# TC35450AF

MOBILE RADIO TELEPHONE BASEBAND LSI

1. GENERAL DESCRIPTION

The TC35450AF is the analog signal processing LSI which fully meets the requirements of the audio signal processing in most mobile telephone applications like cellular radios and cordless telephones.

The LSI consists of audio signal filters, deviation limiter and four op-amps for use anyway in the system.

The LSI is fabricated using CMOS switched-capacitor technique, and can reduce power consumption and equipment size.

QFP 44PIN
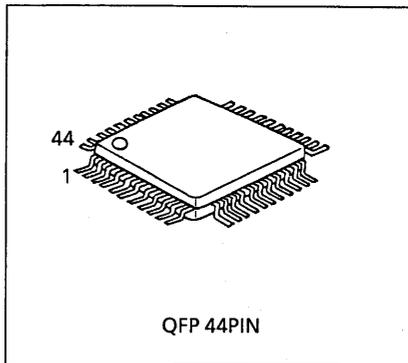
2. FEATURES

☐ 3.7 to 5.5 Volt Power Supply Ranges

☐ Low Supply Current (4V, 5.5mA)

☐ Built-in Power Down Control Circuit

☐ Selectable 3.2MHz X'tal and 400kHz Ceramic Resonator

☐ Wide Operating Temperature Range (−40 ~ 85 °C)

☐ 44PIN QFP Package

2.1 APPLICATIONS

☐ Cellular Radio

☐ Cordless Telephone

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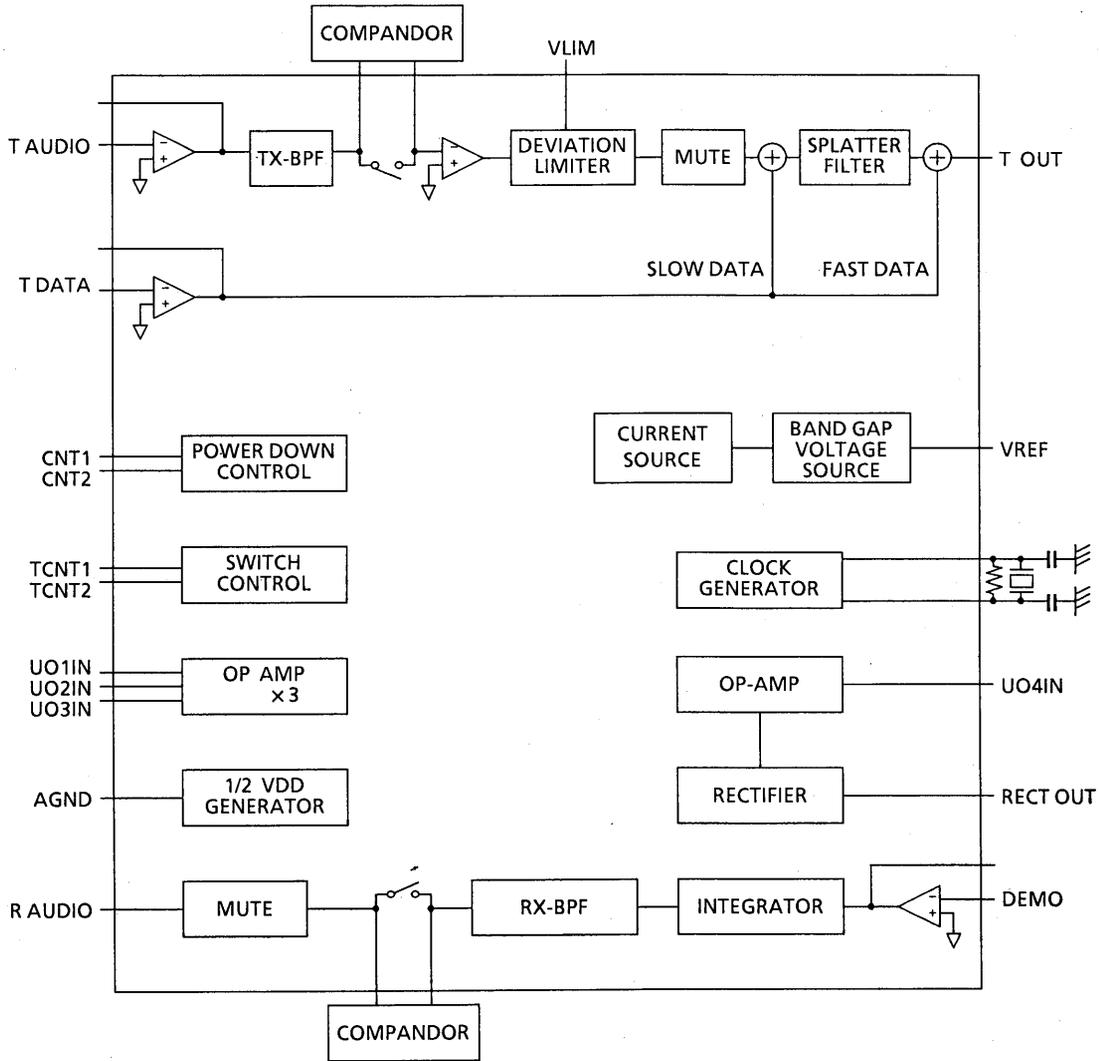
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AUDIO SIGNAL PROCESSOR

3. TC35450AF BLOCK DIAGRAM

TC35450AF-2

AUDIO SIGNAL PROCESSOR

3.   TC35450AF BLOCK DIAGRAM
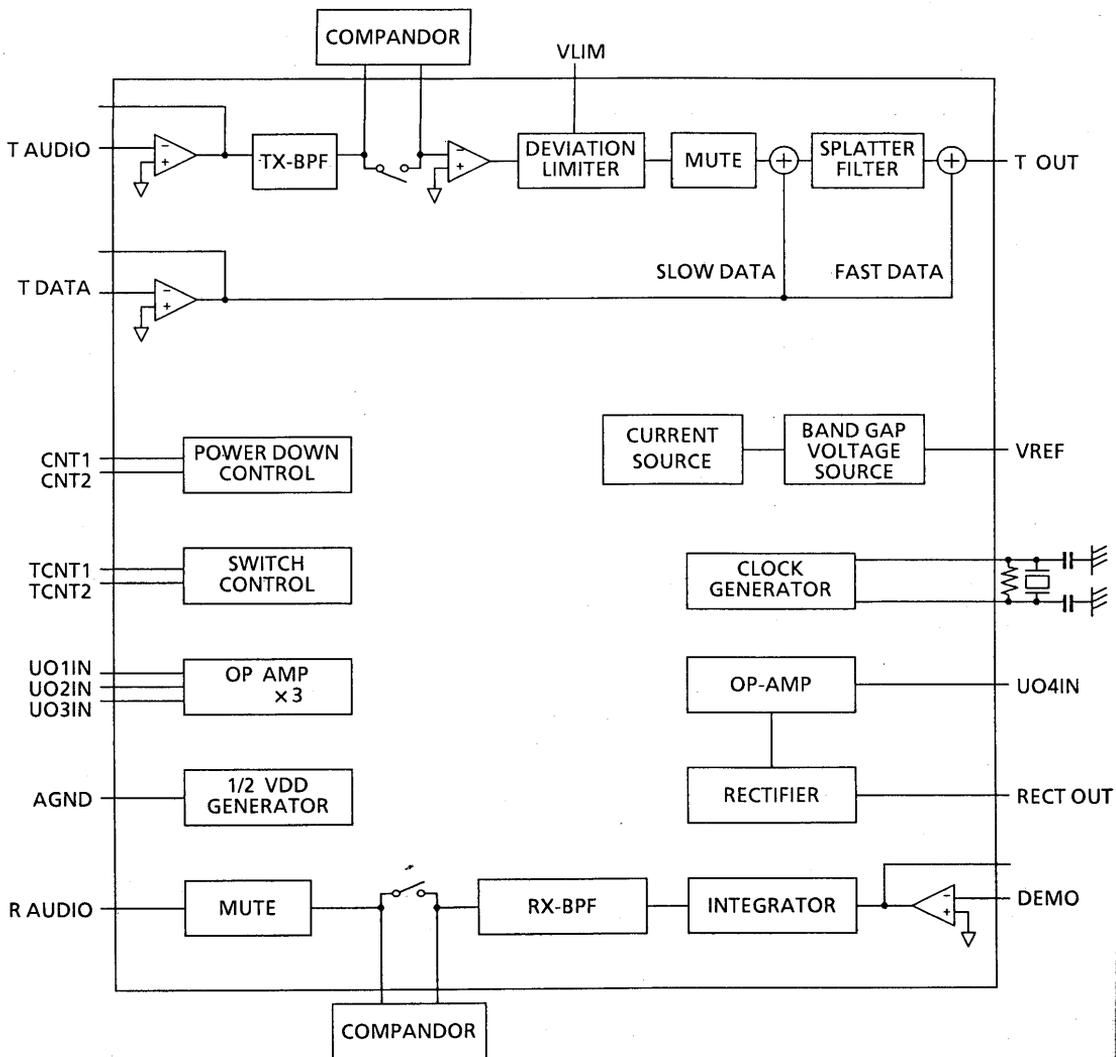
3.1 TRANSMITTER BPF

AAF : Anti-alias filter
SMF : Smoothing filter
▽ : Analog ground (VDD/2)
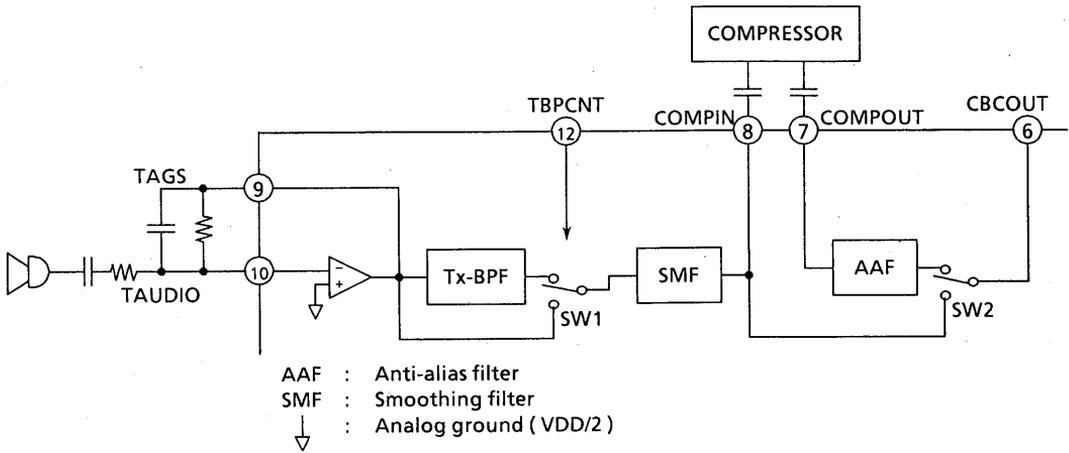
3.2 IDC + SPL, TRANSMITTER DATA
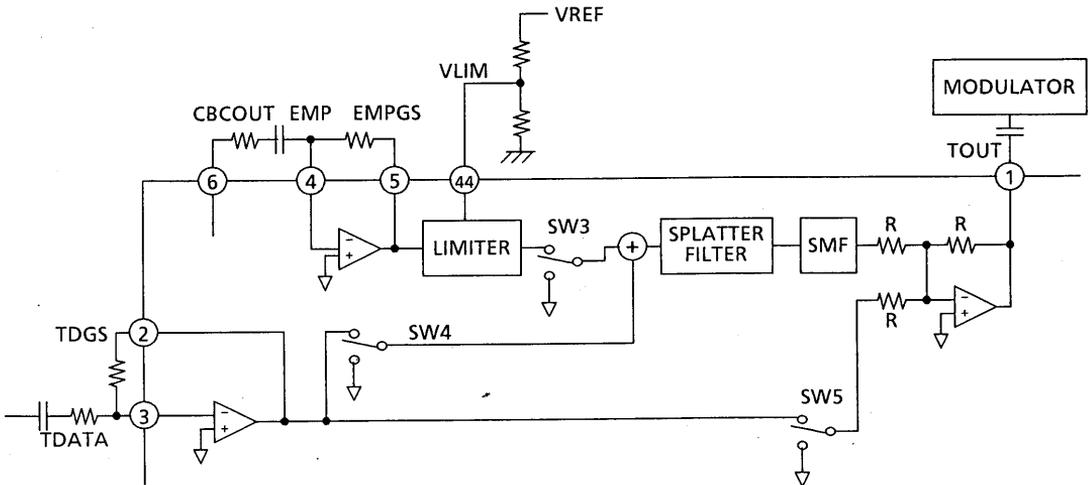
AUDIO SIGNAL PROCESSOR

3.3 RECEIVER
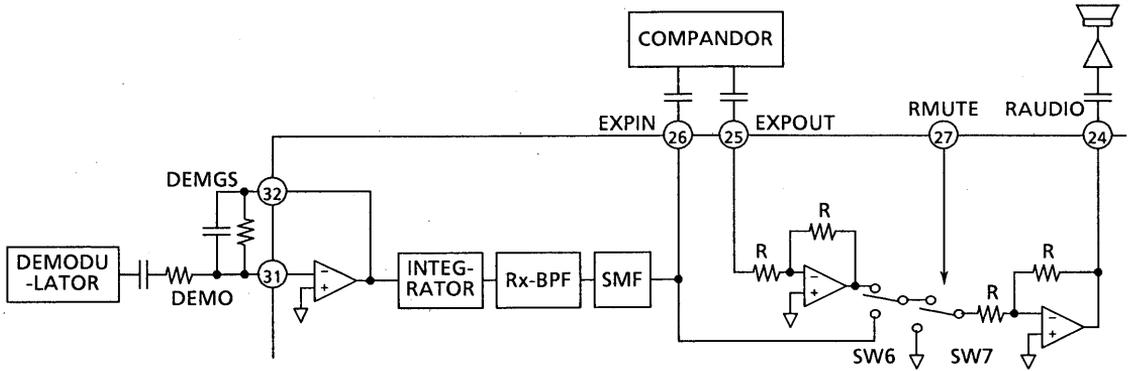
3.4 OP-AMPS
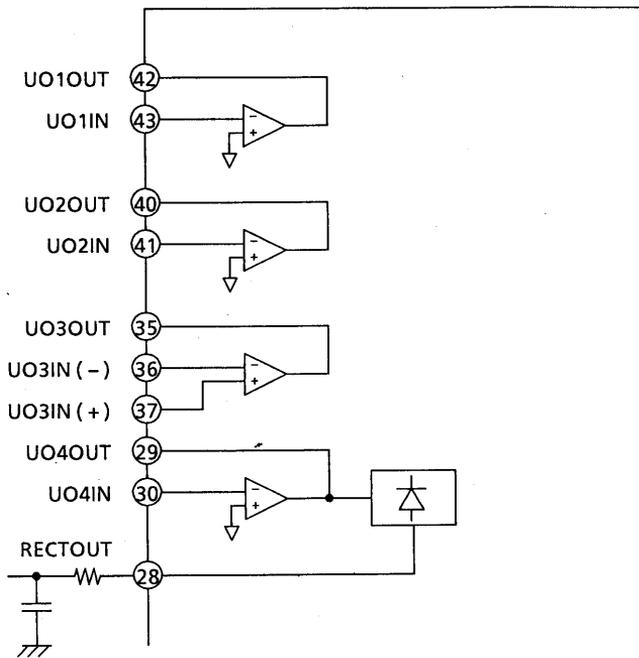
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3.5　　OTHER CIRCUITS
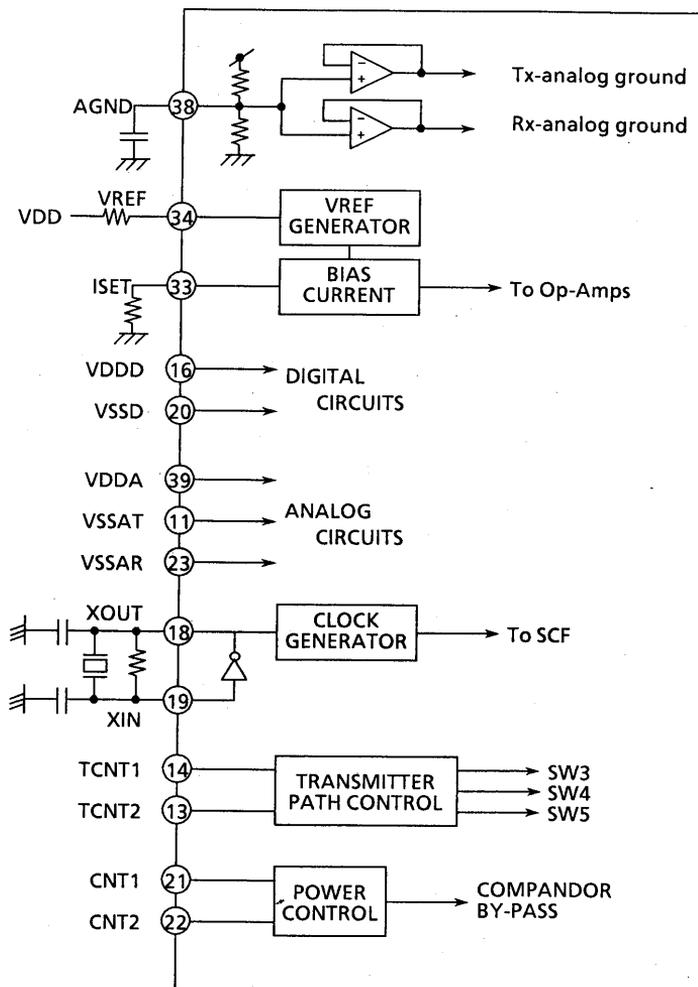
AUDIO SIGNAL PROCESSOR

4.   PIN DESCRIPTION

PIN	SYMBOL	I/O	FUNCTION
1	TOUT	O	Transmission Signal Output Transmit summing data signals and voice signals.
2	TDGS	O	Adjust the signal level of transmission data.
3	TDATA	I	Transmission Data Input
4	EMP	I	IDC Input IDC : Instantaneous Deviation Control
5	EMPGS	O	Adjust the Input Signal Level of IDC Circuit Compose a differentiator using this op-Amp.

6	CBCOUT	O	Compandor By-pass Output
			   When CNT1 is High and CNT2 is low, compandor is Bypassed and
			   transmitter BPF output is applied. In other case, the input at
			   COMPOUT (7pin) is applied.

7	COMPOUT	I	Compressor Input Connect the output terminal of compressor.
8	COMPIN	O	Compressor Output Connect the input terminal of compressor.
9	TAGS	O	Adjust the input level of transmission voice signal.
10	TAUDIO	I	Transmission Voice Signal Input
11	VSSAT	–	VSS of Transmission Analog Circuits

12	TBPCNT	I	Transmitter BPF Bypass Control Input
			   H : Transmitter BPF is bypassed. TAGS (9 pin) output is applied
			          to COMPIN (8 pin).
			   L : Transmitter BPF output is applied to COMPIN.

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	TCNT2
	TCNT1
		I	Transmission Signal Pass Control Inputs
			   These pins control the SW3 to SW5 and change the path of
			   transmission signals. These switches also acts as mute switches for
			   the voice and data signals. (See TRUTH TABLE on Page 9.)

15	CLKSEL	I	Clock Select Input
			   This pin selects oscillator clock frequency.
			   H : 400kHz
			   L : 3.2MHz

16	VDDD	–	VDD of Digital Circuits
17	N.C.	–	No Connection This pin is used internally and should be left open.

PIN	SYMBOL	I/O	FUNCTION
18	XOUT	O	Oscillator Output
19	XIN	I	Oscillator Input
20	VSSD	–	VSS of Digital Circuits

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	CNT1
	CNT2
		I	Power Down Control Inputs
			  These pins control power down logics, and enable or disable part
			  by part in three modes. This enables appropriate power savings.
			  (See TRUTH TABLE on page 9.)

23	VSSAR	–	VSS of Receiver Analog Circuits
24	RAUDIO	O	Receiving Audio Signal Output
25	EXPOUT	I	Expandor Input Connect the input terminal of expandor.
26	EXPIN	O	Expandor Output Connect the output terminal of expandor.

27	RMUTE	I	Receiving Audio Signal Mute Control
			  When this pin is low, receiving audio signal is applied to RAUDIO
			  (24pin). When high, the mute switch inserts loss into the audio
			  path.

28	RECTOUT	O	Rectifier Output
			  The full-wave rectifier consists of zero-cross detector and a buffer.
			  The detector determines the UO4OUT (29pin) output to pass the
			  inverting or non-inverting route accordingly. The rectified output
			  is averaged by external RC circuit.

29	UO4OUT	O	Output of Op-amp 4
30	UO4IN	I	Inverting Input of Op-amp 4
31	DEMO	I	Input of Demodulated Signal
32	DEMGS	O	Adjust the signal level of receiver section.

33	ISET	–	Adjust the bias current.
			  Load resister (12kΩ normally) determines operating current of the
			  chip (5mA).

34	VREF	O	Voltage Reference Output
			  The VREF has small coefficient of temperature. The deviation
			  limiter reference voltage (VLIM 44pin) can be obtained from this
			  voltage source.

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PIN	SYMBOL	I/O	FUNCTION
35	UO3OUT	O	Output of Op-amp 3
36	UO3IN(−)	I	Inverting Input of Op-amp 3
37	UO3IN(+)	I	Non Inverting Input of Op-amp 3

38	AGND	−	Analog Ground
			    This pin is biased (VDD − VSS) /2. External capacitor stabilized
			    analog ground.

39	VDDA	−	VDD of Analog Circuits
40	UO2OUT	O	Output of Op-amp 2
41	UO2IN	I	Inverting Input of Op-amp 2
42	UO1IN	I	Inverting Input of Op-amp 1
43	UO1OUT	O	Output of Op-amp 1
44	VLIM	I	Limiter Reference Voltage Input Limiting voltages are 1/2 VDD + VLIM and 1/2 VDD − VLIM.

5. TRUTH TABLE

5.1 SWITCH (PATH) CONTROL

TCNT1	TCNT2	SW3	SW4	SW5
H	H	ON	OFF	OFF
H	L	OFF	ON	OFF
L	H	OFF	OFF	ON
L	L	ON	OFF	ON

ON : Through
OFF : Mute (VDD/2 is applied.)

TBPCNT	Tx-BPF
H	By-pass (TAGS output is applied.)
L	Non-bypass (Tx-BPF output is applied.)

RMUTE	RECEIVING AUDIO OUTPUT (RAUDIO 24pin)
H	Through
L	Mute (VDD/2 is applied.)

5.2 POWER CONTROL AND COMPANDOR BY-PASS

CNT1	CNT2	MODE	SUPPLY CURRENT (TYP.)	SW2	SW6
H	H	Power on	5.0 mA	To compandor	To compandor
H	L	Power on	5.0 mA	By-pass	By-pass
L	H	Waiting	1.2 mA	To compandor	To compandor
L	L	Power off	1.0 μA	To compandor	To compandor

Power on : All circuits are enable.
Waiting : Op-amp 1~4 (Except rectifier), VREF, ISET, AGND, DEMGS are enable. Other circuits are power down.
Power off : All circuits are power down.

5.3 OSCILLATOR FREQUENCY SELECT CLOCK

CLKSEL	OSCILLATOR FREQUENCY CLOCK
H	400 kHz
L	3.2 MHz

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6. ELECTRICAL CHARACTERISTICS

6.1 MAXIMUM RATINGS

ITEM		SYMBOL	RATING	UNIT
Power Supply Voltage		V_{DD}	$V_{SS} - 0.5 \sim V_{SS} + 7$	V
Input Voltage	Digital	VIN-D	$V_{SS} - 0.5 \sim V_{DD} + 0.5$	V
	Analog	VIN-A	$V_{SS} \sim V_{DD}$	V
Output Voltage	Digital	VOUT-D	$V_{SS} - 0.5 \sim V_{DD} + 0.5$	V
	Analog	VOUT-A	$V_{SS} \sim V_{DD}$	V
Injection Current		IIN	± 10	mA
Power Dissipation		PD	300	mW
Operating Temperature		Topr	-40~85	°C
Storage Temperature		Tstg	-65~150	°C

6.2 RECOMMENDED OPERATING CONDITIONS

(VSS = 0V)

PARAMETER	SYMBOL	TERMINAL	MIN.	TYP.	MAX.	UNIT
Power Supply Voltage	VDD		3.7	4.0	5.5	V
Operating Temperature	TOP		-40	25	85	°C
Input Voltage	VIN		0	–	VDD	V
Clock Frequency	Fck	Note 1	–	3.2	–	MHz
Output Load	RL	TOUT, TDGS, EMPGS, CBCOUT, TAGS, RAUDIO, RECTOUT, UO4OUT, DEMGS, UO3OUT, UO2OUT, UO1OUT	30	–	–	kΩ
	CL		–	–	50	pF
	RL	COMPIN	5	–	–	kΩ
	CL	EXPIN	–	–	50	pF
	RL	VREF	30	–	–	kΩ
	RL	ISET	–	12	–	kΩ

Note 1) We recommended the use of 3.2MHz crystal because of its frequency stability.
The 3.2MHz crystal (type NR-18, NIHON DENPA KOGYO CO., LTD) is used to measure all characteristics of this LSI.

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6.3   DC CHARACTERISTICS

(Ta = 25°C, VDD = 4V)

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	IDD (opr)		–	5.0	5.5	mA
Waiting Current	IDD		–	1.2	1.7	mA
Stand by Current	IDD		–	0.001	1	μA
Input Voltage	VIH	Digital Input Pins (Note 1)	3.6	–	–	V
	VIL		–	–	0.4	
Input Current	IIH	Digital Input Pins	–	–	0.2	μA
	IIL		-0.2	–	–	
	IIH	Analog Input Pins (Note 2)	–	–	0.2	
	IIL		-0.2	–	–	
	IIH	COMPOUT	–	–	33	
	IIL		-33	–	–	
	IIH	EXPOUT	–	–	59	
	IIL		-59	–	–	
Analog Ground (Note 3)	VAG	AGND	-10	0	10	mV
Output Offset (Note 3)	VOS1	EMPGS, TAGS, TDGS, DEMGS, UO1OUT, UO2OUT, UO3OUT, UO4OUT	-20	0	20	mV
	VOS2	RAUDIO, COMPIN, CBCOUT, EXPIN	-100	0	100	
	VOS3	TOUT	-200	0	200	
	VOS4	RECTOUT	-40	0	40	
Output Offset Variation	VS1	TOUT (Note 4)	-15	0	15	mV
	VS2	RAUDIO(Note 5)	-10	0	10	
Voltage Reference	VREF		1.33	1.40	1.47	V
Temperature Coefficient of VREF	TVREF		-240	0	240	ppm/°C

Note 1)   Digital Input Pins   TBPCNT, TCNT2, TCNT1, CLKSEL, CNT1, CNT2, RMUTE

Note 2)   Analog Input Pins   TAUDIO, COMPOUT, EMP, TDATA, DEMO, UO3IN(+), UO3IN(–), UO1IN, UO2IN, UO4IN, VLIM

Note 3)   As analog ground VDD/2 (2V) reference

Note 4)   The difference of the offset (when SW 3 is ON) from the offset (when SW 3 is OFF).

Note 5)   The difference of the offset (when SW6 is ON) from the offset (when SW 6 is OFF).

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6.4 AC CHARACTERISTICS

6.4.1 TRANSMITTER BPF (TAUDIO TO COMPIN)

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
1kHz Absolute Gain	Ga	Input Level -18dBV	-2.5	-2.0	-1.5	dB
Frequency Characteristics (Note 1)	FR	30Hz	–	–	-48.7	dB
		100Hz	–	–	-17.5	
		300Hz	-2.7	–	0.7	
		400~800Hz	-0.7	0	0.7	
		800~1600Hz	-0.2	0	0.2	
		1.6~2.7kHz	-0.3	0	0.7	
		3.0kHz	-1.0	–	0.7	
		10kHz	–	–	-29	
		18.4kHz	–	–	-50	
Distortion	DH		–	–	-46	dB
Output Noise	NL	C Message Weighting	–	–	-76	dBV
Clock Leak	LC		–	–	–	

6.4.2 TRANSMITTER IDC CIRCUITS (COMPOUT TO TOUT)

ITEM		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
1kHz Absolute Gain		Ga	Input Level -12dBV	3.5	4.0	4.5	dB
Frequency Characteristics (Note 1)		FR	100~800Hz	-0.2	0	0.2	dB
			800~1600Hz	-0.15	0	0.2	
			1.6~2.3kHz	-0.4	0	0.2	
			2.7kHz	-2.3	–	0.2	
			3.0kHz	-3.5	–	0.2	
			5.9kHz	–	–	-35	
			7.9kHz	–	–	-50	
			20kHz	–	–	-50	
Limiter Over-shoot	+ peak	SP +	VDD = 4V,	0.882	–	1.159	V
	-peak	SP-	VLIM = 0.541V,	-1.159	–	-0.882	V
	± peak ratio	RSP	Input Level 3dBVrms	-7	0	7	%
Distortion		DH		–	–	-46	dB
Output Noise		NL	C Message Weighting	–	–	-72	dBV
Clock Leak		LC		–	–	–	dBV

Note 1)   Relative gain (1kHz gain standard)
Input Level -23dBV (0dBV = 1Vrms)

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6.4.3 TRANSMITTER SLOW DATA CIRCUITS (TDATA TO TOUT)

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
1kHz Absolute Gain	Ga	Input Level -14dBV	3.5	4.0	4.5	dB
Frequency Characteristics (Note 1)	FR	100~800Hz	-0.2	0	0.2	dB
		800~1600Hz	-0.15	0	0.2	
		1.6~2.3kHz	-0.4	0	0.2	
		2.7kHz	-2.3	–	0.2	
		3.0kHz	-3.5	–	0.2	
		5.9kHz	–	–	-35	
		7.9kHz	–	–	-50	
		20kHz	–	–	-50	
Distortion	DH	(f = 1kHz, -14dBV)	–	–	-40	dB
Output Noise	NL	C Message Weighting	–	–	-72	dBV
Clock Leak	LC		–	–	–	dBV

Note 1)   Relative gain (1kHz gain standard)
Input Level   -23dBV

6.4.4 TRANSMITTER FAST DATA CIRCUITS (TDATA TO TOUT)

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
1kHz Absolute Gain	Ga	Input Level -14dBV	-0.5	0	0.5	dB
Distortion	DH	(f = 1kHz, -14dBV)	–	–	-40	dB
Output Noise	NL	C Message Weighting	–	–	-72	dBV
Clock Leak	LC		–	–	–	dBV

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6.4.5   RECEIVER BPF + INTEGRATOR (DEMO TO EXPIN)

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
1kHz Absolute Gain	Ga	Input Level -10dBV	-11	-10	-9	dB
Frequency Characteristics (Note 1)	FR	75Hz	–	–	-50	dB
		250Hz	–	–	1.0	
		300Hz	-3.0	–	1.0	
		400~800Hz	-1.0	–	1.0	
		800~1600Hz	-0.5	–	0.5	
		1.6~2.3kHz	-1.0	–	1.0	
		3.0kHz	-3.0	–	1.0	
		5.9kHz	–	–	-18.1	
		8.1kHz	–	–	-31.9	
Distortion	DH		–	–	-40	dB
Output Noise	NL	15kHz LPF	–	–	-67	dBV
		C Message Weighting	–	–	-77	dBV
Clock Leak	LC		–	–	–	dBV

Note 1)   Relative gain (1kHz gain standard)   Deviation from an ideal -6kB/oct curve
Input Level   -23dBVrms

6.4.6   Op-Amps 1~4

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Open Loop Gain	GV		–	70	–	dB
Gain Band Width	fT	Open Loop	–	1.0	–	MHz
Phase Margin	GH		–	50	–	deg
Slew Rate	SR		–	0.8	–	v / μs
Input Noise Voltage	en	C Message Weighting	–	-108	–	dBV

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6.4.7   FULL WAVE RECTIFIER (UP4OUT TO RECTOUT)

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
AC / DC Conversion Linearity		Input -10~0dBV (Note 1)	-2.0	0	2.0	dB

6.4.8   OTHERS

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Starting Time	Tpr	Op-Amps 1~4	–	–	1	ms
		Transmitter Slow Data Circuits	–	–	50	
		Others (Note 2)	–	–	100	
Mute Transition Time	Tmt	SW3, SW7	–	–	2 ·	ms
Mute inserting Loss	VmL	SW3, SW7	50	–	–	dB

Note 1)   Deviation from an ideal full-wave rectification characteristic
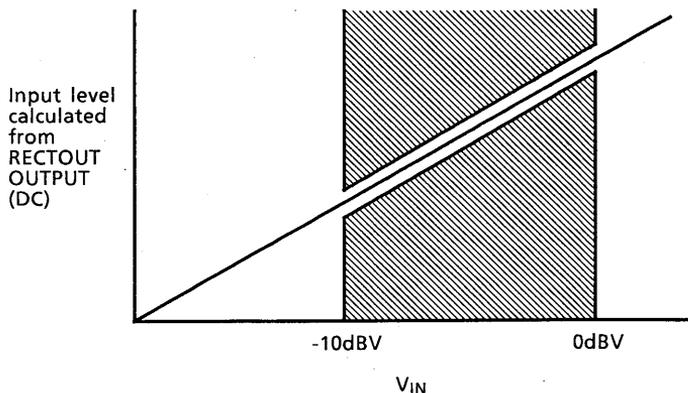
Theoretical Value $V_{OUT}(V) = \dfrac{2\sqrt{2}}{3.14159} A$ Input Level A Vrms

Note 2)   Tx-BPF, Tx-IDC, Rx-BPF + Integrator

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6.5 FREQUENCY CHARACTERISTIC

6.5.1 TRANSMITTER BPF FREQUENCY CHARACTERISTIC
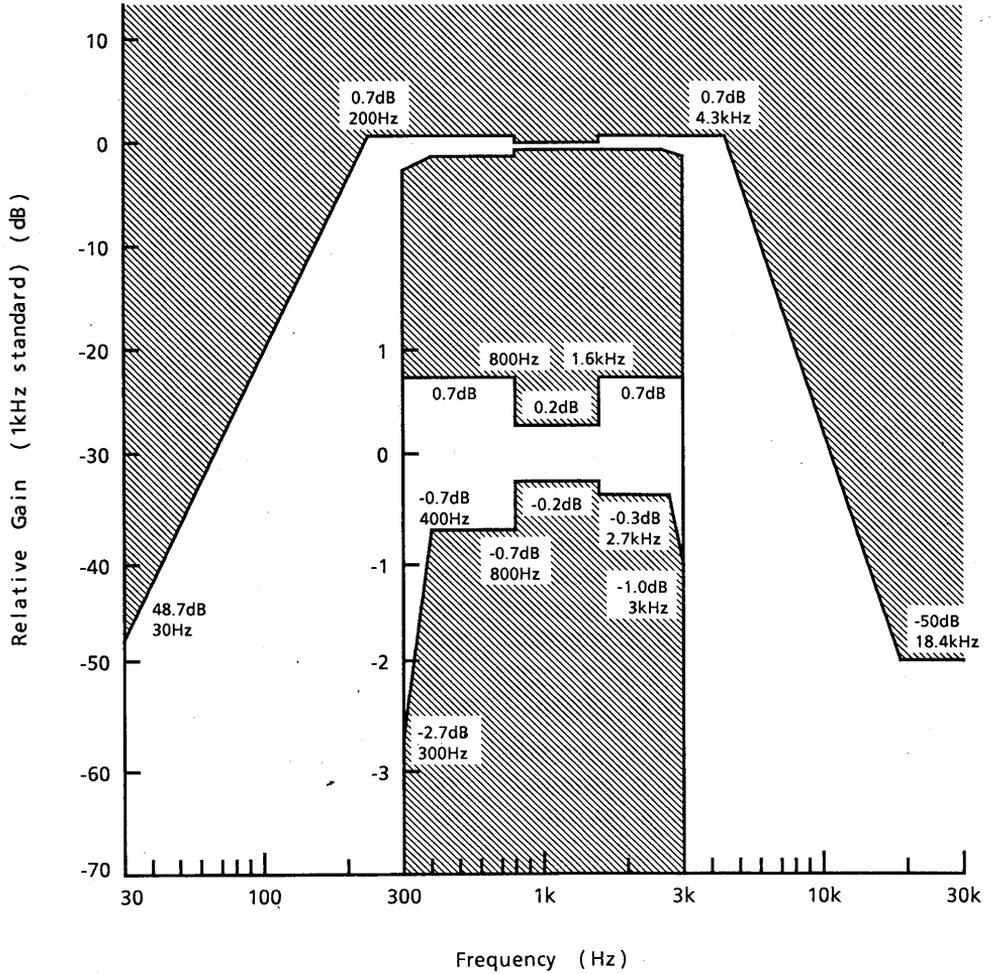
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6.5.2   Tx-SPLATTER FILTER FREQUENCY CHARACTERISTIC (Tx-SLOW DATA CIRCUITS)
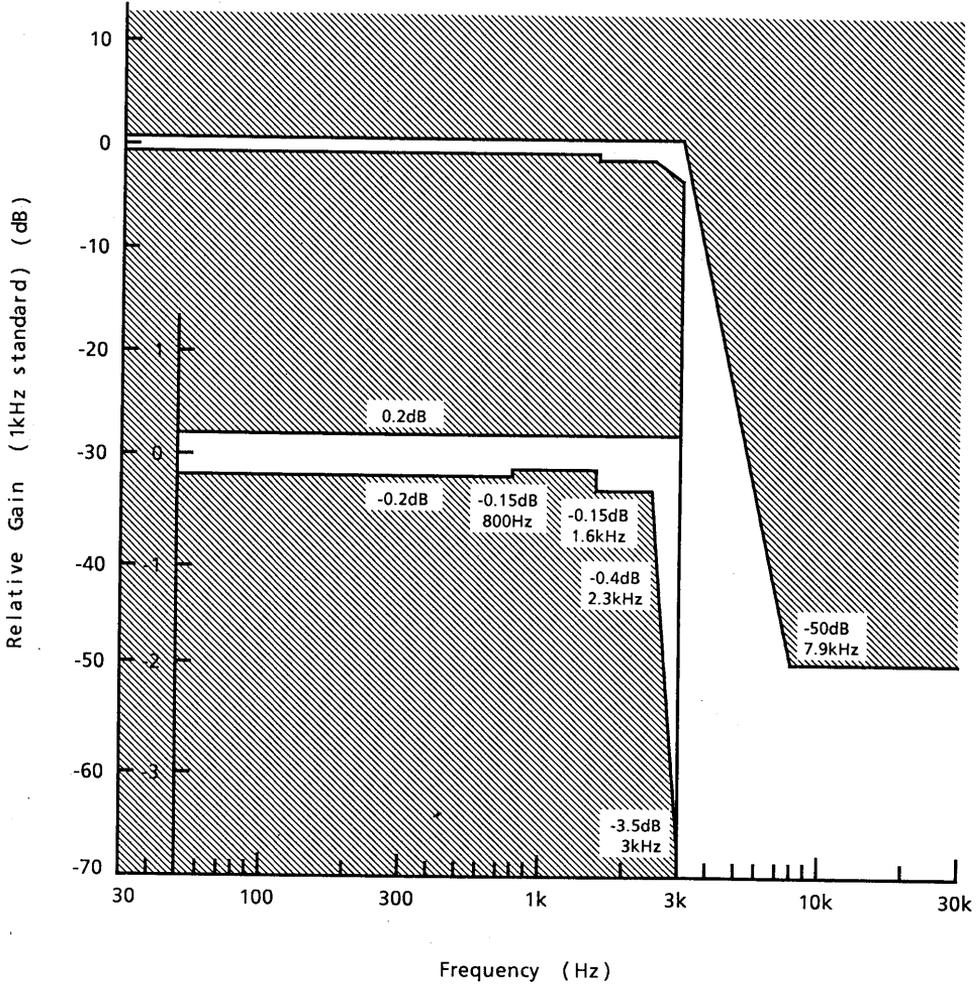
Frequency (Hz)

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6.5.3   RECEIVER BPF + INTEGRATOR FREQUENCY CHARACTERISTICS
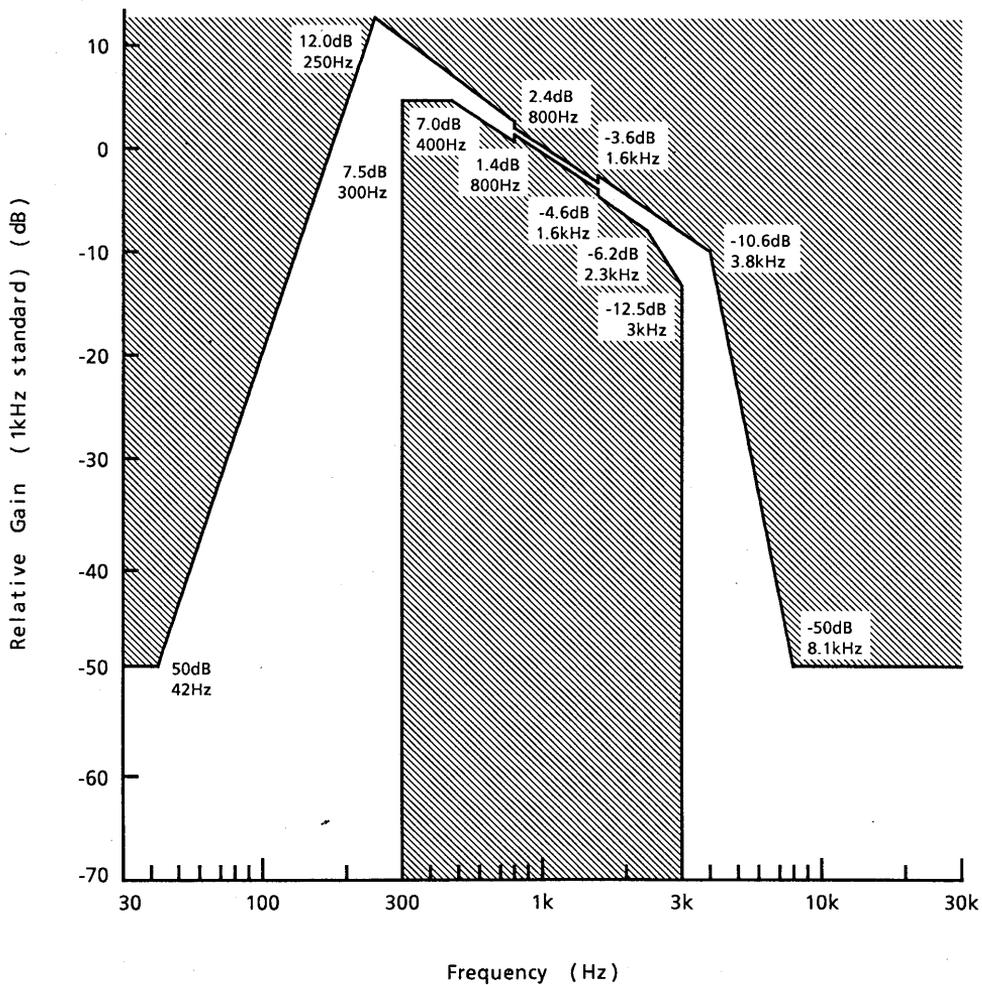
6.5.4   APPLICATION

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