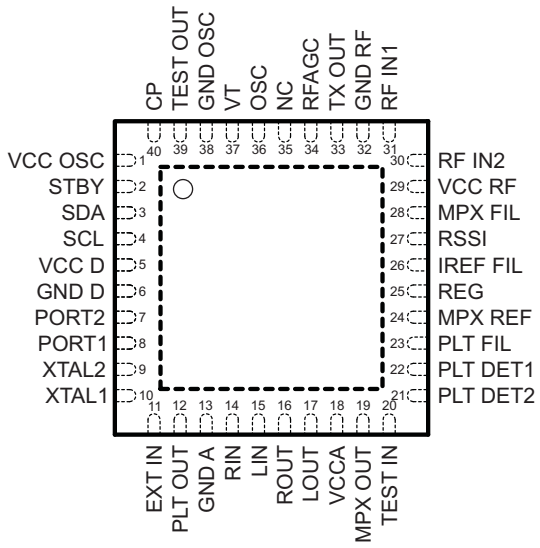
FEATURES

- **Single-Chip FM Stereo Radio and Transmitter**
- **FM Stereo MPX [Receive (Rx), Transmit (Tx)]**
- **Frequency Range 76 MHz to 108 MHz (Rx, Tx)**
- **Low Supply Current**
  - **Rx: 11.5 mA (V_{CC} = 3 V, No RF Input)**
  - **Tx: 13 mA (V_{CC} = 3 V, No Audio Input, RTX = Open)**
- **32.768-kHz Crystal**
- **I^2C Interface**
- **MPX Output for RDS (Rx)**
- **Seek Tuning (Rx)**
- **RFAGC (Rx)**
- **RF Auto-Power Control (Tx)**
- **Pilot Cancel (Rx)**
- **Sixth-Order 15-kHz LPF (Tx)**
- **Programmable De/Pre-Emphasis (50/75 μs)**
- **Pilot Out (Tx)**
- **General-Purpose External Input (Tx)**
- **High Power Selectable RF Output (Tx) –7/–3/1/4 dBm**
- **High Cut Control (HCC), Stereo Noise Control (SNC) (Rx)**
- **Soft Mute (Rx)**
- **V_{CC} = 2.5 V to 4 V**
- **40-Pin QFN Package**

APPLICATIONS

- **Portable Media Players**
- **MP3 Players**
- **Personal Navigation Devices**

RTA PACKAGE
(TOP VIEW)



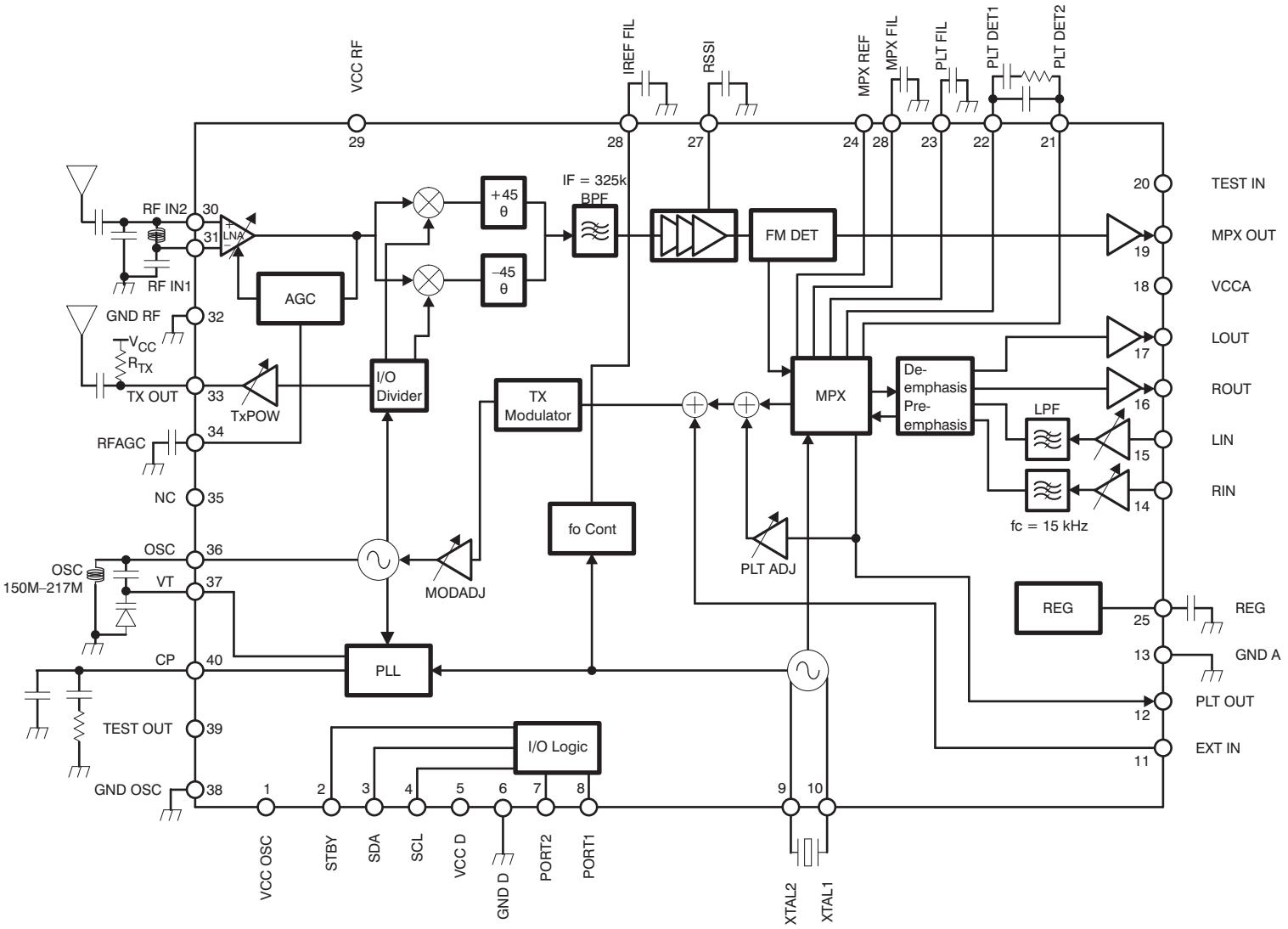
NC – No internal connection

DESCRIPTION

The SN761633 is an FM radio receiver and transmitter IC for portable audio players.

The circuit consists of a stereo FM radio receiver and FM transmitter, and is available in a small-outline package.

FUNCTIONAL BLOCK DIAGRAM



TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION	SCHEMATIC
NAME	NO.		
CP	40	Charge-pump output	Figure 1
EXT IN	11	External signal input	Figure 2
GND A	13	Analog ground	
GND D	6	Digital ground	
GND OSC	38	Oscillator ground	
GND RF	32	RF ground	
IREF FIL	26	Reference current filter	Figure 3
LIN	15	Audio left input	Figure 4
LOUT	17	Audio left output	Figure 5
MPX FIL	28	MPX PLL filter	Figure 6
MPX REF	24	MPX reference voltage filter	Figure 7
MPX OUT	19	MPX output	Figure 8
NC	35	Not connected	
OSC	36	Oscillator input	Figure 9
PLT DET1, PLT DET2	22, 21	Pilot detector PLL loop filter	Figure 10
PLT FIL	23	Pilot level detector filter	Figure 11
PLT OUT	12	Pilot signal output	Figure 12
PORT1, PORT2	8, 7	Port output	Figure 13
REG	25	Regulator filter	Figure 14
RF AGC	34	RFAGC filter	Figure 15
RF IN1, RF IN2	31, 30	RF input	Figure 16
RIN	14	Audio right input	Figure 4
ROUT	16	Audio right output	Figure 5
RSSI	27	RSSI filter	Figure 17
SCL	4	I^2C clock input	Figure 18
SDA	3	I^2C data input/output	Figure 19
STBY	2	Standby control input	Figure 20
TEST IN	20	Test input	Figure 21
TEST OUT	39	Test output	Figure 22
Tx OUT	33	Transmitter output	Figure 23
VCC A	18	Analog power supply	
VCC D	5	Digital power supply	
VCC OSC	1	Oscillator power supply	
VCC RF	29	RF power supply	
VT	37	Tuning voltage output	Figure 1
XTAL1, XTAL2	10, 9	Crystal oscillator input/output	Figure 24

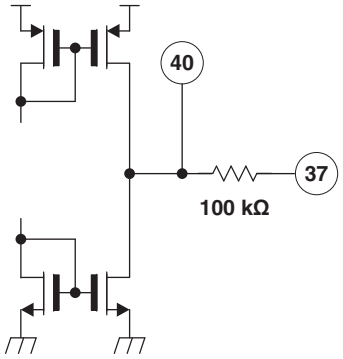


Figure 1. CP and VT

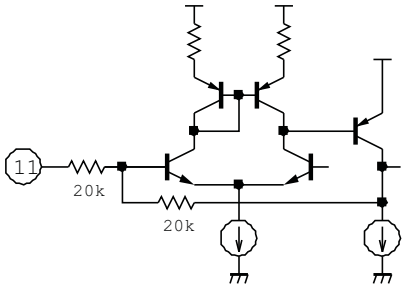


Figure 2. EXT IN

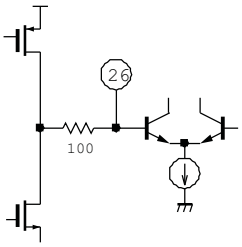


Figure 3. IREF FIL

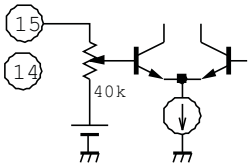


Figure 4. LIN and RIN

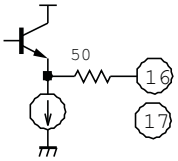


Figure 5. LOUT and ROUT

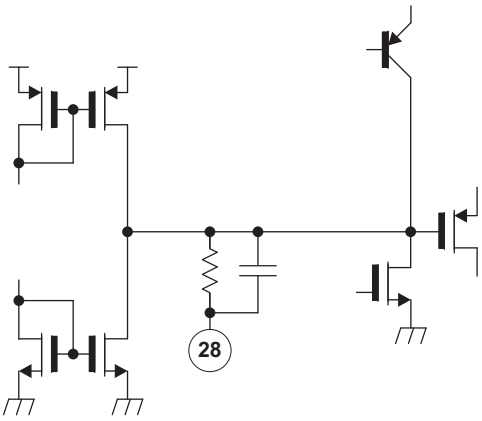


Figure 6. MPX FIL

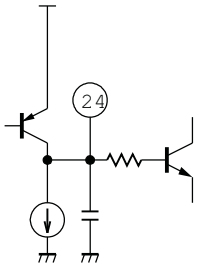


Figure 7. MPX REF

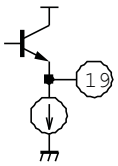


Figure 8. MPX OUT

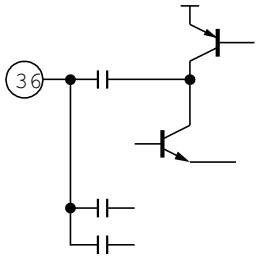


Figure 9. OSC

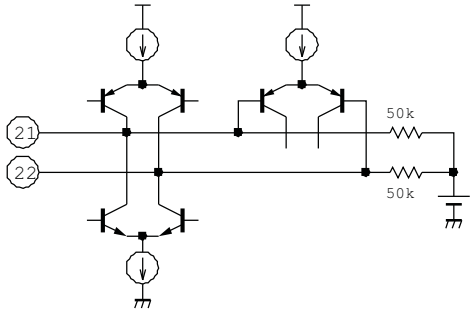


Figure 10. PLT DET1 and PLT DET2

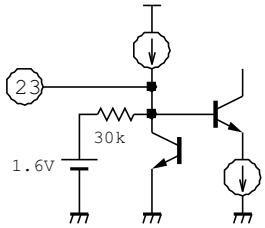


Figure 11. PLT FIL

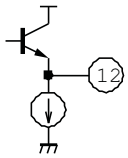


Figure 12. PLT OUT

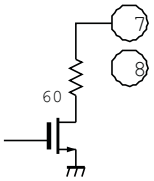


Figure 13. PORT1 and PORT2

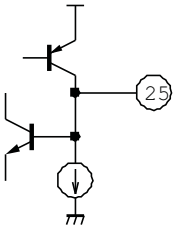


Figure 14. REG

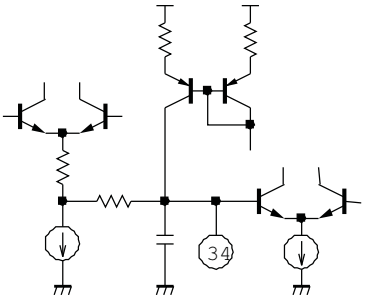


Figure 15. RFAGC

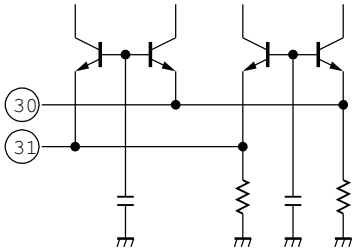


Figure 16. RFIN1 and RFIN2

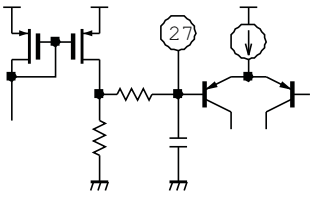


Figure 17. RSSI

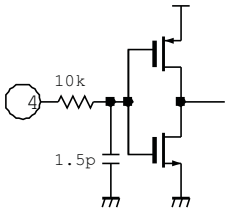


Figure 18. SCL

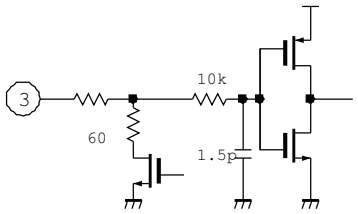


Figure 19. SDA

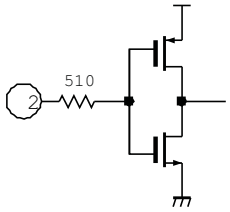


Figure 20. STBY

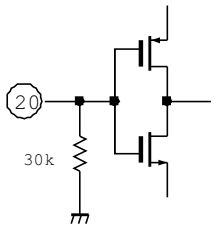


Figure 21. TEST IN

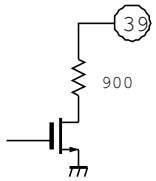


Figure 22. TEST OUT

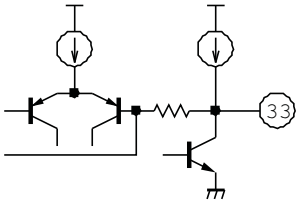


Figure 23. Tx OUT

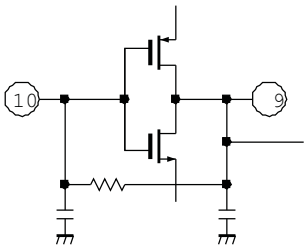


Figure 24. XTAL1 and XTAL2

ABSOLUTE MAXIMUM RATINGS(1)

over recommended operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage range	VCCA, VCCD, VCC RF	–0.3	60	V
V_{IN}	Input voltage range	Other pins	–0.3	V_{CC}	V
T_A	Operating free-air temperature range		–20	85	°C
T_{stg}	Storage temperature range		–65	150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	VCCA, VCCD, VCC RF, VCC OSC	2.5	3	4	V
T_A	Operating free-air temperature		–20		85	°C

CAUTION:

The SN761633 has four V_{CC} pins (VCCA, VCCD, VCC OSC, and VCC RF). Use of a single power source for all V_{CC} pins is recommended. In the case of multiple power supplies, VCCD should be applied first.

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ELECTRICAL CHARACTERISTICS – TOTAL DEVICE

V_{CC} = 3 V, T = 25°C, measured in the circuit of Figure 26; RF input voltage (V_{RF}) = 60 dBµVemf; RF frequency (f_{RF}) = 98.1 MHz, Audio signal frequency (f_{AF}) = 1 kHz, Mono, FM = 22.5 kHzdev (30% at 75-kdev Ref.), BW = LPF 30k (unless otherwise noted)

Supply Voltages and Currents

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{CC}	Supply voltage	VCCA, VCCD, VCC RF, and VCC OSC are the same voltage	2.5	3	4	V
$I_{CC\ Rx}$	Rx-mode supply current	No RF signal input		11.5		mA
$I_{CC\ Tx1}$	Tx-mode supply current 1	No LIN/RIN input, TxPOW[1:0] = 00, R_{Tx} = open		13		mA
$I_{CC\ Tx2}$	Tx-mode supply current 2	No LIN/RIN input, TxPOW[1:0] = 00, R_{Tx} = open, DIS_AFLPF = 1		12		mA
$I_{CC\ Tx3}$	Tx-mode supply current 3	External input only mode, EN_EXTIN = 1, DIS_LRIN = 1, DIS_AFLPF = 1, TxPOW[1:0] = 00, R_{Tx} = open		11.5		mA
$I_{CC\ Tx4}$	Tx-mode supply current 4	No LIN/RIN input, TxPOW[1:0] = 10, R_{Tx} = 300 Ω		18		mA
$I_{CC\ Tx5}$	Tx-mode supply current 5	No LIN/RIN input, TxPOW[1:0] = 11, R_{Tx} = 150 Ω		24		mA
$I_{CC\ STBY1}$	Standby supply current 1	STBY (bit) = 1		0.1	10	µA
$I_{CC\ STBY2}$	Standby supply current 2	STBY (2 pin) = GND		0.1	10	µA

Crystal Oscillator

PARAMETER		TEST CONDITIONS	TYP	UNIT
f_{XTAL}	Crystal oscillator frequency	Crystal C_L = 12.5 pF	32.768	kHz

Voltage-Controlled Oscillator

PARAMETER		MIN	MAX	UNIT
f_{OSC}	Oscillator frequency range	150	217	MHz

Synthesizer

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
N	Programmable counter	14 bit			16383	
f_{REF}	Reference frequency for phase detector			16.384		kHz
f_{STEP}	Tuning frequency step			8.192		kHz
$f_{RANGE\ US}$	US/EU band range for search stop	LOC_HL = 1	10707		13237	dec
			87.387		108.113	MHz
		LOC_HL = 0	10628		13157	dec
			87.390		108.107	MHz
$f_{RANGE\ JPN}$	Japan band range for search stop	LOC_HL = 1	9304		11039	dec
			75.893		90.107	MHz
		LOC_HL = 0	9224		10960	dec
			75.888		90.109	MHz
I_{CP}	Charge-pump current	CP[1:0] = 00		0.6		µA
		CP[1:0] = 01		1.25		
		CP[1:0] = 10		2.5		
		CP[1:0] = 11		5		

I²C Interface

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
V_{IH}	High-level input voltage (SCL, SDA)		$0.7 \times V_{CC}$		V
V_{IL}	Low-level input voltage (SCL, SDA)			$0.3 \times V_{CC}$	V
V_{OL}	Low-level ouput voltage (SDA)	V_{CC} = 3 V, I_{OL} = 500 µA		0.4	V
f_{SCL}	Clock frequency (SCL)			400	kHz

ELECTRICAL CHARACTERISTICS – Rx BLOCK

V_{CC} = 3 V, T_A = 25°C, measured in the circuit of Figure 26; RF input voltage (V_{RF}) = 60 dBµVemf, RF frequency (f_{RF}) = 98.1 MHz, Audio signal frequency (f_{AF}) = 1kHz, Mono, FM = 22.5 kHzdev (30% at 75-kdev Ref.), BW = LPF 30 k (unless otherwise noted)

RF Signal Input

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{TU\ RANGE}$	Tuning frequency range		76		108	MHz
V_{Rx}	Sensitivity input voltage	(S+N)/N = 26 dB, 22.5-kHz dev, De-emphasis = 75 µs		10		dBµVemf
R_{RFIN}	Input resistance	RF IN at 100 MHz, No RF signal input		120		Ω
C_{RFIN}	Input capacitance	RF IN at 100 MHz, No RF signal input		1.5		pF
IR_{Rx}	Image rejection ratio			30		dB

IF Band-Pass Filter

PARAMETER		TEST CONDITIONS	TYP	UNIT
f_{IF}	IF center frequency	Peak frequency, Test mode	325	kHz
B_{IF}	IF bandwidth	–3 dB, Test mode	130	kHz
S_{+200}	Selectivity high side (200 kHz)	325 kHz + 200 kHz, Test mode	25	dB
S_{-200}	Selectivity low side (200 kHz)	325 kHz – 200 kHz, Test mode	30	dB
S_{+100}	Selectivity high side (100 kHz)	325 kHz + 100 kHz, Test mode	8	dB
S_{-100}	Selectivity low side (100 kHz)	325 kHz – 100 kHz, Test mode	7	dB

FM Demodulator MPX OUT

PARAMETER		TEST CONDITIONS	TYP	UNIT
V_{MPXOUT}	MPX OUT output level	22.5 kHz dev, f_{AF} = 1 kHz, EN_MPXOUT = 1	75	mVrms

Soft Mute

PARAMETER		TEST CONDITIONS	TYP	UNIT
$V_{S\ MUTE}$	Soft mute start point	S_MUTE = 1, –3 dB	11	dBµVemf
$ATT_{S\ MUTE}$	Soft mute attenuation	V_{RF} = 60 dBµVemf, S_MUTE = 0 to 1, 0 V applied to RSSI pin externally as pseudo condition of no RF signal input	18	dB

ELECTRICAL CHARACTERISTICS – Rx BLOCK (CONTINUED)

V_{CC} = 3 V, T_A = 25°C, measured in the circuit of Figure 26; RF input voltage (V_{RF}) = 60 dBµVemf, RF frequency (f_{RF}) = 98.1 MHz, audio signal frequency (f_{AF}) = 1kHz, Mono, FM = 22.5 kHzdev (30% at 75 kdev Ref.), BW = LPF 30 k (unless otherwise noted)

High Cut Control

PARAMETER		TEST CONDITIONS		TYP	UNIT
$TC_{DE\ EM}$	De-emphasis time constant	V_{RF} = 60 dBµVemf,	EMTC = 0	50	µs
			EMTC = 1	75	
$TC_{DE\ EM\ HCC}$	De-emphasis time constant on HCC applied	V_{RF} = 60 dBµVemf,	EMTC = 0	150	µs
		V_{RF} = 60 dBµVemf, 0 V applied to RSSI pin externally as pseudo condition of no RF signal input	EMTC = 1	225	

MPX Decoder

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{O\ MONO}$	Mono output level	Mono, 22.5 kHzdev, f_{AF} =1 kHz, De-emphasis = 75 µs		75		mVrms
$V_{O\ ST}$	Stereo output level	L = R, 22.5 kHzdev, f_{AF} =1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%)		75		mVrms
V_{DIFF}	LOUT- and ROUT-level difference	L = R, 22.5 kHzdev, f_{AF} = 1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%) LOUT-level ref.	–1		1	dB
ATT_{MUTE}	MUTE attenuation	MUTE = 1	60			dB
$ATT_{L\ MUTE}$	LOUT MUTE attenuation	MUTE_L = 1	60			dB
$ATT_{R\ MUTE}$	ROUT MUTE attenuation	MUTE_R = 1	60			dB
f_{ODD}	Overdrive deviation margin frequency	f_{AF} = 1 kHz, De-emphasis = 75 s THD < 3%		150		kHz
S/N_{MONO}	Mono signal-to-noise ratio	75 kHzdev (100%)., f_{AF} = 1 kHz, De-emphasis = 75 µs		60		dB
THD_{MONO}	Mono total harmonic distortion	22.5 kHzdev, f_{AF} = 1 kHz, De-emphasis = 75 µs		0.3		%
S/N_{ST}	Stereo signal-to-noise ratio	67.5 kHzdev (90%)., f_{AF} = 1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%)		50		dB
THD_{ST}	Stereo total harmonic distortion	22.5 kHzdev, f_{AF} = 1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%)		1		%
SEP_{ST}	Stereo separation	22.5 kHzdev, f_{AF} = 1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%)		33		dB
$DEV_{PLT\ DET}$	Pilot detect deviation	ST_IND 0 to 1 at I^2C read mode		5		%
$HYS_{PLT\ DET}$	Pilot detect deviation hysteresis			2		dB
V_{SWMST}	Mono-to-stereo switch level	22.5 kHzdev, f_{AF} = 1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%), SNC = 0		33		dBµVemf
HYS_{SWMST}	Mono-to-stereo switch-level hysteresis	22.5 kHzdev, f_{AF} = 1 kHz, De-emphasis = 75 µs, Pilot = 7.5 kHzdev (10%), SNC = 0		2		dB

ELECTRICAL CHARACTERISTICS – Rx BLOCK (CONTINUED)

V_{CC} = 3 V, T_A = 25°C, measured in the circuit of Figure 26; RF input voltage (V_{RF}) = 60 dBµVemf, RF frequency (f_{RF}) = 98.1 MHz, Audio signal frequency (f_{AF}) = 1kHz, Mono, FM = 22.5 kHzdev (30% at 75-kdev ref.), BW = LPF 30 k (unless otherwise noted)

Stereo Noise Control

PARAMETER		TEST CONDITIONS	TYP	UNIT
V_{SNC}	SNC start point	22.5 kHzdev, f_{AF} = 1 kHz, Pilot = 7.5 kHzdev (10%), SNC = 1, Separation = 20 dB	36	dBµVemf

RSSI

PARAMETER		TEST CONDITIONS	TYP	UNIT
$V_{RSSI\ MIN}$	RSSI minimum input level	RSSI[3:0] 0 to1 (dec) at I^2C read mode	9	dBµVemf
RES_{RSSI}	RSSI resolution		2	dB

IF Counter

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{I\ IFCC}$	RF input level for correct IF count	0 to 127		9		dBµVemf
BIT_{IFC}	Counter length			7		Bit
D_{IFC}	Prescaler ratio			64		
$t_{IFC\ GATE}$	Gate time	1/(32.768 kHz/400)		12.207		ms
RES_{IFC}	Resolution	64 × 32.768 kHz/400		5.24288		kHz
$N_{IFC\ CNT}$	Count center	325k/64/32.768 kHz × 400		62		Dec
$N_{IFC\ STOP}$	IF counter result for search stop		57		67	Dec

ELECTRICAL CHARACTERISTICS – Tx BLOCK

V_{CC} = 3 V, T_A = 25°C, measured in the circuit of Figure 26; RF frequency f_{RF} = 98.1 MHz, BAND = 0 (USEU), MODADJ[3:0] = +6 dB (for 98.1 MHz), Audio signal frequency f_{AF} = 1 kHz, 100% means FM 75 kdev, BW = LPF 30 k, TxPOW[1:0] = –7 dBm measured with typical home hi-fi tuner (unless otherwise noted)

AF

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$MODR_{AF\ ADJ}$	AF modulation adjust ratio	AFADJ [2:0] = 000		–9		dB
		AFADJ [2:0] = 001		–6		
		AFADJ [2:0] = 010		–3		
		AFADJ [2:0] = 011 (Ref.)		0		
		AFADJ [2:0] = 100		3		
		AFADJ [2:0] = 101		6		
		AFADJ [2:0] = 110		9		
		AFADJ [2:0] = 111		12		
$V_{IMAX\ 50}$	AF maximum input level (pre-emphasis 50 µs)	AFADJ = 0 dB, EMTC = 0, fs = 400 Hz, L = R each channel			1000	mVpp
		AFADJ = 0 dB, EMTC = 0, fs = 10 kHz, L = R each channel			330	
$V_{IMAX\ 75}$	AF maximum input level (pre-emphasis 75 µs)	AFADJ = 0 dB, EMTC = 1, fs = 400 Hz, L = R each channel			1000	mVpp
		AFADJ = 0 dB, EMTC = 1, fs = 10 kHz, L = R each channel			200	
V_{IAF}	AF yypical input level for 100% dev	AFADJ = 0 dB, fs = 400 Hz, DIS_EM = 0, L = R each channel		250		mVrms
f_{IAFR}	Input frequency range		20		15 k	Hz
R_{IAF}	AF input impedance			40		kΩ
t_{PRE}	Pre-emphasis	EMTC bit = 0		50		µs
		EMTC bit = 1		75		
f_{LPF}	AFLPF frequency response	DIS_AFLPF = 0, –3 dB		15		kHz

Mono Mode

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{O\ MONO}$	Output frequency response	CP = 1.25 µA	20		15 k	Hz
S/N_{MONO98}	Mono signal-to-noise ratio at 98.1 MHz (100% modulation)	L = R = 250 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 5 dB, PLTADJ = off, MONO_ST = 1, RF = 98.1 MHz, BAND = 0		55		dB
THD_{MONO98}	Mono total harmonic distortion at 98.1 MHz (30% modulation)	L = R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 5 dB, PLTADJ = off, MONO_ST = 1, RF = 98.1 MHz, BAND = 0		1		%
S/N_{MONO83}	Mono signal-to-noise ratio at 83 MHz (100% modulation)	L = R = 250 mVrms, f_{AF} = 1kHz, AFADJ = 0 dB, MODADJ = 11 dB, PLTADJ = off, MONO_ST = 1, RF = 83 MHz, BAND = 1		55		dB
THD_{MONO83}	Mono total harmonic distortion at 83 MHz (30% modulation)	L = R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 11 dB PLTADJ = off, MONO_ST = 1, RF = 83 MHz, BAND = 1		0.5		%
$ATT_{MT\ MONO}$	MUTE attenuation	MUTE bit = 1	50			dB

ELECTRICAL CHARACTERISTICS – Tx BLOCK (CONTINUED)

V_{CC} = 3 V, T_A = 25°C, measured in the circuit of Figure 26; RF frequency f_{RF} = 98.1 MHz, BAND = 0 (US/EU), MODADJ[3:0] = +6 dB (for 98.1 MHz), Audio signal frequency f_{AF} = 1 kHz, 100% means FM 75kdev, BW = LPF 30 k, TxPOW[1:0] = –7 dBm measured with typical home hi-fi tuner (unless otherwise noted)

Stereo Mode

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
S/N_{ST98}	Stereo signal-to-noise ratio at 98.1 MHz Main + Sub = 90%, Pilot = 10%	L = R = 225 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 5 dB, PLTADJ = 0 dB, f_{RF}= 98.1 MHz, BAND = 0		55		dB
SEP_{ST98}	Stereo separation at 98.1 MHz Main + Sub = 30%, Pilot = 10%	L or R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 5 dB, PLTADJ = 0 dB,f_{RF} = 98.1 MHz, BAND = 0		25		dB
THD_{ST98}	Stereo total harmonic distortion at 98.1 MHz Main + Sub = 30%, Pilot = 10%	L or R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 5 dB, PLTADJ = 0 dB, f_{RF} = 98.1MHz, BAND = 0		1		%
S/N_{ST83}	Stereo signal-to-noise ratio at 83 MHz Main + Sub = 90%, Pilot = 10%	L = R = 225 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 11 dB, PLTADJ = 0 dB, f_{RF} = 83 MHz, BAND = 1		55		dB
SEP_{ST83}	Stereo separation at 83 MHz Main + Sub = 30%, Pilot = 10%	L or R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 11 dB, PLTADJ = 0 dB, f_{RF} = 83 MHz, BAND = 1		30		dB
THD_{ST83}	Stereo total harmonic distortion at 83 MHz Main + Sub = 30%, Pilot = 10%	L or R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 11 dB, PLTADJ = 0 dB, f_{RF} = 83 MHz, BAND = 1		0.5		%
$DIFF_{ST\ MOD}$	Left and right channel modulation difference	L = R = 75 mVrms, f_{AF} = 1 kHz, AFADJ = 0 dB, MODADJ = 11 dB, PLTADJ = 0 dB, f_{RF} = 98.1 MHz, BAND = 1 Lch level ref.	–1		1	dB

EXT IN

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{EXT\ MAX}$	Maximum input level	EN_EXTIN = 1, DIS_LRIN = 0			500	mVpp
$f_{R\ EXT}$	Input frequency range	EN_EXTIN = 1, DIS_LRIN = 0	20		80 k	Hz
V_{OPLT}	Pilot output level	EN_EXTIN = 1, DIS_LRIN = 0		40		mVrms
$V_{EXT\ TYP}$	Typical input level for 100% dev	EN_EXTIN = 1, DIS_LRIN = 0		125		mVrms

RF Power

PARAMETER		TEST CONDITIONS	TYP	UNIT
V_{TxOUT}	Tx output power	TXPOW[1:0] = 00, R_{TX} = open, R_L = 50 Ω, EN_EXTIN = 0, DIS_LRIN = 1	–7	dBm
		TXPOW[1:0] = 01, R_{TX} = 300 Ω, R_L = 50 Ω, EN_EXTIN = 0, DIS_LRIN = 1	–3	
		TXPOW[1:0] = 10, R_{TX} = 300 Ω, R_L = 50 Ω, EN_EXTIN = 0, DIS_LRIN = 1	1	
		TXPOW[1:0] = 11, R_{TX} = 150 Ω, R_L = 50 Ω, EN_EXTIN = 0, DIS_LRIN = 1	4	

I²C DATA FORMAT

I²C Write Data (R/W = 0)

Table 1. Rx-Mode Write Data (Address Bit 2, 1 = 0,0)

BYTE	BIT 7 (MSB)	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
Address	1	1	0	0	0	0	0	R/W = 0
Data 1	MUTE	SM	N13	N12	N11	N10	N9	N8
Data 2	N7	N6	N5	N4	N3	N2	N1	N0
Data 3	SM_UD	SM_SL1	SM_SL0	LOC_HL	MONO_ST	MUTE_R	MUTE_L	PORT1
Data 4	PORT2	STBY	BAND	A_MUTE	S_MUTE	HCC	SNC	SM_IND
Data 5	DIS_EM	EMTC	EN_MPXOUT	0	0	0	CP1	CP0
Data 6–8	Reserved(1)							

(1) Do not write any data on reserved area. The data of this area is loaded at power-on-reset.

Table 2. Tx-Mode Write Data (Address Bit 2, 1 = 1,1)

BYTE	BIT 7 (MSB)	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
Address	1	1	0	0	0	1	1	R/W = 0
Data 1	MUTE	0	N13	N12	N11	N10	N9	N8
Data 2	N7	N6	N5	N4	N3	N2	N1	N0
Data 3	PLTADJ2	PLTADJ1	PLTADJ0	EN_EXTIN	MONO_ST	TxPOW1	TxPOW0	PORT1
Data 4	PORT2	STBY	BAND	MODADJ3	MODADJ2	MODADJ1	MODADJ0	DIS_AFLPF
Data 5	DIS_EM	EMTC	DIS_LRIN	AFADJ2	AFADJ1	AFADJ0	CP1	CP0
Data 6–8	Reserved(1)							

(1) Do not write any data on reserved area. The data of this area is loaded at power-on-reset.

I²C Write Data (R/W = 1)

Table 3. Rx-Mode Write Data (Address Bit 2, 1 = 0,0)

BYTE	BIT 7 (MSB)	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
Address	1	1	0	0	0	0	0	R/W = 1
Data 1	READY	BAND_LMT	N13	N12	N11	N10	N9	N8
Data 2	N7	N6	N5	N4	N3	N2	N1	N0
Data 3	ST_IND	IFC6	IFC5	IFC4	IFC3	IFC2	IFC1	IFC0
Data 4	RSSI3	RSSI2	RSSI1	RSSI0	LOCKDET	X	X	X

Table 4. Tx-Mode Write Data (Address Bit 2, 1 = 1,1)

BYTE	BIT 7 (MSB)	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
Address	1	1	0	0	0	1	1	R/W = 1
Data 1	0	0	N13	N12	N11	N10	N9	N8
Data 2	N7	N6	N5	N4	N3	N2	N1	N0
Data 3	ST_IND	1	1	1	1	1	1	1
Data 4	1	1	1	1	X	1	1	1

Table 5. Rx-Mode Write Data Symbol Description (Address Bit 2, 1 = 0,0)

SYMBOL	DESCRIPTION			DEFAULT
MUTE	Mute control bit	0: Mute off 1: Mute on		0
SM	Search mode control bit	0: Off 1: On (start search when 0 to 1)		0
N13–N0	Programmable counter bits	Set main counter		All 0
SM_UD	Search up/down set bit	0: Down 1: Up		1
SM_SL1, SM_SL0	Search stop-level bits	SM_L1	SM_L0	RSSI Level	1, 1
		0	0	≥0 (test function)	
		0	1	≥5	
		1	0	≥8	
		1	1	≥12	
LOC_HL	Local high-/low-side injection control bit	0: Low-side LO injection 1: High-side LO injection			1
MONO_ST	Mono/stereo switch	0: Auto stereo 1: Forced mono			0
MUTE_R, MUTE_L	R-ch mute switch, L-ch mute switch	0: Mute off 1: Mute on			0, 0
PORT1	Port 1 control bit	PORT 1 is enable as general purpose port in condition of SM_IND = 0 0: Low (Nch-MOS open drain on) 1: High (Nch-MOS open drain off) When SIM_IND = 1, PORT 1 outputs search indicator.			1
PORT2	Port 2 control bit	0: Low (open drain on) 1: High (open drain off)			1
STBY	Standby control bit	0: Standby off 1: Standby on			1
BAND	Band selection at search mode	0: US/EU band (87.5 MHz to 108 MHz) 1: Japan band (76 MHz to 90 MHz)			0
A_MUTE	Auto mute control bit	0: Off 1: On (auto mute when PLL unlocked or search mode)			0
S_MUTE	Soft mute control bit	0: Off 1: On			0
HCC	High cut control bit	0: Off 1: On			0
SNC	Stereo noise cancel bit	0: Off 1: On			0
SM_IND	Search indicator control bit	0: Disable indicator. Port 1 is controlled by bit PORT1. 1: Enable indicator. Port1 outputs as search indicator (in search sequence: L, Normal operation: H).			0
DIS_EM	Disable De-emphasis bit	0: De-emphasis on 1: De-emphasis off			0
EMTC	Time constant control bit for De-emphasis	0: 50 µs 1: 75 µs			1
EN_MPXOUT	MPX output control bit	0: Output disable 1: Output enable			0
CP1, CP0	CP current selection bit 1, CP current selection bit 0	CP1	CP0	CP Current	1, 0
		0	0	0.6 µA	
		0	1	1.25 µA	
		1	0	2.5 µA	
		1	1	5 µA	

Table 6. Tx-Mode Write Data Symbol Description (Address Bit 2, 1 = 1,1)

SYMBOL	DESCRIPTION		DEFAULT
MUTE	Mute control bit	0: Mute off 1: Mute on	0
N13–N0	Programmable counter bits	Set main counter	All 0
PLTADJ2, PLTADJ1, PLTADJ0	Pilot-level adjust bits	PLTADJ2 / PLTADJ1 / PLTADJ0 / Level 0 / 0 / 0 / –6 dB 0 / 0 / 1 / –4 dB 0 / 1 / 0 / –2 dB 0 / 1 / 1 / 0 dB 1 / 0 / 0 / 2 dB 1 / 0 / 1 / 4 dB 1 / 0 / 0 / 6 dB 1 / 1 / 1 / Pilot off (AFADJ[2:0] = 011, 0 dB = L = R = 10% of 250 mVrms 100% dev)	0, 1, 1
EN_EXTIN	EXT input enable bit	0: Disable EXT IN, PLT OUT 1: Enable EXT IN, PLT OUT	0
MONO_ST	Mono/stereo switch	0: 38 kHz subcarrier on 1: 38 kHz subcarrier off For mono mode, PLTADJ bits have to be set as PLTADJ[2:0] = 111	0
TxPOW1, TxPOW0	Tx power-level selection bits	TxPOW1 / TxPOW0 / Level 0 / 0 / –7 dBm 0 / 1 / 3 dBm 1 / 0 / 1 dBm 1 / 1 / 4 dBm	0, 0
PORT1, PORT2	Port 1 control bit, Port 2 control bit	PORT1 and PORT2 are enabled as general purpose ports. 0: Low (Nch-MOS open drain on) 1: High (Nch-MOS open drain off)	1, 1
STBY	Standby control bit	0: Standby off 1: Standby on	1
BAND	Band selection at search mode	0: US/EU band (87.5 MHz to 108 MHz) 1: Japan band (76 MHz to 90 MHz)	0
MODADJ3, MODADJ2, MODADJ1, MODADJ0	Modulation adjust bits	MODADJ3 / MODADJ2 / MODADJ1 / MODADJ0 / Total Composite Level 0 / 0 / 0 / 0 / 0 dB 0 / 0 / 0 / 1 / 1 dB 0 / 0 / 1 / 0 / 2 dB 0 / 0 / 1 / 1 / 3 dB 0 / 1 / 0 / 0 / 4 dB 0 / 1 / 0 / 1 / 5 dB 0 / 1 / 1 / 0 / 6 dB 0 / 1 / 1 / 1 / 7 dB 1 / 0 / 0 / 0 / 8 dB 1 / 0 / 0 / 1 / 9 dB 1 / 0 / 1 / 0 / 10 dB 1 / 0 / 1 / 1 / 11 dB 1 / 1 / 0 / 0 / 12 dB 1 / 1 / 0 / 1 / 13 dB 1 / 1 / 1 / 0 / 14 dB 1 / 1 / 1 / 1 / 15 dB	
DIS_AFLPF	Disable 15-kHz LPF	0: AF 15-kHz LPF enable 1: AF 15-kHz LPF disable	0
DIS_EM	Disable pre-emphasis bit	0: Pre-emphasis on 1: Pre-emphasis off	0
EMTC	Time constant control bit for pre-emphasis	0: 50 µs 1: 75 µs	1
DIS_LIN, DIS_RIN	MPX output control bit	0: Output disable 1: Output enable	0

Table 6. Tx-Mode Write Data Symbol Description (Address Bit 2, 1 = 1,1) (continued)

SYMBOL	DESCRIPTION					DEFAULT
AFADJ2, AFADJ1, AFADJ0	AF-level adjust bits	AFADJ2	AFADJ0	AFADJ1	Level	0, 1, 1
		0	0	0	–9 dB	
		0	0	1	–6 dB	
		0	1	0	–3 dB	
		0	1	1	0 dB	
		1	0	0	3 dB	
		1	0	1	6 dB	
		1	1	0	9 dB	
		1	1	1	12 dB	
CP1, CP0	CP current selection bit 1, CP current selection bit 0	CP1	CP0		CP Current	1, 0
		0	0		0.6 µA	
		0	1		1.25 µA	
		1	0		2.5 µA	
		1	1		5 µA	

Table 7. Rx-Mode Read Data Symbol Description (Address Bit 2, 1 = 0,0)

SYMBOL	DESCRIPTION	
READY	Ready flag	0: PLL unlocked or search operation 1: Normal operation
BAND_LMT	Band limit flag at end of search operation	0: Not reached band limit (found station) 1: Reached band limit (not found station) (reset to 0 when I^2C date write)
N13–N0	Programmable counter bits	Setting of counter after search
ST_IND	Stereo indicator bit	0: Mono reception 1: Stereo reception
IFC6–0	IF counter result bits	IF counter result (0 to 127 dec) Step frequency = (64 × 32.768 k)/400 = 5.24288 k (Hz)
RSSI3–0	RSSI level bits	RSSI level (0 to 15 dec)
LOCKDET	Lock detect flag	0: Unlocked 1: Locked

Table 8. Tx-Mode Read Data Symbol Description (Address Bit 2, 1 = 1,1)

SYMBOL	DESCRIPTION	
N13–N0	Programmable counter bits	Setting of main counter
ST_IND	Stereo indicator bit	0: Stereo modulation 1: Other status

Table 9. Examples of Tx Mode Adjustment Bit Settings(1)

BAND	Tx FREQUENCY (MHz)	MODADJ LEVEL(2) (dB)	MODADJ BIT[3:0]	AFADJ LEVEL(3) (dB)	AFADJ BIT[2:0]	PLTADJ LEVEL (dB)	PLTADJ BIT[2:0]
US/EU	87.5	9	1001	0	011	0	011
US/EU	108	3	0011	0	011	0	011
JP	76	13	1101	0	011	0	011
JP	90	8	1000	0	011	0	011

(1) These settings are to obtain audio modulation level of 22.5 kHzdev (30% modulation) and pilot level of 7.5 kHzdev (10% modulation) when audio input level = 75 mVrms and audio input frequency = 400 Hz.
(2) An adequate level for each Tx frequency should be selected for MODADJ. See Figure 33 and Figure 34.
(3) AFADJ should be adjusted to maintain audio level × adjust level (dB) less than 250 mVrms. For example, when audio input level for 100% modulation is 500 mVrms, AFADJ should be –6 dB (AFADJ[2:1] = 001).

PLL Setting

N13–N0 14-bit word (NPLL) can be calculated as follows:

f_{IF}= IF frequency (325 kHz)

f_{RF} = Wanted tuning frequency

f_{IXTAL} = Crystal frequency (32.768 kHz)

Rx		Tx
Upper Local Setting	Lower Local Setting	
$N_{PLL} = 4 \times \frac{f_{RF} + f_{IF}}{f_{XTAL}}$	$N_{PLL} = 4 \times \frac{f_{RF} - f_{IF}}{f_{XTAL}}$	$N_{PLL} = 4 \times \frac{f_{RF}}{f_{XTAL}}$

Example for Rx mode:

f_{RF} = 81.3 MHz, lower local

$$N_{PLL} = 4 \times \frac{81.3M - 325k}{32.768} = 9885$$

The PLL word becomes 269Dh (N[13:0] = 10 0110 1001 1101).

Example for Tx mode:

f_{RF} = 88 MHz

$$N_{PLL} = 4 \times \frac{88M}{32.768k} = 10742$$

The PLL word becomes 29F6h (N[13:0] = 10 1001 1111 0110).

Standby Mode

Standby mode can be controlled by STBY pin voltage and STBY bit data as shown in Table 10.

Table 10. Standby Mode

VOLTAGE APPLIED ON STBY PIN	I^2C STBY BIT DATA	DEVICE OPERATION
L	0	Standby
L	1	Standby
H	0	Normal Operation
H	1	Standby

FM Transmitter Block

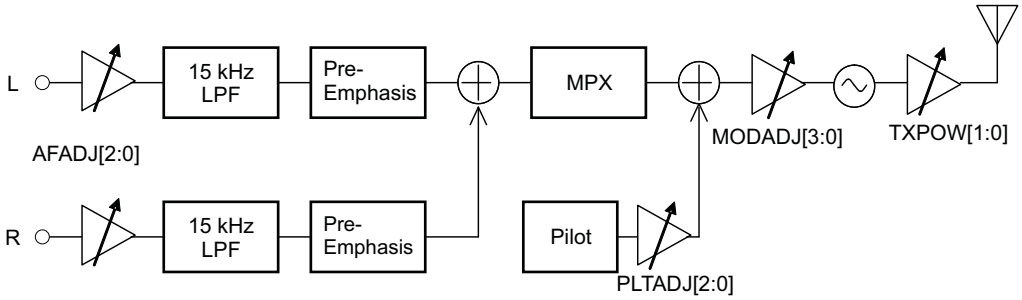
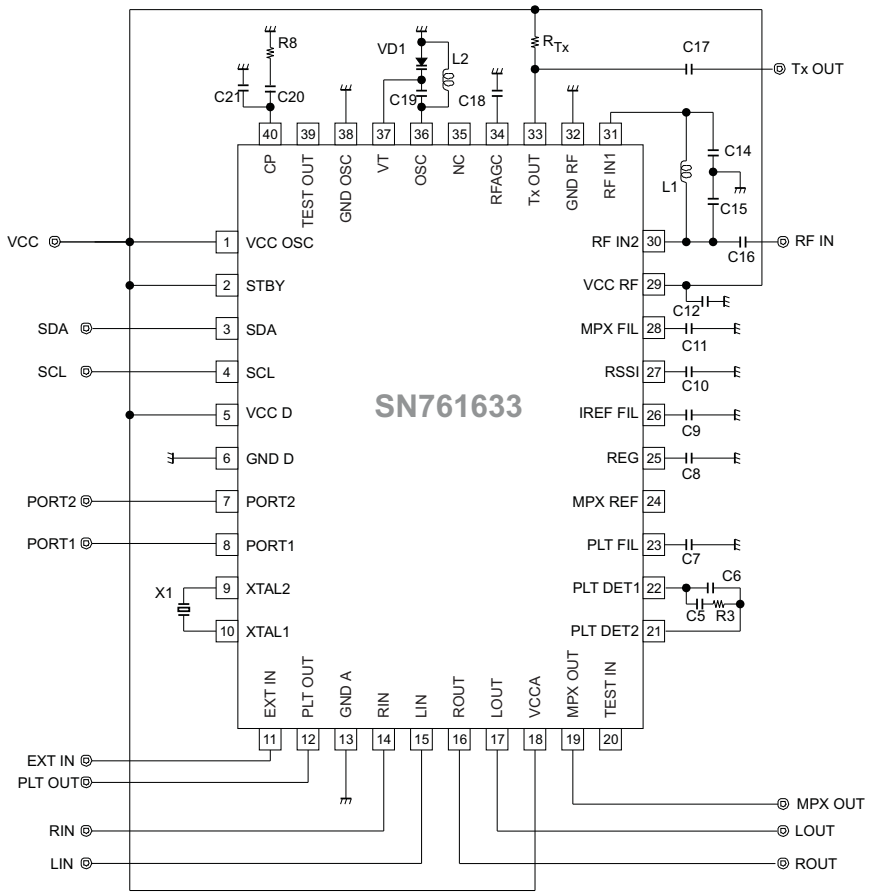


Figure 25. FM Transmitter Block Diagram

Initial setting	Audio input level:	L = R = 75 mVrms, AFADJ = 0 dB, fs = 400 Hz	
	Pilot level:	PLTADJ = 0 dB means 10%	
	FM modulation:	MODADJ depends on Tx frequency to be 22.5 kHz dev.	
	Output power:	TxPOW = –7 dBm	Pullup resistance is not necessary.
		TxPOW =–3, 1 dB	Antenna load 50 Ω add pullup resistance R_{TX} 300 Ω
		TxPOW = 4 dBm	Antenna load 50 Ω add pullup resistance R_{TX} 150 Ω

APPLICATION INFORMATION



PART NAME	VALUE	PART NAME	VALUE
C5 (PLT DET)	0.22 µF	C18 (RFAGC)	4.7 nF
C6 (PLT DET)	22 nF	C19 (OSC)	1 nF
C7 (PLT FIL)	0.1 µF	C20 (CP)	0.47 µF
C8 (REG)	0.1 µF	C21 (CP)	1 nF
C9 (IREF FIL)	0.1 µF	L1 (RF IN)	100 nH
C10 (RSSI)	0.01 µF	L2 (OSC)	24 or 27 nH
C11 (MPX FIL)	0.47 µF	R3 (PLT DET)	2.2 kΩ
C12 (VCC RF)	0.1 µF	R8 (CP)	22 kΩ
C14 (RF IN1)	68 pF	R_{TX} (Tx OUT)	150 or 300 or open
C15 (RF IN2)	22 pF	VD1	BB202 or RKV651KK
C16 (RF IN2)	330 pF	X1	32.768 kHz, C_L = 12.5 pF
C17 (Tx OUT)	0.01 µF		

A. This application information is advisory and a performance check is required at actual application circuits. TI assumes no responsibility for the consequences of use of this circuit, such as an infringement of intellectual property rights or other rights, including patents of third parties.

Figure 26. Application Circuit

RDS Solution

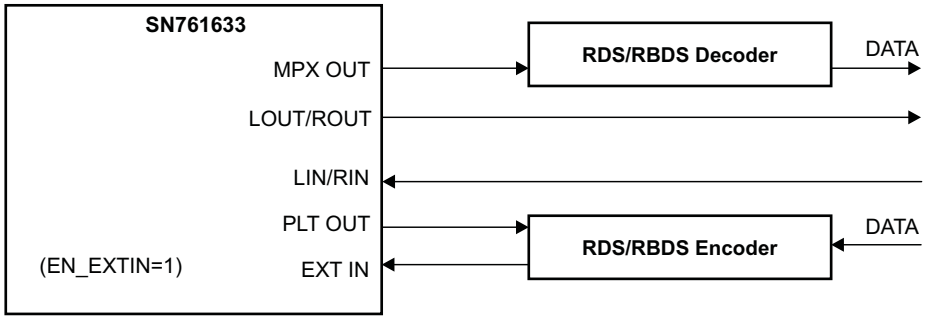


Figure 27. RDS Solution 1

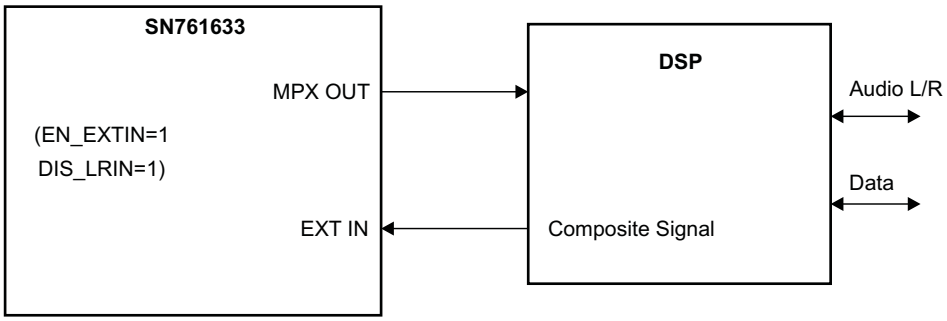


Figure 28. RDS Solution 2 (DSP Interface)

Mixing Mode (Tx)

LIN/RIN and EXT IN signals can be mixed as a Tx signal.

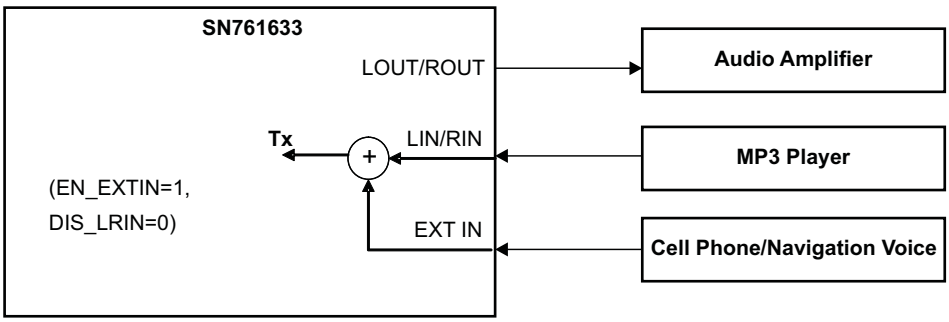
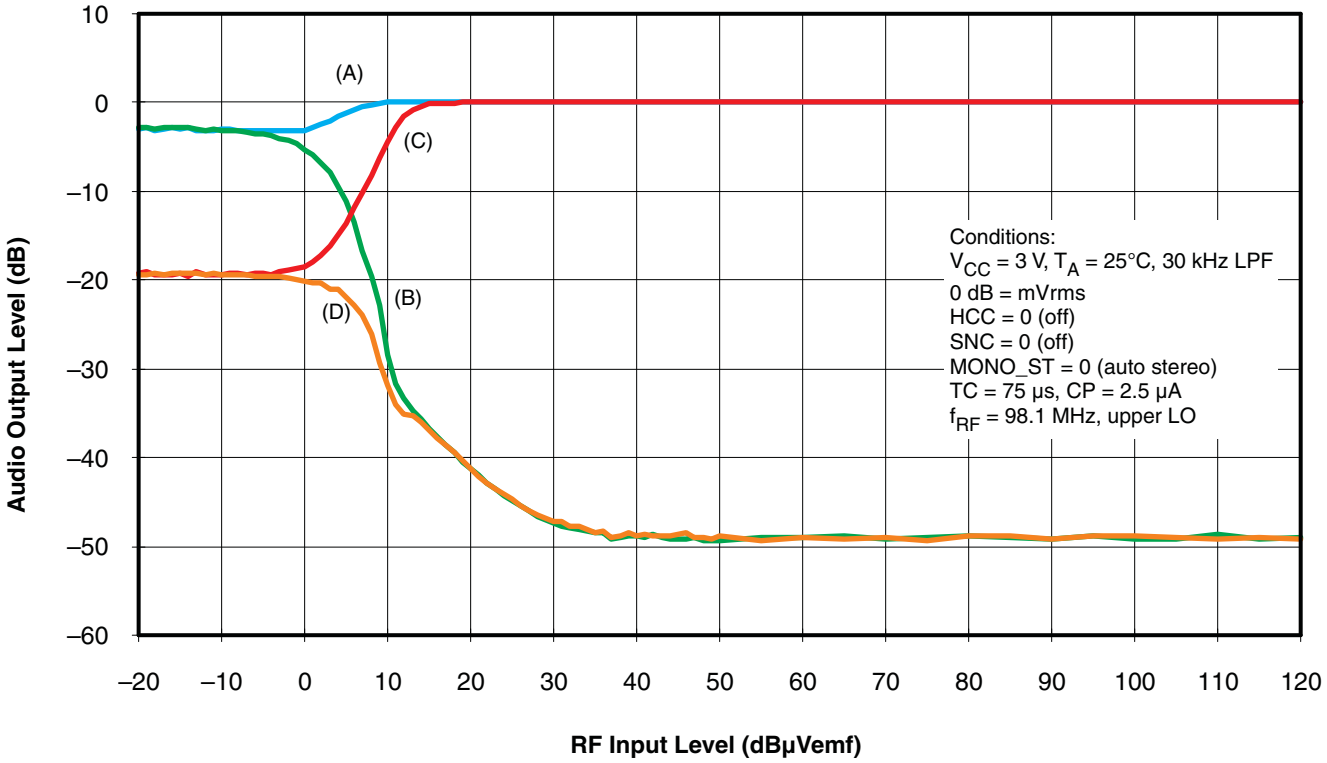


Figure 29. Mixing Mode of Tx Signal

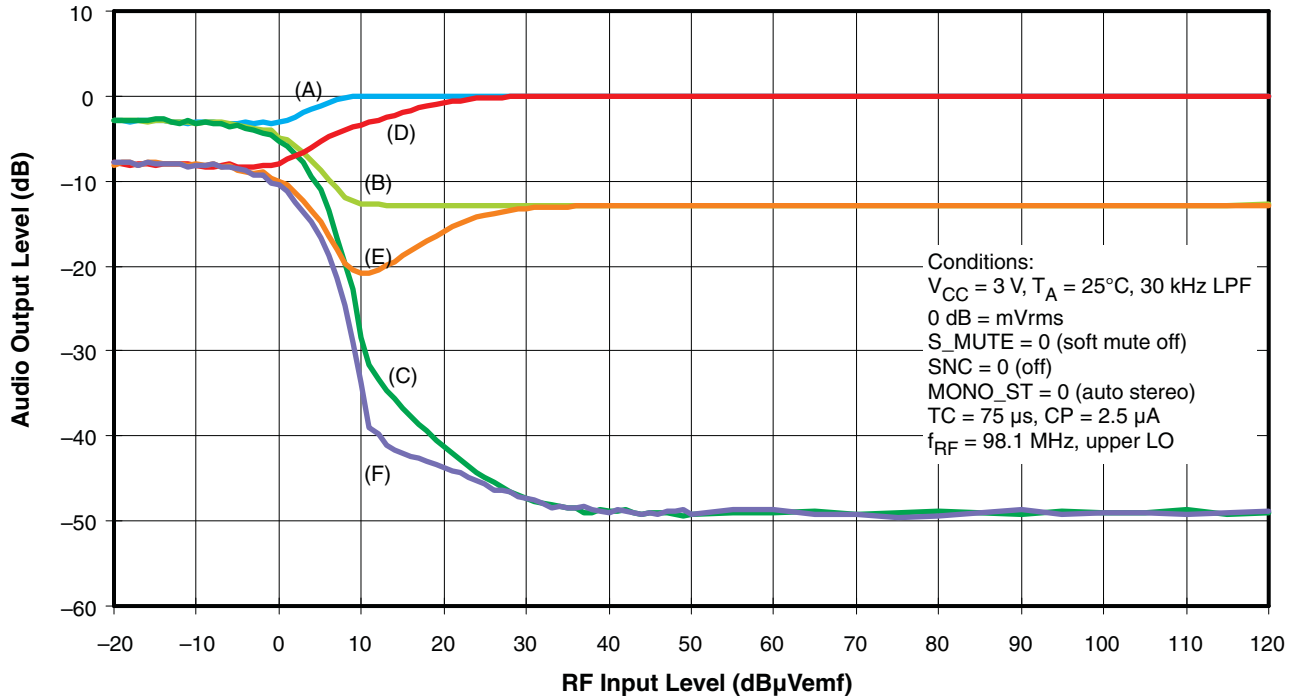
TYPICAL CHARACTERISTICS



A. Mono signal, soft mute off (f_{AF} = 1 kHz, 22.5 kHz dev, 30%)
B. Noise in mono mode, soft mute off
C. Mono signal, soft mute on (f_{AF} = 1 kHz, 22.5 kHz dev, 30%)
D. Noise in mono mode, soft mute on

Figure 30. Rx-Mode FM Mono Characteristics (Soft Mute On/Off)

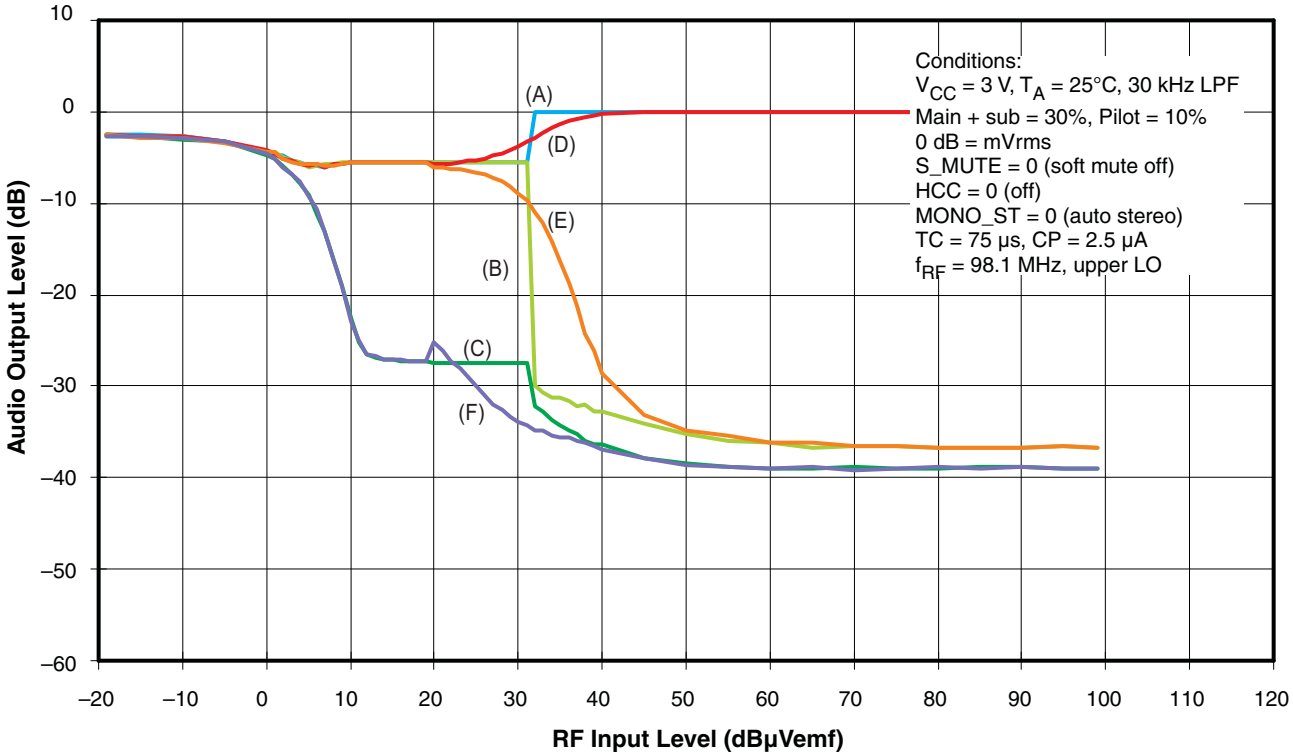
TYPICAL CHARACTERISTICS (continued)



A. Mono signal, high cut off (f_{AF} = 1 kHz, 22.5 kHz dev, 30%)
B. Mono signal, high cut off (f_{AF} = 10 kHz, 22.5 kHz dev)
C. Noise in mono mode, high cut off
D. Mono signal, high cut on (f_{AF} = 1 kHz, 22.5 kHz dev, 30%)
E. Mono signal, high cut on (f_{AF} = 10 kHz, 22.5 kHz dev)
F. Noise in mono mode, high cut on

Figure 31. Rx-Mode FM Mono Characteristics (High Cut Control [HCC] On/Off)

TYPICAL CHARACTERISTICS (continued)



A. Stereo left signal, noise control off (f_{AF} = 1 kHz, 22.5 kHz dev)
B. Stereo right signal, noise control off (audio signal off)
C. Noise in stereo mode, noise control off
D. Stereo left signal, noise control on (f_{AF} =1 kHz, 22.5 kHz dev)
E. Stereo right signal, noise control on (audio signal off)
F. Noise in stereo mode, noise control cut on

Figure 32. Rx-Mode FM Stereo Characteristics [Stereo Noise Control (SNC) On/Off]

TYPICAL CHARACTERISTICS (continued)

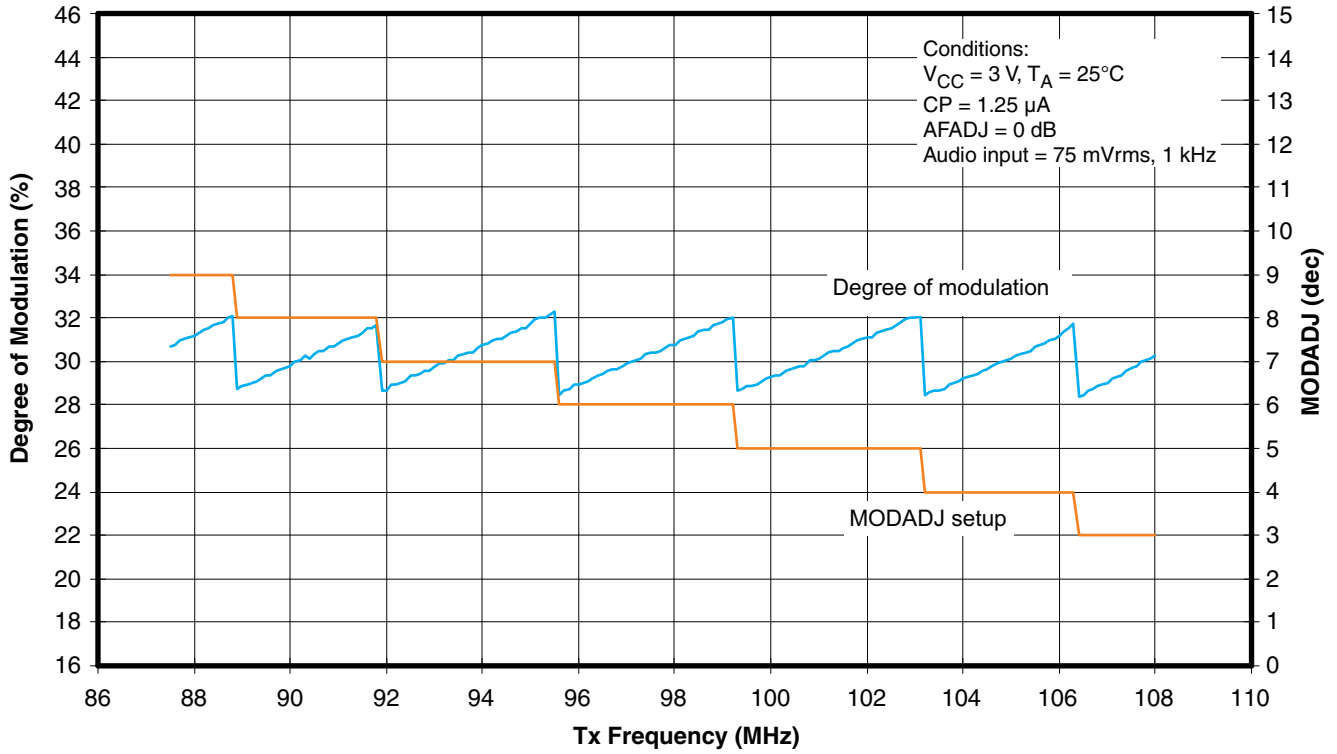


Figure 33. Tx Modulation Characteristics (US/EU Band)

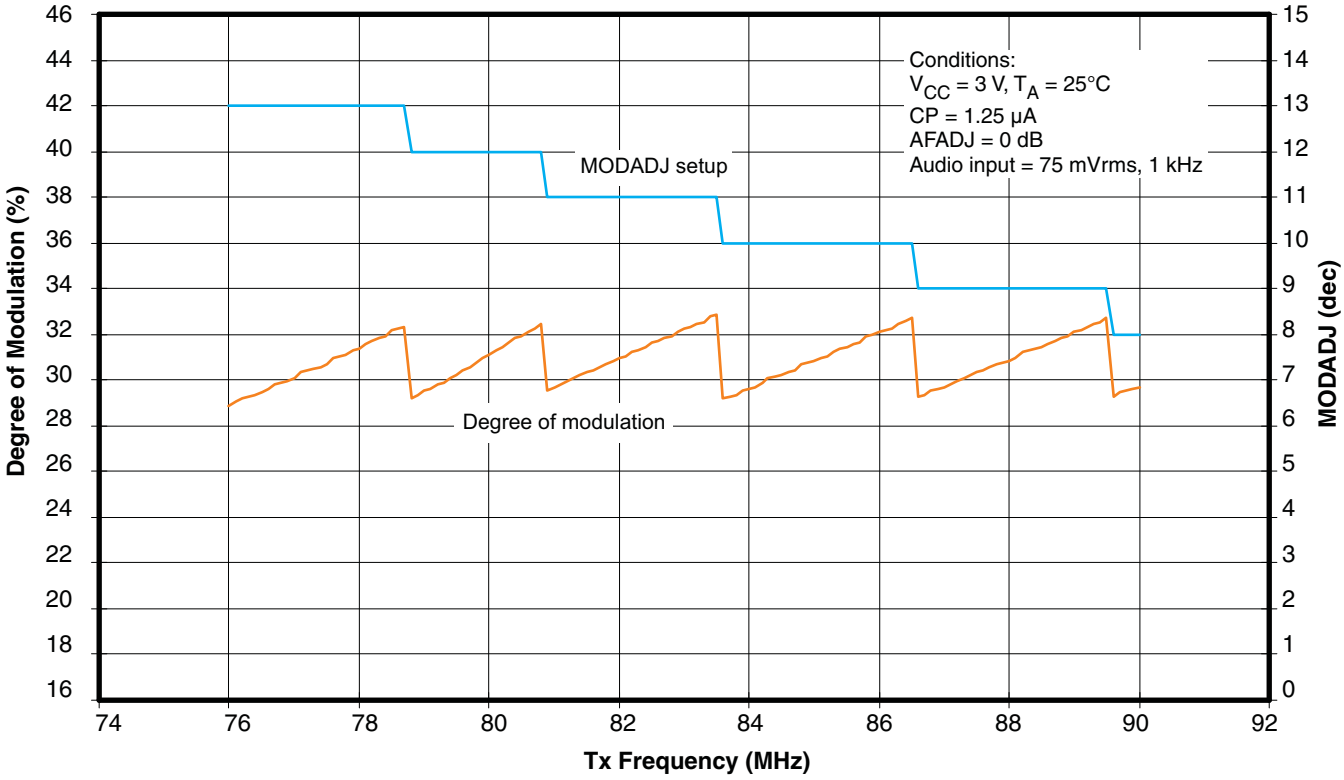


Figure 34. Tx Modulation Characteristics (Japan Band)

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN761633RTAR	OBSOLETE	WQFN	RTA	40		TBD	Call TI	Call TI	-20 to 85	SN76 1633	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

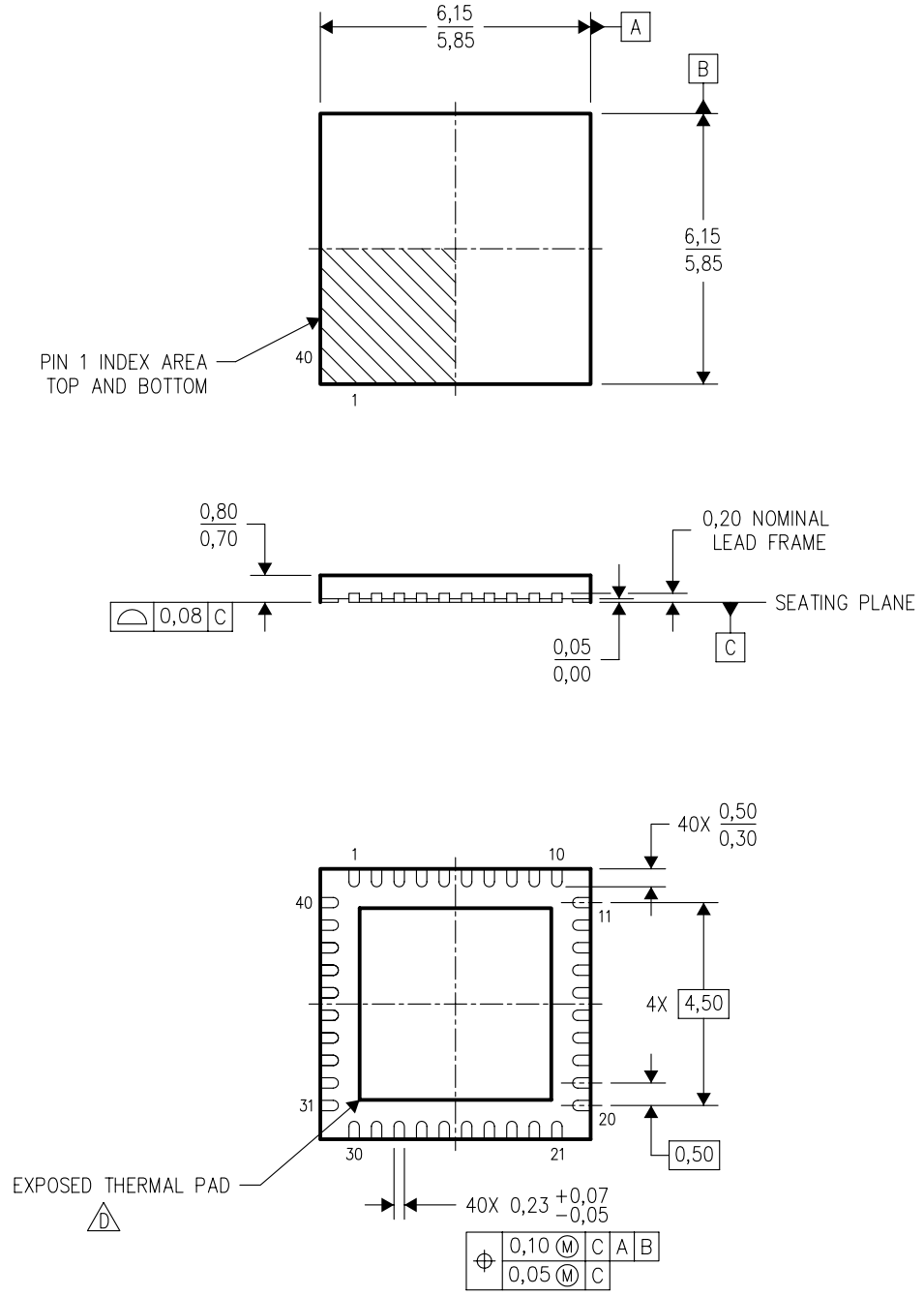
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

RTA (S–PQFP–N40) PLASTIC QUAD FLATPACK



4204422/B 11/04

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. QFN (Quad Flatpack No–Lead) Package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.

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