intermediate Voltage, CLK0		-0.8		0.8	V
V_{IH0}	Input High Voltage, CLK0		V_{CC}-0.5		V_{CC}	V
TRANSMIT INPUT OP AMP						
$IB_x I$	Input Leakage Current, $VF_x I$	V_{BB} ≤ $VF_x I$ ≤ V_{CC}	-100		100	nA
$RI_x I$	Input Resistance, $VF_x I$	V_{BB} ≤ $VF_x I$ ≤ V_{CC}	10			MΩ
$VOS_x I$	Input Offset Voltage, $VF_x I$		-20		20	mV
V_{CM}	Common-Mode Range, $VF_x I$		-2.5		2.5	V
CMRR	Common-Mode Rejection Ratio	-2.5V ≤ V_{IN} ≤ +2.5V	60			dB
PSRR	Power Supply Rejection of V_{CC} or V_{BB}		60			dB
R_{OL}	Open Loop Output Resistance, GS_x			1		kΩ
R_L	Minimum Load Resistance, GS_x		10			kΩ
C_L	Maximum Load Capacitance, GS_x				100	pF
$VO_x I$	Output Voltage Swing, GS_x	R_L ≥ 10k	±2.5			V
A_{VOL}	Open Loop Voltage Gain, GS_x	R_L ≥ 10k	3400			V/V
F_c	Open Loop Unity Gain Bandwidth, GS_x			2		MHz

SPECIFICATIONS

AC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, $T_A = 25°C$. All parameters are specified for a signal level of 0 dBm0 at 1kHz. The 0 dBm0 level is assumed to be 1.54 Vrms measured at the output of the transmit or receive filter.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
TRANSMIT FILTER (Transmit filter input op amp set to the non-inverting unity gain mode, with VF_XI = 1.09 Vrms unless otherwise noted.)						
RL_x	Minimum Load Resistance	$-3.2V < V_{OUT} < 3.2V$	10			kΩ
CL_x	Load Capacitance, VF_xO				100	pF
RO_x	Output Resistance, VF_xO			1	3	Ω
PSRR1	V_{CC} Power Supply Rejection, VF_xO	f = 1 kHz, $VF_xI+ = 0$ Vrms	30			dB
PSRR2	V_{BB} Power Supply Rejection, VF_xO	Same as Above	30			dB
GA_x	Absolute Gain	f = 1 kHz	2.8	3.0	3.2	dB
GR_x	Gain Relative to GA_x	Below 50 Hz			−35	dB
		50 Hz		−41	−35	dB
		60 Hz		−35	−30	dB
		200 Hz	−1.5		0.2	dB
		300 Hz to 3 kHz	−0.15		0.15	dB
		3.3 kHz	−0.45		0.25	dB
		3.4 kHz	−0.70		−0.1	dB
		4.0 kHz		−15	−14	dB
		4.6 kHz and Above			−32	dB
DA_x	Absolute Delay at 1 kHz				230	μs
DD_x	Differential Envelope Delay from 1 kHz to 2.6 kHz				60	μs
DP_x1	Single Frequency Distortion Products				−40	dB
DP_x2	Distortion at Maximum Signal Level	0.16Vrms,1 kHz Signal Applied to VF_xI+, Gain = 20 dB, R_L = 10k			−40	dB
NC_x1	Total C Message Noise at VF_xO with $V_{IN} = 0$				10	dBrnc0
NC_x2	Total C Message Noise at VF_xO with $V_{IN} = 0$	Gain Setting Op Amp at 20 dB, Non-Inverting, Note 3			10	dBrnc0
GA_xT	Temperature Coefficient of 1 kHz Gain			0.0004		dB/°C
GA_xS	Supply Voltage Coefficient of 1 kHz Gain			0.01		dB/V
CT_{RX}	Crosstalk, Receive to Transmit $20 \log \frac{VF_xO}{VF_RO}$	Receive Filter Output = 2.2 Vrms $VF_xI+ = 0$ Vrms, f = 0.2 kHz to 3.4 kHz Measure VF_xO			−60	dB
GR_xL	Gaintracking Relative to GA_x	Output Level = +3 dBm0	−0.1		0.1	dB
		+2 dBm0 to −40 dBm0	−0.05		0.05	dB
		−40 dBm0 to −55 dBm0	−0.1		0.1	dB

AC ELECTRICAL CHARACTERISTICS (Continued)

Unless otherwise specified, $T_A = 25^oC$. All parameters are specified for a signal level of 0 dBm0 at 1KHz. The 0 dBm0 level is assumed to be 1.54 Vrms measured at the output of the transmit or receive filter.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RECEIVE FILTER (Unless otherwise noted, the receive filter is preceded by a sin x/x filter with an input signal level of 1.54 Vrms.)						
IB_R	Input Leakage Current, VF_RI	$-2.5V \le V_{IN} \le 2.5V$	−100		100	nA
RI_R	Input Resistance, VF_RI		10			MΩ
RO_R	Output Resistance, VF_RO			1	3	Ω
CL_R	Load Capacitance, VF_RO				100	pF
RL_R	Load Resistance, VF_RO		10			kΩ
PSRR3	Power Supply Rejection of V_{CC} or V_{BB}, VF_RO	VF_RI Connected to GNDA f = 1 kHz	30			dB
VOS_RO	Output DC Offset, VF_RO	VF_RI Connected to GNDA	−200		200	mV
GA_R	Absolute Gain	f = 1 kHz	−0.2	0	0.2	dB
GR_R	Gain Relative to Gain at 1 kHz	Below 300 Hz			0.125	dB
		300 Hz to 3.0 kHz	−0.15		0.15	dB
		3.3 kHz	−0.45		0.25	dB
		3.4 kHz	−0.7		−0.1	dB
		4.0 kHz			−14	dB
		4.6 kHz and Above			−32	dB
DA_R	Absolute Delay at 1 kHz				100	μs
DD_R	Differential Envelope Delay 1 kHz to 2.6 kHz				100	μs
DP_R1	Single Frequency Distortion Products	f = 1 kHz			−40	dB
DP_R2	Distortion at Maximum Signal Level	2.2 Vrms Input to Sin x/x Filter, f = 1 kHz, R_L = 10k			−40	dB
NC_R	Total C-Message Noise at VF_RO				10	dBrnc0
GA_RT	Temperature Coefficient of 1 kHz Gain			0.0004		dB/°C
GA_RS	Supply Voltage Coefficient of 1 kHz Gain			0.01		dB/V
CT_{XR}	Crosstalk, Transmit to Receive $20 \log \frac{VF_RO}{VF_xO}$	Transmit Filter Output = 2.2 Vrms VF_RI = 0 Vrms, f = 0.3 kHz to 3.4 kHz Measure VF_RO			−60	dB
GR_RL	Gaintracking Relative to GA_R	Output Level = +3 dBm0	−0.1		0.1	dB
		+2 dBm0 to −40 dBm0	−0.05		0.05	dB
		−40 dBm0 to −55 dBm0 Note 5	−0.1		0.1	dB

SPECIFICATIONS

AC ELECTRICAL CHARACTERISTICS (Continued)

Unless otherwise specified, $T_A = 25°C$. All parameters are specified for a signal level of 0 dBm0 at 1KHz. The 0 dBm0 level is assumed to be 1.54 Vrms measured at the output of the transmit or receive filter.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RECEIVE OUTPUT POWER AMPLIFIER						
IBP	Input Leakage Current, PWRI	$-2.5V \le V_{IN} \le 2.5V$	0.1		3	μA
RIP	Input Resistance, PWRI		10			MΩ
ROP1	Output Resistance, PWRO+, PWRO−	Amplifiers Active		1		Ω
CLP	Load Capacitance, PWRO+, PWRO−				500	pF
GA_P+	Gain, PWRI to PWRO+	$R_L = 600\Omega$ Connected Between PWRO+ and PWRO−. Input Level = 0 dBm0 (Note 4)		1		V/V
GA_P-	Gain, PWRI to PWRO−			−1		V/V
GR_PL	Gaintracking Relative to 0 dBm0 Output Level	V = 2.05 Vrms, $R_L = 600\Omega$ (Notes 4, 5)	−0.1		0.1	dB
		V = 1.75 Vrms, $R_L = 300\Omega$ (Notes 4, 5)	−0.1		0.1	dB
S/D_P	Signal/Distortion	V = 2.05 Vrms, $R_L = 600\Omega$ (Notes 4, 5)			−45	dB
		V = 1.75 Vrms, $R_L = 300\Omega$ (Notes 4, 5)			−45	dB
VOSP	Output DC Offset, PWRO+, PWRO−	PWRI Connected to GNDA	−50		50	mV
PSRR5	Power Supply Rejection of V_{CC} or V_{BB}	PWRI Connected to GNDA	45			dB

Note 1: Maximum power consumption will depend on the load impedance connected to the power amplifier. The specification listed assumes 0 dBm is delivered to 600Ωconnected from PWRO+ to PWRO−.
Note 2: Voltage input to receive filter at 0V, VF_RO connected to PWRI, 600Ω from PWRO+ to PWRO−. Output measured from PWRO+ to PWRO−.
Note 3: The 0dBm0 level for the filter is assumed to be 1.54 Vrms measured at the output of the XMT or RCV filter.
Note 4: The 0dBm0 level for the power amplifiers is load dependent. For $R_L = 600\Omega$ to GNDA the 0dBm0 level is 1.43 Vrms measured at the amplifier output for $R_L = 300\Omega$ the 0dBm0 level is 1.22Vrms.
Note 5: VF_RO connected to PWRI, input signal applied to VF_RI.

TYPICAL PERFORMANCE CHARACTERISTICS

Transmit Filter Stage

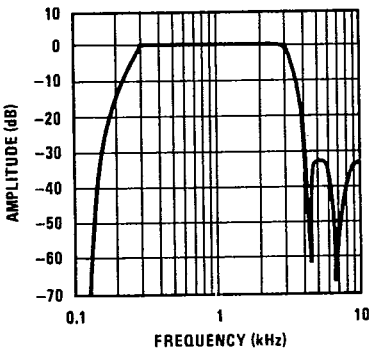


FIGURE 2

Receive Filter Stage

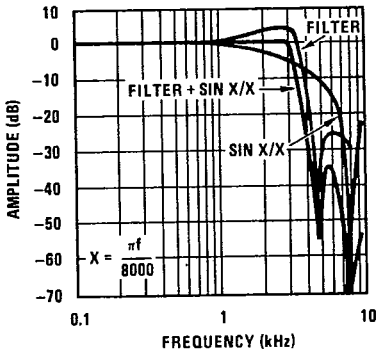


FIGURE 3

PIN ASSIGNMENTS

Pin No.	Name	Function
1	VF_xI+	The non-inverting input to the transmit filter stage.
2	VF_xI-	The inverting input to the transmit filter stage.
3	GS_x	The output used for gain adjustments of the transmit filter.
4	VF_RO	The low power receive filter output. This pin can directly drive the receive port of an electronic hybrid.
5	PWRI	The input to the receive filter differential power amplifier.
6	PWRO+	The non-inverting output of the receive filter power amplifier. This output can directly interface conventional transformer hybrids.
7	PWRO−	The inverting output of the receive filter power amplifier. This output can be used with PWRO+ to differentially drive a transformer hybrid.
8	V_{BB}	The negative power supply pin. Recommended input is −5V.
9	V_{CC}	The positive power supply pin. The recommended input is 5V.
10	VF_RI	The input pin for the receive filter stage.

Pin No.	Name	Function
11	GNDD	Digital ground input pin. All digital signals are referenced to this pin.
12	CLK	Master input clock. Input frequency can be selected as 2.048 MHz, 1.544 MHz or 1.536 MHz.
13	PDN	The input pin used to power down the HC-5512C during idle periods. Logic 1 (V_{CC}) input voltage causes a power down condition. An internal pull-up is provided.
14	CLK0	This input pin selects internal counters in accordance with the CLK input clock frequency: **CLK — Connect CLK0 to:** 2048 kHz — V_{CC} 1544 kHz — GNDD 1536 kHz — V_{BB} An internal pull-up is provided.
15	GNDA	Analog ground input pin. All analog signals are referenced to this pin. Not internally connected to GNDD.
16	VF_xO	The output of the transmit filter stage.

FUNCTIONAL DESCRIPTION

The HC-5512C monolithic filter contains four main sections; Transmit Filter, Receive Filter, Receive Filter Power Amplifier, and Frequency Divider/ Select Logic *(Figure 1)*. A brief description of the operation for each section is provided below.

Transmit filter

The input stage of the transmit filter is a CMOS operational amplifier which provides an input resistance of greater than 10MΩ , a voltage gain of greater than 3,400,. low power consumption (less than 3mW), high power supply rejection, and is capable of driving a 10kΩ load in parallel with up to 100pF. The inputs and output of the amplifier are accessible for added flexibility. Noninverting mode, inverting mode, or differential amplifier mode operation can be implemented with external resistors. It can also be connected to provide a gain of up to 20dB without degrading the overall filter performance.

The input stage is followed by a prefilter which is a two-pole RC active low pass filter designed to attenuate high frequency noise before the input signal enters the switched-capacitor high pass and low pass filters.

A high pass filter is provided to reject 200Hz or lower noise which may exist in the signal path. The low pass portion of the switched-capacitor filter provides stopband attenuation.

The output stage of the transmit filter, the postfilter, is also a two-pole RC active low pass filter which attenuates clock frequency noise by a least 40dB. The output of the transmit filter is capable of driving a ±2.5V peak to peak signal into a 10kΩ load in parallel with up to 100pF.

Receive Filter

The input stage of the receive filter is a prefilter which is similar to the transmit prefilter. The prefilter attenuates high frequency noise that may be present on the receive input signal. A switched capacitor low pass filter follows the prefilter to provide the necessary passband flatness, stopband rejection and sin x/x gain correction. A postfilter which is similar to the transmit postfilter follows the low pass stage. It attenuates clock frequency noise and provides a low output impedance capable of directly driving an electronic subscriber-line-interface circuit.

Receive Filter Power Amplifiers

Two power amplifiers are also provided to interface to transformer coupled line circuits in PCM applications. These two amplifiers are driven by the output of the receive postfilter through gain setting resistors, R3, R4 *(Figure 4)*. The power amplifiers can be deactivated, when not required, by connecting the power amplifier input (pin 5) to the negative power supply V_{BB}. This reduces the total filter power consumption by approximately 10mW-20mW depending on output signal amplitude.

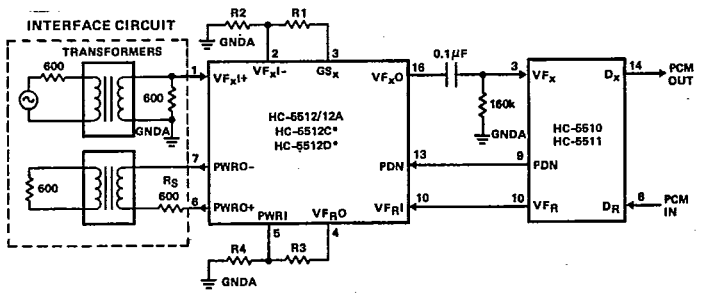
Power Down Control

A power down mode is also provided. A logic 1 power down command applied on the PDN pin (pin 13) will reduce the total filter power consumption to less than 1mW. If the PWRI pin (pin 5) is connected to V_{BB}, the power amplifier output will enter a high impedance (tri-state) mode. Otherwise, the power amplifier output will be clamped to V_{BB}.

Frequency Divider and Select Logic Circuit

This circuit divides the external clock frequency down to the switching frequency of the low pass and high pass switched capacitor filters. The divider also contains a TTL-CMOS interface circuit which converts the external TTL clock level to the CMOS logic level required for the divider logic. This interface circuit can also be directly driven by CMOS logic. A frequency select circuit is provided to allow the filter to operate with 2.048MHz, 1.544MHz or 1.536MHz clock frequencies. By connecting the frequency select pin CLK0 (pin 14) to V_{CC}, a 2.048MHz clock input frequency is selected. Digital ground selects 1.544MHz and V_{BB} selects 1.536MHz.

INTERFACE CIRCUIT FOR HC-5510 CODEC



Note 1: Transmit voltage gain = $\frac{R1 + R2}{R2} \times \sqrt{2}$ (The filter itself introduces a 3dB gain) (R1 +R2 ≥ 10k).

Note 2: Receive gain = $\frac{R4}{R3 + R4}$ (R3 +R4 ≥ 10k)

Note 3: In the configuration shown, the receive filter power amplifiers will drive a 600Ω T to R termination to a signal level of 8.5dBm. An alternative arrangement, using a transformer winding ratio equivalent to 1.414:1 and 300Ω resistor, R_S, will provide a maximum signal level of 10.1dBm across a 600Ω termination impedance.

*Note 4: Although the HC-5512C/D may be used in some PCM telephone applications, it does not meet CCITT and D3/D4 specifications for PCM telephone transmission systems.

FIGURE 4

INTERFACE CIRCUIT FOR HC-55564 CVSD

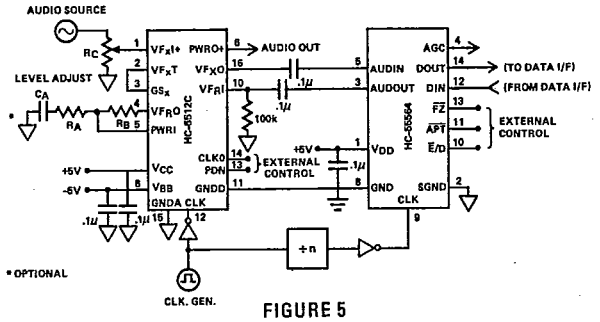


FIGURE 5

APPLICATIONS INFORMATION

Gain Adjust

Figure 4 shows the signal path interconnections between the HC-5512C and HC-5510 single channel CODEC. The transmit RC coupling components have been chosen both for minimum passband droop and to present the correct impedance to the CODEC during sampling.

Figure 5 shows the signal path interconnections between the HC-5512C and the HC-55564 CVSD. For the circuit shown, the audio signal into the CVSD should be 1Vp-p over the 3.2kHz band to obtain a flat response. R_A, R_B and C_A form a simple lead lag filter at the output of the HC-5512C receive filter which introduces a pole and a zero at 3.3kHz to help compensate against the filters' inherent sin x/x characteristic. (See Figure 3). Note that the transmit side of the filter provides an inherent +3dB voltage gain, and the resistor RD, at VFRI causes a voltage loss from audio out to VFRI, owing to the 100KΩ output impedance of the CVSD at audio out. Generally, the higher the RD value used, the more thermal noise introduced to the circuit.

Optimum noise and distortion performance will be obtained for the HC-5512C filter when operated with system peak overload voltages of ±2.5V to ±3.2 at VF_XO and VF_RO. When interfacing to a PCM CODEC or CVSD with a peak overload voltage outside this range, further gain or attenuation may be required.

For example, the HC-5512/5512A/5512C/5512D filter can be used with the HC-5510/5511 series CODEC which has a 5.5V peak overload voltage, or with the HC-55564 CVSD which has a 4.0V peak overload voltage. A gain stage following the transmit filter output and an attenuation stage following the CODEC or CVSD output are required in this case.

Board Layout

Care must be taken in PCB layout to minimize power supply and ground noise. Analog ground of each filter and each CVSD should be connected to digital ground at a single point, which should be bypassed to both power supplies. Further power supply decoupling adjacent to each filter and CODEC, and each filter and CVSD is recommended. Ground loops should be avoided between GNDA and GNDD, between the GNDA traces of adjacent filters and CODECs, and between the analog ground traces of adjacent filters and CVSDs.