Cordless Telephone Signal Processor

Description

The programmable cordless phone signal processor includes all necessary low-frequency parts such as microphone- and earphone amplifier, compander, pre-emphasis, deemphasis, scrambler, data management, power-supply management, as well as RF receiving parts such as IF converter, FM demodulator. RSSI and low-noise amplifier.
Several gains and mutes in transmit and receive direction are controlled by the serial bus while compander, pre- and deemphasis and scrambler can be bypassed.

Features

RF Receiver Part

- Low-noise amplifier
- IF converter
- FM demodulator
- RSSI

Low-Frequency Part

- Symmetrical input of microphone amplifier
- Symmetrical output of earpiece amplifier
- Compander
- Pre- and deemphasis
- Scrambler
- Data management
- Power-supply management
- Serial bus

Application: CT0

Block Diagram

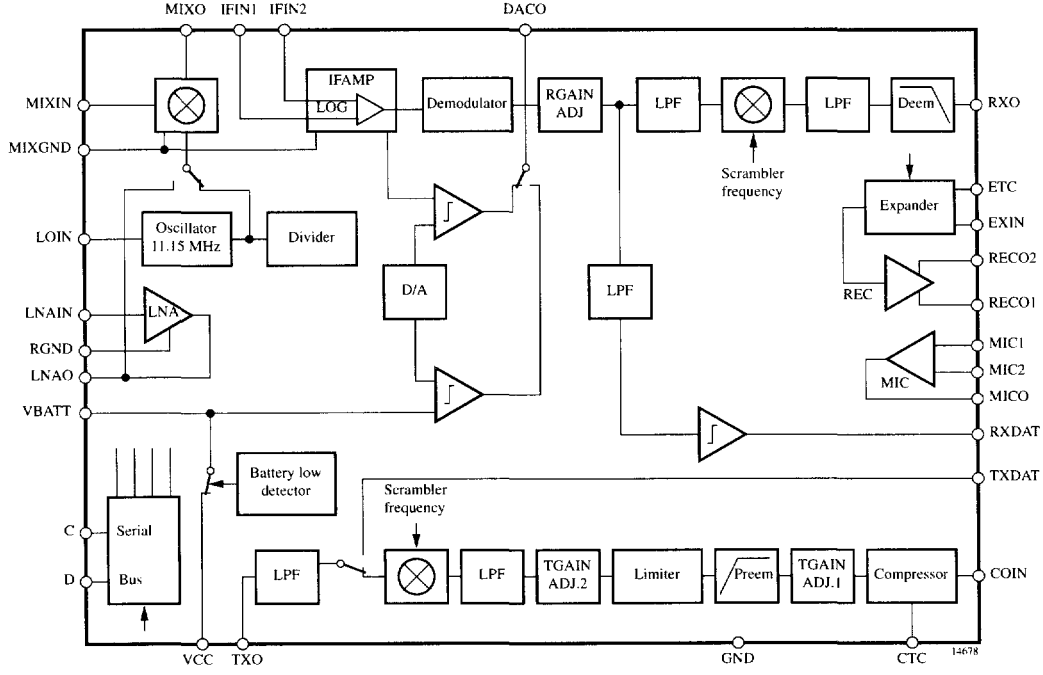

Figure 1. Block diagram

Pin Description

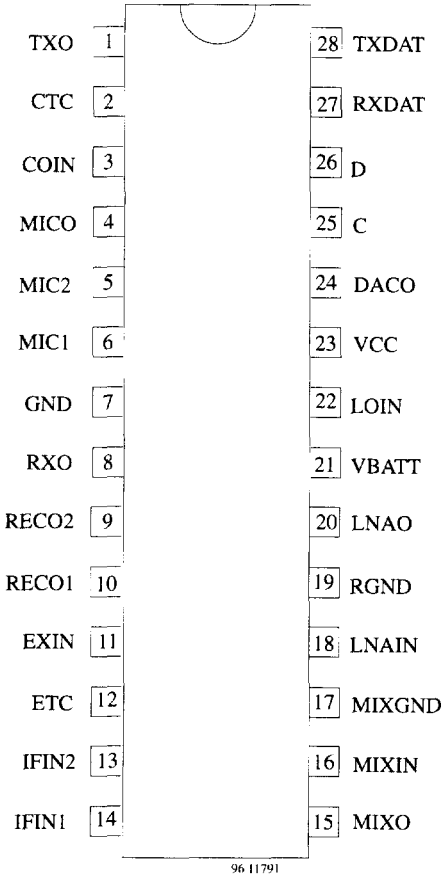

Figure 2. Pinning

Pin	Symbol	Function
1	TXO	Transmit section analog output
2	CTC	Compressor time constant control analog output
3	COIN	Compressor analog input
4	MICO	Microphone amplifier output
5	MIC2	Non-inverting input of microphone amplifier
6	MIC1	Inverting input of microphone amplifier
7	GND	LF analog/ digital ground
8	RXO	Intermediate receive analog output
9	RECO2	Symmetrical output of receive amplifier
10	RECO1	Symmetrical output of receive amplifier
11	EMN	Expander analog input
12	ETC	Expander time constant control analog output
13	IFIN2	Symmetrical IF amplifier input
14	IFIN1	Symmetrical IF amplifier input
15	MIXO	Mixer output
16	MIXIN	Mixer input
17	MIXGND	IF amplifier and mixer ground
18	LNAIN	Low-noise amplifier input
19	RGND	Low-noise amplifier ground
20	LNAO	Low-noise amplifier output/ External LO input
21	VBATT	Battery supply
22	LOIN	Local oscillator input (11.15 MHz)
23	VCC	Supply-voltage output for peripherals and internal supply of digital part
24	DACO	D/A comparator output
25	C	Clock input of serial bus
26	D	Data input of serial bus
27	RXDAT	Receive data digital output
28	TXDAT	Transmit data input

Ordering Information

Extended Type Number	Package	Remarks
U3500BM-BFL	SO28	Tube
U3500BM-BFLG3	SO28	Taped and reeled

Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	V_{Batt}, V_{CC}	5.5	V
Junction temperature	T_j	+125	°C
Ambient temperature	T_{amb}	–25 to +75	°C
Storage temperature	T_{stg}	–50 to +125	°C
Power dissipation T_{amb} = 60°C	P_{tot}	1	W

Thermal Resistance

Parameters		Symbol	Value	Unit
Junction ambient	SO28	R_{thJA}	120	K/W

Electrical Characteristics

Test conditions (unless otherwise specified): $V_{Batt} = V_{CC} = 3.6$ V, T_{amb} = +25°C

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
Current consumption							
ERX2 ELNA ERXHF ERX1 ERXO EEA EDEE ETX EPREE							
0 0 0 0 0 0 0 0 0							
Operating-voltage range			3.1	3.6	5.2	V	
Inactive mode	V_{Batt} = 2.9 V		30	60	80	µA	
Standby mode				100	120	µA	
RX waiting for RSSI	ELNA = ERXHF = 1		1.7	2.5	3.4	mA	
RX waiting for data	ELNA = ERXHF = ERX1 = 1		1.45	1.9	2.45	mA	
Operating current, RX and TX completely active	ERX2 = ELNA = ERXHF = ERX1 = ERXO = EEA= EDEE = GDEM = ETX = 1		4.5	6.5	9.5	mA	
Low-noise amplifier (LNA) f = 41.4 MHz, input level = –50 dBm							
Supply current			0.8	1	1.2	mA	3
Input impedance			160	200	240	Ω	3
Output impedance			40	80	120	Ω	3
Gain	f = 50 MHz		20	23	26	dB	3
Noise figure	Bandwidth = 1 MHz			4	5	dB	3
1-dB input compression point			–27	–24		dBm	3
Third-order input intercept point	f = 41.4 MHz f = 41.4125 MHz Input level = –60 dBm		–15	–12		dBm	3
Frequency range FRF			20		50	MHz	3

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
Receiver **IF mixer,** f = 10.7 MHz							
Input resistance			2000	3000	4000	Ω	4
Input capacitance			2.5	3	3.5	pF	4
Output impedance			1200	1500	1800	Ω	4
Gain GVMIX	Input level 7 mV_{rms}	G_{MIX}	13	15	17	dB	4
Input compression point			–17			dBm	4
Third-order input intercept point			–9			dBm	4
Carrier breakthrough from internal LO (11.15 MHz) to IF output					300	μV_{rms}	4
Carrier breakthrough from internal LO (11.15 MHz) to RF input					10	μV_{rms}	4
IF amplifier: RSSI							
Input resistance			1.6	2	2.5	kΩ	5
RSSI sensitivity	VIF = 0 μV_{rms} starting from 0 increase RSSI level until mean of sampled signal at DACO is ≤ 0.2 RSSI level = CON0 VIF = 25.4 μV_{rms}, f = 450 kHz increase RSSI level again until mean of sampled signal at DACO is ≤0.2. RSSI level = CON1 RSSI sensitivity = CON1–CON0		1				5
RSSI-input voltage dynamic range			60	65		dB	5
RSSI level number of programmable steps *)				127			5
RSSI-level step size in the logarithmic region			0.35	0.46	0.6	dB	5

*) RSSI Level Programming (Typical Values)

Input Voltage VIF (μV_{rms})	RSSI Level (Decimal)
0	5
25.4	8
42.4	14
424	54
4240	97
42400	111

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
RF demodulator	fIF = 450 kHz, fMOD = 1 kHz, V_{IF} = 500 μV_{rms}						
BSCR EDEE GRX0	GRX1 GRX2 GRX3		ERX1		ERXO		ERX2
1 0 1	1 1 0		1		1		1
Recovered audio	GDEM = 0, ΔfFM = 2.5 kHz GDEM = 1, ΔfFM = 5.0 kHz		0.4 0.4	0.8 0.8	1.6 1.6	Vpp Vpp	6
Recovered audio output voltage drop	V_{Batt} = 3.1 to 5.2 V		–1		+1	dB	6
AM rejection ratio	30% AM		30	35		dB	6
RX audio							
Change of RX0 signal deemphasis bypass	EDEE = 0		–0.5	0	0.5	dB	6
Gain-adjust range			12	15	17	dB	6
Gain-adjust step			0.8	1	1.2	dB	6
Output signal vs. frequency relative to 1 kHz (0 dB) deemphasis bypassed	100 Hz 300 Hz 1800 Hz 3200 Hz 4100 Hz		–7.5 –2.0 –1.3 –0.8	–6.5 –1.0 –0.3 0.2	–5.5 0 0.7 1.2 –60	dB	6
Output signal vs. frequency relative to 1 kHz (0 dB) deemphasis enable EDEE = 1	100 Hz 300 Hz 1800 Hz 3200 Hz 4100 Hz		–0.7 3.7 –5.7 –10	0.3 4.7 –4.7 –9.0	1.3 5.7 –3.7 –8.0 –66	dB	6
Total harmonic distortion	ΔFM = 250 Hz ΔFM = 2.50 kHz				3.5 3.5	% %	6
Audio mute	ΔFM = 2.5 kHz, ERXO = 0 ERX1 = 0, ERX2 = 0		65			dB	6
Output impedance					100	Ω	
Expander EEA	GEA0 GEA1	GEA2	GEA3		GEA4		
1	0 0	0	1		1		
Gain-reference level	VEXIN = –10 dBV_{rms}	G_{OREC}	11	13	15	dB	7
Change of gain when expander is bypassed	BCOMP = 1		–0.5		0.5	dB	7
Gain tracking	VEXIN = –20 dBV_{rms} VEXIN = –30 dBV_{rms} VEXIN = –35 dBV_{rms} VEXIN = –40 dBV_{rms}		–21 –41 –53	 –50 –60	–19 –39 –47	dB	7
Input impedance			9.5		14.5	kΩ	7
Gain change vs. supply voltage	V_{Batt} = 3.1 to 5.2 V		–0.5		0.5	dB	7
Attack time	VEXIN = step –20 dBV_{rms} → –14 dBV_{rms}, measure time after step, when output voltage has 0.75 times the final value	t_f		16		ms	7
Release time	VEXIN = step 14 dBV_{rms} → –20 dBV_{rms}, measure time after step, when output voltage has 1.5 times of the final value	t_f		16		ms	7

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
Earpiece amplifier BCOMP = 1, EEA = 1, VEXIN = 100 mV_{rms}							
Medium gain	GEA0 GEA1 GEA2 GEA3 0 0 0 0 GEA4 = 1		4	5	6	dB	7
Minimum gain	GEA0 GEA1 GEA2 GEA3 0 0 0 0 GEA4 = 0		–12	–11	–10	dB	7
Gain-change versus V_S	V_{Batt} = 3.1 to 5.2 V		–0.2		0.2	dB	7
Gain-adjust range				31		dB	7
Gain adjust step			0.8	1	1.2	dB	7
Output impedance				10	30	Ω	7
Distortion		d_t			2	%	7
Output offset voltage	VEXIN = 0 mV_{rms}		–200		200	mV	7
Output-voltage swing	Increase VEXIN until distortion (RECO1/ RECO2) is 5%		4.8	5.0		Vpp	7
Maximum gain	GEA0 GEA1 GEA2 GEA3 1 1 1 1 GEA4 = 1		19	20	21	dB	7
Low-frequency transmitter GMIC EPREE BSCR G1TX G2TX BCOMP ETX 1 1 1 1000 1000 1 1							
Microphone amplifier VMIC = 10 mV_{rms}, fIN = 1 kHz							
Gain	High gain: GMIC = 1 Low gain: GMIC = 0		31 23	32 24	33 25	dB dB	8
Gain change versus V_S	V_{Batt} = 3.1 to 5.2 V		–0.2	0	0.2	dB	8
Differential input impedance			41	75	103	kΩ	8
Output impedance				10	35	Ω	8
Distortion	VMIC = 10 mV_{rms}	d_t			1	%	8
Output noise (psophmetrically weighted)	VMIC = 0 V_{rms} high gain (inputs closed across 200 Ω)				50	μV_{rmsp}	8
TX audio VCOIN = –20 dBV_{rms}							
Gain	GTX (COIN, TXO)		2.5	5.5	8.5	dB	9
Change of gain TXO	EPREE = 0		–0.5	0	0.5	dB	9
Gain between 3.2 and 5.2 V			–1	0	+1	dB	9
TX gain-adjust range adj. 1			12	15	18	dB	9
TX gain-adjust step adj. 1			0.8	1	1.2	dB	9
LIM gain-adjust range adj. 2				15		dB	9
LIM gain-adjust range adj. 2			0.8	1	1.2	dB	9
TX gain vs. frequency (preemphasis bypassed) relative to 1 kHz reference level 0 dB	100 Hz 300 Hz 1800 Hz 3200 Hz 4100 Hz		–1.3 –1.3 –0.8 –1.9 –25.9	–0.3 –0.3 0.2 0.9 –23.9	0.7 0.7 1.2 0.1 –21.9	dB	9
Gain vs. frequency with preemphasis relative to 1 kHz reference level 0 dB	100 Hz 300 Hz 1800 Hz 3200 Hz 4100 Hz		–0.8 –6.8 3.3 6.0 16.6	–7.0 –5.8 4.3 7.0 –14.6	–6.0 –4.8 5.3 8.0 –12.6	dB	9
Total band ripple	V_{Batt} = 3.1 to 5.2 V VCOIN = –20 dBV				2	dB	9

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
Limiter							
Output voltage	Increase VCOIN until d = 5% at TX0, then measure VTX0		1.05		2.0	Vpp	9
Mute	ETX = 0, VCOIN = –10 dBV attenuation at TX0 output		56			dB	9
Output impedance TXO			7	10	14	kΩ	9
Compressor BSCR EPREE G2TX0 G2TX1 G2TX2 G2TX3 EIX G1TX0 G1TX1 G1TX2 G1TX3 1 0 0 1 0 1 1 0 0 1 0							
Input impedance	BCOMP = 1		9	14	22	kΩ	9
Gain reference level G0TX	VCOIN = –10 dBV_{rms}	G_{0TX}	1	5.5	10	dB	9
Gain change when compressor is bypassed	VCOIN = –10 dBV_{rms} BCOMP = 1		0.5		0.5	dB	9
Gain tracking	VCOIN = –30 dBV_{rms} VCOIN = –50 dBV_{rms} VCOIN = –60 dBV_{rms} VCOIN = –70 dBV_{rms}		–11 –21 –22	 –30	–9 –19 –28	dB	9
Attack time	VCOIN= step –30 dBV_{rms} → –18 dBV_{rms} measure time after step when output voltage has 1.5 times the final value	t_f		3.5		ms	9
Release time	VCOIN= step –18 dBV_{rms} → –30 dBV_{rms} measure time after step when output voltage has 0.75 times the final value	t_f		14.4		ms	9
Scrambler EPREE BSCR BCOMP 0 0 1							
Conversion gain versus frequency FIN (1 kHz) reference level 0 dB	FIN=1kHz, FOUT=3.1kHz FIN=0.1kHz, FOUT=4.0kHz FIN=0.3kHz, FOUT=3.8kHz FIN=0.7kHz, FOUT=3.4kHz FIN=1.8kHz, FOUT=2.3kHz FIN=2.6kHz, FOUT=1.5kHz FIN=3.2kHz, FOUT=0.9kHz FIN=3.4kHz, FOUT=0.7kHz		–1.0 –4.4 –2.1 –0.8 –1.1 –1.1 –2.5 –5	0 –3.4 –1.1 0.2 –0.1 –0.1 –0.5 –4	1.0 –2.4 –0.1 1.2 0.9 0.9 –0.5 –3	dB	11
Carrier break through				10	20	mV_{rms}	
Descrambler EDEE BSCR BCOMP 0 0 1							
Conversion gain vs. frequency	FIN=4kHz, FOUT=0.1kHz FIN=3.8kHz, FOUT=0.3kHz FIN=3.4kHz, FOUT=0.7kHz FIN=2.3kHz, FOUT=1.8kHz FIN=1.5kHz, FOUT=2.6kHz FIN=0.9kHz, FOUT=3.2kHz FIN=0.7kHz, FOUT=3.4kHz		–3.6 –1.3 –0.4 –1.5 –0.4 –1.7 –1.9	–2.6 –0.3 0.6 0.5 0.6 –0.3 –0.9	–1.6 0.7 1.6 0.5 1.6 0.7 0.1	dB	11
Carrier break through	Measure FOUT = 4.099 kHz			0.1	0.5	mV_{rms}	

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
Data management							
Receive-data management	GDEM ERX1 ERXHF 1 1 1						
Duty cycle RXDAT	V_{IF} = 100 µV_{rms} f_{IF} = 450 kHz f_{MIF} = 1 kHz Δf_{IF} = 5 kHz		0.4	0.5	0.6		10
Transmit-data management	ETX1 1						
Input impedance TXDAT				200		kΩ	10
Final value of step response	ETDM = 1, BSCR = 1 V_{TXDAT} = step 1.5 V → 1.75 V Measure step at TXO			311		mV	10
Logical part							
Inputs: C, D Low voltage input High voltage input Input leakage current (0 < VI < V_{CC})			 0.8 × V_{CC} –1		 0.2 × V_{CC} +5	 µA	
Input LOIN Input leakage current (0 < VI < V_{CC})			 –5		 5	 µA	
Outputs: DACO, RXDAT Output low Output high	 Iol = 10 µA Ioh = –10 µA		 0.9 × V_{CC}		 0.1 × V_{CC}		
Serial bus Data set-up time Data hold time Clock low time Clock high time Hold time before transfer condition Data low pulse on transfer condition Data high pulse on transfer condition		 t_{sud} t_{hd} t_{cl} t_{ch} t_{eon} t_{eh} t_{eof}	 0.1 0 2 2 0.1 0.2 0.2			 µs µs µs µs µs µs µs	14

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	Fig.
Battery management							
Max. battery low	DA0 to 6 = 1, RBAT = 1		3.7	3.95	4.1	V	
Min. battery low over switch	DA0 to 6 = 27 BIN, RBAT = 1		3.05	3.2	3.35	V	
Max. battery high	DA0 to 6 = 1, RBAT = 0		4.75	5.05	5.25	V	
Min. battery high	DA0 to 6 = 0, RBAT = 0		3.83	4.1	4.27	V	
Adjust step			3.5	7.5	11.5	mV	
Max. – Min.			852.5	952.5	1052.5	mV	
MINBL – SWOFF			100	200	300	mV	
Battery switch							
Off threshold	DA0 to 6 = 1, RBAT = 1		2.9	3.0	3.1	V	
On threshold	DA0 to 6 = 27 BIN, RBAT = 1		3.1	3.2	3.35	V	
Hysteresis			220	250	280	mV	
Switch R_{on}	DA0 to 6 = 0, RBAT = 0			35	50	Ω	

Max bat low : MAXL (battery voltage when all DAC bits are high, low range)

Min bat low : MINBL (battery voltage when DAC bits are 001 1011, low range)

Max bat high : MAXBH (battery voltage when all DAC bits are high, high range)

Min bat high : MINBH (battery voltage when all DAC bits are low, high range)

Adjust step : Adjust step

Max – Min : MAXBH – MINBH

MINBL – SWOFF : MINBL – SWOFF

Off threshold : SWOFF (off threshold of the battery switch)

On threshold : SWON (on threshold of the battery switch)

Hysteresis : SWON– SWOFF

Switch R_{on} : Switch R_{on} (resistance of the switch transistor, when switch is "ON")

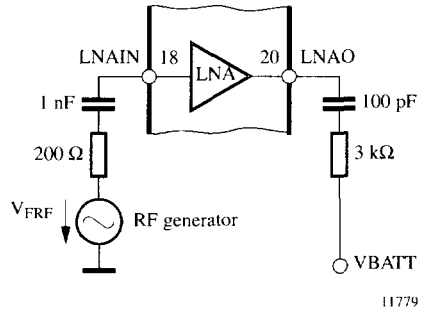

Figure 3.

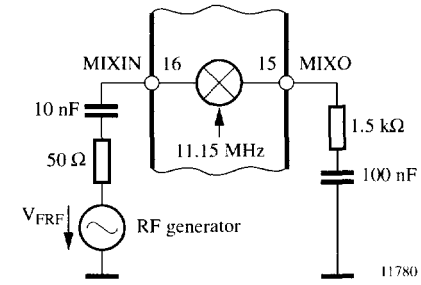

Figure 4.

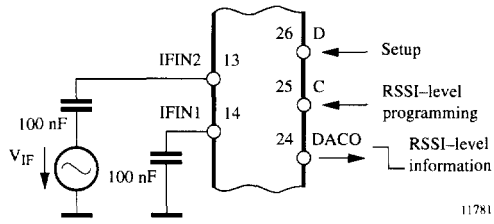

Figure 5.

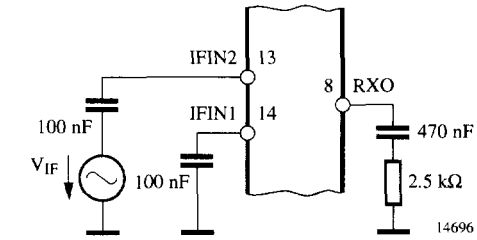

Figure 6.

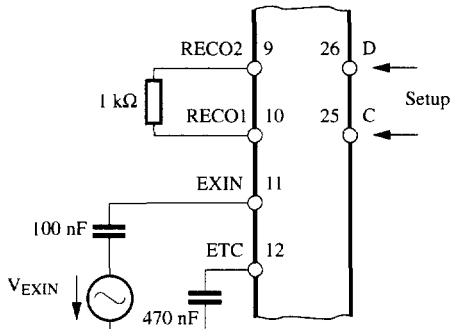

Figure 7.

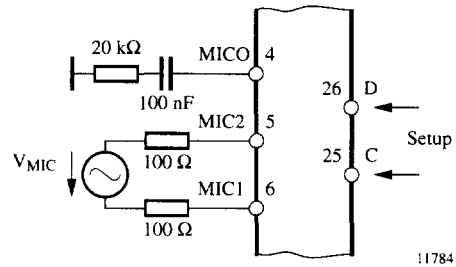

Figure 8.

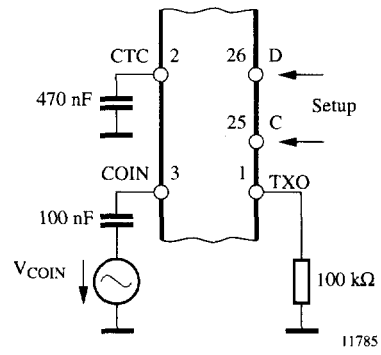

Figure 9.

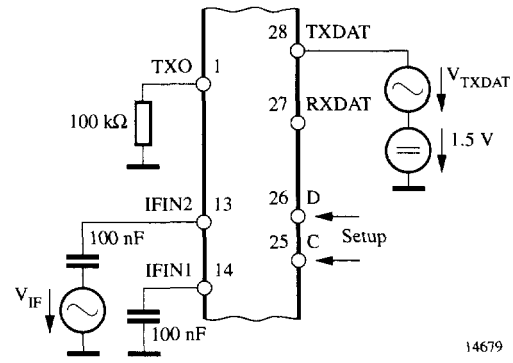

Figure 10.

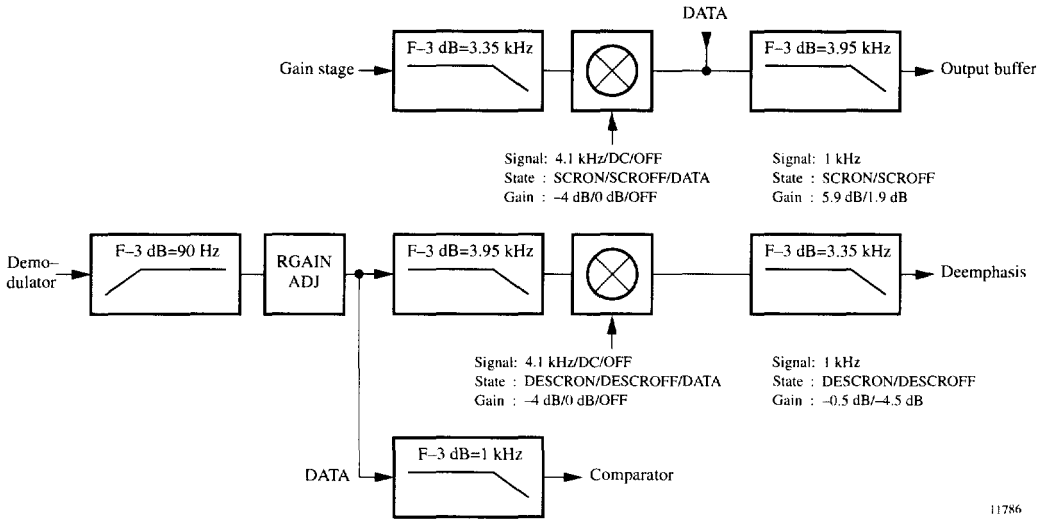

Figure 11.

Serial Bus Interface

The circuit is remoted by an external microcontroller through the serial bus (programming can be started 10 µs after power supply settled).
The data is a 12-bit word:
A3 – A0: address of the destination register (0 to 15)
D7 – D0: contents of register
The data line must be stable when the clock is high and data must be serially shifted.
After 12 clock periods, the transfer to the destination register is (internally) generated by a low-to-high transition of the data line when the clock is high.

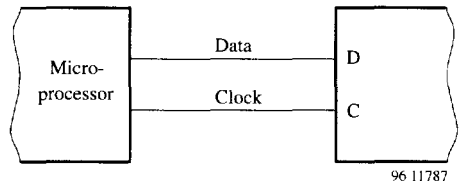

Figure 12.

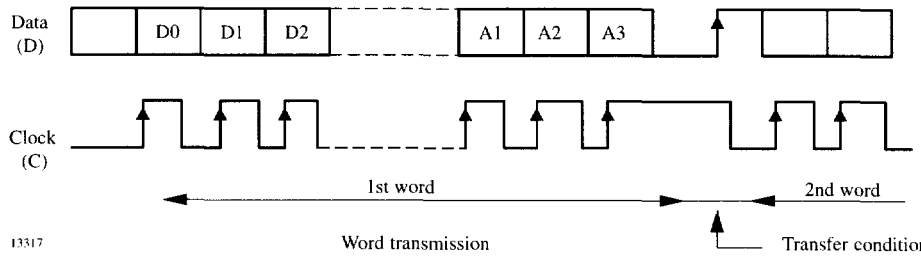

Figure 13.

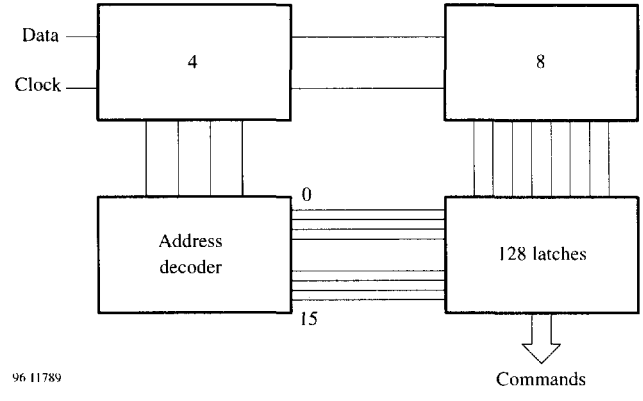

Figure 14.

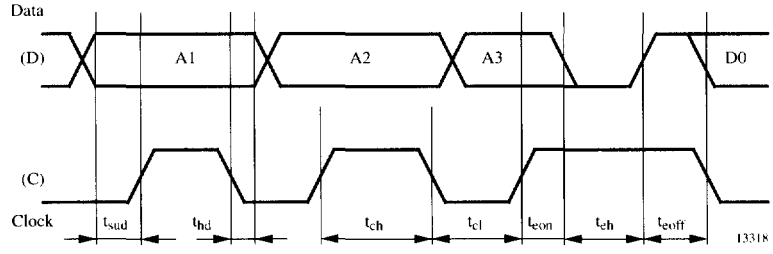

Figure 15.

Content of Internal Registers

The registers have the following structure:

D7	D6	D5	D4	D3	D2	D1	D0

RO: Reference for D/A converter

MUXDA	DA6	DA5	DA4	DA3	DA2	DA1	DA0

MUXDA: D/A multiplexing
DA(6:0): Reference voltage D/A

R1: Gain adjustment RECLF

GEA3	GEA2	GEA1	GEA0	GRX3	GRX2	GRX1	GRX0

GEA(3:0): Gain earpiece amplifier (see also R5)
GRX(3:0): Gain adjustment RX

R2: Gain adjustment TRANLF

G2TX3	G2TX2	G2TX1	G2TXO	G1TX3	G1TX2	G1TX1	G1TX0

G2TX(3:0): Gain adjustment TX after limiter
G1TX(3:0): Gain adjustment TX

R3: Enable functions receive

GDEM	EDDE	EEA	ERXO	ERX1	ERXHF	ELNA	ERX2

GDEM: Gain demodulator
EDDE: Enable deemphasis (disables bypass)
EEA: Enable earpiece amplifier
ERXO: Enable RXO output
ERXHF: Enable mixer and IF amplifier
ELNA: Enable low-noise amplifier
ERX(1:0): Enable parts of RXLF

R4: Enable functions transmit

SSCCK	RBAT	BCOMP	BSCR	GMIC	ETDM	EPREE	ETX

SSCCK: Shift SC-clock (chifts SC-clock by 17/16)
RBAT: Battery detection high/low range
BCOMP: Bypass compressor and expander
BSCR: Bypass scrambler and descrambler
GMIC: Gain of microphone preamplifier
ETDM: Enable transmit data management
EPREE: Enable preemphasis (disables bypass)
ETX: Enable TX low frequency part

R5:

free	free	free	free	free	free	GEA4	EXTLO

GEA4: Gain earpiece amplifier MSB (see also R1)
EXTLO: Select input mixer

R6 – R15: reserved for **U3550BM**

Example of Mode Setting Using Enable Bits

(U3500B + U3550B)

	Active Mode (Transmission)	Active Mode (PLL Convergence Waiting)	Receive Mode (Only Data)	Receive Mode (RX Waiting)	Standby Mode (ex. Battery Low)	Inactive Mode (Switch Off)
*PA (VTX PIN), EEA	X					
*EVCO1 ETX, ERX2, ERXO	X	X				
ERX1	X	X	X			
ERXHF, ELNA *EVCO3 RSSI / Battery Management (MUXDA)	X	X	X	X		
LOGIC PART (Enables when V_{Batt} > 3.2 V)	X	X	X	X	X	
Switch Comparator (Always Enabled)	X	X	X	X	X	X

* refer to U3550BM

Application Circuit

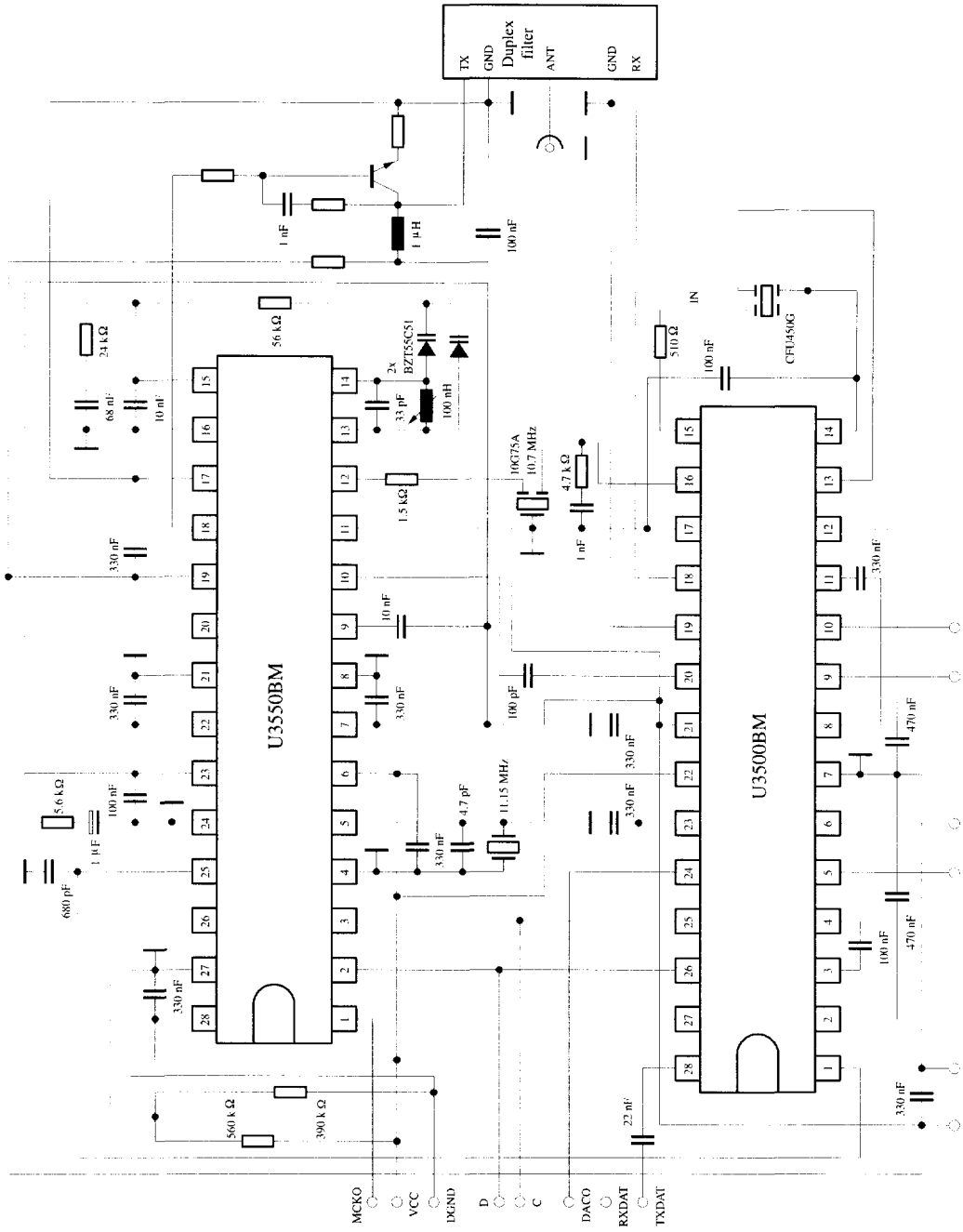

Figure 16. Application circuit

Package Information

Package SO28

Dimensions in mm