

DATA SHEET

TEA5757; TEA5759 **Self Tuned Radio (STR)**

Product specification
Supersedes data of 1996 Jan 09
File under Integrated Circuits, IC01

1999 Aug 26

Self Tuned Radio (STR)

TEA5757; TEA5759

FEATURES

- The tuning system has an optimized IC partitioning both from application (omitting interferences) and flexibility (removable front panel option) point of view: the tuning synthesizer is on-chip with the radio
- The tuning quality is superior and requires no IF-counter for stop-detection; it is insensitive to ceramic filter tolerances
- In combination with the microcontroller, fast, low-power operation of preset mode, manual-search, auto-search and auto-store are possible
- The local (internal) controller function facilitates reduced and simplified microcontroller software
- The high integration level (radio and tuning synthesizer on one chip) means fewer external components with regard to the communication between the radio and the microcontroller (90% less components compared to the digital tuning application of a radio IC with external PLL tuning function) and a simple and small printed-circuit board
- There will be no application considerations for the tuning system, with regards to quality and high integration level, since there will be no external 110 MHz buffers, loop filter or false lock elimination
- The inherent FUZZY LOGIC behaviour of the Self Tuned Radio (STR), which mimics hand tuning, yields a potentially fast yet reliable tuning operation
- The level of the incoming signal at which the radio must lock is software programmable
- Two programmable ports

- High selectivity with distributed IF gain
- Soft mute
- Signal dependent stereo-blend
- High impedance MOSFET input on AM
- Wide supply voltage range of 2.5 to 12 V
- Low current consumption 18 mA at AM and FM (including tuning synthesizer)
- High input sensitivity
- Low output distortion
- Due to the new tuning concept, the tuning is independent of the channel spacing.

GENERAL DESCRIPTION

The TEA5757; TEA5759 is a 44-pin integrated AM/FM stereo radio circuit including a novel tuning concept. The radio part is based on the TEA5712.

The TEA5757 is used in FM-standards in which the local oscillator frequency is above the radio frequency (e.g. European and American standards).

The TEA5759 is the version in which the oscillator frequency is below the radio frequency (e.g. Japanese standard).

The new tuning concept combines the advantages of hand tuning with electronic facilities and features. User 'intelligence' is incorporated into the tuning algorithm and an improvement of the analog signal processing is used for the AFC function.

ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|-------------|---------|--|----------|
| | NAME | DESCRIPTION | VERSION |
| TEA5757H | QFP44 | plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 × 10 × 1.75 mm | SOT307-2 |
| TEA5759H | | | |

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QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|--------------------------------|---|---|------|------|------------------|--------------|
| V_{CC1} | supply voltage | | 2.5 | – | 12 | V |
| V_{CC2} | supply voltage for tuning | | – | – | 12 | V |
| V_{tune} | tuning voltage | | 0.7 | – | $V_{CC2} - 0.75$ | V |
| I_{CC1} | supply current | AM mode | 12 | 15 | 18 | mA |
| | | FM mode | 13 | 16 | 19 | mA |
| I_{DD} | supply current | AM mode | – | 3.3 | – | mA |
| | | FM mode | – | 2.7 | – | mA |
| I_{CC2} | supply current for tuning in preset mode (band-end to band-end) | | – | – | 800 | μ A |
| T_{amb} | ambient temperature | | –15 | – | +60 | $^{\circ}$ C |
| AM performance; note 1 | | | | | | |
| V_{10} | AF output voltage | $V_{i1} = 5$ mV | 36 | 45 | 70 | mV |
| V_{i1} | RF sensitivity input voltage | $(S+N)/N = 26$ dB | 40 | 55 | 70 | μ V |
| THD | total harmonic distortion | $V_{i1} = 1$ mV | – | 0.8 | 2.0 | % |
| FM performance; note 2 | | | | | | |
| V_{10} | AF output voltage | $V_{i5} = 1$ mV | 40 | 48 | 57 | mV |
| V_{i5} | RF limiting sensitivity | V_{10} at –3 dB; V_{10} is 0 dB at $V_{i5} = 1$ mV | 0.4 | 1.2 | 3.8 | μ V |
| THD | total harmonic distortion | IF filter SFE10.7MS3A20K-A | – | 0.3 | 0.8 | % |
| MPX performance; note 3 | | | | | | |
| α_{CS} | channel separation | | 26 | 30 | – | dB |

Notes

- $V_{CC1} = 3$ V; $V_{CC2} = 12$ V; $V_{DDD} = 3$ V; $f_i = 1$ MHz; $m = 0.3$; $f_m = 1$ kHz; measured in Fig.9 with S1 in position A and S2 in position B; V_n refers to pin voltages; $V_{i(n)}$ refers to test circuit (see Fig.9).
- $V_{CC1} = 3$ V; $V_{CC2} = 12$ V; $V_{DDD} = 3$ V; $f_i = 100$ MHz; $\Delta f_m = 22.5$ kHz; $f_m = 1$ kHz; measured in Fig.9 with S2, S3 and S5 in position A; V_n refers to pin voltages; $V_{i(n)}$ refers to test circuit (see Fig.9).
- $V_{CC1} = 3$ V; $V_{CC2} = 12$ V; $V_{DDD} = 3$ V; $V_{i3(L+R)} = 155$ mV; $V_{pilot} = 15.5$ mV; $f_i = 1$ kHz; measured in Fig.9 with S2 and S3 in position B.

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BLOCK DIAGRAM

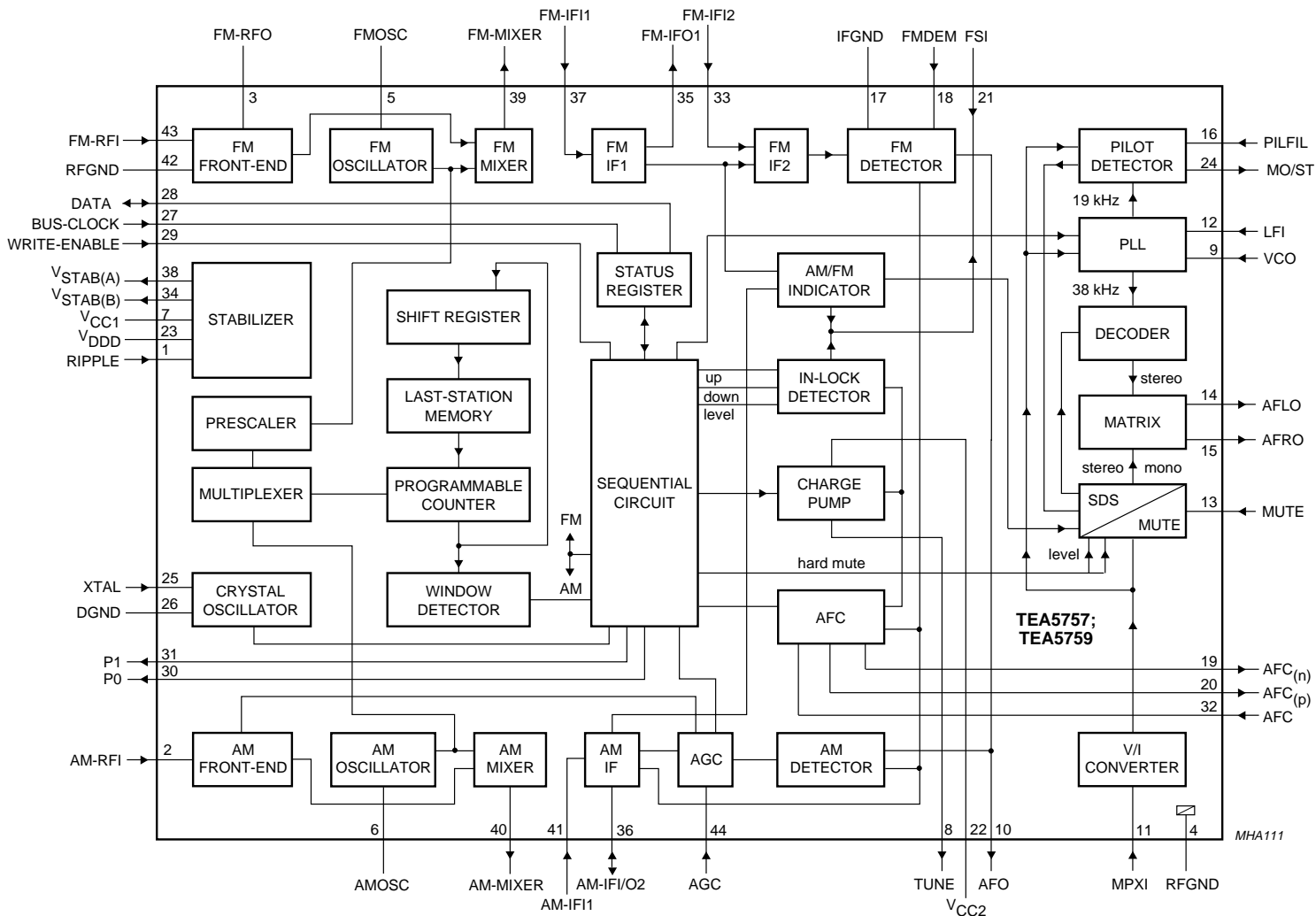


Fig.1 Block diagram.

Self Tuned Radio (STR)

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PINNING

| SYMBOL | PIN | DESCRIPTION |
|----------------------|-----|---|
| RIPPLE | 1 | ripple capacitor input |
| AM-RFI | 2 | AMRF input |
| FM-RFO | 3 | parallel tuned FMRF circuit to ground |
| RFGND | 4 | RF ground and substrate |
| FMOSC | 5 | parallel tuned FM-oscillator circuit to ground |
| AMOSC | 6 | parallel tuned AM-oscillator circuit to ground |
| V _{CC1} | 7 | supply voltage |
| TUNE | 8 | tuning current output |
| VCO | 9 | voltage controlled oscillator input |
| AFO | 10 | AM/FM AF output (output impedance typical 5 k Ω) |
| MPXI | 11 | stereo decoder input (input impedance typical 150 k Ω) |
| LFI | 12 | loop-filter input |
| MUTE | 13 | mute input |
| AFLO | 14 | left channel output (output impedance typical 4.3 k Ω) |
| AFRO | 15 | right channel output (output impedance typical 4.3 k Ω) |
| PILFIL | 16 | pilot detector filter input |
| IFGND | 17 | ground of IF, detector and MPX stage |
| FMDEM | 18 | ceramic discriminator input |
| AFC _(n) | 19 | AFC negative output |
| AFC _(p) | 20 | AFC positive output |
| FSI | 21 | field-strength indicator |
| V _{CC2} | 22 | supply voltage for tuning |
| V _{DDD} | 23 | digital supply voltage |
| MO/ST | 24 | mono/stereo and tuning indication output |
| XTAL | 25 | crystal input |
| DGND | 26 | digital ground |
| BUS-CLOCK | 27 | bus-clock input |
| DATA | 28 | bus data input/output |
| WRITE-ENABLE | 29 | bus write-enable input |
| P0 | 30 | programmable output port (P0) |
| P1 | 31 | programmable output port (P1) |
| AFC | 32 | 450 kHz LC-circuit |
| FM-IFI2 | 33 | FMIF input 2 (input impedance typical 330 Ω) |
| V _{STAB(B)} | 34 | internal stabilized supply voltage (B) |
| FM-IFO1 | 35 | FMIF output 1 (output impedance typical 330 Ω) |
| AM-IFI/O2 | 36 | input/output to IF-Tank (IFT); output: current source |
| FM-IFI1 | 37 | FMIF input 1 (input impedance typical 330 Ω) |
| V _{STAB(A)} | 38 | internal stabilized supply voltage (A) |
| FM-MIXER | 39 | ceramic filter output (output impedance typical 330 Ω) |
| AM-MIXER | 40 | open-collector output to IFT |

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| SYMBOL | PIN | DESCRIPTION |
|--------|-----|--|
| AM-IF1 | 41 | IFT or ceramic filter input (input impedance typical 3 kΩ) |
| RFGND | 42 | FMRF ground |
| FM-RFI | 43 | FMRF aerial input (input impedance typical 40 Ω) |
| AGC | 44 | AGC capacitor input |

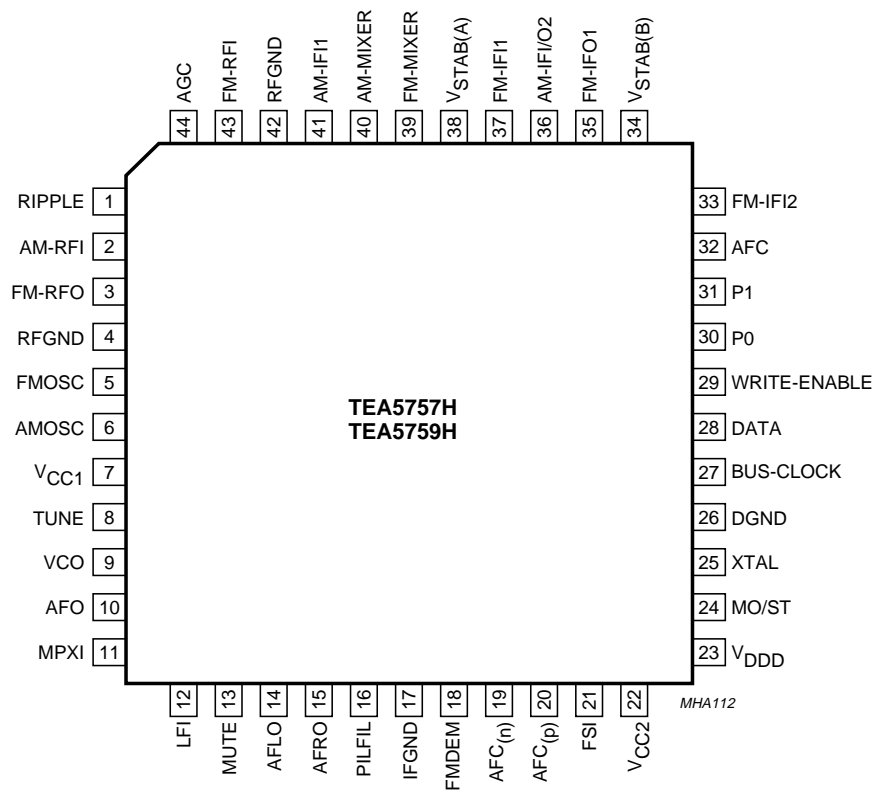


Fig.2 Pin configuration.

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FUNCTIONAL DESCRIPTION

The TEA5757; TEA5759 is an integrated AM/FM stereo radio circuit including digital tuning and control functions.

The radio

The AM circuit incorporates a double balanced mixer, a one-pin low-voltage oscillator (up to 30 MHz) and is designed for distributed selectivity.

The AM input is designed to be connected to the top of a tuned circuit. AGC controls the IF amplification and for large signals it lowers the input impedance of the AM front-end.

The first AM selectivity can be an IF-Tank (IFT) as well as an IFT combined with a ceramic filter; the second one is an IFT.

The FM circuit incorporates a tuned RF stage, a double balanced mixer, a one-pin oscillator and is designed for distributed IF ceramic filters. The FM quadrature detector uses a ceramic resonator (or LC).

The PLL stereo decoder incorporates a signal dependent stereo-blend circuit and a soft-mute circuit.

Tuning

The tuning concept of the Self Tuned Radio (STR) is based on FUZZY LOGIC: it mimics hand tuning (hand tuning is a combination of coarse and fine tuning to the qualitatively best frequency position). As a consequence the tuning system is very fast.

The tuning algorithm, which is controlled by the sequential circuit (see Fig.1), is completely integrated; so there are only a few external components needed.

The bus and the microcontroller can be kept very simple. The bus only consists of three wires (BUS-CLOCK, DATA and WRITE-ENABLE). The microcontroller must basically give two instructions:

- Preset operation
- Search operation.

PRESET OPERATION

In preset mode, the microcontroller has to load information such as frequency band, frequency and mono/stereo. This information has to be sent via the bus to the STR.

The internal algorithm controls the tuning sequence as follows:

1. The information is loaded into the shift register, the last-station memory and the counter.

2. The Automatic Frequency Control (AFC) is switched off.
3. The counter starts counting the frequency and the tuning voltage is varied until the desired frequency roughly equals the real frequency.
4. The AFC is then switched on and the counter is switched off.
5. The real frequency is more precisely tuned to the desired frequency.

After the AFC has tuned the real frequency to the desired frequency an in-lock signal can be generated. In order to get a reliable in-lock signal, there are two parameters measured: the field strength and the S-curve. The field strength indicates the strength of the station and by looking at the S-curve the system can distinguish false in-locks from real in-locks (false in-locks occur on the wrong slope of the S-curve).

In the event of fading or pulling the in-lock signal becomes logic 0 and the synthesizer will be switched on again and the algorithm will be repeated.

SEARCH OPERATION

During a search operation, the only action the microcontroller has to take is: sending the desired band plus the direction and the search sensitivity level to the STR. The search operation is performed by the charge pump until an in-lock signal is generated (combination of measuring the field strength and the S-curve). The AFC then fine tunes to the station. The frequency belonging to the found station will be counted by the counter and written into the last-station memory and the shift register of the counter. At this time the frequency is available in the shift register and can be read by the microcontroller.

The microcontroller decides whether the frequency is within the desired frequency band. If so, this frequency can be stored under a preset and if not, a new search action should be started.

To ensure that the search function operates correctly under all conditions the following search sequence must be applied:

- Store the current frequency in the memory
- Issue the search command
- Wait for data valid and read the new frequency
- If the new frequency is the same as the stored frequency, issue a pre-set step (e.g. 50 kHz) and start the search sequence again.

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Description of the bus

The TEA5757; TEA5759 radio has a bus which consists of three wires, as shown in Table 1.

Table 1 Bus signals

| SIGNAL | DESCRIPTION | PIN |
|--------------|-----------------------------|-----|
| BUS-CLOCK | software driven clock input | 27 |
| DATA | data input/output | 28 |
| WRITE-ENABLE | write/read input | 29 |

These three signals, together with the mono/stereo pin (MO/ST; pin 24), communicate with the microcontroller. The mono/stereo indicator has two functions, which are controlled by the BUS-CLOCK, as shown in Table 2.

Table 2 Bus-clock functions

| BUS-CLOCK | MO/ST (PIN 24) | RESULT |
|-----------|----------------|-----------|
| LOW | LOW | stereo |
| LOW | HIGH | mono |
| HIGH | LOW | tuned |
| HIGH | HIGH | not tuned |

The TEA5757; TEA5759 has a 25-bit shift register; see Table 3 for an explanation of the shift register bits.

If in search mode no transmitter can be found, all frequency bits of the shift register are set to logic 0.

The bus protocol is depicted in Figs 3 and 4.

Table 3 Explanation of the shift register bits

| BIT | DESCRIPTION | LOGIC STATE | RESULT |
|-------------------|-------------------------|-------------|--|
| S.24 (MSB) | search start/end | 0 | after a search when a station is found or after a preset |
| | | 1 | during the search action |
| D.23 | search up/down | 0 | indicates if the radio has to search down |
| | | 1 | indicates if the radio has to search up |
| M.22 | mono/stereo | 0 | stereo is allowed |
| | | 1 | mono is required (radio switched to forced mono) |
| B0.21 | band | see Table 4 | selects FM/MW/LW/SW band |
| B1.20 | | | |
| P0.19 | port | note 1 | user programmable bits which e.g. can be used as band switch driver |
| P1.18 | | | |
| S0.17 | search-level of station | see Table 5 | determines the locking field strength during an automatic search, automatic store or manual search |
| S1.16 | | | |
| 15 | dummy | – | buffer |
| F.14 to F.0 (LSB) | frequency | – | determine the tuning frequency of the radio; see Table 6 for the bit values |

Note

- The output pins 30 and 31 can drive currents up to 5 mA; bits P0.19 and P1.18 control the output voltage of the control pins P0 (pin 30) and P1 (pin 31):
 - Bit P0.19 LOW sets P0 (pin 30) to LOW.
 - Bit P0.19 HIGH sets P0 (pin 30) to HIGH.
 - Bit P1.18 LOW sets P1 (pin 31) to LOW.
 - Bit P1.18 HIGH sets P1 (pin 31) to HIGH.

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Table 4 Truth table for bits B0.21 and B1.20

| B0.21 | B1.20 | BAND SELECT |
|-------|-------|-------------|
| 0 | 0 | FM |
| 0 | 1 | MW |
| 1 | 0 | LW |
| 1 | 1 | SW |

Table 5 Truth table for bits S1.16 and S0.17

| S1.16 | S0.17 | SIGNAL RECEPTION | |
|-------|-------|-------------------------|-------------------------|
| | | FM (μV) | AM (μV) |
| 0 | 0 | >5 | >28 |
| 0 | 1 | >10 | >40 |
| 1 | 0 | >30 | >63 |
| 1 | 1 | >150 | >1000 |

Table 6 Values for bits F.14 to F.0

| BIT | BIT VALUE | FM VALUE ⁽¹⁾ (kHz) | AM VALUE ⁽²⁾ (kHz) |
|------|-----------|-------------------------------------|-------------------------------------|
| F.14 | 2^{14} | – | 16384 |
| F.13 | 2^{13} | 102400 | 8192 |
| F.12 | 2^{12} | 51200 | 4096 |
| F.11 | 2^{11} | 25600 | 2048 |
| F.10 | 2^{10} | 12800 | 1024 |
| F.9 | 2^9 | 6400 | 512 |
| F.8 | 2^8 | 3200 | 256 |
| F.7 | 2^7 | 1600 | 128 |
| F.6 | 2^6 | 800 | 64 |
| F.5 | 2^5 | 400 | 32 |
| F.4 | 2^4 | 200 | 16 |
| F.3 | 2^3 | 100 | 8 |
| F.2 | 2^2 | 50 | 4 |
| F.1 | 2^1 | 25 | 2 |
| F.0 | 2^0 | 12.5 | 1 |

Notes

- FM value of the affected oscillators:
 - FM VALUE = FMRF + FMIF (for TEA5757).
 - FM VALUE = FMRF – FMIF (for TEA5759).
- AM value of the affected oscillators:
AM VALUE = AMRF + AMIF.

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READING DATA

While WRITE-ENABLE is LOW data can be read by the microcontroller. At a rising edge of the BUS-CLOCK, data is shifted out of the register. This data is available from the point where the BUS-CLOCK is HIGH until the next rising edge of the BUS-CLOCK occurs (see Fig.3).

To read the entire shift register 24 clock pulses are necessary.

WRITING DATA

While WRITE-ENABLE is HIGH the microcontroller can transmit data to the TEA5757; TEA5759 (hard mute is active). At a rising edge of the BUS-CLOCK, the register shifts and accepts one bit into LSB. At clock LOW the microcontroller writes data (see Fig.4).

To write the entire shift register 25 clock pulses are necessary.

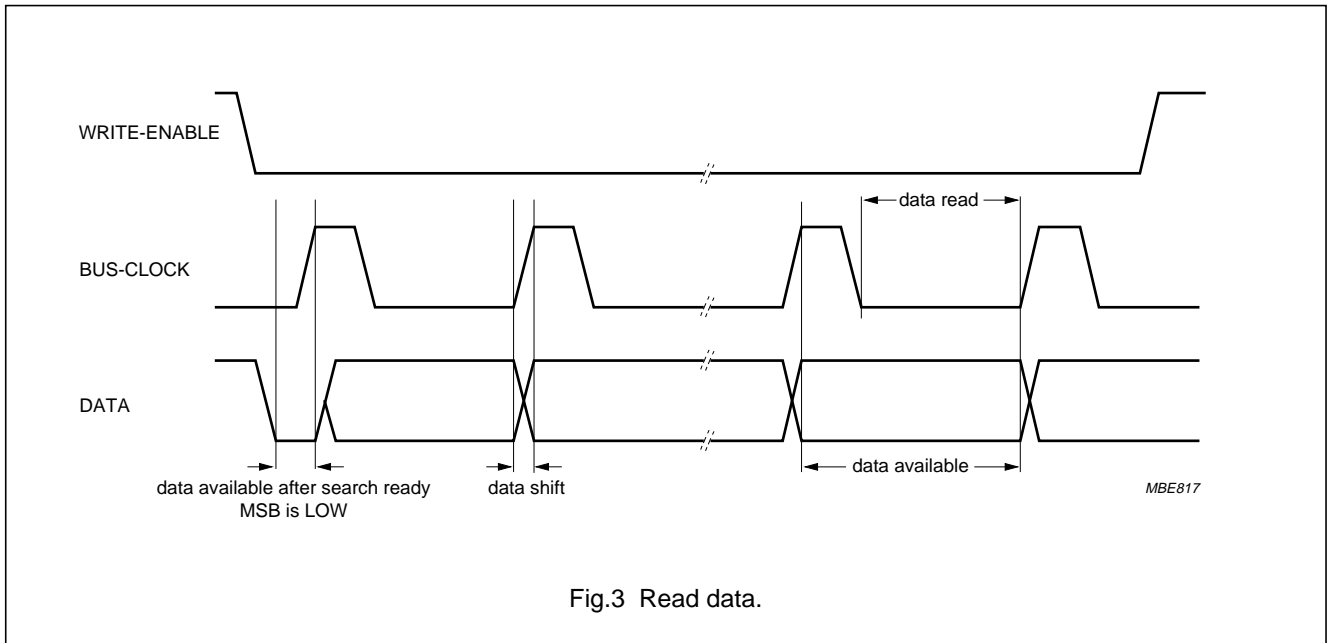


Fig.3 Read data.

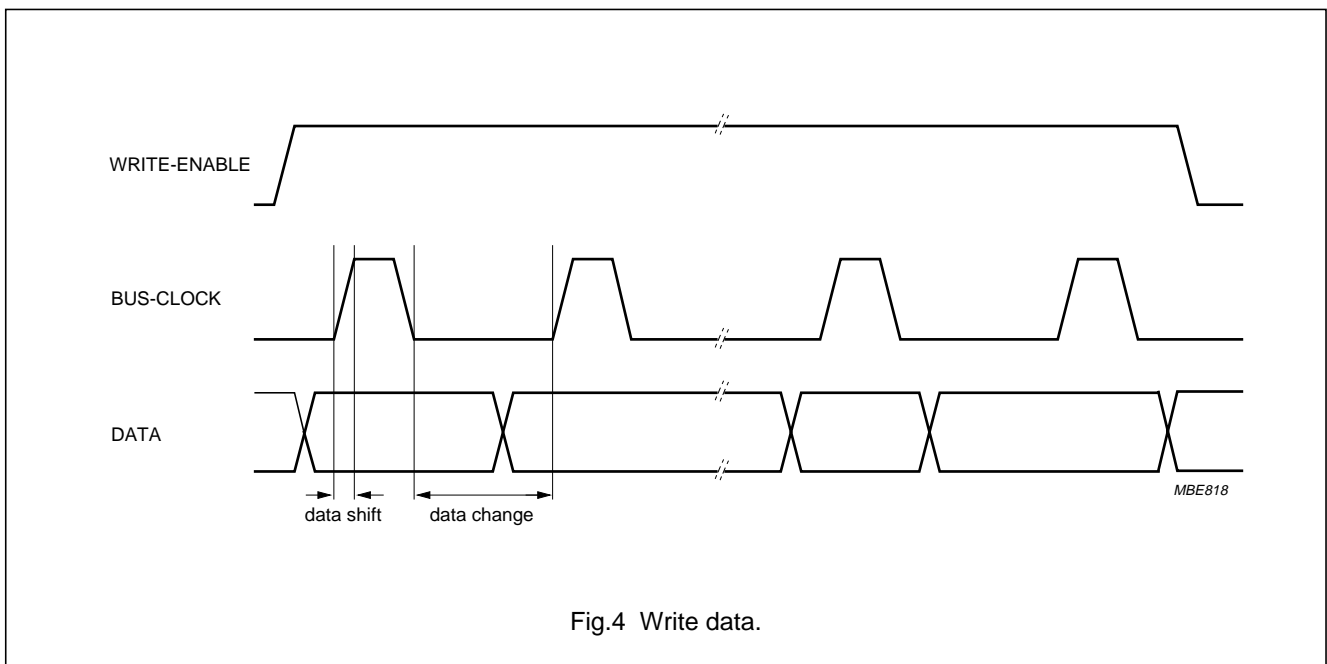


Fig.4 Write data.

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BUS TIMING

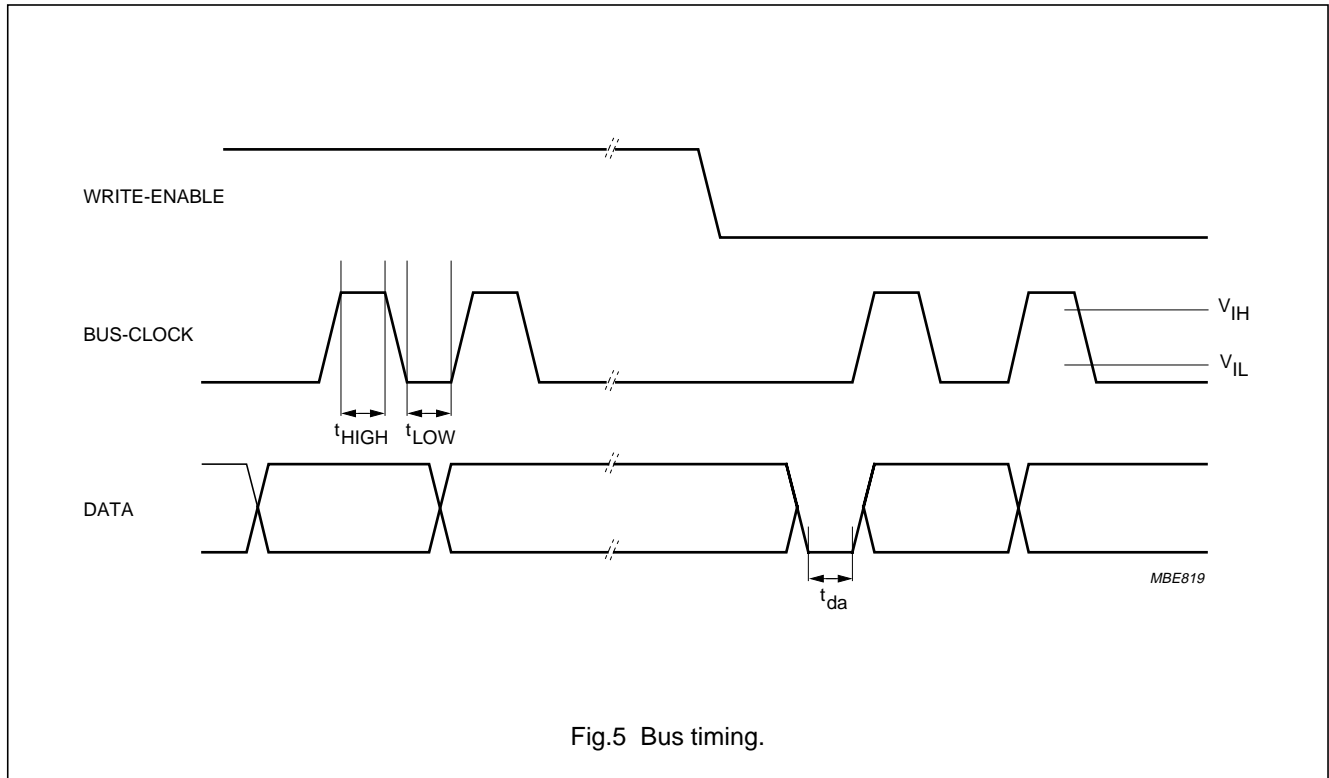


Fig.5 Bus timing.

Table 7 Digital inputs

| SYMBOL | PARAMETER | MIN. | MAX. | UNIT |
|-----------------------|---|------|------|---------|
| Digital inputs | | | | |
| V_{IH} | HIGH-level input voltage | 1.4 | – | V |
| V_{IL} | LOW-level input voltage | – | 0.6 | V |
| Timing | | | | |
| f_{clk} | clock input frequency | – | 300 | kHz |
| t_{HIGH} | clock HIGH time | 1.67 | – | μ s |
| t_{LOW} | clock LOW time | 1.67 | – | μ s |
| t_{da} | shift register available after 'search ready' | – | 14 | μ s |

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|-----------|---|--------------------------|------|------|------|
| V_{CC1} | supply voltage | | 0 | 13.2 | V |
| P_{tot} | total power dissipation | $T_{amb} = 70\text{ °C}$ | – | 250 | mW |
| T_{stg} | storage temperature | | –65 | +150 | °C |
| T_{amb} | ambient temperature | | –15 | +60 | °C |
| T_j | junction temperature | | –15 | +150 | °C |
| V_{es} | electrostatic handling voltage for all pins | note 1 | – | ±200 | V |

Note

1. Charge device model; equivalent to discharging a 200 pF capacitor via a 0 Ω series resistor.

THERMAL CHARACTERISTICS

| SYMBOL | PARAMETER | CONDITIONS | VALUE | UNIT |
|---------------|---|-------------|-------|------|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | in free air | 65 | K/W |

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CHARACTERISTICS

$V_{CC1} = 3\text{ V}$; $T_{amb} = 25\text{ °C}$; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------------|---|-----------------------|-------|------|------------------|---------------|
| V_{CC1} | supply voltage | | 2.5 | – | 12 | V |
| V_{CC2} | supply voltage for tuning | | – | – | 12 | V |
| V_{DDD} | supply voltage for digital part | | 2.5 | – | 12 | V |
| V_{tune} | tuning voltage | | 0.7 | – | $V_{CC2} - 0.75$ | V |
| I_{CC2} | supply current for tuning in preset mode (band-end to band-end) | | – | – | 800 | μA |
| $f_{BUS-CLOCK(max)}$ | maximum BUS-CLOCK frequency | | – | – | 300 | kHz |
| I_{CC1} | current consumption during acquisition of V_{CC1} | AM mode | 12 | 15 | 18 | mA |
| | | FM mode | 12.5 | 15.5 | 18.5 | mA |
| I_{DD} | current consumption during acquisition of I_{DD} | AM mode | – | 4.8 | – | mA |
| | | FM mode | – | 5.5 | – | mA |
| I_{CC1} | current consumption after acquisition of V_{CC1} | AM mode | 12 | 15 | 18 | mA |
| | | FM mode | 13 | 16 | 19 | mA |
| I_{DD} | current consumption after acquisition of I_{DD} | AM mode | – | 3.3 | – | mA |
| | | FM mode | – | 2.7 | – | mA |
| t_{search} | synthesizer auto-search time for empty band | FM mode | – | – | 10 | s |
| t_{acq} | synthesizer preset acquisition time between two band limits | FM | – | 100 | – | ms |
| | | MW | – | 100 | – | ms |
| | | LW | – | 200 | – | ms |
| | | SW | – | 500 | – | ms |
| f_{band} | frequency band range of the synthesizer | AM mode | 0.144 | – | 30 | MHz |
| | | FM mode | 50 | – | 150 | MHz |
| Δf_{FM} | AFC inaccuracy of FM | | – | – | 1 | kHz |
| Δf_{AM} | AFC inaccuracy of AM | | – | – | 100 | Hz |
| $I_{P0(sink)}$ | sink current of software programmable output P0 | $V_{30} = 3\text{ V}$ | 4 | 6 | – | mA |
| $I_{P1(sink)}$ | sink current of software programmable output P1 | $V_{31} = 3\text{ V}$ | 4 | 6 | – | mA |
| $I_{P0(source)}$ | source current of software programmable output P0 | $V_{30} = 0\text{ V}$ | 5 | 9 | – | mA |
| $I_{P1(source)}$ | source current of software programmable output P1 | $V_{31} = 0\text{ V}$ | 5 | 9 | – | mA |

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AM CHARACTERISTICS

Input frequency $f_i = 1$ MHz; $m = 0.3$; $f_m = 1$ kHz; measured in test circuit at pin 10 (see Fig.9); S2 in position B; V_{i1} measured at input of matching network at pin 2; matching network adjusted to maximum output voltage at low input level; V_n refers to pin voltages; $V_{i(n)}$ refers to test circuit (see Fig.9); unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------|--|---|------|------|------|---------|
| V_{10} | AF output voltage | $V_{i1} = 5$ mV | 36 | 45 | 70 | mV |
| V_{i1} | RF sensitivity input voltage | $(S+N)/N = 26$ dB | 40 | 55 | 70 | μ V |
| V_{i1} | large signal voltage handling capacity | $m = 0.8$; THD $\leq 8\%$ | 150 | 300 | – | mV |
| PSRR | power supply ripple rejection $\left(\frac{V_{10}}{\Delta V_7}\right)$ | $\Delta V_7 = 100$ mV (RMS); 100 Hz; $V_7 = 3.0$ V | – | –47 | – | dB |
| I_i | input current (pin 2) | $V_{44} = 0.2$ V | – | 0 | – | μ A |
| C_i | input capacitance (pin 2) | $V_{44} = 0.2$ V | – | – | 4 | pF |
| G_c | front-end conversion gain | $V_{44} = 0.2$ V | 5 | 10 | 14 | dB |
| | | $V_{44} = 0.9$ V | –26 | –14 | 0 | dB |
| $(S+N)/N$ | signal plus noise-to-noise ratio | | – | 50 | – | dB |
| THD | total harmonic distortion | $V_{i1} = 1$ mV | – | 0.8 | 2.0 | % |
| α_{450} | IF suppression | $V_{10} = 30$ mV | – | 56 | – | dB |

FM CHARACTERISTICS

Input frequency $f_i = 100$ MHz; $\Delta f = 22.5$ kHz; $f_m = 1$ kHz; measured in test circuit (see Fig.9) at pin 10; S2 in position B; V_n refers to pin voltages; $V_{i(n)}$ refers to test circuit (see Fig.9); unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|-----------|--|---|------|------|------|---------|
| V_{10} | AF output voltage | $V_{i5} = 1$ mV | 40 | 48 | 57 | mV |
| V_{i5} | RF sensitivity input voltage | $(S+N)/N = 26$ dB | 1 | 2 | 3.8 | μ V |
| V_{i5} | RF limiting sensitivity | V_{10} at -3 dB; V_{10} is 0 dB at $V_{i5} = 1$ mV | 0.4 | 1.2 | 3.8 | μ V |
| V_{i5} | large signal voltage handling capacity | THD $< 5\%$ | – | 500 | – | mV |
| PSRR | power supply ripple rejection $\left(\frac{V_{10}}{\Delta V_7}\right)$ | $\Delta V_7 = 100$ mV (RMS); 100 Hz; $V_7 = 3.0$ V | –44 | – | – | dB |
| G_c | front-end conversion gain $\left(\frac{V_{37}}{V_{i5}}\right)$ | | 12 | 18 | 22 | dB |
| $(S+N)/N$ | signal plus noise-to-noise ratio | $V_{i5} = 1$ mV | – | 62 | – | dB |
| THD | total harmonic distortion | IF filter SFE10.7MS3A20K-A | – | 0.3 | 0.8 | % |

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STEREO DECODER CHARACTERISTICS

$V_{i3(L+R)} = 155 \text{ mV}$; $V_{\text{pilot}} = 15.5 \text{ mV}$; $f = 1 \text{ kHz}$; apply unmodulated RF signal of 100 mV to front-end to set radio to maximum channel separation; soft mute off (S4 in position A); unless otherwise specified.

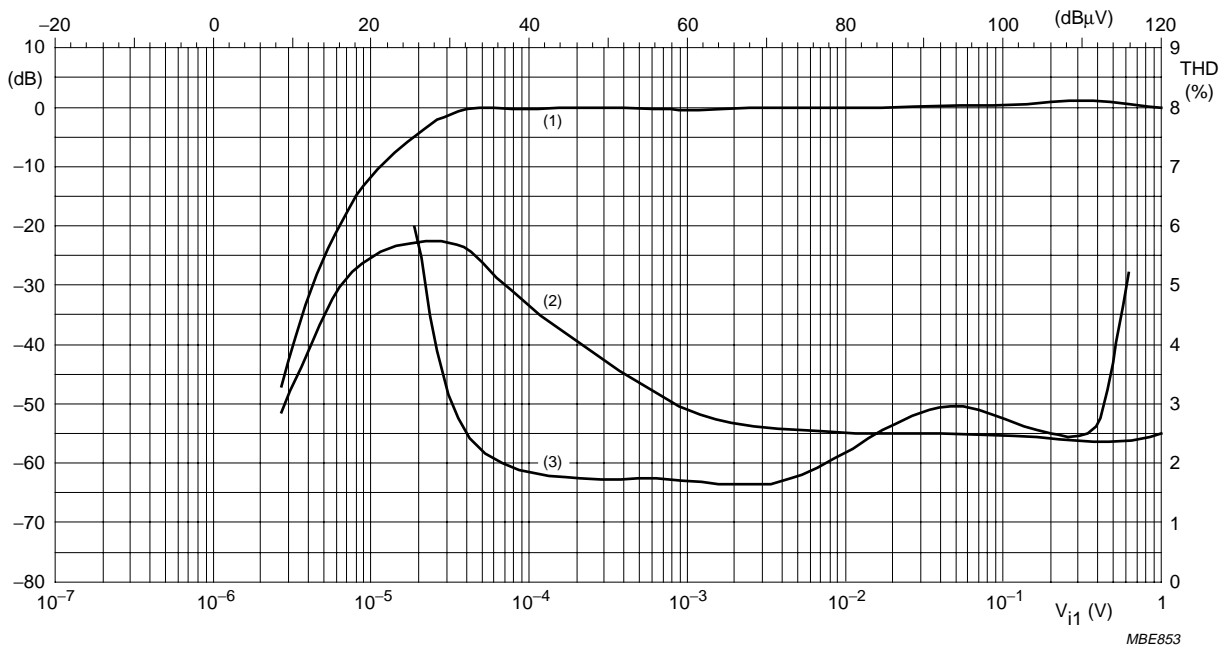
| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|--------------------------|----------------------------------|---|------|------|------|------|
| $V_{14/15}$ | AF output voltage | | – | 160 | – | mV |
| $V_{\text{pilot}(s)}$ | switch to stereo | | – | 8 | 12 | mV |
| $V_{\text{pilot}(m)}$ | switch to mono | | 2 | 5 | – | mV |
| $V_{\text{AF-L}}/V_{i3}$ | MPX voltage gain | | –1.5 | – | +1.5 | dB |
| (S+N)/N | signal plus noise-to-noise ratio | $V_{\text{pilot}} = 15.5 \text{ mV}$ (stereo) | – | 74 | – | dB |
| THD | total harmonic distortion | | – | 0.5 | 1.0 | % |
| α_{cs} | channel separation | | 26 | 30 | – | dB |
| α_{19} | carrier and harmonic suppression | 19 kHz (200 mV) = 0 dB | 27 | 32 | – | dB |
| α_{38} | | 38 kHz | 16 | 21 | – | dB |
| α | stereo-blend | $V_{i5} = 200 \mu\text{V}$ | 22 | 30 | – | dB |
| | | $V_{i5} = 20 \mu\text{V}$ | – | 1 | 2 | dB |
| mute(s) | soft mute depth | $V_{i5} = 3 \mu\text{V}$; $V_{14} = V_{15}$ | –1 | 0 | – | dB |
| | | $V_{i5} = 1 \mu\text{V}$; $V_{14} = V_{15}$ | – | –6 | –10 | dB |

TUNING CHARACTERISTICS

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|-----------------------|----------------------------|---|------|------|------|---------------|
| V_{FM} | FM voltage levels | $\alpha_{-3 \text{ dB}}$ -point at $V_{i5} = 2 \mu\text{V}$ | | | | |
| | high (auto-store/search) | $S_0 = 1$; $S_1 = 1$ | 60 | 150 | 500 | μV |
| | medium (auto-store/search) | $S_0 = 0$; $S_1 = 1$ | 10 | 30 | 55 | μV |
| | low (auto-store/search) | $S_0 = 1$; $S_1 = 0$ | 4 | 10 | 20 | μV |
| V_{AM} | AM voltage levels | $\alpha_{-3 \text{ dB}}$ -point at $V_{i5} = 2 \mu\text{V}$ | | | | |
| | high (auto-store/search) | $S_0 = 1$; $S_1 = 1$ | 400 | 1000 | 2500 | μV |
| | medium (auto-store/search) | $S_0 = 0$; $S_1 = 1$ | 50 | 63 | 80 | μV |
| | low (auto-store/search) | $S_0 = 1$; $S_1 = 0$ | 32 | 40 | 50 | μV |
| $V_{\text{AFC(off)}}$ | AFC voltage off mode | $\alpha_{-3 \text{ dB}}$ -point at $V_{i5} = 2 \mu\text{V}$ | | | | |
| | | FM mode | – | 3 | – | μV |
| | | AM mode | – | 25 | – | μV |
| mute(h) | hard mute depth | WRITE-ENABLE = HIGH | – | 60 | – | dB |

Self Tuned Radio (STR)

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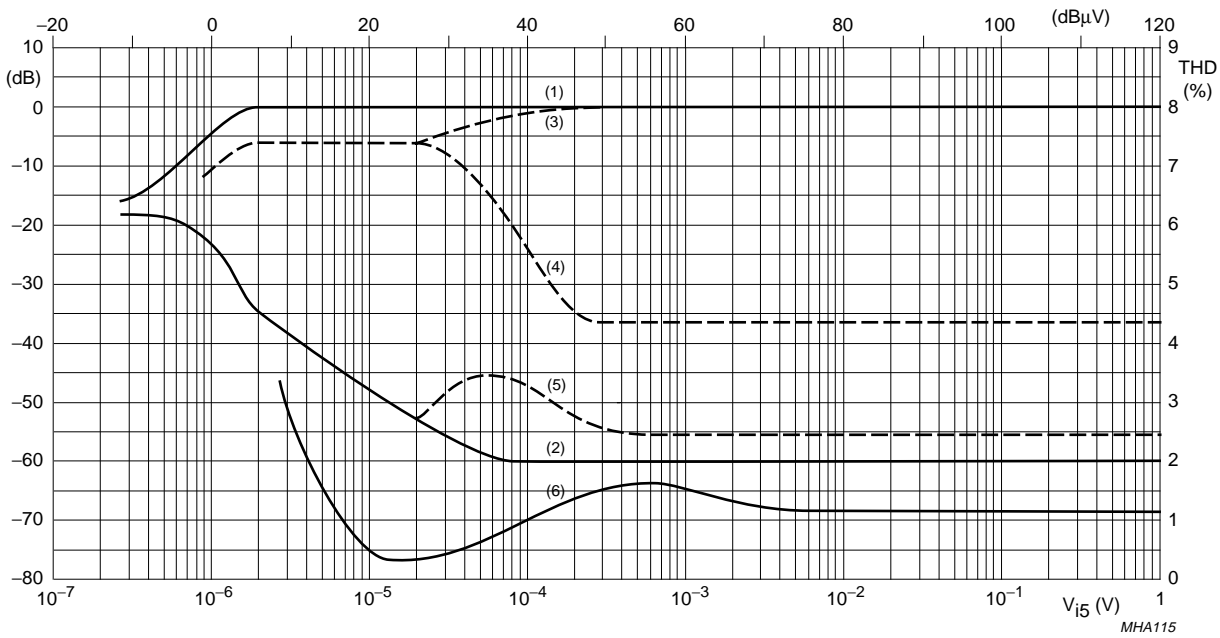
- (1) Audio signal.
- (2) Noise.
- (3) Harmonic distortion.

Fig.6 AM mode.

MBE853

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- (1) Mono signal.
- (2) Noise in mono mode.
- (3) Left channel with modulation left.
- (4) Right channel with modulation left.
- (5) Noise in stereo mode.
- (6) Harmonic distortion (measured with $\Delta f = 75$ kHz).

Fig.7 FM mode.

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INTERNAL CIRCUITRY

Table 8 Equivalent pin circuits and pin voltages

| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|------------|----------------|-----|--------------------|
| | | AM | FM | |
| 1 | RIPPLE | 2.1 | 2.1 | <p>MBE821</p> |
| 2 | AM-RFI | 0 | 0 | <p>MBE822</p> |
| 3 | FM-RFO | 0 | 0 | <p>MHA105</p> |
| 4 | RFGND | 0 | 0 | |
| 5 | FMOSC | 0 | 0 | <p>MBE823</p> |

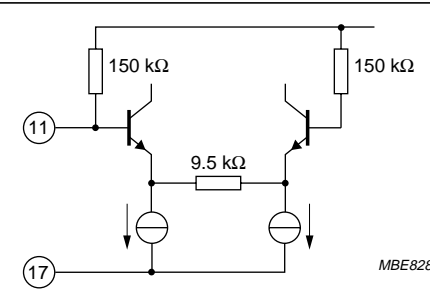
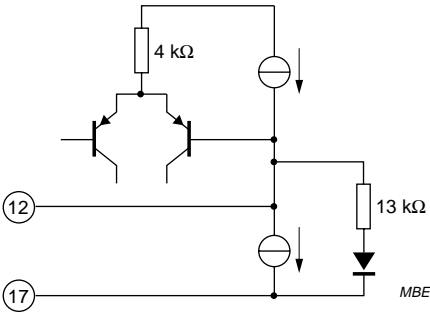
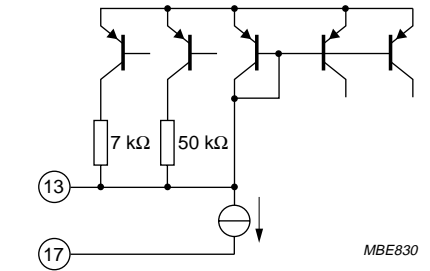
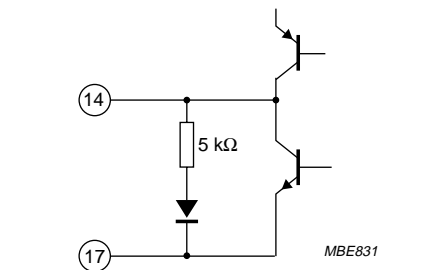
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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|------------------|----------------|------|--------------------|
| | | AM | FM | |
| 6 | AMOSC | 0 | 0 | |
| 7 | V _{CC1} | 3.0 | 3.0 | |
| 8 | TUNE | - | - | |
| 9 | VCO | 1.3 | 0.95 | |
| 10 | AFO | 0.6 | 0.7 | |

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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|------------|----------------|------|--|
| | | AM | FM | |
| 11 | MPXI | 1.23 | 1.23 |  <p>MBE828</p> |
| 12 | LFI | 0.1 | 0.8 |  <p>MBE829</p> |
| 13 | MUTE | 0.7 | 0.7 |  <p>MBE830</p> |
| 14 | AFLO | 0.65 | 0.65 |  <p>MBE831</p> |

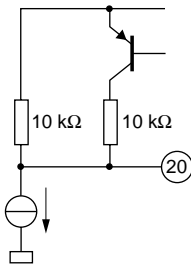
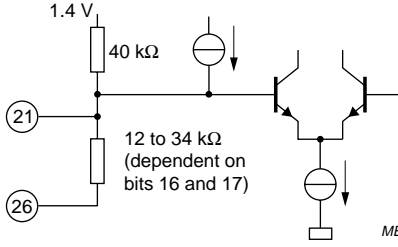
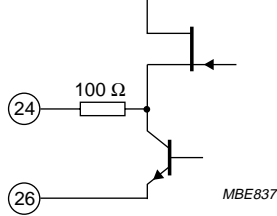
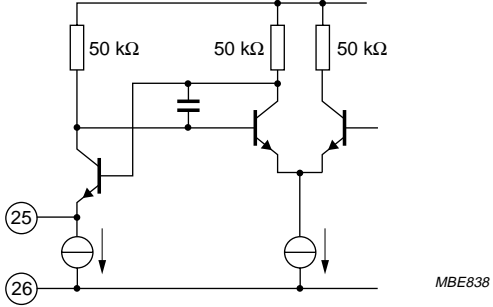
Self Tuned Radio (STR)

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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|--------------------|----------------|------|--|
| | | AM | FM | |
| 15 | AFRO | 0.65 | 0.65 | <p>The diagram shows a transistor circuit with a 5 kΩ resistor connected between pin 15 and the base of a transistor. A diode is connected between the base and pin 17. The transistor is labeled MBE832.</p> |
| 16 | PILFIL | 0.95 | 0.95 | <p>The diagram shows a complex transistor circuit with two 10 kΩ resistors and several current sources. Pin 16 is connected to the base of a transistor. The circuit is labeled MBE833.</p> |
| 17 | IFGND | 0 | 0 | |
| 18 | FMDEM | - | 1.0 | <p>The diagram shows a transistor circuit with a 180 Ω resistor connected between pin 18 and the base of a transistor. A 910 Ω resistor is connected between the base and the emitter. The transistor is labeled MBE834.</p> |
| 19 | AFC _(n) | - | - | <p>The diagram shows a transistor circuit with two 10 kΩ resistors. Pin 19 is connected to the junction of the two resistors. The circuit is labeled MHA106.</p> |

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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|--------------------|----------------|-----|--|
| | | AM | FM | |
| 20 | AFC _(p) | - | - |  <p>MHA107</p> |
| 21 | FSI | - | - |  <p>1.4 V 40 kΩ 12 to 34 kΩ (dependent on bits 16 and 17)</p> <p>MBE836</p> |
| 22 | V _{CC2} | - | - | |
| 23 | V _{DDD} | 3.0 | 3.0 | |
| 24 | MO/ST | - | - |  <p>100 Ω</p> <p>MBE837</p> |
| 25 | XTAL | - | - |  <p>50 kΩ 50 kΩ 50 kΩ</p> <p>MBE838</p> |
| 26 | DGND | 0 | 0 | |

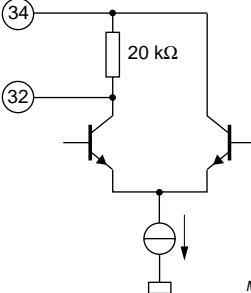
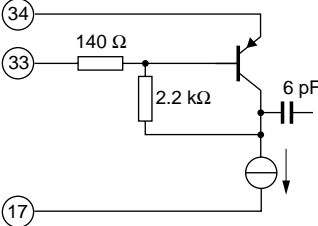
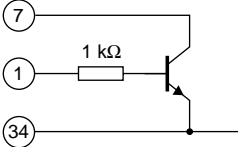
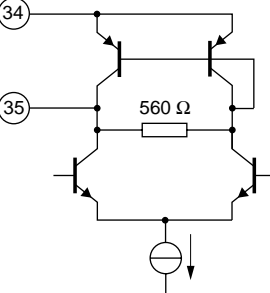
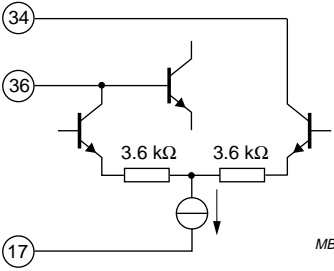
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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|--------------|----------------|----|--------------------|
| | | AM | FM | |
| 27 | BUS-CLOCK | - | - | |
| 28 | DATA | - | - | |
| 29 | WRITE-ENABLE | - | - | |
| 30 | P0 | - | - | |
| 31 | P1 | - | - | |

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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|----------------------|----------------|------|--|
| | | AM | FM | |
| 32 | AFC | - | - |  <p>MBE842</p> |
| 33 | FM-IFI2 | - | 0.73 |  <p>MBE843</p> |
| 34 | V _{STAB(B)} | 1.4 | 1.4 |  <p>MBE844</p> |
| 35 | FM-IFO1 | - | 0.69 |  <p>MBE845</p> |
| 36 | AM-IFI/O2 | 1.4 | 1.4 |  <p>MBE846</p> |

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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|----------------------|----------------|------|--------------------|
| | | AM | FM | |
| 37 | FM-IF11 | - | 0.73 | <p>MBE847</p> |
| 38 | V _{STAB(A)} | 1.4 | 1.4 | <p>MBE848</p> |
| 39 | FM-MIXER | - | 1.0 | <p>MHA110</p> |
| 40 | AM-MIXER | 1.4 | 1.4 | <p>MBE850</p> |
| 41 | AM-IF11 | 1.4 | 1.4 | <p>MBE851</p> |

Self Tuned Radio (STR)

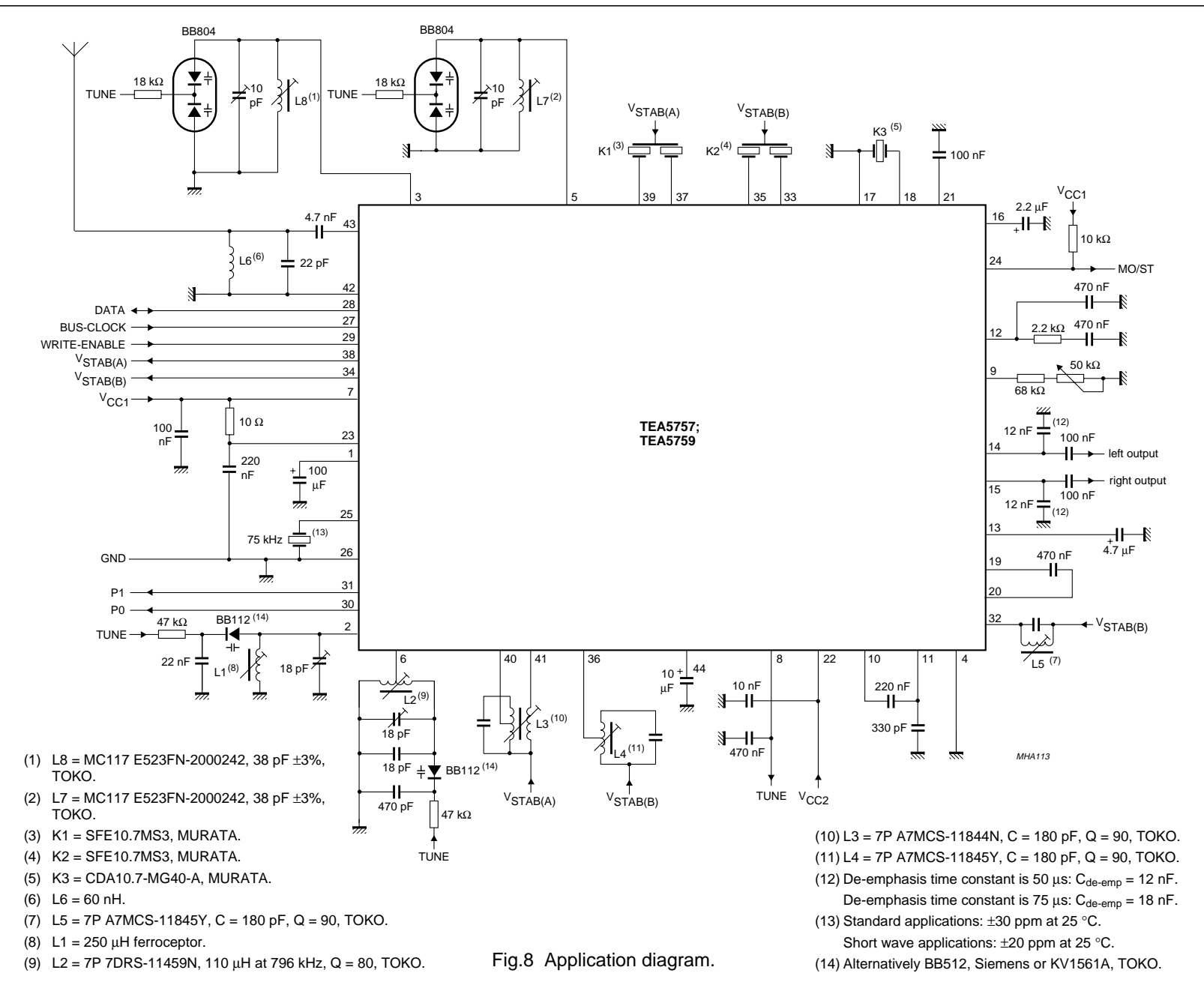
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| PIN NO. | PIN SYMBOL | DC VOLTAGE (V) | | EQUIVALENT CIRCUIT |
|---------|------------|----------------|------|--------------------|
| | | AM | FM | |
| 42 | RFGND | 0 | 0 | |
| 43 | FM-RFI | - | 0.73 | |
| 44 | AGC | 0.1 | 0.7 | |

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TEST AND APPLICATION INFORMATION



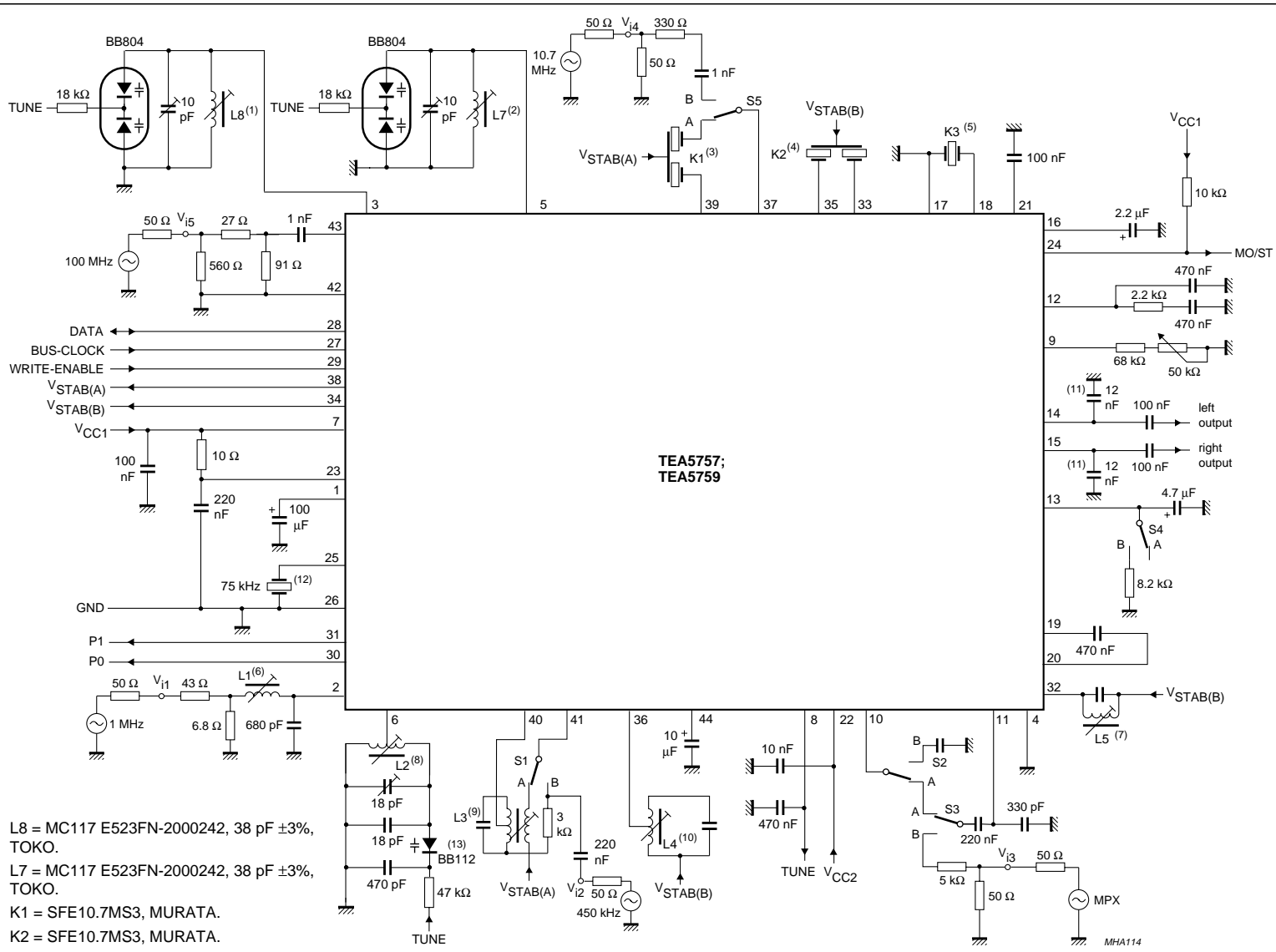
- (1) L8 = MC117 E523FN-2000242, 38 pF ±3%, TOKO.
- (2) L7 = MC117 E523FN-2000242, 38 pF ±3%, TOKO.
- (3) K1 = SFE10.7MS3, MURATA.
- (4) K2 = SFE10.7MS3, MURATA.
- (5) K3 = CDA10.7-MG40-A, MURATA.
- (6) L6 = 60 nH.
- (7) L5 = 7P A7MCS-11845Y, C = 180 pF, Q = 90, TOKO.
- (8) L1 = 250 μH ferroceptor.
- (9) L2 = 7P 7DRS-11459N, 110 μH at 796 kHz, Q = 80, TOKO.

- (10) L3 = 7P A7MCS-11844N, C = 180 pF, Q = 90, TOKO.
- (11) L4 = 7P A7MCS-11845Y, C = 180 pF, Q = 90, TOKO.
- (12) De-emphasis time constant is 50 μs: C_{de-emp} = 12 nF.
De-emphasis time constant is 75 μs: C_{de-emp} = 18 nF.
- (13) Standard applications: ±30 ppm at 25 °C.
Short wave applications: ±20 ppm at 25 °C.
- (14) Alternatively BB512, Siemens or KV1561A, TOKO.

Fig.8 Application diagram.

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- (1) L8 = MC117 E523FN-2000242, 38 pF ±3%, TOKO.
- (2) L7 = MC117 E523FN-2000242, 38 pF ±3%, TOKO.
- (3) K1 = SFE10.7MS3, MURATA.
- (4) K2 = SFE10.7MS3, MURATA.
- (5) K3 = CDA10.7-MG40-A, MURATA.
- (6) L1 = 22281-30091.
- (7) L5 = 7P A7MCS-11845Y, C = 180 pF, Q = 90, TOKO.
- (8) L2 = 7P 7DRS-11459N, 110 µH at 796 kHz, Q = 80, TOKO.
- (9) L3 = 7P A7MCS-11844N, C = 180 pF, Q = 90, TOKO.
- (10) L4 = 7P A7MCS-11845Y, C = 180 pF, Q = 90, TOKO.

- (11) De-emphasis time constant is 50 µs: C_{de-emp} = 12 nF.
De-emphasis time constant is 75 µs: C_{de-emp} = 18 nF.
- (12) Standard applications: ±30 ppm at 25 °C.
Short wave applications: ±20 ppm at 25 °C.
- (13) Alternatively BB512, Siemens or KV1561A, TOKO.

Fig.9 Test circuit.

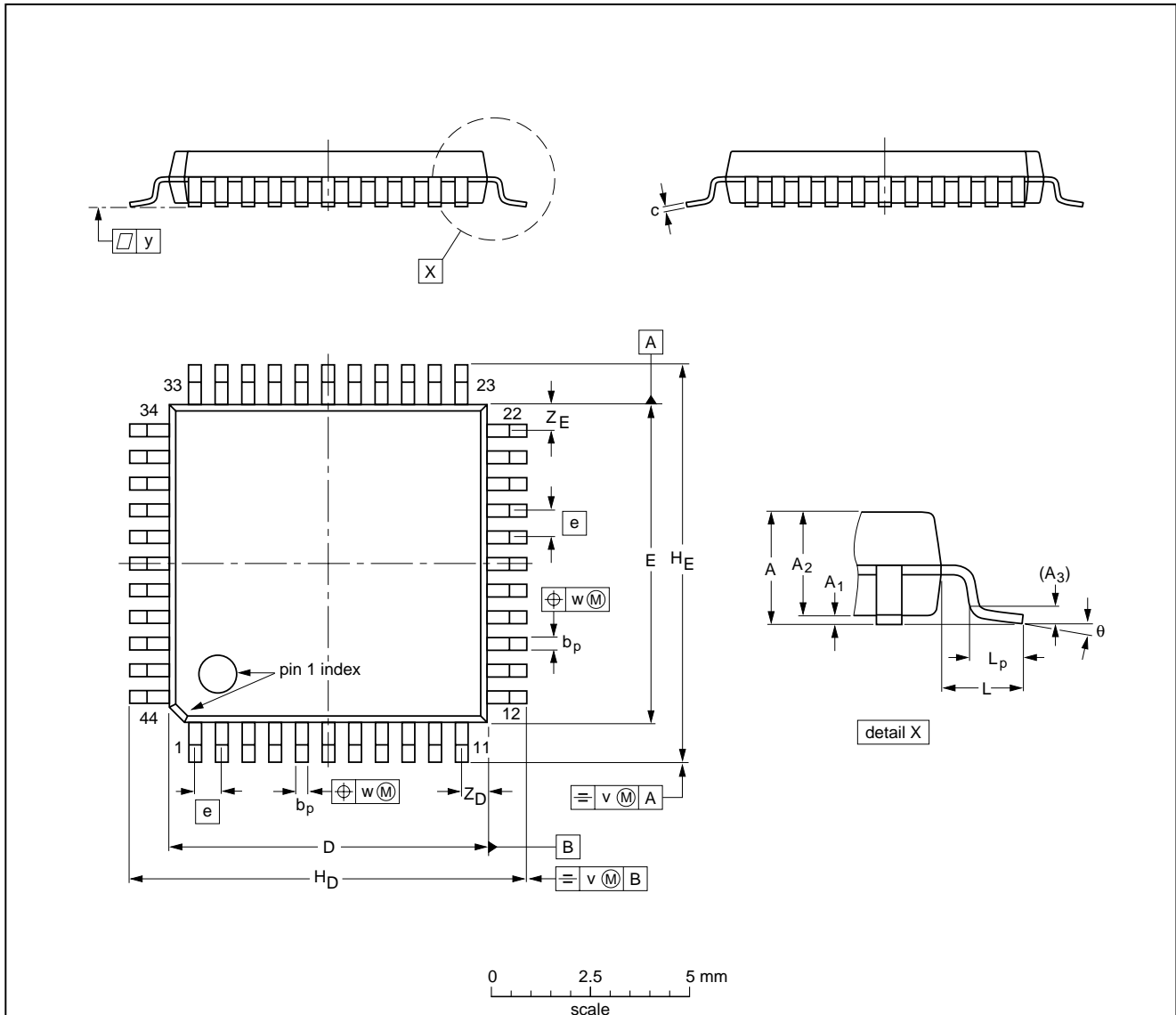
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PACKAGE OUTLINE

QFP44: plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 x 10 x 1.75 mm

SOT307-2



DIMENSIONS (mm are the original dimensions)

| UNIT | A max. | A ₁ | A ₂ | A ₃ | b _p | c | D ⁽¹⁾ | E ⁽¹⁾ | e | H _D | H _E | L | L _p | v | w | y | Z _D ⁽¹⁾ | Z _E ⁽¹⁾ | θ |
|------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|-----|----------------|----------------|-----|----------------|------|------|-----|-------------------------------|-------------------------------|-----------|
| mm | 2.10 | 0.25 0.05 | 1.85 1.65 | 0.25 | 0.40 0.20 | 0.25 0.14 | 10.1 9.9 | 10.1 9.9 | 0.8 | 12.9 12.3 | 12.9 12.3 | 1.3 | 0.95 0.55 | 0.15 | 0.15 | 0.1 | 1.2 0.8 | 1.2 0.8 | 10° 0° |

Note
1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|-------|------|--|---------------------|----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT307-2 | | | | | | 95-02-04 97-08-01 |

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SOLDERING

Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferably be kept below 230 °C.

Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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Suitability of surface mount IC packages for wave and reflow soldering methods

| PACKAGE | SOLDERING METHOD | |
|---------------------------------|-----------------------------------|-----------------------|
| | WAVE | REFLOW ⁽¹⁾ |
| BGA, SQFP | not suitable | suitable |
| HLQFP, HSQFP, HSOP, HTSSOP, SMS | not suitable ⁽²⁾ | suitable |
| PLCC ⁽³⁾ , SO, SOJ | suitable | suitable |
| LQFP, QFP, TQFP | not recommended ⁽³⁾⁽⁴⁾ | suitable |
| SSOP, TSSOP, VSO | not recommended ⁽⁵⁾ | suitable |

Notes

- All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the "Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods".
- These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
- If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
- Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
- Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

DEFINITIONS

| Data sheet status | |
|---|---|
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| Limiting values | |
| Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | |
| Application information | |
| Where application information is given, it is advisory and does not form part of the specification. | |

LIFE SUPPORT APPLICATIONS

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