

# Remote Controlled Single-Chip-Telephone AS2540

DATA SHEET (PRELIMINARY)

## General Description

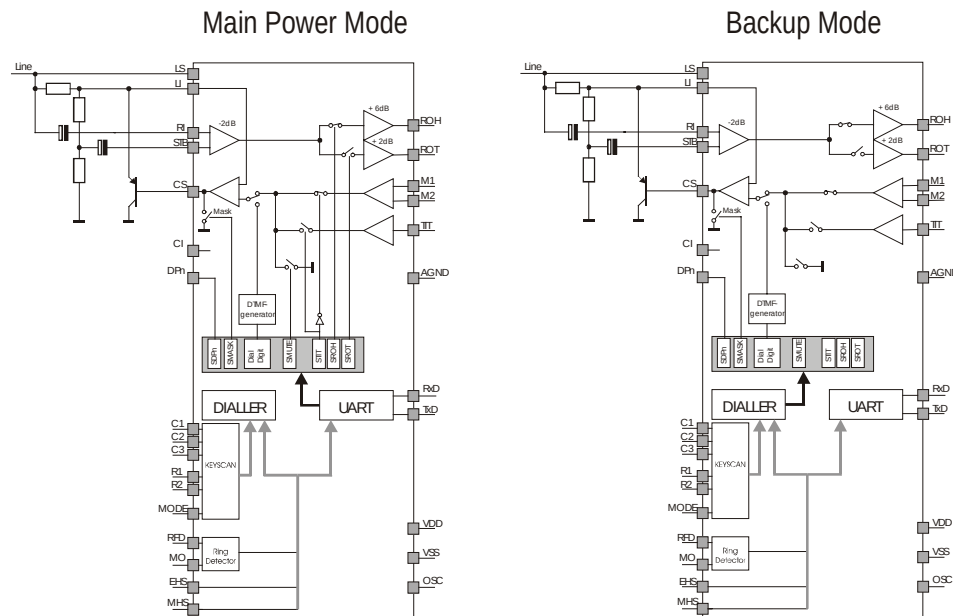
The AS2540 is a CMOS integrated circuit that incorporates a speech circuit (line-adaptation, 2/4-wire conversion, separate Rx- and Tx-amplifiers for handset and modem), MF dialler, ring frequency detector, ring melody generator and a two wire serial interface. It shall act as an a/b-line-powered device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

## Block Diagram



## 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

## Pin Description

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

| Pin #          | Symbol         | Function                                                                                                                                       |
|----------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 25             | OSC            | <b>O</b> scillator Input<br>Input for ceramic resonator 3.58MHz.<br>Recommended type: Murata CSA 3.58MG312AM or compatible                     |
| 12             | AGND           | <b>A</b> nalogue <b>G</b> round<br>Special ground for the internal amplifiers                                                                  |
| 26             | RXD            | <b>R</b> ecieve <b>D</b> ata Input<br>Schmitt trigger input to serial interface                                                                |
| 27             | TXD            | <b>T</b> ransmit <b>D</b> ata Output<br>Open drain output from serial interface                                                                |
| 20<br>21       | R1<br>R2       | Keyboard <b>R</b> ows                                                                                                                          |
| 22<br>23<br>24 | C1<br>C2<br>C3 | Keyboard <b>C</b> olumns                                                                                                                       |
| 10             | ROT            | <b>R</b> ecieve <b>O</b> utput to <b>T</b> ransformer<br>Output for driving a transformer with an ac impedance larger than 10k $\Omega$        |
| 1              | TIT            | <b>T</b> ransformer <b>I</b> nput from <b>T</b> ransformer<br>Single ended input for transformer                                               |
| 9              | ROH            | <b>R</b> ecieve <b>O</b> utput to <b>H</b> andset<br>Output for driving a dynamic earpiece with an impedance from 150 $\Omega$ to 300 $\Omega$ |
| 13<br>14       | M2<br>M1       | <b>M</b> icrophone Inputs<br>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 ( $MHS \cap EHS = \text{logical } 0$ ), 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 ( $MHS \cap EHS = \text{logical } 0$ ), 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 ( $MHS \cup EHS = \text{logical } 1$ ), 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  $\rightarrow$  MPM is only possible before AS2540 has started dialling digits independently.

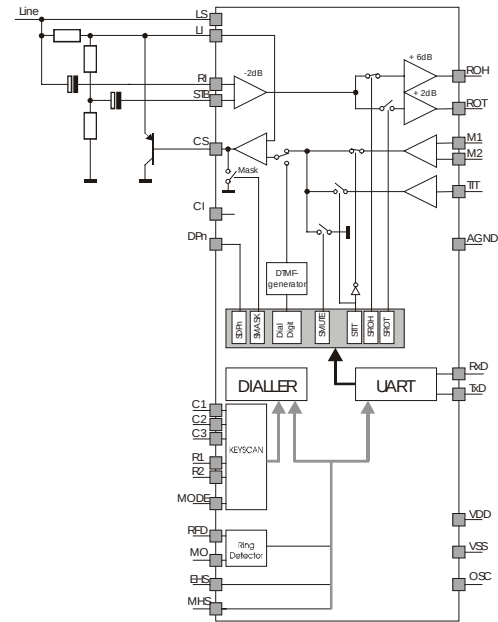
#### Main Power Mode

Manual hook-switch and/or electronic hook-switch is closed, AS2540 is supplied with line current ( $MHS \cup EHS = \text{logical } 1$ ), 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 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.

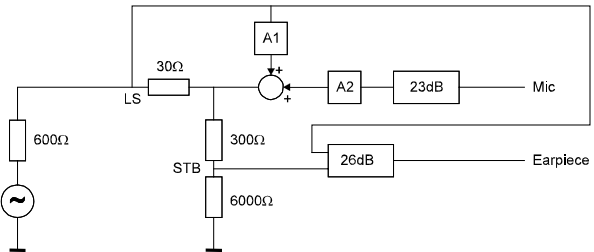
### DC conditions

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:  $V_{LS} = V_{LI} + I_{Line} \cdot 30\Omega$ . 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.

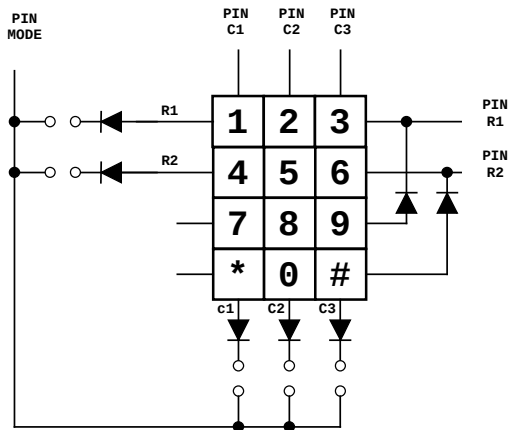
Receive path

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   | X | d5 | d4 | d3 | d2 | d1 | 1   |
| MSB |   |    |    |    |    |    | 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  | <i>reserved</i>      | <LineEvent>                     |
| x  | x  | 1  | 1  | 1  | 0  | 0  | 1  | <i>reserved</i>      | <LineEvent>                     |
| x  | x  | 1  | 1  | 1  | 1  | 0  | 1  | <i>reserved</i>      | <LineEvent>                     |
| x  | x  | 1  | 1  | 1  | 1  | 1  | 1  | <i>reserved</i>      | <LineEvent>                     |

### Tx messages

<Ack> message

#### <Ack> message format for <RequestStatus>

|           |    |    |    |    |    |   |          |
|-----------|----|----|----|----|----|---|----------|
| b7<br>MSB | b6 | b5 | b4 | b3 | b2 | 0 | 1<br>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) ...              |                                |

## &lt;Line Event&gt; Message

## &lt;LineEvent&gt; message format

|                         |           |           |   |   |   |   |                 |
|-------------------------|-----------|-----------|---|---|---|---|-----------------|
| <b>b7</b><br><b>MSB</b> | <b>b6</b> | <b>b5</b> | 1 | 1 | 1 | 1 | 1<br><b>LSB</b> |
|-------------------------|-----------|-----------|---|---|---|---|-----------------|

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

|                      |                      |                      |
|----------------------|----------------------|----------------------|
| <b>1</b><br>697+1209 | <b>2</b><br>697+1336 | <b>3</b><br>697+1477 |
| <b>4</b><br>770+1209 | <b>5</b><br>770+1336 | <b>6</b><br>770+1477 |
| <b>7</b><br>852+1209 | <b>8</b><br>852+1336 | <b>9</b><br>852+1477 |
| <b>*</b><br>941+1209 | <b>0</b><br>941+1336 | <b>#</b><br>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.

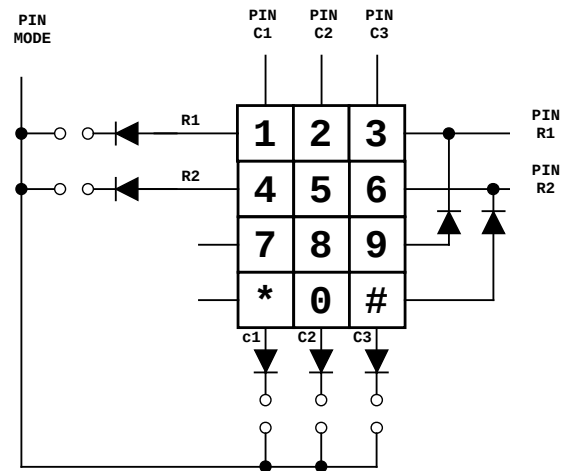
### Toner ringer melody

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.

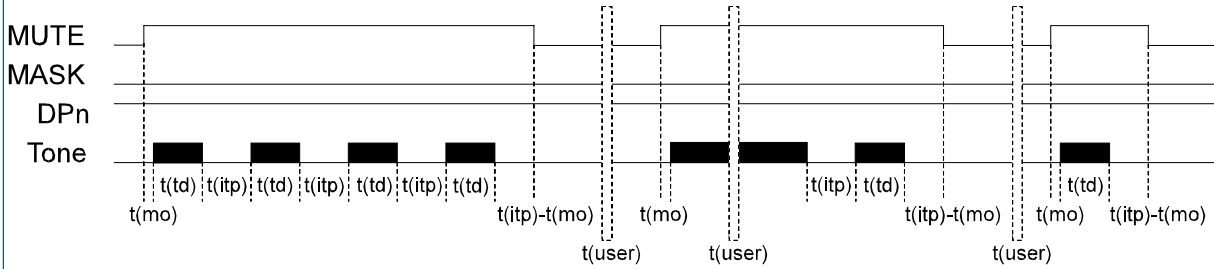
### Keyboard connections



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

## 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<br>Resonator Murata CSA 3.58MG312AM | 3.58MHz         |
| Operating Temperature                                    | -15°C to +60°C  |

## DC characteristics

I<sub>Line</sub>=15mA w/o operation of SI through optocouplers, unless other specified

| Symbol | Parameter                                  | Conditions                       | Min | Typ | Max | Units | Test |
|--------|--------------------------------------------|----------------------------------|-----|-----|-----|-------|------|
| IDD    | Operating Current                          | Speech Mode                      |     | 3   | 5   | mA    | Y    |
|        |                                            | Speech Mode with SI              |     | 5   |     | mA    | N    |
|        |                                            | MF Dialling                      |     | 4   |     | mA    | N    |
|        |                                            | LD Dialling, VDD=2.5V            |     | 200 |     | μA    | N    |
|        |                                            | Ring Mode, VDD=2.5V              |     | 300 |     | μA    | N    |
| VLI    | Line Voltage                               | 15mA ≤ I <sub>LINE</sub> ≤ 100mA | 4.2 | 4.5 | 4.8 | V     | Y    |
| IOL    | Output Current, Sink CS,<br>DPn, MO<br>TXD | VOL=0.4V                         |     | 1   |     | mA    | N    |
|        |                                            | VOL=10mA                         |     | 10  |     | mA    | 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<br>M1/M2 → LS         | ZAC(syn)=1000Ω | +36.5 | +38 | +39.5 | dB    | Y    |
| ATTX   | Transmit Gain<br>TIT → LS           | ZAC(syn)=1000Ω | +6.5  | +8  | +9.5  | dB    | Y    |
| THD    | Distortion                          | VLS=0.25VRMS   |       |     | 2     | %     | Y    |
| VAGC   | Soft Clip Level<br>M1/M2 → LS at LS |                |       | 2.0 |       | VP    | N    |
| ASCO   | Soft Clip Overdrive<br>M1/M2        |                |       | 20  |       | dB    | N    |
| ZIN    | Input Impedance<br>M1/M2 - TIT      |                |       | 20  |       | kΩ    | N    |
| VNO    | Noise Output Voltage<br>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<br>LS → ROH          | ZAC(syn)=1000Ω | +0.5 | +2  | +3.5 | dB    | Y      |
| ATRX   | Receive Gain<br>LS → ROT          | ZAC(syn)=1000Ω | -3.5 | -2  | -0.5 | dB    | Y<br>Y |
| THD    | Distortion                        | VLS=0.25VRMS   |      |     | 2    | %     | Y      |
| VAGC   | Soft Clip Level<br>ROH            |                |      | 1   |      | VP    | N      |
| ASCO   | Soft Clip Overdrive<br>ROH        |                |      | 10  |      | dB    | N      |
| VNO    | Noise Output Voltage<br>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    |
| $\Delta$ VL-H | Preemphasis L-H               |                 | 2.0 | 2.6  | 3.2 | dB    | Y    |
| UFC           | Unwanted Frequency Components | 300Hz - 4.3kHz  |     |      | -40 | dBm   | Y    |
|               |                               | 4.3kHz - 7kHz   |     |      | -46 | dBm   | Y    |
|               |                               | 7kHz - 10kHz    |     |      | -52 | dBm   | Y    |
|               |                               | 10kHz - 14kHz   |     |      | -58 | dBm   | Y    |
|               |                               | 14kHz - 28.5kHz |     |      | -70 | dBm   | Y    |
|               |                               | 28.5kHz - 40kHz |     |      | -80 | dBm   | Y    |
| $\Delta$ f    | 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    |

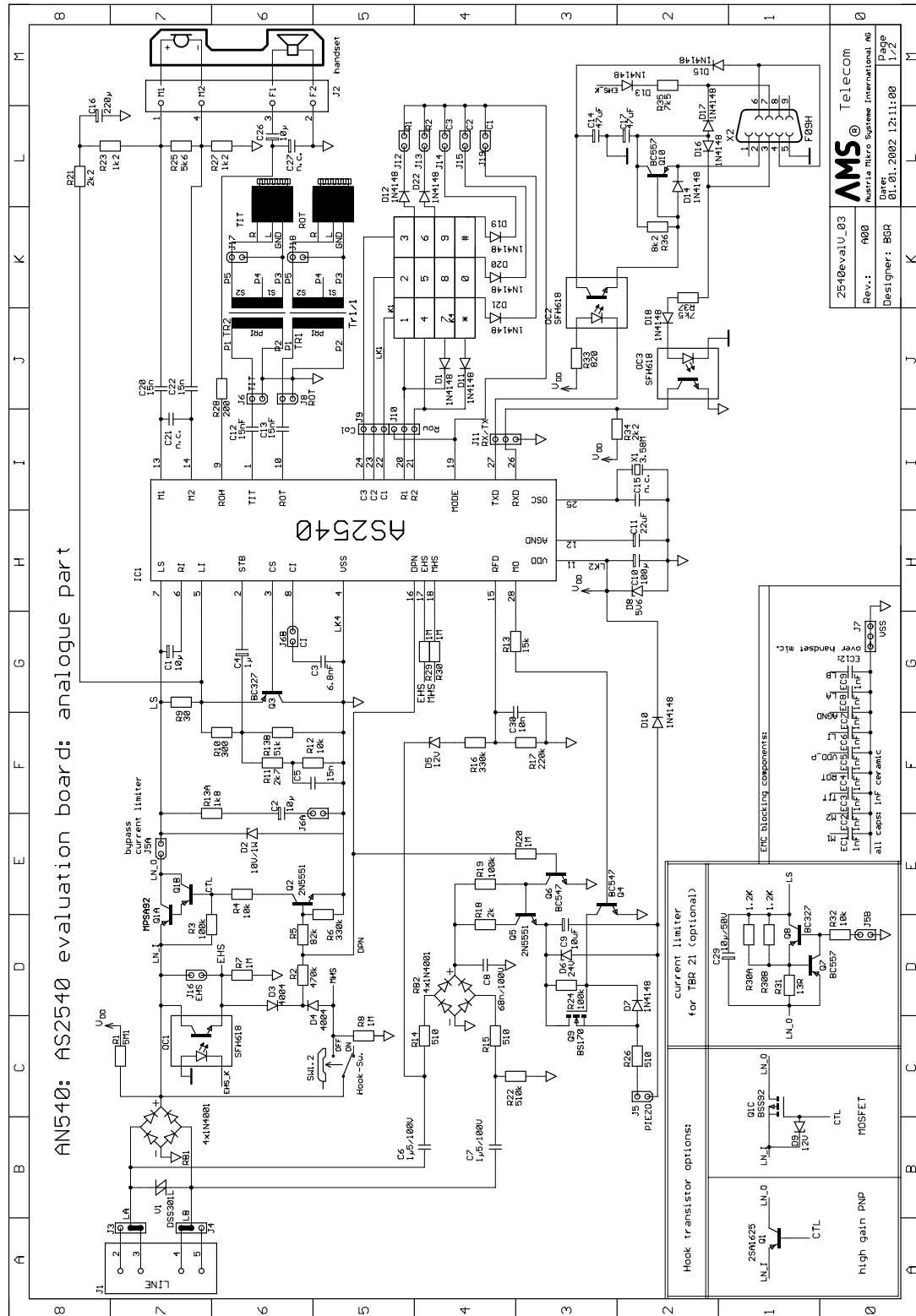
**Serial Interface**

| 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    |
|        |                               |                        |     |       |     |       |      |
|        |                               |                        |     |       |     |       |      |

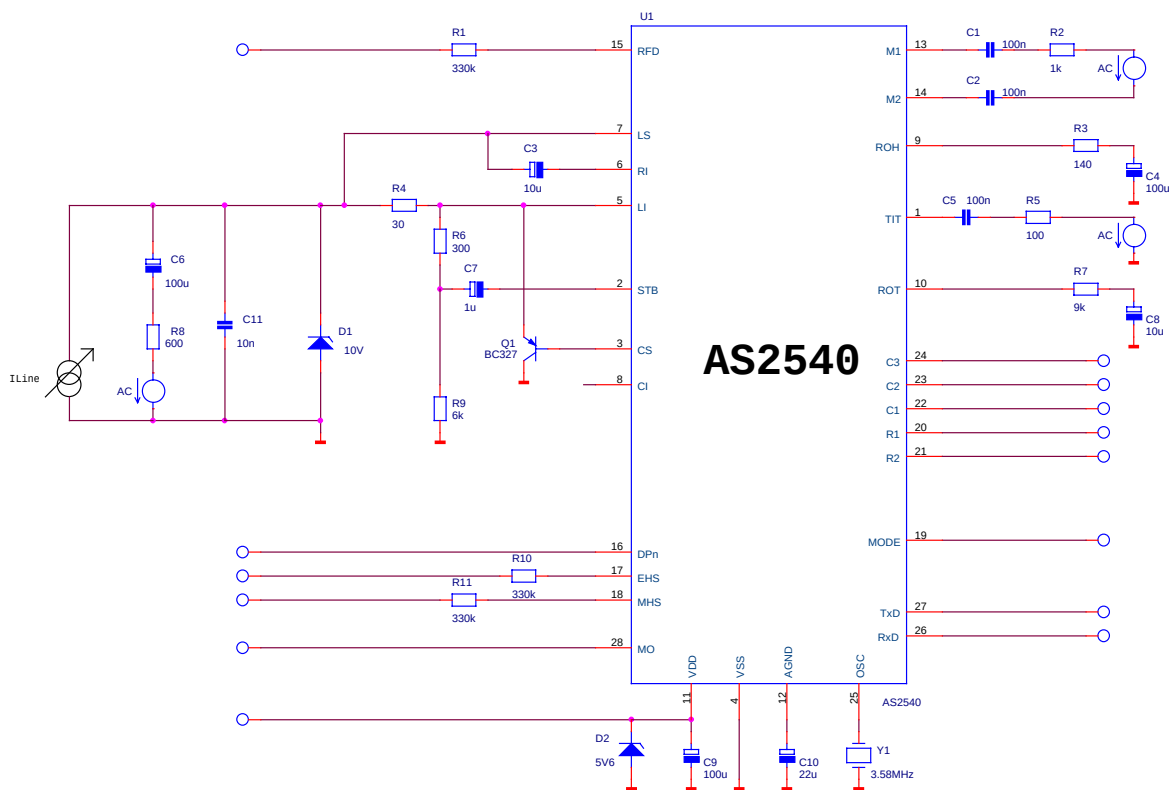
**Miscellaneous**

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

## Typical Application



## Test Circuit

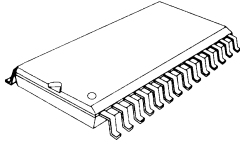




## Packaging

The device is available in the packages outlined below (not to scale). For exact mechanical package dimensions please see austriamicrosystems<sub>AG</sub> 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<br>AS2540<br>Austria |
|-------------------------------------------------------------------------------------|------------------------------|

|     |                               |
|-----|-------------------------------|
| YY  | year of production            |
| WW  | calendar week of production   |
| AAA | ams <sub>AG</sub> 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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