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is now

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The technical content of this austriamicrosystems datasheet is still valid.

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General Description

The AS2540 is a CMOS integrated circuit that incorporates a speech circuit (line-adaptation, 2/4-wire conversion, separate Rx- and Tx-amplifiers for handset and modem), MF dialler, ring frequency detector, ring melody generator and a two wire serial interface. It shall act as an a/b-line-powered device in order to interface a main-powered CPU to the analogue telephone line.

AS2540 can operate in a so-called mainpower mode and in a backup mode. During mainpower mode, a watchdog timer is running on AS2540, which has to be reset via the serial interface, which is connected to the CPU through opto-couplers. During backup mode (= The main-power failure or SW engine problem), AS2540 can operate as an independent basic MF dialler (digits 0-9*#)

Applications

- Web Telephones
- Answering Machines
- Fax Machines
- Base Station of Cordless Telephones
- Hospital Communication Units
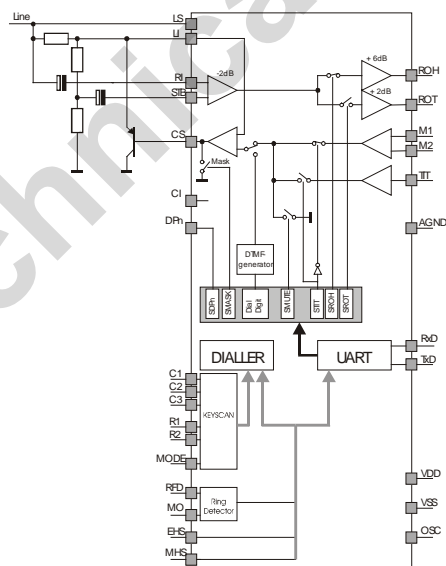
Key Features

- Line Interface, Speech Circuit, MF Dialler and Tone Ringer on a 28 pin CMOS chip
- Programmable via 2-wire serial interface (UART 9600 baud, 8N1)
- Watch dog timer for Backup Mode
- Additional input for modem transmit path
- Additional output for modem receive path
- CMOS for high EMC immunity
- Low Noise (max. −72 dBm)
- Operating range from 15mA to 100mA (down to 5mA with reduced performance)
- Soft clipping for handset operation to avoid harsh distortion
- Line loss compensation selectable by pin option
- Real and complex impedance selectable by external components
- Side tone adaption selectable by external components
- Ring frequency discrimination
- 3-tone ring melody generator

Package

- 28 pin SOIC
- Dice-on-Foil

Block Diagram

Main Power Mode

Backup Mode
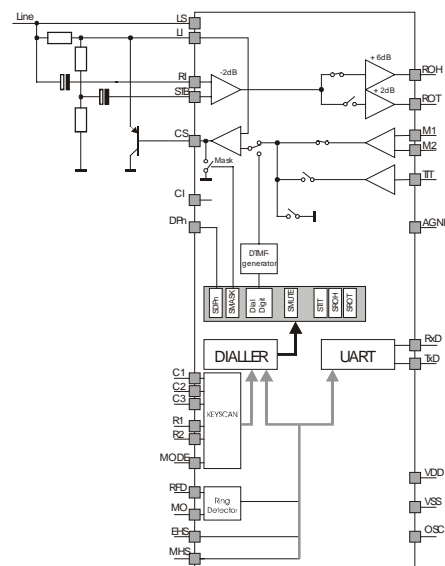
Pin Description

Pin #	Symbol	Function
15	RFD	**R**ing **F**requency **D**iscrimination Schmitt trigger input for ring frequency discrimination. Disabled during off-hook.
7	LS	**L**ine Current **S**ense Input Input for sensing the line current
5	LI	**L**ine **I**nput Input used for power extraction and line current sensing
6	RI	**R**eceive **I**nput Input for ac-separated receive signal
2	STB	**S**ide **T**one **B**alance Input Input for side tone cancellation network
3	CS	**C**urrent **S**hunt Control Output N-channel open drain output to control the external high power shunt transistor for synthesising ac- and dc- impedance, modulation of line voltage and shorting the line during make periods of pulse dialling
8	CI	**C**omplex **I**mpedance Input Input pin for the capacitor to program a complex impedance
16	DPn	**D**ial **P**ulse Output Open drain output pulls low during break periods of pulse dialling and flash
17	EHS	**E**lectronic **H**ook **S**witch Schmitt Trigger Input to detect an electronic off-hook.
18	MHS	**M**anual **H**ook **S**witch Schmitt Trigger Input to detect a manual off-hook.
19	MODE	**D**TMF **L**evel **S**election -4/-6dBm —> DLS open -6/-8dBm —> DLS-r1 -8/-10dBm —> DLS-r2 **L**ine **L**oss **C**ompensation Select Pin 45mA-75mA —> LLC open 20mA-50mA —> LLC-r3 None —> LLC-r4
28	MO	Ring **M**elody **O**utput PDM output of the ring melody generator.
11	VDD	**V**oltage **D**rain **D**rain Positive Power Supply
4	VSS	**V**oltage **S**ource **S**ource Negative Power Supply

Pin #	Symbol	Function
25	OSC	**O**scillator Input Input for ceramic resonator 3.58MHz. Recommended type: Murata CSA 3.58MG312AM or compatible
12	AGND	**A**nalogue **G**round Special ground for the internal amplifiers
26	RXD	**R**eceive **D**ata Input Schmitt trigger input to serial interface
27	TXD	**T**ransmit **D**ata Output Open drain output from serial interface
20 21	R1 R2	Keyboard **R**ows
22 23 24	C1 C2 C3	Keyboard **C**olumns
10	ROT	**R**eceive **O**utput to **T**ransformer Output for driving a transformer with an ac impedance larger than 10kΩ
1	TIT	**T**ransformer **I**nput from **T**ransformer Single ended input for transformer
9	ROH	**R**eceive **O**utput to **H**andset Output for driving a dynamic earpiece with an impedance from 150Ω to 300Ω
13 14	M2 M1	**M**icrophone Inputs Differential inputs for the microphone (electret)

Functional Description

Modes of operation

There are 4 possible modes:

Idle Mode

Manual hook-switch and electronic hook-switch (e.g. relay) is open (MHS ∩ EHS = logical 0), no ring signal is applied, the oscillator is stopped, signalling via the serial interface is not possible.

Ringing Mode

AS2540 is supplied via the ring capacitor and external path, manual hook -switch and electronic hook-switch is open (MHS ∩ EHS = logical 0), the oscillator is running, a valid incoming ringing is signalled via the serial interface to the CPU. If the CPU does not reply the AS2540 switches into backup mode and sends a ring melody to the MO output.

Backup Mode

Manual hook-switch and/or electronic hook-switch is closed (MHS ∪ EHS = logical 1), AS2540 is supplied with line current, the oscillator is running, the keyscan is enabled and the handset path is switched on, signalling via the serial interface is possible. After AS2540 has started dialling in backup mode, he must not be interrupted any more in order to ensure consistent dialling. A mode transition BM -> MPM is only possible before AS2540 has started dialling digits independently.

Main Power Mode

Manual hook-switch and/or electronic hook-switch is closed, AS2540 is supplied with line current (MHS ∪ EHS = logical 1), the oscillator is running, the keyscan is disabled, AS2540 is controlled via the serial interface, handset path or monitor path or modem path is on, signalling via the serial interface is possible.

Select Operation Mode

Command Message	Switches ON	Switches OFF
<SetHandsetPath>	SROH	SROT & STIT
<SetModemPath>	SROT & STIT	
<SetMonitorPath>	SROH & SROT	STIT

Example Main Power Mode
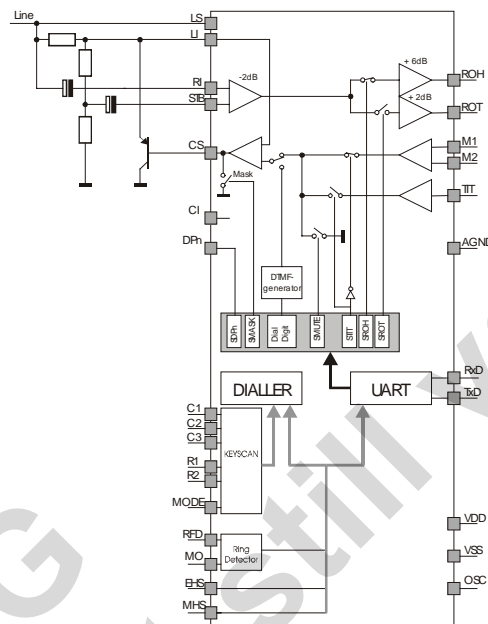
Start-up in backup mode

As soon as AS2540 is supplied with line current, the external Vdd capacitor will be charged up via the LI and VDD pin and after the Vdd voltage has reached the operating level, the handset path of the speech circuit is switched on. This off-hook status is also signalled to the internal logic via the MHS or EHS pin in order to start the pinscan and subsequently set the country specific modes. Additionally a <LineEvent> message is sent to the CPU.

Start-up in ring mode

When a ringing signal is applied to the line, Vdd of AS2540 is charged up via an external path. After Vdd has reached the operating voltage the oscillator starts and AS2540 discriminates the ring frequency. After a valid ring frequency is applied on the RFD pin, the logic sends a <LineEvent> message is sent to the CPU and a watchdog timer is started. When the <LineEvent> message is not quit by the CPU before the watchdog timer has finished the countdown, AS2540 changes into backup mode and sends out a melody via the MO pin.

DC conditions

The normal operating mode is from 15mA to 100mA. An operating mode with reduced performance is from 5mA to 15mA. In the line hold range from 0mA to 5mA the device is in a power down mode and the voltage at LI is reduced to a maximum of 3.5V

The DC characteristic is determined by the voltage at LI pin and a 30Ω resistor between LI and LS pin. It can be calculated by the following equation: $V_{LS} = V_{LI} + I_{Line} * 30\Omega$. The t.m. voltage at the LI pin is 4.5V. The calculation leads to the following DC resistances: 330Ω to 75Ω at line currents from 15mA to 100mA.

2/4 wire conversion

AS2540 has a built-in dual Wheatstone bridge with one common ground. This provides a maximum of independence of AC impedance and side tone from each other. One can adapt side tone without changing the AC impedance.
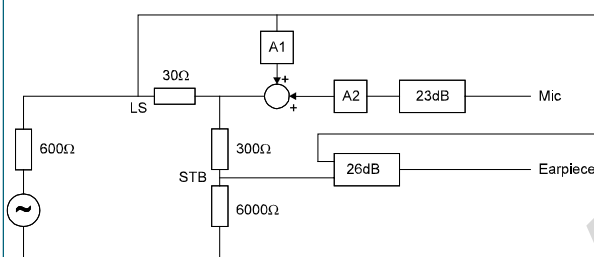
A1=3.4/3.5   A2=-0.4

AC impedance

The ac impedance of AS2540 is set to t.m. 1000Ω. With the external capacitor at CI pin it can be programmed complex. With a parallel impedance at the LS pin it can be programmed to 600Ω.

Side Tone

A good sidetone cancellation can be achieved by using the following equation:

$Z_{BAL}/Z_{LINE} = 10$

Transmit path

The gain of the M1/M2 —> LS transmit path is set to 38dB for ac-impedance 1000Ω. The input is differential with an impedance of 25kΩ. The soft clip circuit limits the output voltage at LS to 2Vp. The attack time is 30μs/6dB and the decay time is 20ms/6dB.

The gain of the TIT —> LS transmit path is set to 8dB for ac-impedance 1000Ω. The input is single ended with an impedance of 25kΩ. The soft clip circuit is not active for this input. The dynamic range of this path is 2.5Vp at LS.

Receive path

The gain of the LS —> ROH receive path is set to 2dB for ac-impedance 1000Ω. The receive input is the differential signal of RI and STB. During DTMF dialling a MF comfort tone is applied to ROH which is -30dB relative to the line level. The soft clip circuit limits the output voltage at ROH to 1Vp. It prevents harsh distortion and acoustic shock.

The gain of the LS —> ROT receive path is set to 0dB for ac-impedance 1000Ω. The receive input is the differential signal of RI and STB. The soft clip circuit is not active for this output.

Modescan

The DTMF-level on the line and the function of the line loss compensation can be selected with the connection of the MODE-pin to the keyboard matrix. The MODE-pin is scanned once after each OFF-Hook transition.
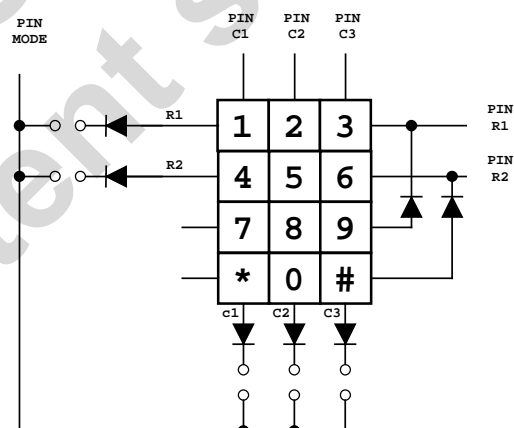
C3	C2	C1	R2	R1	LLC	Dtmf Level
					45mA-75mA	-6dBm
			X	X	45mA-75mA	-8dBm
		X			45mA-75mA	-10dBm
	X				20mA-50mA	-6dBm
X					20mA-50mA	-8dBm
	X	X			20mA-50mA	-10dBm
X		X			No LLC	-6dBm
X	X				No LLC	-8dBm
X	X	X			No LLC	-10dBm

X indicates connection to pin mode

Serial interface

The communication principle is derived from a standard UART:

- Baud Rate 9600
- Start Bit 1
- Data Bits 8
- Parity None
- Stop Bit 1
- LSB is transferred prior to MSB

Rx - messages

Message Format							
X MSB	X	d5	d4	d3	d2	d1	1 LSB

d7	d6	d5	d4	d3	d2	d1	d0	DTMF-dial message	Notes
x	x	0	1	0	1	0	1	Digit 0	Starts DTMF dialling of digit
x	x	0	0	0	0	1	1	Digit 1	Starts DTMF dialling of digit
x	x	0	0	0	1	0	1	Digit 2	Starts DTMF dialling of digit
x	x	0	0	0	1	1	1	Digit 3	Starts DTMF dialling of digit
x	x	0	0	1	0	0	1	Digit 4	Starts DTMF dialling of digit
x	x	0	0	1	0	1	1	Digit 5	Starts DTMF dialling of digit
x	x	0	0	1	1	0	1	Digit 6	Starts DTMF dialling of digit
x	x	0	0	1	1	1	1	Digit 7	Starts DTMF dialling of digit
x	x	0	1	0	0	0	1	Digit 8	Starts DTMF dialling of digit
x	x	0	1	0	0	1	1	Digit 9	Starts DTMF dialling of digit
x	x	0	1	0	1	1	1	Digit *	Starts DTMF dialling of digit
x	x	0	0	0	0	0	1	Digit #	Starts DTMF dialling of digit
x	x	0	1	1	0	0	1	Digit A	Starts DTMF dialling of digit
x	x	0	1	1	0	1	1	Digit B	Starts DTMF dialling of digit
x	x	0	1	1	1	0	1	Digit C	Starts DTMF dialling of digit
x	x	0	1	1	1	1	1	Digit D	Starts DTMF dialling of digit
x	x	1	0	0	0	0	1	KeyReleased	Stops Dialling

d7	d6	d5	d4	d3	d2	d1	d0	Pin-Control message	Notes
x	x	1	0	1	1	0	1	SetDPn_HIGH	Release pin Dpn (open drain)
x	x	1	0	0	0	1	1	SetDPn_LOW	Force pin DPn = VSS
x	x	1	0	0	1	0	1	SetMask	Force LI-Voltage to 1.2 V
x	x	1	0	0	1	1	1	ResetMask	

d7	d6	d5	d4	d3	d2	d1	d0	Pin-Control message	Notes
x	x	1	0	1	1	1	1	SetTestmode	FOR FACTORY TEST ONLY
x	x	1	0	1	0	0	1	MuteON	Mute Transmit path
x	x	1	0	1	0	1	1	MuteOFF	

d7	d6	d5	d4	d3	d2	d1	d0	Path-Control message	Notes
x	x	1	1	0	0	1	1	SetHandsetPath	
x	x	1	1	1	0	1	1	SetMonitorPath	
x	x	1	1	0	1	0	1	SetModemPath	
x	x	1	1	0	0	0	1	RequestStatus	AS2540 sends Status information
x	x	1	1	0	1	1	1	*reserved*	<LineEvent>
x	x	1	1	1	0	0	1	*reserved*	<LineEvent>
x	x	1	1	1	1	0	1	*reserved*	<LineEvent>
x	x	1	1	1	1	1	1	*reserved*	<LineEvent>

Tx messages

<Ack> message

<Ack> message format for <RequestStatus>							
b7 MSB	b6	b5	b4	b3	b2	0	1 LSB

b7	b6	b5	b4	b3	b2	b1	b0	Status	Remark
1						0	1	valid ring signal detected	Status of AS2540
0						0	1	no ring signal	
	1					0	1	manual hook switch - off-hook (pin MHS)	
	0					0	1	manual hook switch - on-hook (pin MHS)	
		1				0	1	electronic hook switch - off-hook (pin EHS)	
		0				0	1	electronic hook switch - on-hook (pin EHS)	
			0	0	0	0	1	no LLC comparator	coded status of LLC comparator
			0	0	1	0	1	LLC comparator 20mA (45mA) ...	
			0	1	0	0	1	LLC comparator 26mA (51mA) ...	
			0	1	1	0	1	LLC comparator 32mA (57mA) ...	
			1	0	0	0	1	LLC comparator 38mA (63mA) ...	
			1	0	1	0	1	LLC comparator 44mA (69mA) ...	
			1	1	0	0	1	LLC comparator 50mA (75mA) ...	

<Line Event> Message

<LineEvent> message format							
b7 MSB	b6	b5	1	1	1	1	1 LSB

b7	b6	b5	b4	b3	b2	b1	b0	Status	Remark
1			1	1	1	10	1	valid ring signal detected	
0			1	1	1	10	1	no ring signal	
	1		1	1	1	10	1	manual hook switch - off-hook (pin MHS)	Status of AS2540
	0		1	1	1	10	1	manual hook switch - on-hook (pin MHS)	
		1	1	1	1	10	1	electronic hook switch - off-hook (pin EHS)	
		0	1	1	1	10	1	electronic hook switch - on-hook (pin EHS)	

Protocol

Line Events

AS2540 has 3 inputs, namely MHS (Manual Hook Switch), EHS (Electronic Hook Switch) and RFD (Ring Frequency Detector), which sense the state of the two hook-switches and discriminate an applied ring signal. The MHS is connected to the manual hook switch which is operated by the handset and the EHS is connected to an electronic hook switch which is operated by the CPU. Whenever the state of these inputs changes, AS2540 immediately sends <LineEvent> to the CPU after a debounce time. MHS and EHS up-debouncing lasts 15ms, down-debouncing lasts 85ms. RFD start to discriminate the ring frequency immediately but will send a <LineEvent> message with a delay of 102ms. A status change of MHS and EHS pins must not change the momentary selected path of the speech network.

The <LineEvent>-message is sent without consideration of the momentary activities of AS2540 in order to meet PTT requirements (e.g. line break signalling). The code for the <LineEvent>-message is chosen with regard to the minimum current consumption in order to operate the optocouplers. Pending <Ack>-messages will be queued after the <LineEvent>-message. An already running transmissions of <Ack> will not be interrupted and <LineEvent> will be sent afterwards in this case.

- **Mode transitions   Idle → BM → MPM → Idle**
AS2540 always starts up in backup mode and is prepared to act like an independent dialler. <LineEvent> is sent to the CPU and AS2540 remains in back-up mode until any

valid message is sent from the CPU. This makes sure that a non-operable CPU does not disable basic dialling functions.

- **Mode transition   MPM → BM**
A watchdog timer is started after <LineEvent> and is reset whenever AS2540 receives a message from the CPU via the serial interface. If the CPU does not send any further valid message within 2400ms, AS2540 goes back into back-up mode, immediately locks the UART and remains in backup mode till next on-hook.

Dialling Functions

DTMF

The DTMF generator provides 8 frequencies (in Hz):

1 697+1209	2 697+1336	3 697+1477
4 770+1209	5 770+1336	6 770+1477
7 852+1209	8 852+1336	9 852+1477
* 941+1209	0 941+1336	# 941+1477

The MF output levels are set to -4/-6dB which should allow efficient backup dialling under all line conditions. The TONE/PAUSE ratio is 90ms/90ms. The preemphasis between low group and high group frequencies is t.m. 2.6dB.

FLASH timing

CPU can control the DPn pin and the MASK-mode of AS2540 via serial interface.

Tone Ringer

Ring frequency discrimination

The ring frequency discrimination assures that only signals with a frequency between 13Hz and 70Hz are regarded as valid ring signals.

When a valid ring signal is present for 102ms continuously, the ring melody generator is activated and remains active as long as a valid ring signal is present.

Once the ring melody generator has started, the ring signal is continuously monitored and the ring melody generator is instantly turned off according to the momentary presence of a valid or invalid ring signal until next off-hook.
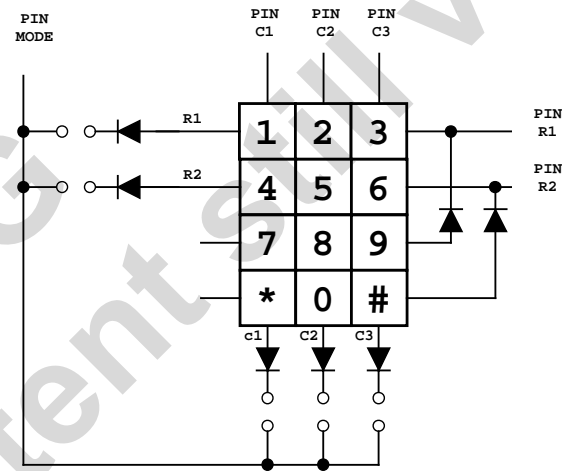
Toner ringer melody

The 3 basic melody frequencies are:
- F1=880Hz
- F2=1067Hz
- F3=1333Hz

The repetition rate is set to 4 which means that the sequence of F1, F2, F3, F1, F2, F3 is repeated 4 times within a second.
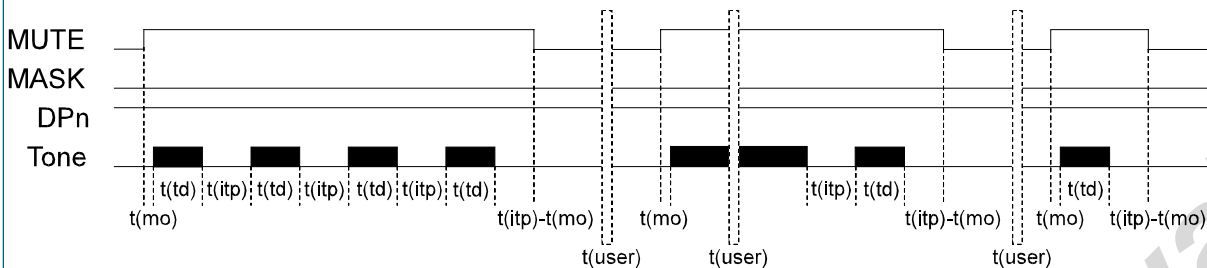
Keyboard connections

Double contacts under keys 0-9*#: One contact is connected to AS2540, the other one to CPU.

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Timing diagrams (unscaled)

Dialling - MF mode

Electrical characteristics

Electrical characteristics are measured with the Test Circuit application. Typical mean values will not be tested.

Absolute maximum ratings

Positive Supply Voltage	-0.3V <= VDD <= 7V
Input Current	+/- 25mA
Input Voltage (LS)	-0.3V <= Vin <= 10V
Input Voltage (LI, CS)	-0.3V <= Vin <= 8V
Input Voltage (STB, RI)	-2V <= Vin <= VDD+0.3V
Digital Input Voltage	-0.3V <= Vin <= VDD+0.3V
Electrostatic Discharge (HBM 1.5kΩ-100pF)	+/- 800V
Storage Temperature	-65°C to +125°C

Recommended operating conditions

Supply Voltage (generated internally)	3.6V <= VDD <= 5V
Oscillator Frequency Resonator Murata CSA 3.58MG312AM	3.58MHz
Operating Temperature	-15°C to +60°C

DC characteristics

I_{Line}=15mA w/o operation of SI through optocouplers, unless other specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
IDD	Operating Current	Speech Mode Speech Mode with SI MF Dialling LD Dialling, VDD=2.5V Ring Mode, VDD=2.5V		3 5 4 200 300	5	mA mA mA µA µA	Y N N N N
VLI	Line Voltage	15mA<=ILINE<=100mA	4.2	4.5	4.8	V	Y
IOL	Output Current, Sink CS, DPn, MO TXD	VOL=0.4V VOL=10mA		1 10		mA mA	N N
IOH	Output Current, Source MO	VOH=VDD-0.4V		-1		mA	N

Transmit characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
AMTX	Transmit Gain M1/M2 —> LS	ZAC(syn)=1000Ω	+36.5	+38	+39.5	dB	Y
ATTX	Transmit Gain TIT —> LS	ZAC(syn)=1000Ω	+6.5	+8	+9.5	dB	Y
THD	Distortion	VLS=0.25VRMS			2	%	Y
VAGC	Soft Clip Level M1/M2 —> LS at LS			2.0		VP	N
ASCO	Soft Clip Overdrive M1/M2			20		dB	N
ZIN	Input Impedance M1/M2 - TIT			20		kΩ	N
VNO	Noise Output Voltage LS	TAMP=25°C			-72	dBmp	Y
RL	Return Loss	ZAC(syn)=1000Ω	18			dB	Y

Receive characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
AHRX	Receive Gain LS —> ROH	ZAC(syn)=1000Ω	+0.5	+2	+3.5	dB	Y
ATRX	Receive Gain LS —> ROT	ZAC(syn)=1000Ω	-3.5	-2	-0.5	dB	Y Y
THD	Distortion	VLS=0.25VRMS			2	%	Y
VAGC	Soft Clip Level ROH			1		VP	N
ASCO	Soft Clip Overdrive ROH			10		dB	N
VNO	Noise Output Voltage ROH - ROT	TAMP=25°C			-72	dBmp	Y
ZIN	Input Imp. RI			8		kΩ	N
ST	Sidetone	VRI<=0.25VRMS	24			dB	Y
RL	Return Loss	ZAC(syn)=1000Ω	18			dB	Y

LD characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
t(td)	Flash Duration	DPN pin status can be directly controlled via serial interface					

DTMF characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
VMFlow	Tone Level Low Group LS			-6		dBm	Y
ΔVL-H	Preemphasis L-H		2.0	2.6	3.2	dB	Y
UFC	Unwanted Frequency Components	300Hz - 4.3kHz 4.3kHz - 7kHz 7kHz - 10kHz 10kHz - 14kHz 14kHz - 28.5kHz 28.5kHz – 40kHz			-40 -46 -52 -58 -70 -80	dBm dBm dBm dBm dBm dBm	Y Y Y Y Y Y
Δf	Frequency Deviation				1.2	%	Y
t(td)	Tone Duration		80	82.3	85	ms	Y
t(itp)	Inter Tone Pause		80	82.3	85	ms	Y
t(mo)	Mute Overhang				6	ms	Y
VCT-H	Comfort Tone (DTMF)	ROH rel. to LS		-30		dB	N

Ringer characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
f1	Frequency 1		770	800	830	Hz	Y
f2	Frequency 2		1025	1067	1110	Hz	Y
f3	Frequency 3		1280	1333	1385	Hz	Y
fMIN	Min. Det. Frequency		12	13	14	Hz	Y
fMAX	Max. Det. Frequency		68	70	75	Hz	Y
tDT	Detection Time	Initially		102		ms	N

Serial Interface

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
tRXD-r	RXD signal rise time	Vdd=4V,RPull-up=1.2kΩ		30		μs	N
tRXD-f	RXD signal fall time			30		μs	N
Vcomp	Input comparator level at RXD			Vdd/2		V	N
BRRXD	RXD baud rate	+/-2%		9600		bps	N
BRTXD	TXD baud rate	+/-2%		9600		bps	Y

Miscellaneous

Symbol	Parameter	Conditions	Min	Typ	Max	Units	Test
tD	Key Debouce Time			15		ms	N
ttime-out	Watch-dog Timer			2400		ms	N

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Typical Application

AN540: AS2540 evaluation board: analogue part

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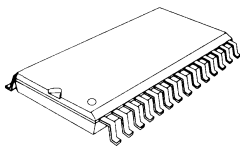
Test Circuit

AS2540
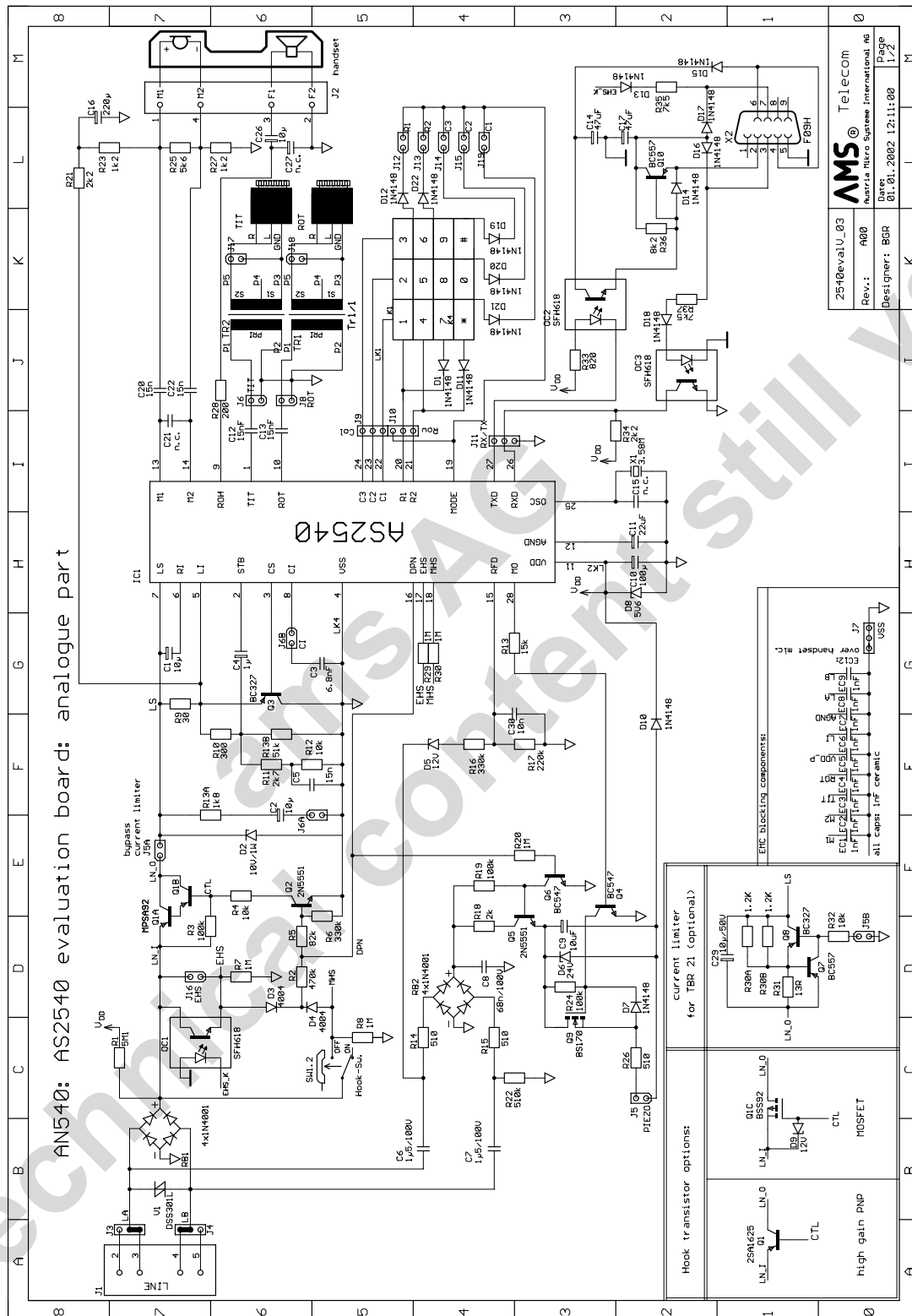
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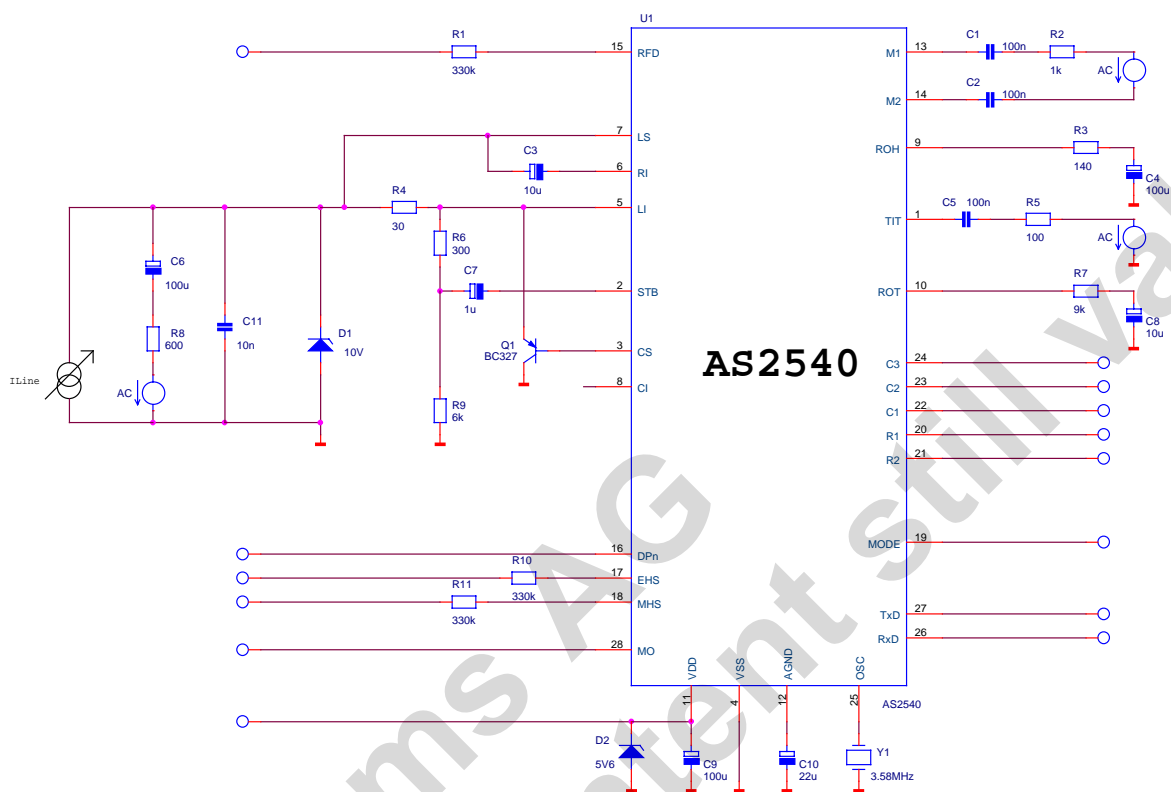
Packaging

The device is available in the packages outlined below (not to scale). For exact mechanical package dimensions please see austriamicrosystemsAG packaging information.

28-pin plastic SOIC (suffix T)

Max. Body Length   18.1mm / 713mil
Max. Body Width   7.6mm / 300mil
Pitch   1.27mm / 50mil

Pin-out

```
 1 – TIT          MO – 28
 2 – STB         TxD – 27
 3 – CS          RxD – 26
 4 – VSS         OSC – 25
 5 – LI           C3 – 24
 6 – RI           C2 – 23
 7 – LS           C1 – 22
 8 – CI           R2 – 21
 9 – ROH          R1 – 20
10 – ROT        MODE – 19
11 – VDD         MHS – 18
12 – AGD         EHS – 17
13 – M1          DPn – 16
14 – M2          RFD – 15
```

Marking

YYWWAAA
AS2540
Austria

YY   year of production
WW   calendar week of production
AAA   *ams*AG assembly ID

Ordering Information

Number	Package	Description
AS2540T	SOIC28	plastic small outline package - 28 leads (suffix T)
AS2540Q	Dice-on-Foil	dice

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