GOULD

AMI Semiconductors

212A/V.22 Modem Filter With Equalizers

Advanced Product Description

S35212B

Features

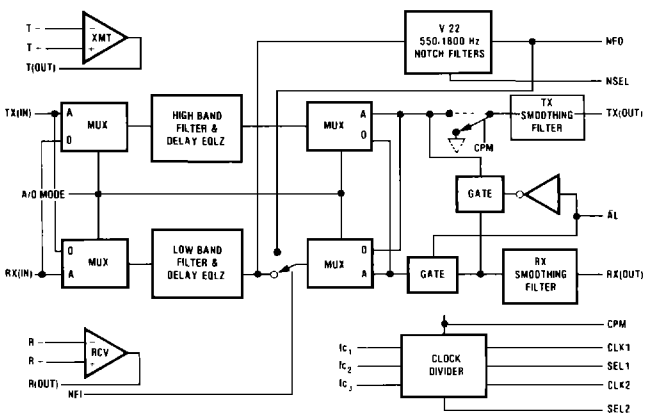
- ☐ Bell 212A/V.22/V.22BIS Compatible
- ☐ Usable for Bell 103/113 Applications
- ☐ High and Low Band Filters With Compromise Group Delay Equalizers and Smoothing Filters
- ☐ Guard Tone Notch Filters for CCITT V.22/V.22BIS Applications
- ☐ Originate/Answer Operating Modes
- ☐ Low Power CMOS: 75 mW Typ.
- ☐ Two Uncommitted Operational Amps
- ☐ Choice of Clocking Frequencies: 2.4576 MHz, 1.2288 MHz, or 153.6 kHz
- ☐ Call Progress Tone Filter Capabilities
- ☐ Analog Loopback Test Capability

General Description

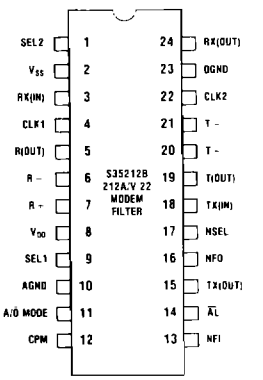
The S35212B Modem Filter is a monolithic CMOS integrated circuit. It does the filter/equalizing functions of Bell 212A and CCITT V.22 (or V.22BIS) modems. The S35212B includes high band and low band filters. It features on-chip originate/answer mode selection. Included are compromise amplitude and group delay equalizers for full compromise equalization. There is a CCITT notch filter included. It provides rejection at 1800 Hz or 550 Hz. The NFI pin switches the notch filter in or out of the low band filter path. It is in for V.22 and out for 212A operation. Two uncommitted operational amplifiers are available to use for gain control or anti-aliasing filters. A con-

Modems, Filters & PCM Products

Block Diagram



Pin Configuration



tinuous low pass filter is also included on the RX(OUT) pin to act as a smoothing filter. SEL2 switches the S35212B between the normal data mode and the call progress monitoring mode. The CPM pin switches on a second call progress mode. For maximum flexibility the S35212B will operate from a 2.4576 MHz, 1.2228 MHz or 153.6 kHz clock. The S35212B has Analog Loopback capability to switch the transmit carrier output back through the receive output for testing.

Pin Name	Pin Number	Function
SEL2 *	1	Logic '0' for normal operation. Logic '1' scales down the frequency response by a factor of 6 for Call Progress Tone Detection through the high-band filter.
V_{SS}	2	Negative Supply Voltage (−5 Volts).
RX(IN)	3	Receive Signal Input.
CLK1 *	4	2.4576 MHz or 1.2288 MHz Clock Input. This input is TTL and CMOS compatible. Leave open when using CLK2.
R(OUT)	5	Receive Uncommitted Op Amp Output (10 kΩ load maximum).
R−	6	Receive Uncommitted Op Amp Negative Input.
R+	7	Receive Uncommitted Op Amp Positive Input.
V_{DD}	8	Positive Supply Voltage (+5 Volts).
SEL1	9	Logic '0' selects 1.2288 MHz. Logic '1' selects 2.4576 MHz clock into Pin 4.
AGND	10	Analog Ground.
MODE (A/$\overline{O}$) *	11	Orginate/Answer Mode Control Input. A logic '0' sets the device in Originate Mode with the transmit signal in the low-band and receive signal in the high-band. A logic '1' reverses the connections.
CPM *	12	This pin scales down the frequency response of the low-band filter by 2.5 for Call Progress Detection, leaving the high-band filter to receive incoming carriers.
NFI *	13	Notch Filter Insert. A logic '1' inserts the notch filter in the path from the low-band filter.
$\overline{AL}$ ‡	14	Analog Loopback Control Input. A logic '0' sets the device in Loopback Mode. A logic '1' sets the device in Normal Mode.
TX(OUT)	15	Transmit Signal Output This output will drive a 20k load.
NFO	16	Notch Filter Output. This output will drive a 20k load.
NSEL *	17	A logic '0' on this input programs the notch filter to reject 500 Hz. A logic '1' programs it to reject 1800 Hz.
TX(IN)	18	Transmit Signal Input.
T(OUT)	19	Transmit Uncommitted Op Amp Output (10 kΩ load maximum).
T+	20	Transmit Uncommitted Op Amp Positive Input
T−	21	Transmit Uncommitted Op Amp Negative Input.
CLK2 *	22	153.6 kHz Clock Input. This input is TTL and CMOS compatible. Leave open when using CLK1.
DGND	23	Digital Ground.
RX(OUT)	24	Receive Signal Output. This output will drive a 20k load.

*Internal Pull-downs ‡Internal Pull-up.

Absolute Maximum Ratings

DC Supply Voltage ($V_{DD} - V_{SS}$) ..... +13.5V
Operating Temperature ..... 0°C to +70°C
Storage Temperature ..... −55°C to +125°C
Analog Input ..... $V_{SS} - 0.3V \leq V_{IN} \leq V_{DD} + 0.3V$

D.C. Electrical Operating Characteristics:

$T_A = 0°C$ to $+70°C$; $V_{DD} = +5V \pm 10\%$; $V_{SS} = -5V \pm 10\%$ unless otherwise specified.

Symbol	Parameter/Conditions	Min.	Typ.	Max.	Units
V_{IN}	High Level Logic Input (Pins 1, 4, 9, 11, 12, 13, 14, 17, 22)	2.0		V_{DD}	V
V_{IL}	Low Level Logic Input (Pins 1, 4, 9, 11, 12, 13, 14, 17, 22)	V_{SS}		0.8	V
R_{IN}	Input Resistance (Pins 3 and 18) RX(IN), TX(IN)		5		MΩ
C_{IN}	Input Capacitance (Pins 3 and 18) RX(IN), TX(IN)		10		pF
P_D	Power Dissipation @ ±5.5V		75	150	mW

A.C. System Specifications:

$T_A = 25°C$; $V_{DD} = +5V \pm 10\%$; $V_{SS} = 5V \pm 10\%$ unless otherwise specified.

Symbol	Parameter/Conditions		Min.	Typ.	Max.	Units
V_O	Reference Signal Level Input			1		VRMS
V_{MAX}	Maximum Signal Level Input			1.4		VRMS
BW	Bandwidth (both bands; −3 dB)			960		Hz
A_{FO}	Gain at Center Frequencies		−1	0	+1	dB
ICN_L	Idle Channel Noise — Low-Band Filter			22	33	dBrnC0
ICN_H	Idle Channel Noise — High-Band Filter			23	33	dBrnC0
N_{FT}	Clock Feedthrough with Respect to Reference Signal Level	TX		−40		dB
		RX		−60		dB
THD_{RX}						
THD_{TX}						

Frequency vs. Amplitude Performance of Low- and High- Band Filters

Frequency (Hz) Low-Band Filter	Relative Gain (dB) Min.	Max.
400		−35
800	−1	+1
1200	0	
1600	−1.5	+1
1800		−18
2000		−48
2400		−55
2800		−50

Frequency (Hz) High-Band Filter	Relative Gain (dB) Min.	Max.
800		−50
1200		−53
1600		−50
2000	−2.5	+0.5
2400	0	
2800	0	+2.5
3200		−10
3500		−20

Notch Filter Response

Frequency (Hz)	Relative Gain (dB) Min.	Max.
Low-Band Filter + 1800 Hz Notch Filter		
1200 Hz	−1	+1
1800 Hz		−45
Low-Band Filter + 550 Hz Notch Filter		
1200 Hz	−1	+1
550 Hz		−35

Frequency Response Characteristics

The curves on this page illustrate typical filter responses of the S35212B. Figure 1 shows the basic band split function. This allows full duplex operation within a voice channel. Figures 2 and 3 show the frequency response of the two filters. These curves include the compromise equalizers. Figures 4 and 5 show the typical group delay response of the filters and equalizers.

Call Progress Monitoring (Pins 1, 12)

The S35212B has two methods of doing call progress monitoring. The first method, in common with the S35212A, uses pin 1, SEL2, for activation. The second method, uses pin 12, CPM, for activation.

Figure 1. Typical Amplitude vs. Frequency Plot

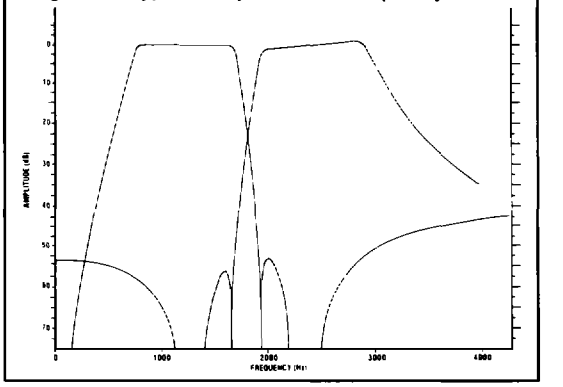


Figure 2. Typical Low-Band Amplitude vs. Frequency Plot

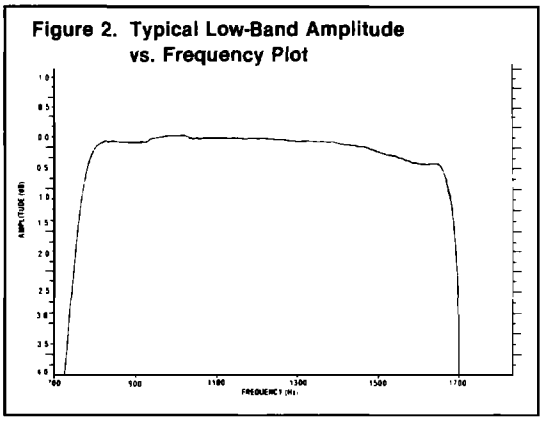


Figure 3. Typical High-Band Amplitude vs. Frequency Plot

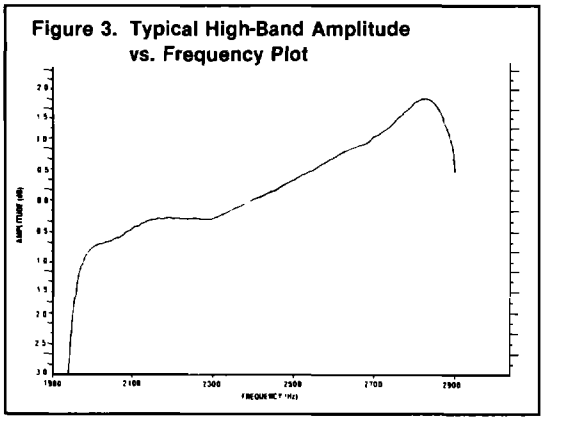


Figure 4. Typical Low-Band Group Delay vs. Frequency Plot

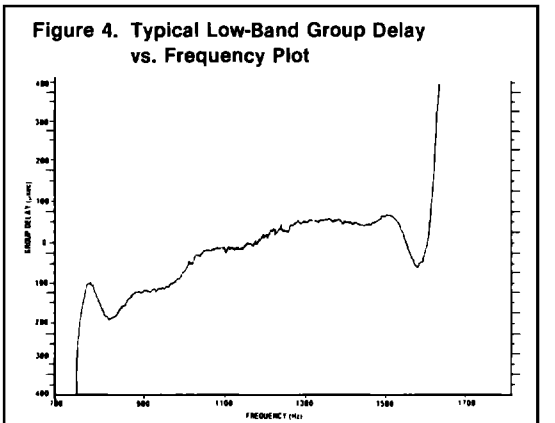
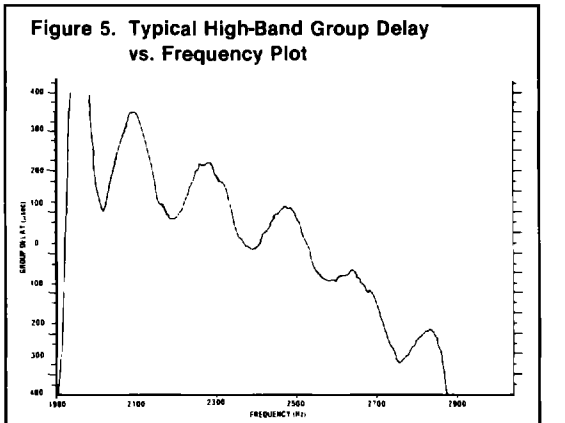


Figure 5. Typical High-Band Group Delay vs. Frequency Plot



The center frequencies of the two filters shift down to one-sixth of their original values when pin 1 goes high. The high-band 2400 Hz filter centers around 400 Hz. Its passband is approximately 300 to 480 Hz. Precision dial tone (350/440 Hz) will pass. Ringback (440/480 Hz) and half of busy/reorder (480/620 Hz) will also pass.

The second method, using pin 12, leaves the high-band filter at 2400 Hz. It shifts the low-band filter down by a factor of 2.5 for a center frequency of 480 Hz. The 620 Hz frequency passes through along with the others. Because the high-band filter remains at 2400 Hz, it takes fewer instructions to switch between call progress tones and data carrier. The receive input goes to both filters under this condition. Either the received carrier or the CPM tones are available at the receive output pin.

The modem's energy detector software can determine the cadence or timing of the information to identify the proper status of the call.

The second mode also squelches the transmit output to the line. No tones will come from the originating modem until answering carrier detection. This is not necessary with the S35213 modem chip, as it already has a squelch command for this purpose.

V.22 Notch Filter (Pins 13, 16, 17)

The S35212B includes a notch filter for CCITT V.22 modem operation. This filter notches out the guard tone required in V.22 operation. When a V.22 modem answers, it sends the 2100 Hz answer tone, and then the 2400 Hz data carrier. It is also required to send along with the data carrier a guard tone of 1800 Hz. (Some adminstrations require 550 Hz.) The purpose of this tone is to prevent the network from disconnecting. It provides energy at another point in the spectrum other than 2400 Hz. This simulates speech and will not trigger signaling receivers. The tone is only 3 dB below the data carrier. It is 600 Hz closer to the desired receive frequency of 1200 Hz, requiring additional filtering to maintain performance.

Pin 13, NFI, when made high, switches in the notch filter. It goes between the output of the low-band filter and the receive smoothing filter. Pin 17, NSEL, when high, provides 1800 Hz notching. When low, it provides 550 Hz notching.

Call Progress Tones

Frequencies	Timing/Cadence	Condition Indicated
350 + 440 Hz	Constant Tone	Dial Tone
440 + 480 Hz	2sec on, 4sec off	Audible Ringing
480 + 620 Hz	0.5sec on, 0.5sec off (60 ppm)	Line Busy (Station Busy)
480 + 620 Hz	0.25sec on, 0.25sec off (120 ppm)	Trunk Busy (Reorder)

The output of the low-band filter, through the notch filter, is always available at pin 16, Notch Filter Out. This is the same as the S35212A.

Analog Loopback (ALB) (Pin 14)

When pin 14, $\overline{AL}$, is low, the signal at pin 18, TX(IN), passes through the filter selected by pin 11, A/$\overline{O}$, and out through pin 5, RX(OUT). An internal pull-up resistor holds this pin high when not used. The S35212B will directly replace the S35212A without any circuit changes.

Analog Loopback tests the local modem and terminal/computer hardware and software. Any character sent from the keyboard echoes back to the screen after being sent to the modem. It is modulated by the modem and sent out to the filter. If pin 14 is low, the analog signal passes back through the RX(OUT) pin to the modem. It is demodulated and returned to the terminal/computer as received data.

Clock Input Selection (Pins 4, 9, 22)

The filter uses one of three possible clock frequencies. Either 2.4576 MHz or 1.2288 MHz can be applied to pin 4, CLK1. Pin 9, SEL1, when high, selects the divider for 2.4576 MHz. When low, it selects the divider for 1.2288 MHz. When using the S35212B with the S35213 modem chip, or if a 153.6 kHz clock is available, the clock is applied to pin 22, CLK2. Leave pins 4 and 9 open.

Compatibility with Previous Filters (Pins 12, 13, 14)

The S35212B plugs directly into any socket that previously held an S35212 or S35212A. It functions exactly as the S35212 as long as pins 12, 13, and 14 are open. Pins 12 and 13 may be low and pin 14 high for the same results. The S35212B directly replaces the S35212A when pins 12 and 13 are open or low.

Answer/Originate Mode Selection (Pin 11)

Pin 11 selects the filters for the particular mode of operation. When it is low for the originate mode, the transmit path is through the low-band filter. Receive is through the high-band filter. When this pin is high for the answer mode, the transmit path is through the high-band filter. Receive is through the low-band filter. An internal pull-down resistor keeps the chip in the originate mode when this pin is not connected.

Operation Mode Selection

The four control pins, 12 (CPM), 1 (SEL2), 14 ($\overline{AL}$), and 11 (A/$\overline{O}$) put the S35212B into 12 different operating modes. The first eight modes are the same as the S35212A. The additional four modes of the S35212B provide additional call progress monitoring using pin 12. Only five of the 12 modes are normally used. Analog Loopback testing uses another two modes. See Table 1 below.

Uncommitted Operational Amplifiers

The two operational amplifiers are available to use as gain stages or anti-aliasing filters for the complete modem circuit. These are CMOS op amps. They do not have low impedance drive capability. Do not load by less than 10 kΩ. The open loop voltage gain is typically about 86 dB and the unity gain frequency is about 1.5 MHz with < 5 pF loading. Input offset voltages will be 10 mV or less.

Using one of the op amps for anti-aliasing is a good idea. The receive input to the filters must be band limited to avoid aliasing. The telephone network band limits the incoming signals from distant modems.

Nevertheless, local noise or noise on the modem board itself can create problems. Figure 6 shows a

Table 1. Operating Modes

Function	Mode	12 CPM	1 SEL2	14 $\overline{AL}$	11 A/$\overline{O}$	18 TX(IN)	15 TX(OUT)	3 RX(IN)	24 RX(OUT)
Normal Orig.	0	0	0	1	0	L	L	H	H
Normal Ans.	1	0	0	1	1	H	H	L	L
ALB - Orig.	2	0	0	0	0	L	L	H	L
ALB - Ans.	3	0	0	0	1	H	H	L	H
CPM1 - Orig.	4	0	1	1	0	L/6	L/6	H/6	H/6
Test - N/U	5	0	1	1	1	H/6	H/6	L/6	L/6
Test - N/U	6	0	1	0	0	L/6	L/6	H/6	H/6
Test - N/U	7	0	1	0	1	H/6	H/6	L/6	L/6
Det Ans Tone	8	1	X	1	0	—	SQT	L/2.5+H	H
Test - N/U	9	1	X	1	1	H	SQT	L/2.5	L/2.5
Det CPM Tone	10	1	X	0	0	—	SQT	L/2.5+H	L/2.5
Test - N/U	11	1	X	0	1	H	SQT	L/2.5	H

Notes: SQT indicates that the transmit output is squelched.
L indicates the filter with a center frequency of 1200 Hz
H indicates the filter with a center frequency of 2400 Hz
+ indicates connection to both filters
– indicates no filter connection
X indicates a "don't care" condition.
L/6 indicates the low-band filter scaled down by 6.
L/25 indicates the low-band filter scaled down by 2.5.

Normal operation uses modes 0 and 1 for originate and answer
Call progress capability uses modes 4, 8, or 10
Analog Loopback testing uses modes 2 and 3
Modes 5, 6, 7, 9, and 11 are additional test modes not normally used.

second-order low-pass filter constructed around the receive op amp. It is a critically-damped, unity-gain, Sallen-Key filter with a cutoff frequency of 6 kHz.

Figures 7 and 8 illustrate the signal path during CPM2 modes 8 and 10. The A/$\overline{O}$, pin 14, is used to select between Call Progress Tones through the low-band filter or data/voice through the high-band filter.

Figure 6. Anti-Aliasing Low-Pass Filter for S35212B

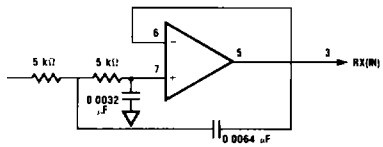


Figure 7. Call Progress Monitor Mode 8: Monitoring Answer Tone/Voice

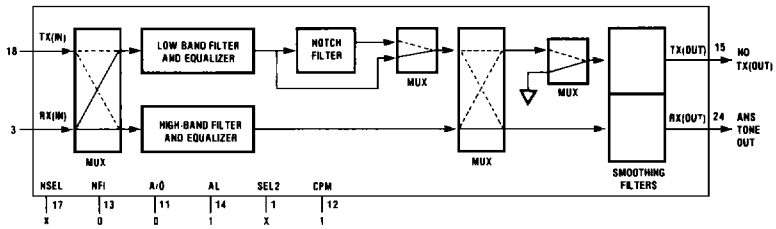


Figure 8. Call Progress Monitor Mode 10: Monitoring Call Progress Tones