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, FSK modem, power-supply management, as well as RF receiving parts such as IF converter, FM demodulator, RSSI.

Several gains and mutes in transmit and receive direction are controlled by a serial bus while compander, pre- and deemphasis and scrambler can be bypassed.

Features

RF Receiver Part

- 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 by FSK coding
- Power-supply management
- Serial bus

Application: CT1, CT1 plus, 900 MHz USA

Block Diagram

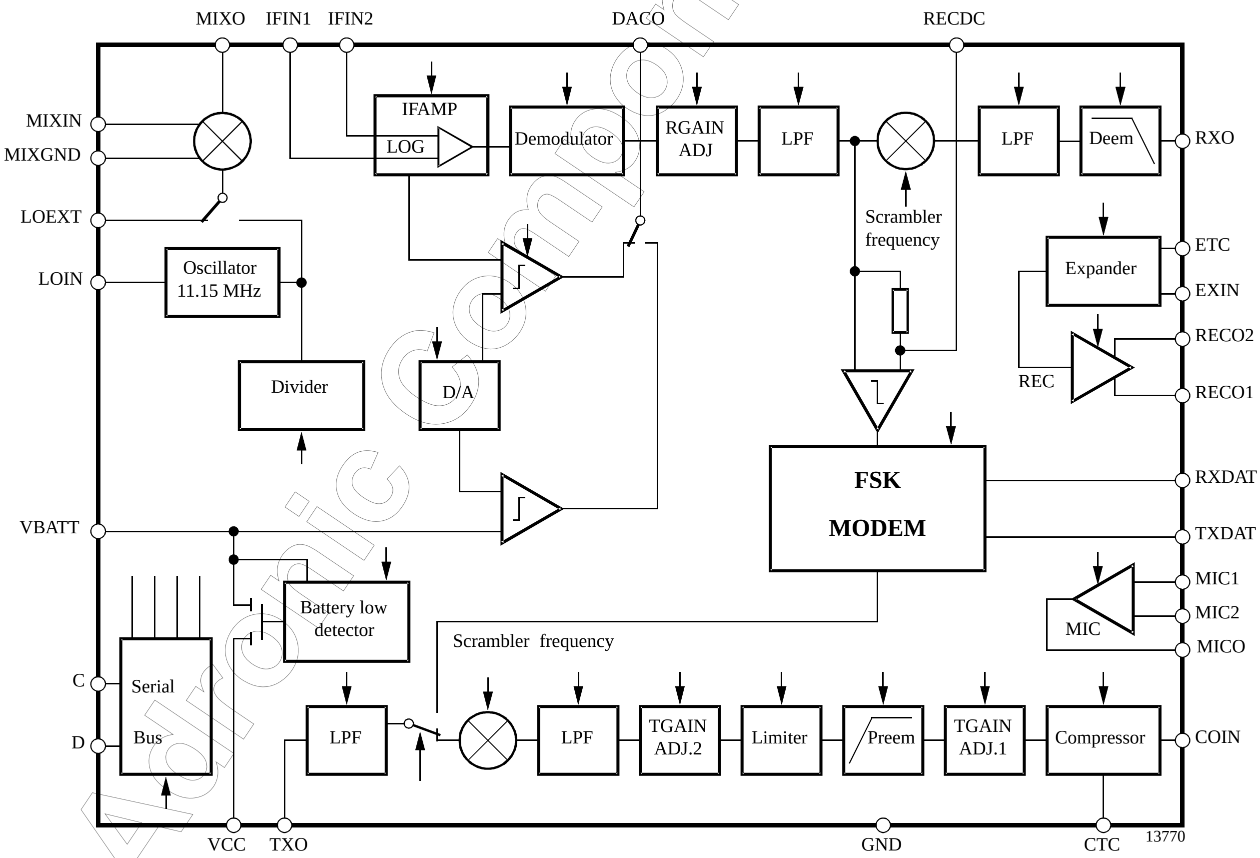


Figure 1. Block diagram

Preliminary Information

Ordering Information

Extended Type Number	Package	Remarks
U3501BM	SO28	

Pin Description

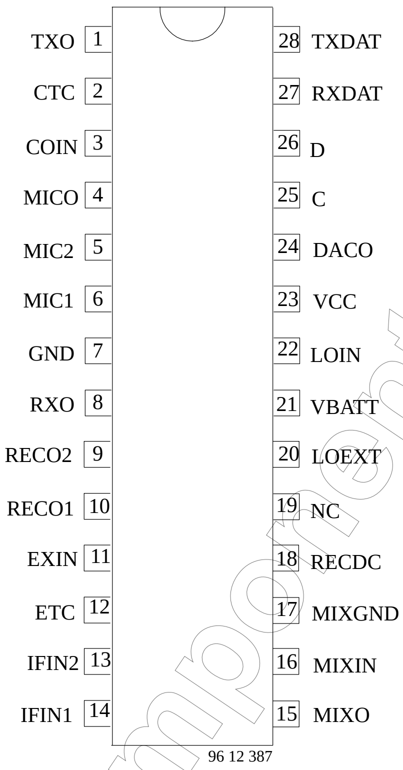
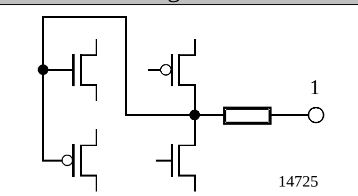
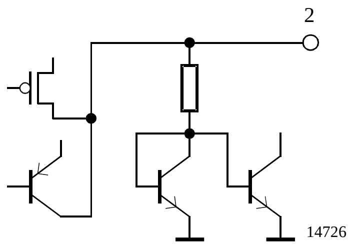
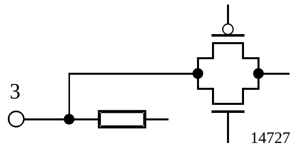
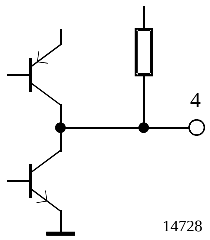
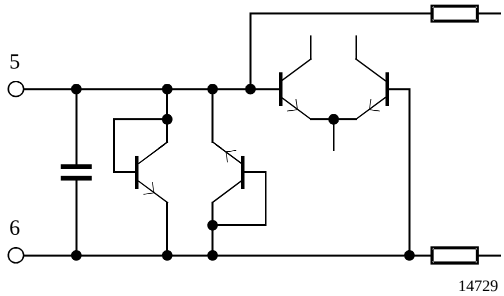
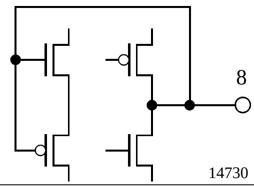
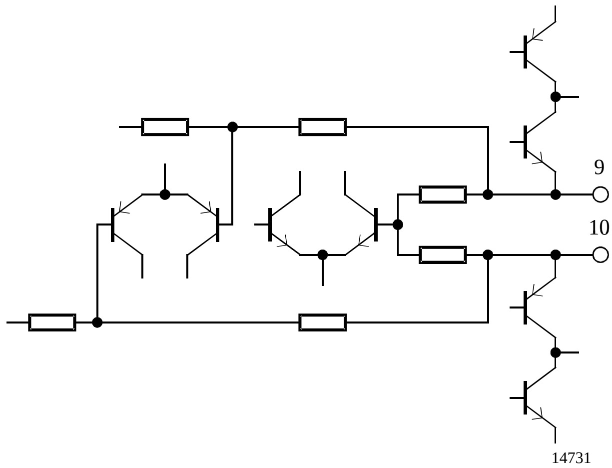
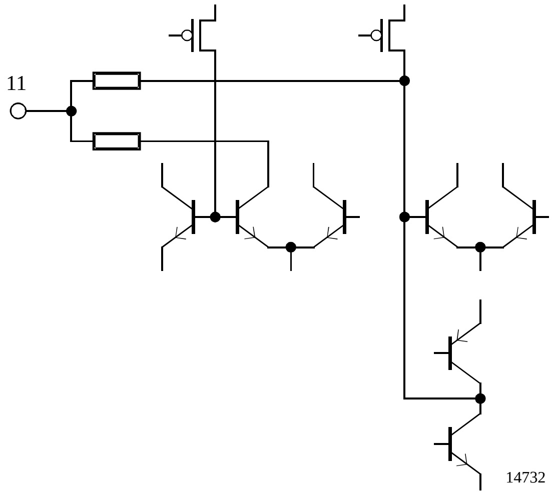
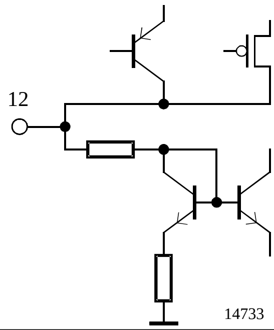
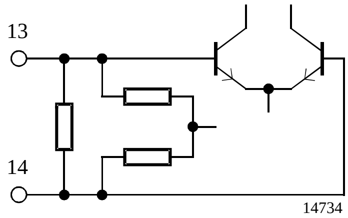
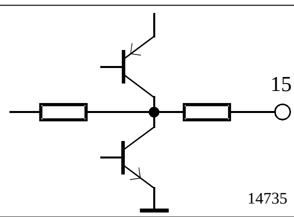
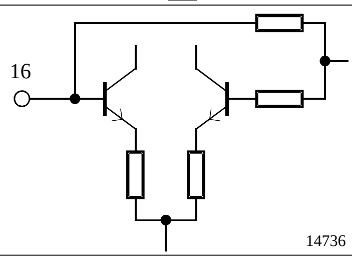
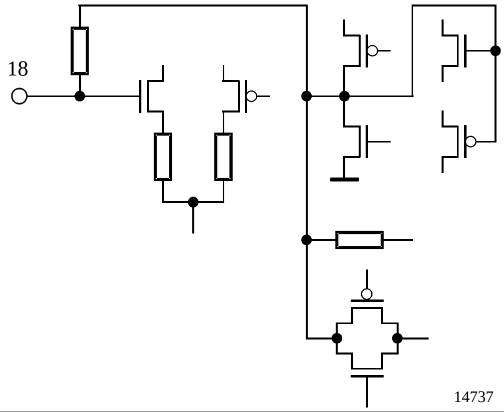
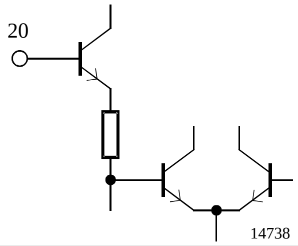
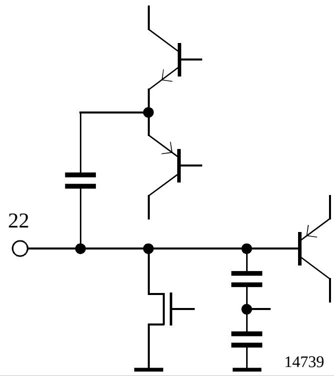
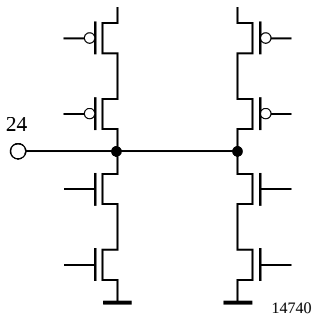


Figure 2. Pinning

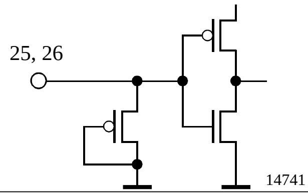
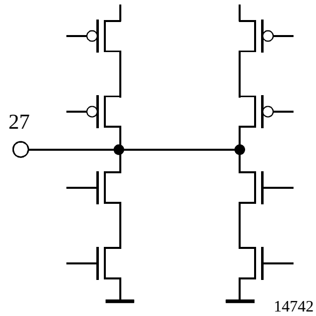
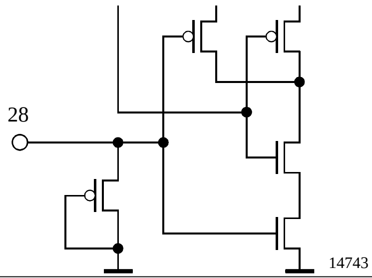
Pin	Symbol	Function	Configuration
1	TXO	Transmit section analog output	
2	CTC	Compressor time constant control analog output	

Pin	Symbol	Function	Configuration
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	

Pin	Symbol	Function	Configuration
11	EXIN	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	

Pin	Symbol	Function	Configuration
18	RECDC	Reference-voltage generation for FSK demodulator	
19	NC	Not connected	
20	LOEXT	External LO input	
21	VBATT	Battery supply	
22	LOIN	Local oscillator input for TCO or SC filter oscillator: 11.15 MHz	
23	VCC	Supply-voltage output for peripherals and internal supply of digital part	
24	DACO	D/A comparator output	

Preliminary Information

Pin	Symbol	Function	Configuration
25	C	Clock input of serial bus	
26	D	Data input of serial bus	
27	RXDAT	Receive data digital output	
28	TXDAT	Transmit data digital input	

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	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	4.7	V	
Inactive mode	V_{Batt} = 2.9 V		30	60	80	µA	
Standby mode				0.3	0.5	mA	
RX waiting for RSSI	ERXHF = 1		1.0	1.6	2.4	mA	
RX demodulating MODEM-signal	ERXHF = ERX1 = 1		1.7	2.6	3.7	mA	
Operating current, RX and TX completely active	ERX2 = ELNA = ERXHF = ERX1 = ERXO = EEA = EDEE = GDEM = ETX = 1			7	11.5	mA	
Input resistance			2	3	4	kΩ	3
Input capacitance				3		pF	3
Output impedance			1.2	1.5	1.8	kΩ	3
Gain GVMIX	Input level 7 mV_{rms}	G_{MIX}	13	15	17	dB	3
Input compression point			–17			dBm	3
Third-order input intercept point			–9			dBm	3
Carrier breakthrough from internal LO (11.15 MHz) to IF output					300	$µV_{rms}$	3
Carrier breakthrough from internal LO (11.15 MHz) to RF input					10	µV	3
Receiver **IF mixer**, f = 10.7 MHz							
IF amplifier: RSSI							
Input resistance			1.6	2	2.5	kΩ	4
RSSI sensitivity	V_{IF} = 0 $µV_{rms}$ starting from 0 increase RSSI level until mean of sampled signal at DACO is ≤ 0.2 RSSI level = CON0 V_{IF} = 6 $µV_{rms}$, F = 450 kHz increase RSSI level again until mean of sampled signal at DACO is ≤ 0.2. RSSI level = CON1 RSSI sensitivity = CON1-CON0		4				4
RSSI input voltage dynamic range				65		dB	4
RSSI level number of steps *)				127			4
RSSI level step-size in the logarithmic region				0.46		dB	4

*) RSSI Level Programming (Typical Values)

Input Voltage V_{IF} (μV_{rms})	RSSI Level (Decimal)
0	8
6	15
10	23
100	67
1000	114
10000	

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit	Fig.
RF demodulator f_{IF} = 450 kHz, f_{mod} = 1 kHz, V_{IF} = 500 μV_{rms} BSCR 1, EDEE 0, GRX0 1, GRX1 1, GRX2 1, GRX3 0, ERX1 1, ERXO 1							
Recovered audio (peak-to-peak)	GDEM = 0, Δf_{FM} = 2.5 kHz GDEM = 1, Δf_{FM} = 5 kHz		0.4 0.4	0.8 0.8	1.6 1.6	V V	5
Recovered audio output voltage drop	V_{Batt} = 3.2 V to 4.7 V		–3			dB	5
AM rejection ratio	30% AM			35		dB	5
RX audio, GDEM = 0							
Change of RX0 signal deemphasis bypass	EDEE = 0; 1		–0.5	0	0.5	dB	5
Gain adjust range				15		dB	5
Gain adjust step			0.8	1	1.2	dB	5
Output signal vs. frequency relative to 1 kHz (0 dB) deemphasis bypassed	100 Hz 300 Hz 1800 Hz 3400 Hz 4350 Hz		–8.0 –2.2 –1.4 –0.8 –80	–7.0 –1.2 –0.4 0.2 –60	–6.0 –0.2 0.6 1.2 –55	dB	5
Output signal versus frequency relative to 1 kHz (0 dB) deemphasis enable EDEE = 1	100 Hz 300 Hz 1800 Hz 3400 Hz 4350 Hz		–1.6 3.2 –5.7 –10.5 –80	–0.6 4.2 –4.7 –9.5 –60	0.4 5.2 –3.7 –8.5 –55	dB	5
Total harmonic distortion	ΔFM = 250 Hz ΔFM = 2.50 kHz				2.5 2.5	%	5
Audio mute	ΔFM = 2.5 kHz ERX0 = 0 ERX1 = 0 ERX2 = 0		65			dB	5
Output impedance					100	Ω	5

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit	Fig.
Expander EEA GEA0 GEA1 GEA2 GEA3 GEA4 1 0 0 0 1 1							
Gain reference level	V_{EXIN} = –10 dBV_{rms}	G_{OREC}	11	13	15	dB	6
Change of gain when expander is bypassed	BCOMP = 1		–0.5		0.5	dB	6
Gain tracking	V_{EXIN} = –20 dBV_{rms} V_{EXIN} = –30 dBV_{rms} V_{EXIN} = –35 dBV_{rms} V_{EXIN} = –40 dBV_{rms}		–21 –41 –53	 –50 –60	–19 –39 –47	dB	6
Input impedance			9.5		14.5	kΩ	6
Gain change versus supply voltage	V_{Batt} = 3.2 V to 4.7 V		–0.5		0.5	dB	6
Attack time	V_{EXIN} = step –20 dBV_{rms} → –14 dBV_{rms}, measure time after step when output voltage is 0.75 times the final value	t_r		16		ms	6
Release time	V_{EXIN} = step 14 dBV_{rms} → –20 dBV_{rms}, measure time after step when output voltage is 1.5 times the final value	t_f		16		ms	6
Earpiece amplifier BCOMP = 1, EEA = 1, V_{EXIN} = 100 mV_{rms}							
Maximum gain	GEA0 GEA1 GEA2 GEA3 1 1 1 1 GEA4 = 1		19	20	21	dB	6
Medium gain	GEA0 GEA1 GEA2 GEA3 0 0 0 0 GEA4 = 1		4	5	6	dB	6
Minimum gain	GEA0 GEA1 GEA2 GEA3 0 0 0 0 GEA4 = 0		–12	–11	–10	dB	6
Gain change vs. supply voltage	V_{Batt} = 3.2 V to 4.7 V		–0.2		0.2	dB	6
Gain adjust range				31		dB	6
Gain adjust step			0.8	1	1.2	dB	6
Output impedance				10	30	Ω	6
Distortion		d_t			1	%	6
Output offset voltage	V_{EXIN} = 0 mV_{rms}		–200		200	mV	6
Output voltage swing (peak-to-peak)	Increase V_{EXIN} until distortion (RECO1/ RECO2) is 5%	V_{pp}	4.8	5.0		V	6

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit	Fig.
Low-frequency transmitter GMIC 1, EPREE 1, BXCR 1, G1TX 1000, G2TX 1000, BCOMP 1, ETX 1							
Microphone amplifier V_{MIC} = 10 mV_{rms}, f_{IN} = 1 kHz							
Gain	High gain: GMIC = 1 Low gain: GMIC = 0		31 23	32 24	33 25	dB	7
Gain change vs. supply voltage	V_{Batt} = 3.2 V to 4.7 V		–0.2	0	0.2	dB	7
Differential input impedance			41	75	103	kΩ	7
Output impedance				10	35	Ω	7
Distortion	V_{MIC} = 10 mV_{rms}	d_t			1	%	7
Output noise (psophmetrically weighted)	V_{MIC} = 0 V_{rms} high gain (inputs closed across 200 Ω)				50	μV_{rmsp}	7
TX audio V_{COIN} = –20 dBV_{rms}							
Gain	GTX (TXO, COIN)		2.5	5.5	8.5	dB	8
Change of gain TXO	EPREE = 0		–0.5	0	0.5	dB	8
Gain between 3.2 and 4.7 V			–1	0	–1	dB	8
TX gain adjust range adj. 1				15		dB	8
TX gain adjust step adj. 1			0.8	1	1.2	dB	8
LIM gain adjust range adj. 2				15		dB	8
LIM gain adjust range adj.2			0.8	1	1.2	dB	8
TX gain versus frequency (pre-emphasis bypassed) relative to 1 kHz reference level 0 dB	100 Hz 300 Hz 1800 Hz 3400 Hz 4350 Hz		–1.3 –1.2 –0.8 –1.1 –20.0	–0.3 –0.2 0.2 –0.1 –24.0	0.7 0.8 1.2 0.7 –28.0	dB	8
Gain versus frequency with pre-emphasis relative to 1 kHz reference level 0 dB	100 Hz 300 Hz 1800 Hz 3400 Hz 4350 Hz		–7.5 –6.5 3.3 6.9 –15.0	–6.5 –5.8 4.3 7.0 –14.0	–5.5 –4.5 5.3 8.9 –13.0	dB	8
Total band ripple	V_{Batt} = 3.2 V to 4.7 V V_{COIN} = –20 dBV				2	dB	8
Limiter							
Output voltage (peak-to-peak)	Increase V_{COIN} until d = 5% at TX0 then measure VTX0		1.2	1.68	2.3	V	
Mute	ETX = 0, V_{COIN} = –10 dBV attenuation at TX0 output		65			dB	
Output impedance			7	10	14	kΩ	

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit	Fig.
Compander / compressor BSCR 1, EPREE 0, G2TX0 0, G2TX1 1, G2TX2 0, G2TX3 1, ETX 1, G1TX0 0, G2TX1 0, G1TX2 1, G1TX3 0							
Input impedance	BCOMP = 1		9	14	22	kΩ	8
Gain reference level G0TX	V_{COIN} = –10 dBV_{rms}	G_{0TX}	1	5.5	10	dB	8
Gain change when compresser is bypassed	V_{COIN} = –10 dBV_{rms} BCOMP = 1		0.5		0.5	dB	8
Gain tracking	V_{COIN} = –30 dBV_{rms} V_{COIN} = –50 dBV_{rms} V_{COIN} = –60 dBV_{rms} V_{COIN} = –70 dBV_{rms}		–11 –21 –22	 –30	–9 –19 –28	dB	8
Attack time	V_{COIN} = step –30 dBV_{rms} → –18 dBV_{rms} measure time after step when output voltage is 1.5 times the final value	t_r		3.5		ms	8
Release time	V_{COIN} = step –18 dBV_{rms} → –30 dBV_{rms} measure time after step when output voltage is 0.75 times the final value	t_f		14.4		ms	8
Scrambler EPREE 0, BSCR 0, BCOMP 1							
Conversion gain versus frequency f_{IN} (1 kHz) reference level 0 dB	f_{IN}=100Hz, f_{OUT}=4255Hz f_{IN}=300Hz, f_{OUT}=4055Hz f_{IN}=700Hz, f_{OUT}=3655Hz f_{IN}=1800Hz, f_{OUT}=2555Hz f_{IN}=2600Hz, f_{OUT}=1755Hz f_{IN}=3400Hz, f_{OUT}=955Hz f_{IN}=3600Hz, f_{OUT}=755Hz f_{IN}=1000Hz, f_{OUT}=3355Hz		–4.5 –2.3 –0.9 –1.1 –1.1 –2.5 –4.9 –1	–3.5 –1.3 0.1 –0.1 –0.1 –1.5 –3.9 0	–2.5 –0.3 1.1 0.9 0.9 –0.5 –2.8 1	dB	9
Carrier break through	Measure f_{OUT} = 4355 kHz			10	20	mV_{rms}	
Descrambler EDEE 0, BSCR 0, BCOMP 1							
Conversion gain versus frequency	f_{IN}=4255Hz, f_{OUT}=100Hz f_{IN}=4055Hz, f_{OUT}=300Hz f_{IN}=3655Hz, f_{OUT}=700Hz f_{IN}=2555Hz, f_{OUT}=1800Hz f_{IN}=1755Hz, f_{OUT}=2600Hz f_{IN}=955Hz, f_{OUT}=3400Hz f_{IN}=755Hz, f_{OUT}=3600Hz f_{IN}=3355Hz, f_{OUT}=1000Hz		–3.8 –1.6 –0.5 –1.7 –0.7 –1.4 –1.7 –1	–2.6 –0.6 0.5 –0.7 6.3 –0.4 –0.7 0	–1.8 0.1 1.5 0.3 1.3 0.6 0.3 1	dB	9
Carrier break through	Measure f_{OUT} = 4355 kHz			0.1	0.5	mV_{rms}	

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit	Fig.
FSK modem (1200 Bauds)							
FSK-demodulator Input signal discriminator IFIN1-IFIN2——RXDAT 2100 Hz —— = 0 1300 Hz —— = 1	IFIN = 450 kHz VIFIN = 0.5 mV_{rms} df = 2.4 kHz ERX1 = 1 GDEM = 0 (high gain) GRX3 = 1 (+1dB)		1720		1660	Hz Hz	
FSK – modulator TXDAT —— TXO Output signal level TXDAT —— TXOUT Signal distortion TXDAT —— TXOUT	ETX = 1 EFSK = 1 TXDAT = 0 TXOUT = 2100 Hz TXDAT = 1 TXOUT = 1300 Hz TXDAT = 0 TXOUT = 2100 Hz TXDAT = 1 TXOUT = 1300 Hz		0.87		1.54 1.54 2 2	Vpp Vpp % %	
Output signal frequency	TXDAT = 0 TXDAT = 1		2100 1300			Hz	
Output signal – Distortion – Offset level			1.5	2		% V	
Logical part							
Inputs: C, D, TXDAT Low-voltage input High-voltage input Input leakage current (0 < VI < V_{CC})			2.5 –1		0.5 1	V V µA µA	
Input LOIN Input leakage current pin XCK (0 < VI < V_{CC})			–5		5	µA	
Outputs: DACO, RXDAT Output low Output high	l_{ol} = 10 µA l_{oh} = –10 µA		$0.9 \times V_{CC}$		$0.1 \times V_{CC}$		
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	12

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit	Fig.
Battery management							
Max batlow	DA0 to 6 = 1, RBAT = 1		3.8	3.95	4.1	V	
Min batlow over switch	DA0 to 6 = 27 BIN, RBAT = 1		3.05	3.2	3.35	V	
Max bathigh	DA0 to 6 = 1, RBAT = 0		4.85	5.05	5.25	V	
Min bathigh	DA0 to 6 = 0, RBAT = 0		3.93	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		3.15	3.25	3.35	V	
Hysteresis			220	250	280	mV	
Switch R_{on}	DA0 to 6 = 0, RBAT = 0			35	50	Ω	

Max batlow : MAXBL (battery voltage when all DAC bits are high, low range)
Min batlow : MINBL (battery voltage when DAC bits are 0011011, low range)
Max bathigh : MAXBH (battery voltage when all DAC bits are high, high range)
Min bathigh : 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”)

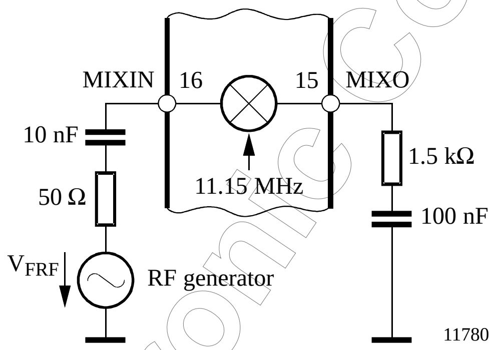


Figure 3. Test circuit

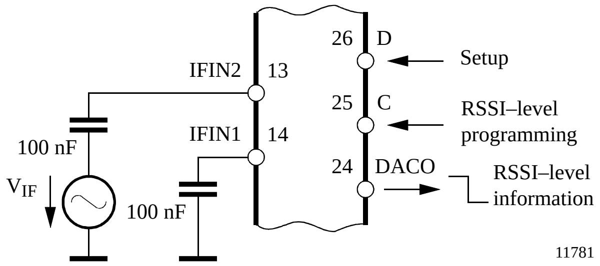


Figure 4.

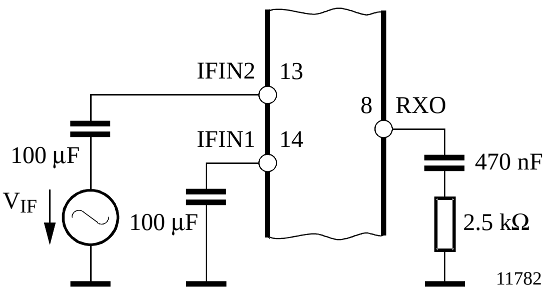
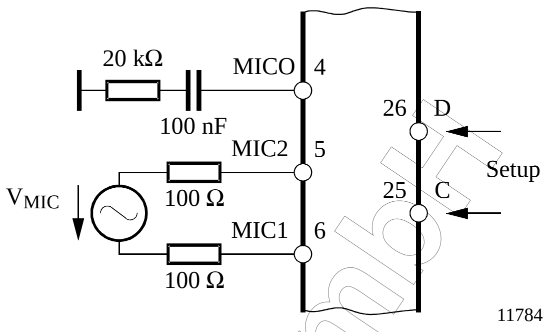


Figure 5.



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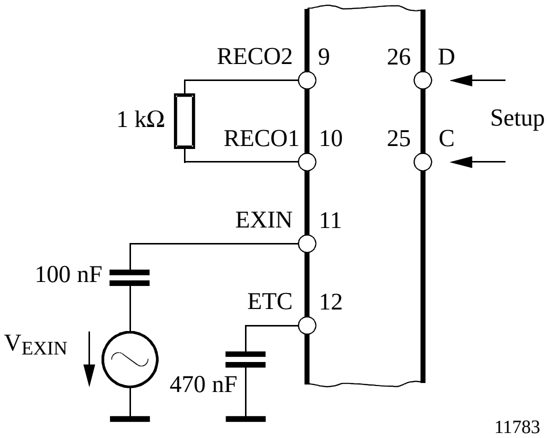

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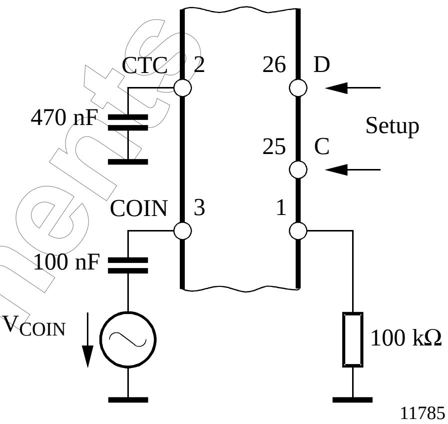

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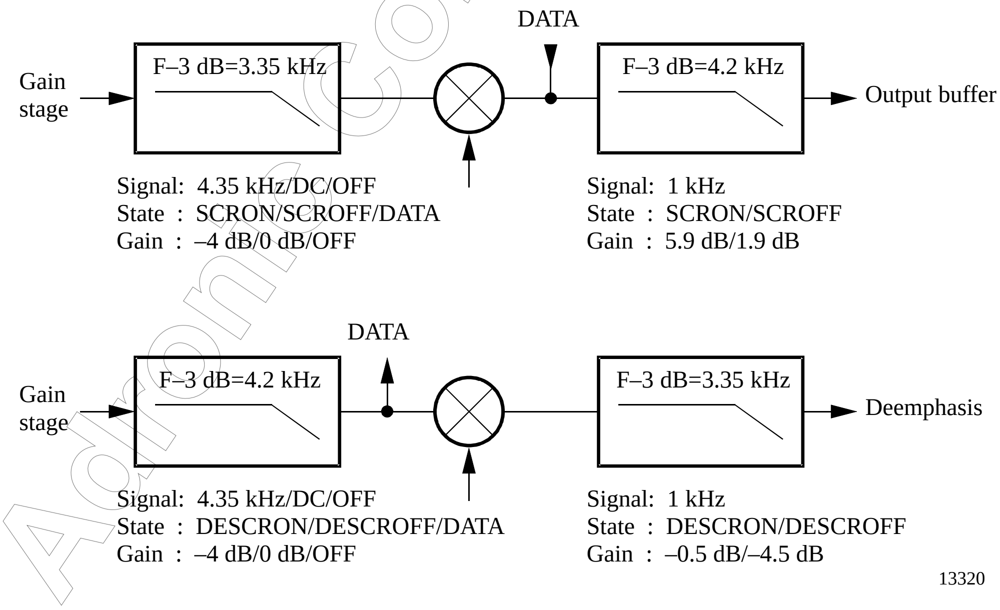


Figure 9.

Serial Bus Interface

The circuit is remoted by an external microcontroller trough the serial bus.

The data is an 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 shifted serially.

After 12 clock periods, the transfer to the destination register is generated (internally) by a low to high transition of the data line when the clock is high.

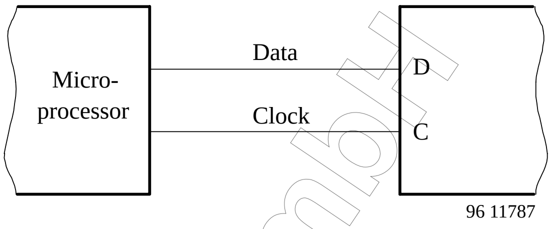


Figure 10.

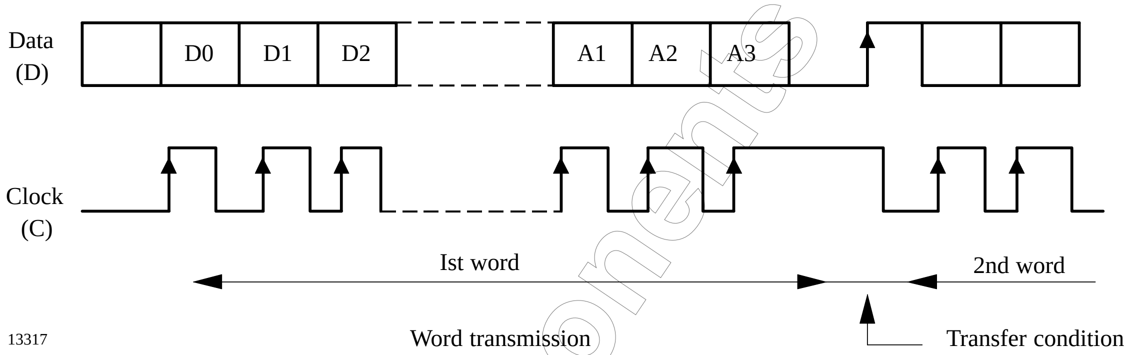


Figure 11. Serial bus transmission

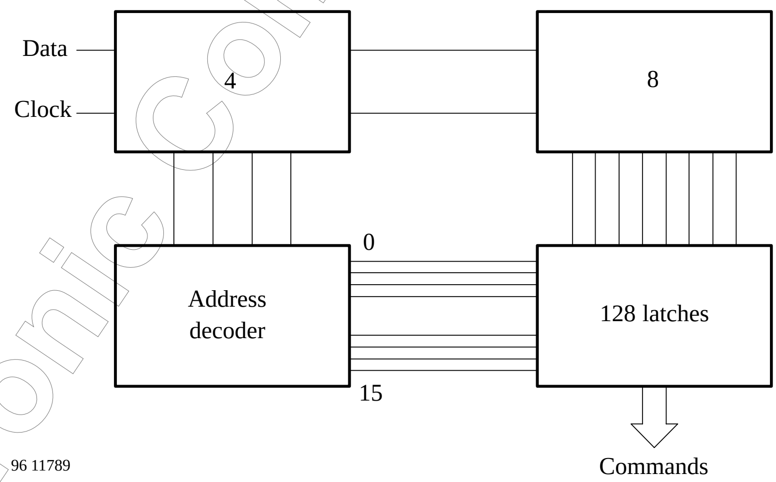


Figure 12.

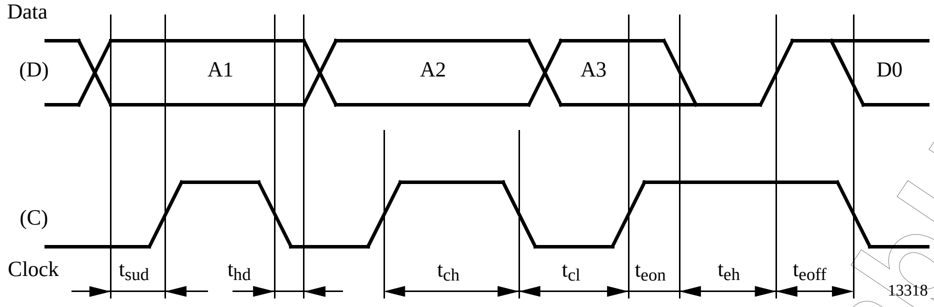


Figure 13.

Content of Internal Registers

The register have the following structure:

D7	D6	D5	D4	D3	D2	D1	D0

R0: 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	G2TX0	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	free	ERX2

GDEM: Gain demodulator
EDDE: Enable deemphasis (disables bypass)
EEA: Enable earpiece amplifier
ERXO: Enable RXO output
ERXHF: Enable mixer and IF amplifier
ERX(1:2): Enable parts of RXLF

R4: Enable functions transmit

SRSSI	RBAT	BCOMP	BSCR	GMIC	EFSK	EPREE	ETX

SRSSI: RSSI sample hold
RBAT: Battery detection high/low range
BCOMP: Bypass compressor and expander
BSCR: Bypass scrambler and descrambler
GMIC: Gain of microphone preamplifier
EFSK: Enable modulator of FSK modem
EPREE: Enable pre-emphasis (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 U3500BM

Example of Mode Setting Using Enable Bits and Battery Switch

U3501BM, see figure 14

	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)
Transmitter *MC	X					
*ETX, ERX2, ERXO	X	X				
ERX1	X	X	X			
ERXHF, ELNA *EVCO3 RSSI/Battery Management (MUXDA)	X	X	X	X		
MC + LOGIC PART (Enabled when V_{Batt} > 3.2V)	X	X	X	X	X	
Switch Comparator of VCC (Always Enabled)	X	X	X	X	X	X

MC = Microcontroller, *MC = Link directly from microcontroller

Application Circuit

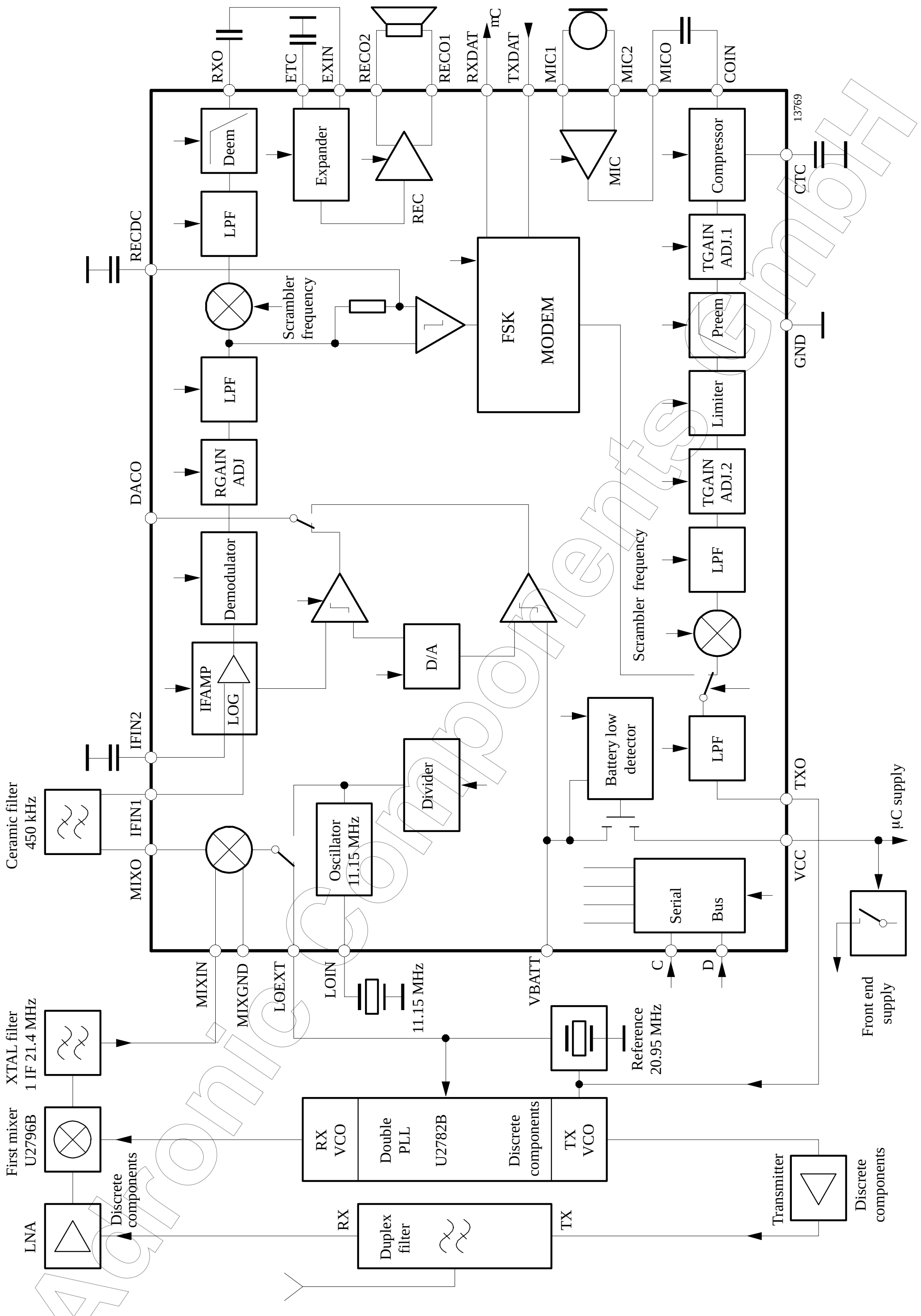
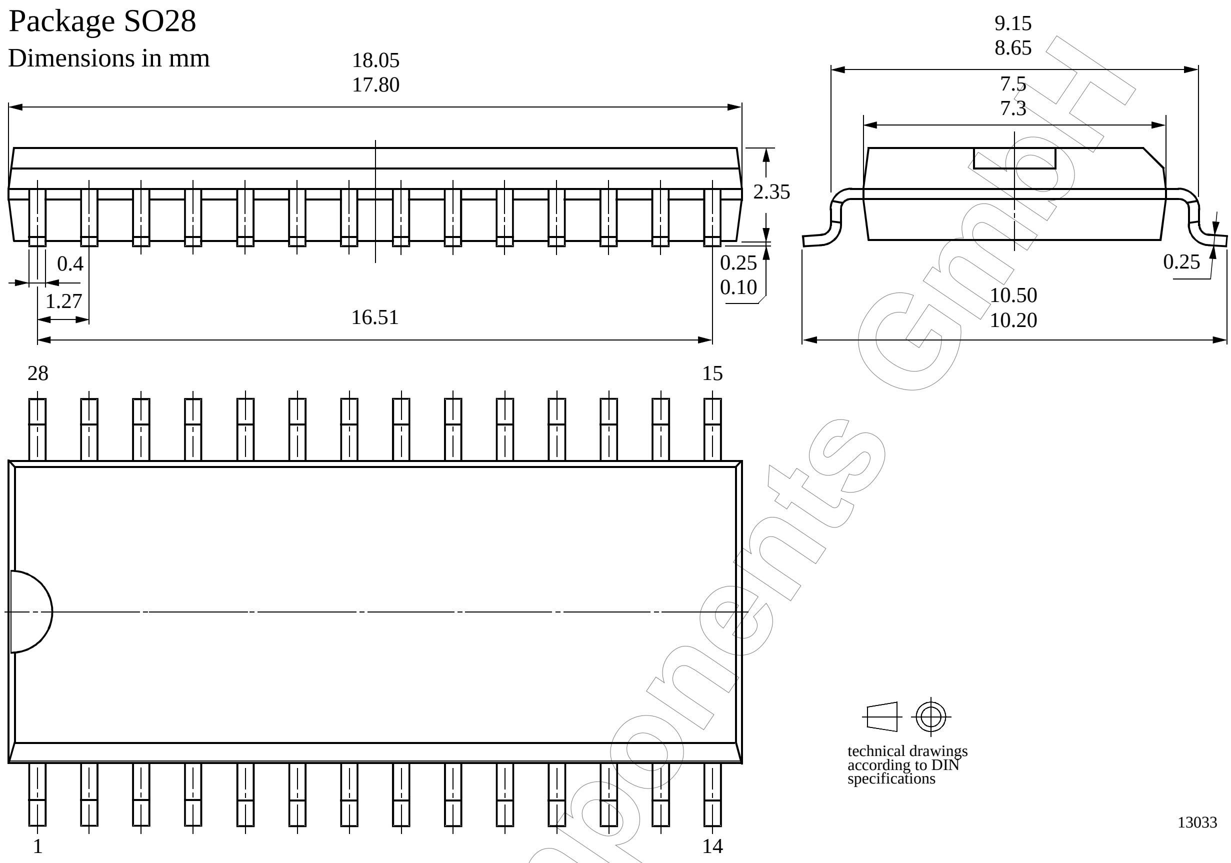


Figure 14. Application circuit

Preliminary Information

Package Information



Ozone Depleting Substances Policy Statement

It is the policy of **TEMIC Semiconductor GmbH** to

1. Meet all present and future national and international statutory requirements.

2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

TEMIC Semiconductor GmbH has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively

2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA

3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

TEMIC Semiconductor GmbH can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

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