Cellular Radio Telephone Filter IC

Description

CXD1230M is a filter IC developed for cellular radio telephone. Usage in conjunction with DATA • SAT LSI CXD1231Q-Z provides a modem.

Features

- Adoption of switched capacitor technology realizes substantial filter shrinkage.
- Conforms with North American AMPS standards and British TACS standards.
- 5V single supply operation.
- Low consumption [37.5mW (Typ.) 5V during operation]

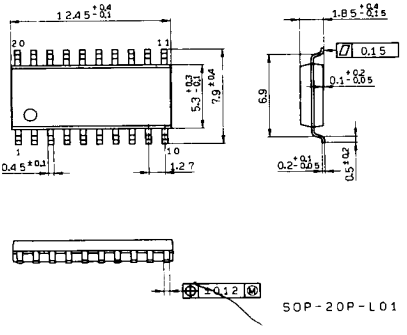
Functions

- Received WIDE BAND DATA filtering.
- Received SAT filtering.
- Received SAT PLL lock detection.
- Transmitted WIDE BAND DATA, ST, SAT, addition.
- Transmitted WIDE BAND DATA, ST, SAT, filtering.

Package Outline

Unit : mm

20 pin SOP (Plastic)



Structure

Silicon gate CMOS IC

Absolute Maximum Ratings

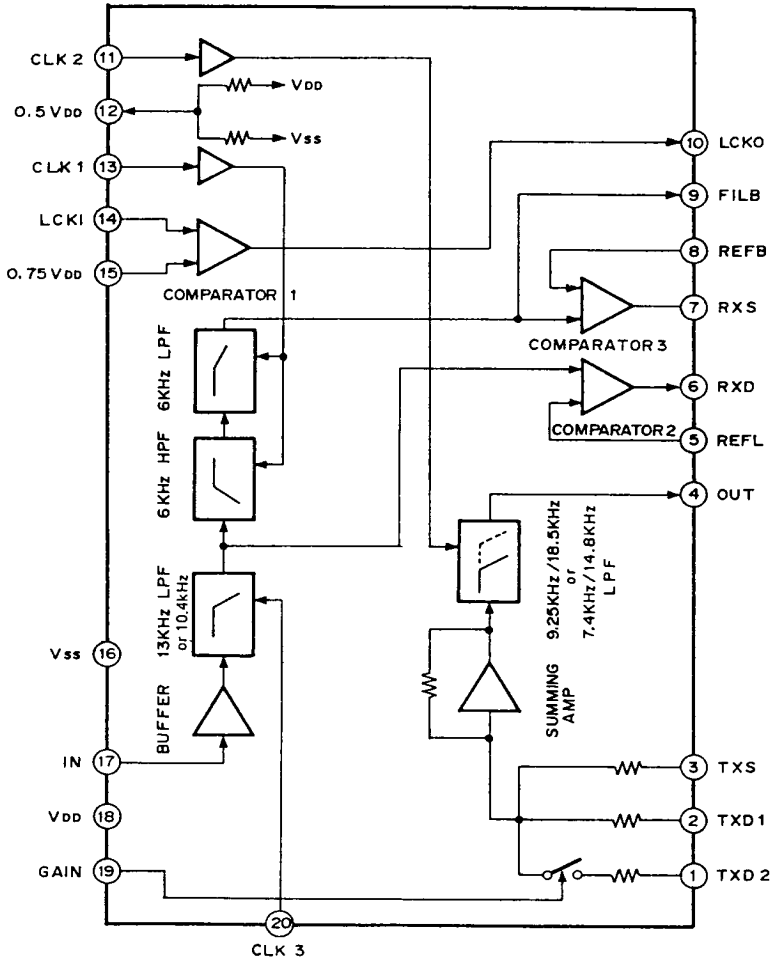
• Supply voltage	V_{DD}	−0.3 to +7.0	V
• Input voltage	V_{IN}	−0.3 to V_{DD}+0.3	V
• Output voltage	V_{OUT}	−0.3 to V_{DD}+0.3	V
• Operating temperature	Topr	−34 to +75	°C
• Storage temperature	Tstg	−55 to +150	°C

Recommended Operating Conditions

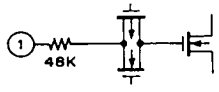
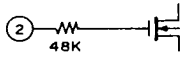
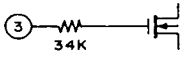
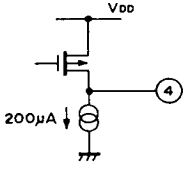
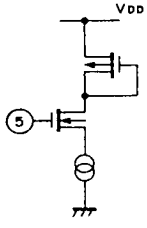
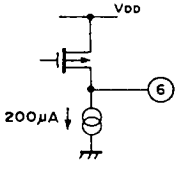
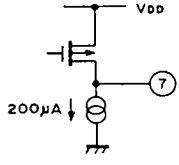
• Supply voltage	V_{DD}	4.75 to 5.25	V
• Operating temperature	Topr	−34 to +75	°C

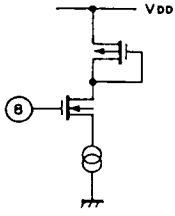
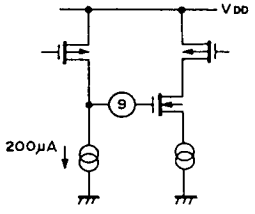
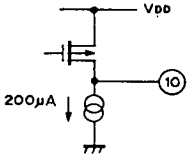
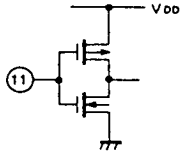
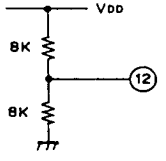
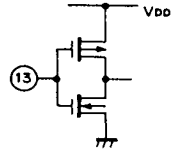
71229-ST

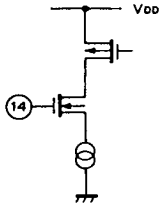
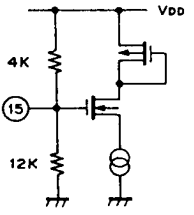
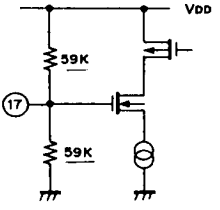
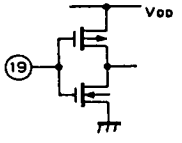
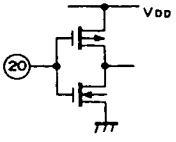
Block Diagram



Pin Description and Equivalent Circuit

No.	Symbol	Voltage	I/O	Equivalent circuit	Description
1	TXD2		I		Input pin 1 for transmission of WIDE BAND DATA and ST from mobile station to land station.
2	TXD1		I		Input pin 2 for transmission of WIDE BAND DATA and ST from mobile station to land station.
3	TXS		I		Input pin for transmission of SAT from mobile station to land station.
4	OUT		O		Output pin for Transfer LPF (low pass filter) with variable cutoff frequency.
5	REFL		I		Comparator reference voltage input pin for WIDE BAND DATA received by mobile station from land station. Eliminates LPF output offset for received WIDE BAND DATA by means of 1 external capacitance.
6	RXD		O		Comparator output pin for WIDE BAND DATA received by mobile station fromland station. When LPF for received WIDE BAND DATA output voltage exceeds reference voltage (pin5), output level of this pin goes from "low" to "high."
7	RXS		O		Comparator output pin for SAT received by mobile station from land station. When 6kHz LPF for received SAT output voltage exceeds reference voltage (pin 8), output level of this pin goes from "low" to "high."

No.	Symbol	Voltage	I/O	Equivalent circuit	Description
8	REFB		I		Comparator reference voltage input pin for SAT received by mobile station from land station. Eliminates 6kHz LPF output offset for received SAT, by means of 1 external capacitance.
9	FILB		O		6kHz LPF output pin for SAT received by mobile station from land station. Connected to the comparator input used to receive SAT.
10	LCKO		O		Comparator output pin for PLL lock detection of received SAT. When input voltage (pin 14) exceeds reference voltage (pin 15), output level of this pin goes from "low" to "high."
11	CLK2		I		Clock input pin of transfer LPF with variable cutoff frequency. Cut off frequency in AMPS mode with 400kHz input is 18.5kHz ; with 200kHz input it is 9.25kHz. In TACS mode with 320kHz input cutoff frequency is 14.8kHz ; with 160kHz input it is 7.4kHz.
12	0.5VDD	2.5V	O		Internal operational amplifiers virtual ground level output pin. Output voltage of this pin will be half that of the supplied voltage. An external capacitance of 3.3 is required as a ripple filter.
13	CLK1		I		Clock input pin for 6kHz HPF (high pass filter) of received SAT and 6kHz LPF. Input clock frequency is 400kHz in both AMPS mode and TACS modes.

No.	Symbol	Voltage	I/O	Equivalent circuit	Description
14	LCKI		I		Input pin for comparator used to detect PLL lock of received SAT.
15	0.75V_{DD}	3.75V	I		Reference voltage input pin for comparator used to detect PLL lock of received SAT. This pin is biased at 3/4 of the supplied voltage. An external capacitance of 3.3 is required as ripple filter.
16	V_{SS}				Ground pin
17	IN	2.5V	I		Input pin for WIDE BAND DATA and SAT received by mobile station from land station. Connected to voltage follower with input biased at half that of supplied voltage.
18	V_{DD}				Supply voltage pin
19	GAIN		I		Gain switching input pin for WIDE BAND DATA and ST to be transmitted. Input level must be "low" for ST transmission, and "high" for data transmission.
20	CLK3		I		Clock input pin for received WIDE BAND DATA LPF. In AMPS mode 400kHz, while in TACS mode 320kHz is input.

Note) 1. Pin voltage value is at V_{DD}=5V.
2. Resistance and current values are at Typ.

Electrical Characteristics

See electrical characteristics test circuits 1 to 3

Ta = 25°C, V_{DD} = 5V

Item		Symbol	Condition	Min.	Typ.	Max.	Unit
Current Consumption		I_{DD}			7.5	10.0	mA
Input voltage	Received signal input	IN				1.0	Vp-p
	Transmitted signal input 1	TXD1				0.7	Vp-p
	Transmitted signal input 2	TXD2				0.7	Vp-p
	Transmitted signal input 3	TXS				1.0	Vp-p
Input impedance	Received signal input	Z_{IN}		24	29		kΩ
	Transmitted signal input 1	Z_{TXD1}		40	48		kΩ
	Transmitted signal input 2	Z_{TXD2}		40	48		kΩ
	Transmitted signal input 3	Z_{TXS}		30	34		kΩ
Output voltage	7kHz band pass filter	FILB				1.0	Vp-p
	9kHz/18kHz low pass filter	OUT				2.0	Vp-p
	Comparator reference voltage	REF		3.55	3.75	3.90	V
	Analog reference voltage	AREF		2.35	2.50	2.65	V
Gain	Transmitted signal input 1	G_{TXD1}		−3.4	−2.9	−2.4	dB
	Transmitted signal input 2	G_{TXD2}		−3.4	−2.9	−2.4	dB
	Transmitted signal input 3	G_{TXS}		−0.5	0	+0.5	dB
Blocking range attenuation	Received data filter 1		AMPS mode, 13kHz, 1Vp-p input	−3.85	−3.35	−2.85	dB
	Received data filter 2		TACS mode 10.6kHz, 1Vp-p input	−3.56	−3.06	−2.56	dB
	Received SAT filter 1		AMPS mode 3kHz, 1Vp-p input	−23.0	−22.57	−21.07	dB
			AMPS mode 7kHz, 1Vp-p input	−0.05	0	+0.05	dB
			AMPS mode 12kHz, 1Vp-p input	−9.40	−8.90	−8.40	dB
	Received SAT filter 2		TACS mode 3kHz, 1Vp-p input	−27.88	−26.38	−24.00	dB
			TACS mode 7kHz, 1Vp-p input	−0.05	0	+0.05	dB
			TACS mode 12kHz, 1Vp-p input	−13.00	−12.28	−11.78	dB
	Transmitted filter 1		AMPS mode CLK2 = 400kHz 18.5kHz, 0.5Vp-p input	−3.08	−2.58	−2.08	dB
			AMPS mode CLK2 = 200kHz 9.25kHz, 0.5Vp-p input	−2.93	−2.43	−1.93	dB

Item		Symbol	Condition	Min.	Typ.	Max.	Unit
Blocking range attenuation	Transmitted filter 2		TACS mode CLK2=320kHz 15.4kHz, 0.5Vp-p input	−3.51	−3.01	−2.51	dB
			TACS mode CLK2=160kHz 7.7kHz, 0.5Vp-p input	−3.61	−3.11	−2.61	dB

Electrical Characteristics Test Circuit 1 (Frequency Characteristics, Output Voltage)

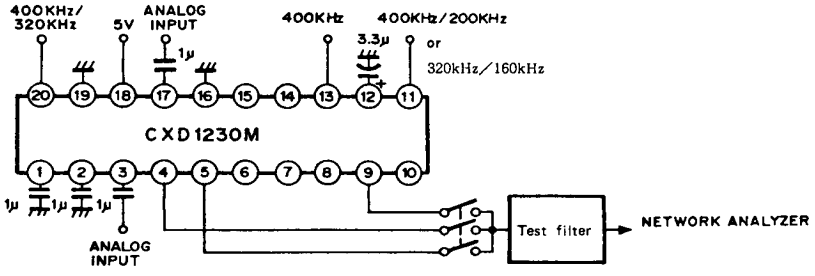


Fig.1

Electrical Characteristics Test Circuit 2 (Summing Amplifier Gain)

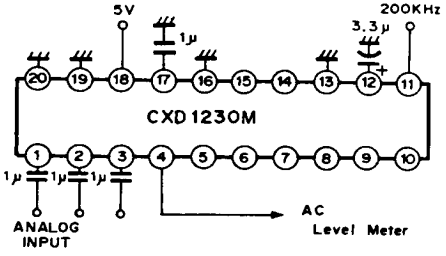


Fig.2

Electrical Characteristics Test Circuit 3 (Current Consumption)

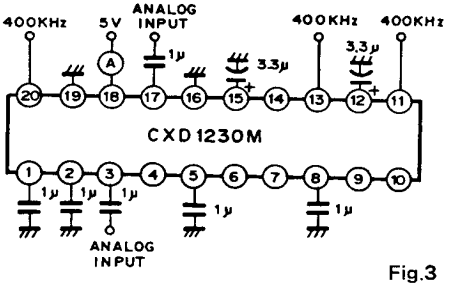


Fig.3

Operations

CXD1230M is a filter IC developed for cellular mobile telephone based on North American AMPS Standards (Advanced Mobile Phone Service) and British TACS Standards (Total Access Communication System).
By using this IC in conjunction with DATA•SAT LSI CXD1231Q-Z, a modem with the following funcions can be set up :

(1) Filtering of received WIDE BAND DATA
(2) Filtering of received SAT
(3) Detection of PLL lock of received SAT
(4) Summing of WIDE BAND DATA, ST, and SAT to be transmitted
(5) Filtering of WIDE BAND DATA, ST, and SAT to be transmitted

This section provides brief descriptions of these function.

1. Filtering of received WIDE BAND DATA

With the cellular mobile telephone system, data is transmitted between band and mobile stations, during speech or hand-off, in order to set channels. This data, called WIDE BAND DATA, is manchester coded. Transfer speed is 20kbaud for AMPS standards and 16kbaud for TACS standards. The received WIDE BAND DATA is fed through a buffer amplifier via a voltage follower to the quartic Butterworth low pass filter that operates as a data demodulating roll-off filter. In CXD1230M, as a switched capacitor filter is used, a cutoff frequency proportionate to the sampling clock frequency is obtained. Accordingly, with AMPS standards, when the sampling clock frequency is 400kHz, the low pass filter cutoff frequency is 13kHz (Typ.). Similarly, with TACS standards, when the sampling clock frequency is 320kHz, the low pass filter cutoff frequency is 10.4kHz (Typ.). The filter output is shaped to the CMOS logic level by means of a comparator and then sent out to CXD1231Q-Z.

2. Filtering of received SAT

In the cellular mobile telephone system, even during speech, a sine wave signal called SAT (Supervisory Audio Tone) is transmitted between the land station and mobile station to have them recognize each other. SATs of three frequencies, 5.97kHz, 6.00kHz, and 6.03kHz, are available for, both AMPS and TACS. The SAT frequency to be used is determined at the hand-off time by 2 bits data called SCC (SAT Color Code) which is transmitted from the land station to the mobile station. During speech, the mobile station recognizes the land station by receiving SAT from the land station, and the land station recognizes the mobile station by receiving SAT from the mobile station.

Similarly to the WIDE BAND DATA, SAT received from the land station is fed through the buffer amplifier to the 13kHz quartic Butterworth low pass filter. Then SAT is fed to the 6kHz quartic Butterworth high pass filter to prevent interference from the voice component (300Hz to 3kHz), and then to the 6kHz quadratic Tchebycheff low pass filter (pass range ripple 1dB) to reduce the high band noise (6kHz to 13kHz) in the event of a weak electric field strength. These 6kHz highpass and low pass filters are of switched capacitor type, providing a cutoff frequency of 6kHz (Typ.) when the sampling clock frequency is 400kHz. The above three filters constitute a band pass filter with a center frequency of approx. 7kHz so that SAT can be efficiently detected. The output of the 6kHz low pass filter is shaped to the CMOS logic level with a comparator, and is then sent out to CXD1231Q-Z.

3. Detection of PLL lock of received SAT

In CXD1231Q, DPLL locks when the SAT having the frequency specified with SCC is received. CXD1230M has a comparator to detect this lock/unlock state. The comparator output changes from "low" level to "high" level when the level of the SAT lock detect signal (SDET) from CXD1231Q-Z exceeds the reference voltage ($0.75V_{DD}$).

4. Summing of WIDE BAND DATA, ST, and SAT to be transmitted

In the cellular mobile telephone system, WIDE BAND DATA or ST, and SAT are transmitted from the mobile station to the land station. ST is a signal transmitted at the end of the call or ringing. The frequency is 10kHz for AMPS standards and 8kHz for TACS standards. From CXD1231Q-Z to CXD1230M, the WIDE BAND DATA, ST and the SAT are fed through a −18dB attenuation pad.

CXD1230M has an inverting amplifier which operates as a summing amplifier to sum these signals before transmission. In the transmission filter of the next stage summing amplifier during WIDE BAND DATA transmission, a quatric Butterworth low pass filter with a cutoff frequency of 18.5kHz for AMPS standards and 14.8kHz for TACS standards, is selected. During ST transmission a qaqtric Butterworth low pass filter with a cutoff frequency of 9.25kHz for AMPS standards and 7.4kHz for TACS standards, is selected.

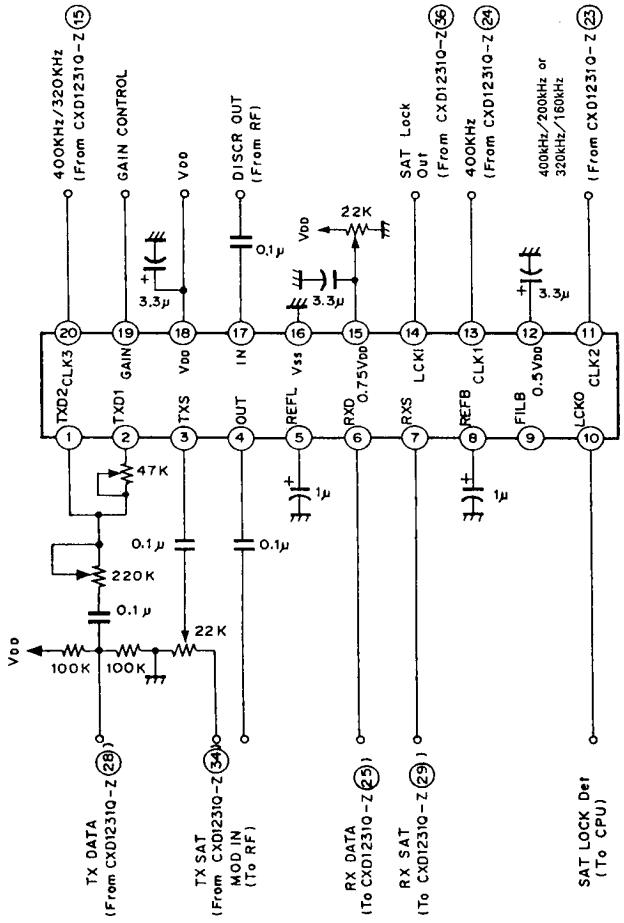
To compensate for the amplitude characteristics difference (−2.98dB to −4.62dB) between the 18.5kHz, 14.8kHz and 9.25kHz, 7.4kHz low pass filters at the ST frequency (10kHz), +3dB or −2.9dB can be selected as the summing amplifier gain. When ST is transmitted, +3dB gain can be obtained by setting the gain control input (GAIN) to "low" level, and −2.9dB gain by setting GAIN to "high" level. CXD1230M is provided with two input pins (TXD1 and TXD2) before the WIDE BAND DATA and ST so that the gain can be further adjusted by inserting appropriate resistors into the respective input lines. This allows the output level difference between ST transmission and data transmission to be completely compensated.

5. Filtering of WIDE BAND DATA, ST, and SAT to be transmitted

In the next stage of the summing amplifier, a low pass filter is provided to remove high-order harmonics from the summing amplifier output. The AMPS standards require a "20kHz ±10% quartic Butterworth low pass filter" as the transmission WIDE BAND DATA roll-off filter. In CXD1230M, the filter used in the next stage of the summing amplifier is an 18.5kHz quartic Butterworth low pass filter, and this filter also satisfies the condition of 38dB or more attenuation at 60kHz specified by AMPS. When ST and SAT are transmitted, the cutoff frequency of this transmitting filter must be lowered from 18.5kHz because the frequencies of ST and SAT are 10kHz and 6kHz, respectively. CXD1230M making the best of the switched capacitor filter merits, provides a cutoff frequency of 18.5kHz (Typ.) when the sampling frequency is 400kHz, and 9.25kHz (Typ.) when the sampling frequency is 200kHz.

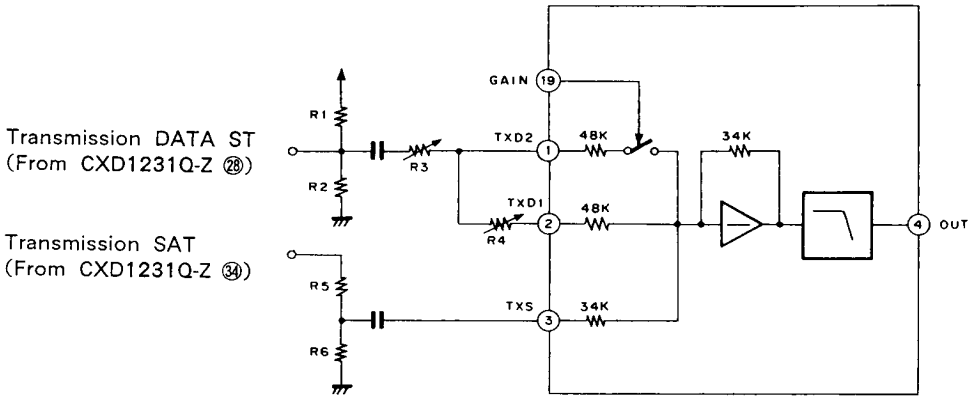
Similarly, for the TACS standards, a cutoff frequency of 14.8kHz (Typ.) when the sampling frequency is 320kHz, and 7.4kHz (Typ.) when the sampling frequency is 160kHz, are provided to cope with the transmission speed difference.

Application Circuit



Application Notes

1. Summing amplifier gain adjustment and Transmission DATA, ST, SAT input level adjustment.



Note) Resistances are typical values.

The following explanation applies to AMPS standards.

The summing amplifier configuration shown in the above figure is that of an inverting amplifier.

Accordingly, during TXS input (Transmission SAT) a gain of 0 dB (Typ.) is obtained. During TXD1 and TXD2 input (Transmission DATA, ST), when R4=0 Ω, that is when pins 1 and 2 are short-circuited, a gain of +3.0dB (Typ.) is obtained when SW is ON and −2.9dB (Typ.) when SW is Off. Gain switching during Transmission DATA and ST is provided because of the difference in cutoff frequency between the filter used for data transmission (18.5kHz) and that used for ST transmission (9.25kHz). This would cause a transmission output level difference of −3.0 to −4.6dB between DATA and ST. The summing amplifier gain is set to −2.9dB and the transmission output level difference compensated by turning SW on and the summing amplifier gain to +3.0dB through setting the gain control input to "Low" during ST transmission. Also, for the same purpose the gain control input is set to "High" and SW turned Off during data transmission ST. Still as at this stage level compensation is not complete, through the insertion of R4 gain adjustment becomes possible. For all practical purposes proceed as follows.

① Set the CLK2 frequency to 400kHz and the gain control level to "High". Apply a 10kHz, 0.7Vp-p sine wave to pin 2 through R4 and measure the transmission filter output at pin 4. The measurement obtained corresponds to the output level during Data transmission.

② Set CLK frequency to 200kHz and the gain control level to "Low". Apply a 10kHz 0.7Vp-p sine wave to pins 1 and 2 through R4 and measure at pin 4 level the transmission filter output. The measurement obtained corresponds to the output level during ST transmission.

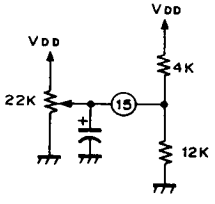
③ Adjust R4 to equalize the readings of the transmission output levels obtained at the above measurements.

For TACS standards as the transmission speed is 0.8 times (16k baud) that of AMPS standards, the respective frequencies above are all multiplied by 0.8 times to make a similar gain adjustment possible.

The MODEM (CXD1231Q-Z) transmission DATA, ST output and transmission SAT output are attenuated through R3, R5 and R6 and then input to CXD1230M.
The attenuation ratio of R3, R5 and R6 is set to −18dB.

The MODEM (CXD1231Q-Z) cannot be convected as it is by capacitor coupling to CXD1230M because the MODEM transmission DATA, ST output pin turns to high impedance by turning ENBL pin 30 to "Low" level, except during transmission. In this case, external resistors R1 and R2 (EX : 100kΩ) are used to bias the center voltage and then the capacitor coupling is executed.

2. 0.75 V_{DD} adjustment

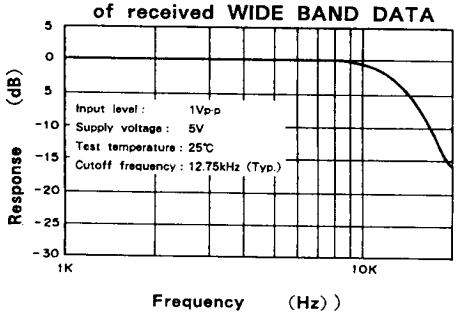


Note) Resistances are typical values.

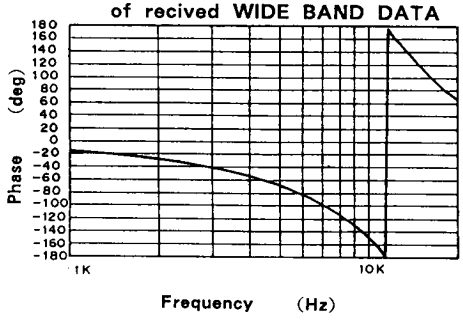
Supply voltage divided to 0.75V_{DD} inside CXD1230M is output at pin 15 (0.75V_{DD}). This value can be adjusted as shown in the above figure.

AMPS mode

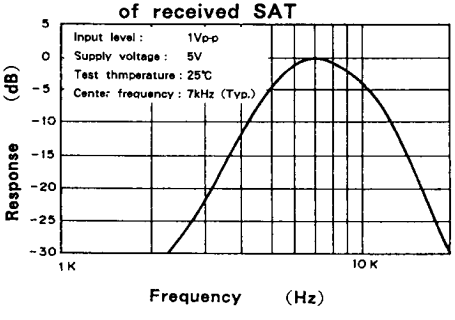
LPF amplitude characteristics of received WIDE BAND DATA



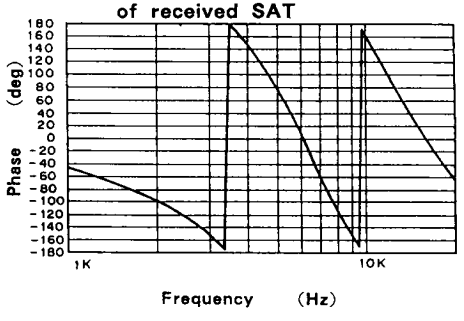
LPF amplitude characteristics of recived WIDE BAND DATA



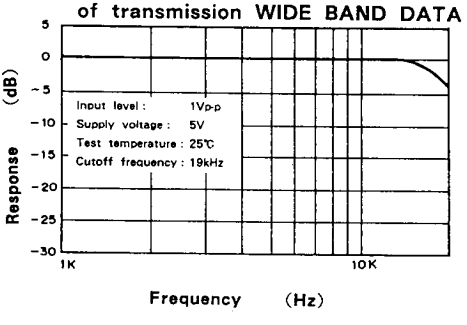
BPF amplitude characteristics of received SAT



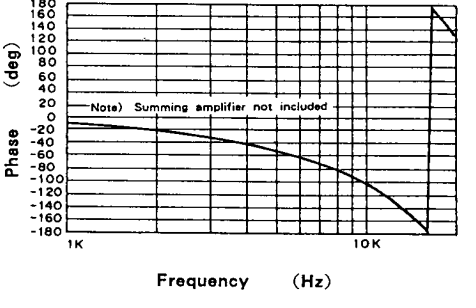
BPF amplitude characteristics of received SAT



LPF amplitude characteristics of transmission WIDE BAND DATA

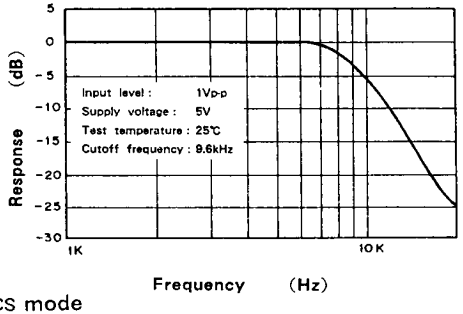


LPF amplitude characteristics of transmission WIDE BAND DATA

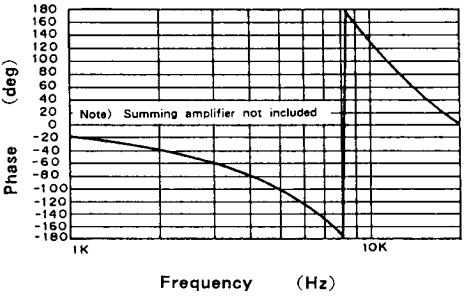


TACS mode

LPF amplitude characteristics of transmission SAT, ST

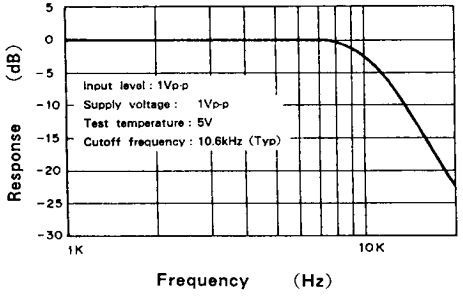


LPF phase characteristics for ST, SAT transmission

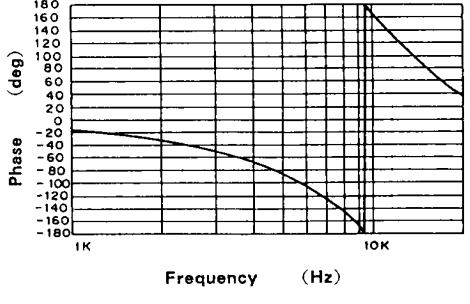


TACS mode

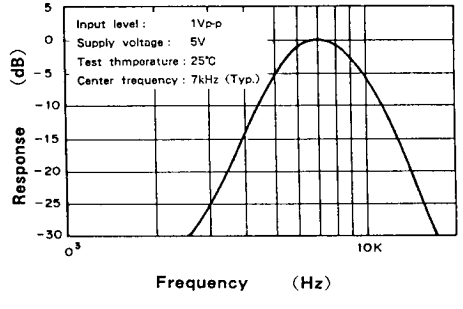
LPF phase characteristics of received WIDE BAND DATA



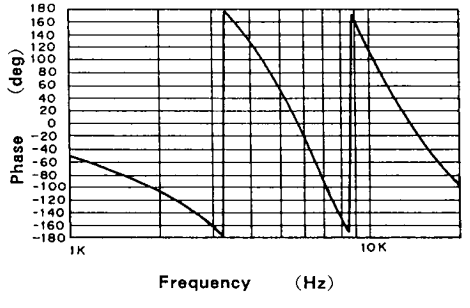
LPF phase characteristics of received WIDE BAND DATA



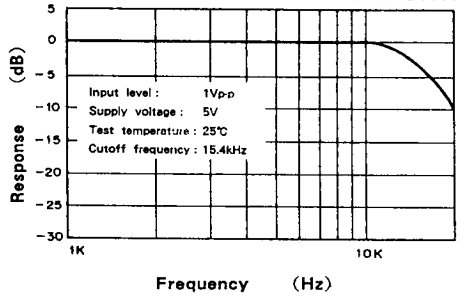
BPF phase characteristics of received SAT



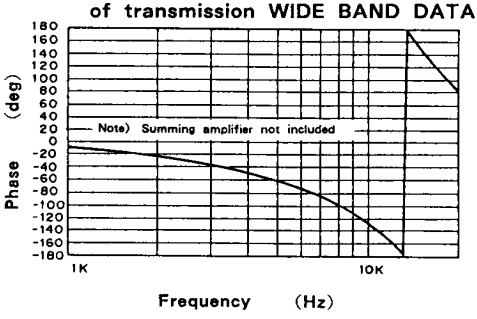
BPF phase characteristics of received SAT



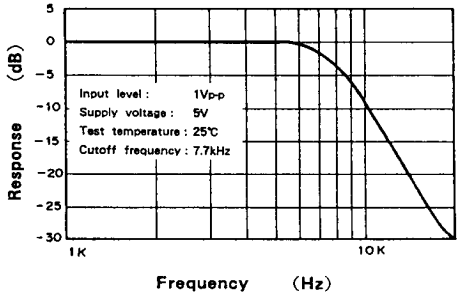
LPF phase characteristics of transmission WIDE BAND DATA



LPF phase characteristics of transmission WIDE BAND DATA



LPF amplitude characteristics of transmission SAT, ST



LPF phase characteristics for ST, SAT transmission