



# SANYO Semiconductors

## DATA SHEET

### Thick-Film Hybrid IC

# STK404-200-E — One-Channel Class AB Audio Power Amplifier IC 60W

### Overview

The STK404-200-E is a hybrid IC designed to be used in 60W (1-channel) class AB audio power amplifiers.

### Applications

- Audio power amplifiers.

### Features

- 1-channel audio power amplifier
- Built-in standby circuit
- Overcurrent protection
- Output DC offset protection
- Shutdown circuit when latch-up occurs
- Error signal output (open collector)

### Series Models

|                                     | STK404-200-E        | STK404-230-E    |
|-------------------------------------|---------------------|-----------------|
| Output 1 (10%/1kHz)                 | 100W×1 channels     | 150W×1 channels |
| Output 2 (0.4%/20Hz to 20kHz)       | 60W×1 channels      | 100W×1 channels |
| Maximum rated $V_{CC}$ (6Ω)         | ±50V                | ±63V            |
| Recommended operating $V_{CC}$ (6Ω) | ±36V                | ±44V            |
| Dimensions (excluding pin height)   | 59.2mm×25.5mm×8.5mm |                 |

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# STK404-200-E

## Specifications

**Absolute Maximum Ratings** at Ta = 25°C (excluding rated temperature items), Tc=25°C unless otherwise specified

| Parameter                          | Symbol                  | Conditions  | Ratings          | Unit |
|------------------------------------|-------------------------|---|------------------|------|
| Maximum supply voltage 1           | V <sub>CC</sub> max (1) | #11 (+V <sub>CC</sub> ), #10 (-V <sub>CC</sub> ), #7 (+PRE), #6 (-PRE),<br>No signal          | ±57              | V    |
| Maximum supply voltage 2           | V <sub>CC</sub> max (2) | #11 (+V <sub>CC</sub> ), #10 (-V <sub>CC</sub> ), #7 (+PRE), #6 (-PRE),<br>R <sub>L</sub> ≥6Ω | ±50              | V    |
| Minimum operating supply voltage   | V <sub>CC</sub> min     | #11 (+V <sub>CC</sub> ), #10 (-V <sub>CC</sub> ), #7 (+PRE), #6 (-PRE)                        | ±25              | V    |
| STBY pin applied voltage           | *4 V <sub>st</sub> max  | Pin 1 (STBY)  | -0.3 to +5.5     | V    |
| STBY pin applied current           | I <sub>st</sub> max     | Pin 1 (STBY)  | 1.0              | mA   |
| OC pin maximum input current       | I <sub>oc</sub> max     | Pin 9 (OC)  | ±5               | mA   |
| DC pin maximum input current       | I <sub>dc</sub> max     | Pin 8 (DC)  | +5               | mA   |
| ERROR pin input voltage            | V <sub>error</sub>      | Pin 2 (ERROR)   | +V <sub>CC</sub> | V    |
| ERROR pin input current            | I <sub>error</sub>      | Pin 2 (ERROR)   | 20               | mA   |
| Thermal resistance                 | θ <sub>j-c</sub>        | Per power transistor  | 1.7              | °C/W |
| Junction temperature               | T <sub>J</sub> max      | Must meet both T <sub>J</sub> max and T <sub>c</sub> max conditions                           | 150              | °C   |
| Operating IC substrate temperature | T <sub>c</sub> max      |   | 125              | °C   |
| Storage ambient temperature        | T <sub>stg</sub>        |   | -30 to +125      | °C   |
| Allowable load shorted time        | *3 t <sub>s</sub>       | V <sub>CC</sub> =±36V, R <sub>L</sub> =6Ω, f=50Hz, P <sub>O</sub> =50W                        | 0.3              | s    |

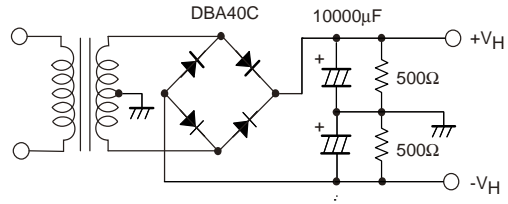
**Electrical Characteristics** at Tc=25°C, R<sub>L</sub>=6Ω, R<sub>g</sub>=600Ω, V<sub>G</sub>=30dB, non-inductive load R<sub>L</sub>, unless otherwise specified

| Parameter                                    | Symbol                          | Conditions *2       |           |                    |         | Ratings               |           |      | unit  |    |
|--|---------------------------------|---------------------|-----------|--------------------|---------|-----------------------|-----------|------|-------|----|
|  |                                 | V <sub>CC</sub> (V) | f (Hz)    | P <sub>O</sub> (W) | THD (%) | min                   | typ       | max  |       |    |
| Output power *1                              | P <sub>O</sub> (1)              | ±36                 | 20 to 20k |                    | 0.4     | 60                    |           |      | W     |    |
|  | P <sub>O</sub> (2)              | ±36                 | 1k        |                    | 10      |                       | 100       |      |       |    |
| Total harmonic distortion *1                 | THD                             | ±36                 | 20 to 20k | 60                 |         |                       | 0.4       |      | %     |    |
| Frequency characteristics *1                 | f <sub>L</sub> , f <sub>H</sub> | ±36                 |           | 1.0                |         | +0 -3dB               | 20 to 50k |      | Hz    |    |
| Input impedance                              | r <sub>i</sub>                  | ±36                 | 1k        | 1.0                |         |                       | 55        |      | kΩ    |    |
| Output noise voltage *3                      | V <sub>NO</sub>                 | ±43                 |           |                    |         | R <sub>g</sub> =2.2kΩ |           | 1.0  | mVrms |    |
| Quiescent current                            | I <sub>CCO</sub>                | ±43                 |           |                    |         | R <sub>L</sub> =∞     |           | 50   | mA    |    |
| Output neutral voltage                       | V <sub>N</sub>                  | ±43                 |           |                    |         |                       | -70       | 0    | +70   | mV |
| Pin 8 output DC (+) offset detection voltage | V <sub>DC</sub> (-)             | ±36                 |           |                    |         |                       |           | 0.5  | 0.7   | V  |
| Pin 8 output DC (-) offset detection voltage | V <sub>DC</sub> (-)             | ±36                 |           |                    |         |                       | -0.7      | -0.5 |       | V  |
| Pin 9 overcurrent detection voltage          | V <sub>OC</sub>                 | ±36                 |           |                    |         |                       |           | 0.5  | 0.7   | V  |
| Pin 1 threshold voltage for standby ON *4    | V <sub>ST ON</sub>              | ±36                 |           |                    |         | Standby mode          |           | 0    | 0.6   | V  |
| Pin 1 threshold voltage for standby OFF *4   | V <sub>ST OFF</sub>             | ±36                 |           |                    |         | Operating mode        | 2.5       | 3.0  |       | V  |

[Remarks]

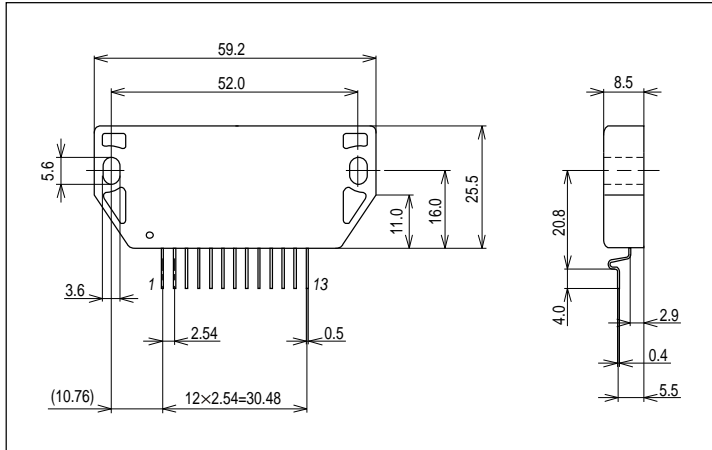
- \*1: Unless otherwise specified, use a constant-voltage power supply to supply power when inspections are carried out.
- \*2: The output noise voltage values shown are peak values read with a VTVM. However, an AC stabilized (50Hz) power supply should be used to minimize the influence of AC primary side flicker noise on the reading.
- \*3: Use the designated transformer power supply circuit shown in the figure below for allowable load shorted time and output noise voltage measurement.
- \*4: Use the standby pin (pin 1) so that the applied voltage never exceeds the maximum rating.  
The power amplifier is turned on by applying +2.5V to +5.5V to the standby pin (pin 1).
- \*5: The -Pre V<sub>CC</sub> (pin 6) must be at the lowest level under any circumstances so that the reverse-bias current does not flow.
- \* Thermal design must be implemented based on the conditions under which the customer's end products are expected to operate on the market.
- \* The weight of hybrid IC alone: 15g  
Package dimensions (length×width×height): 502mm×247mm×282mm

Designated transformer power supply  
(MG-250 equivalent)

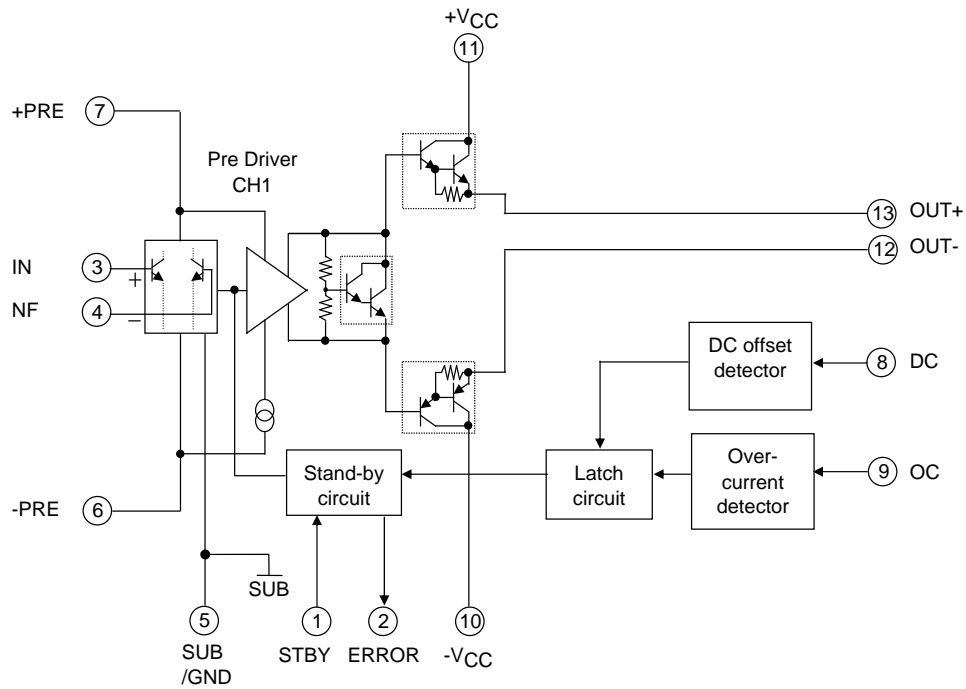


### Package Dimensions

unit:mm (typ)

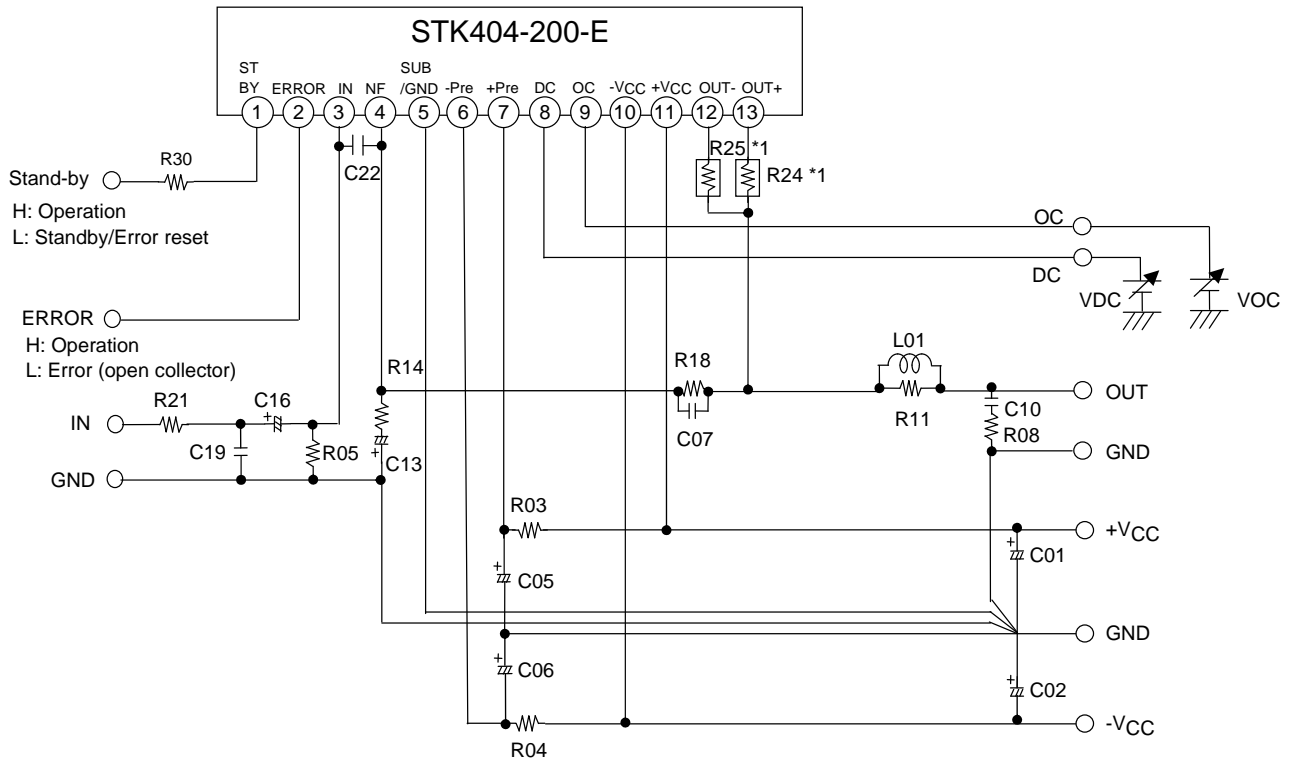


### Internal Block Circuit



# STK404-200-E

## Test Circuit



\*1 Metal plate cement resistor:  $0.22\Omega \pm 10\%$  (5W)

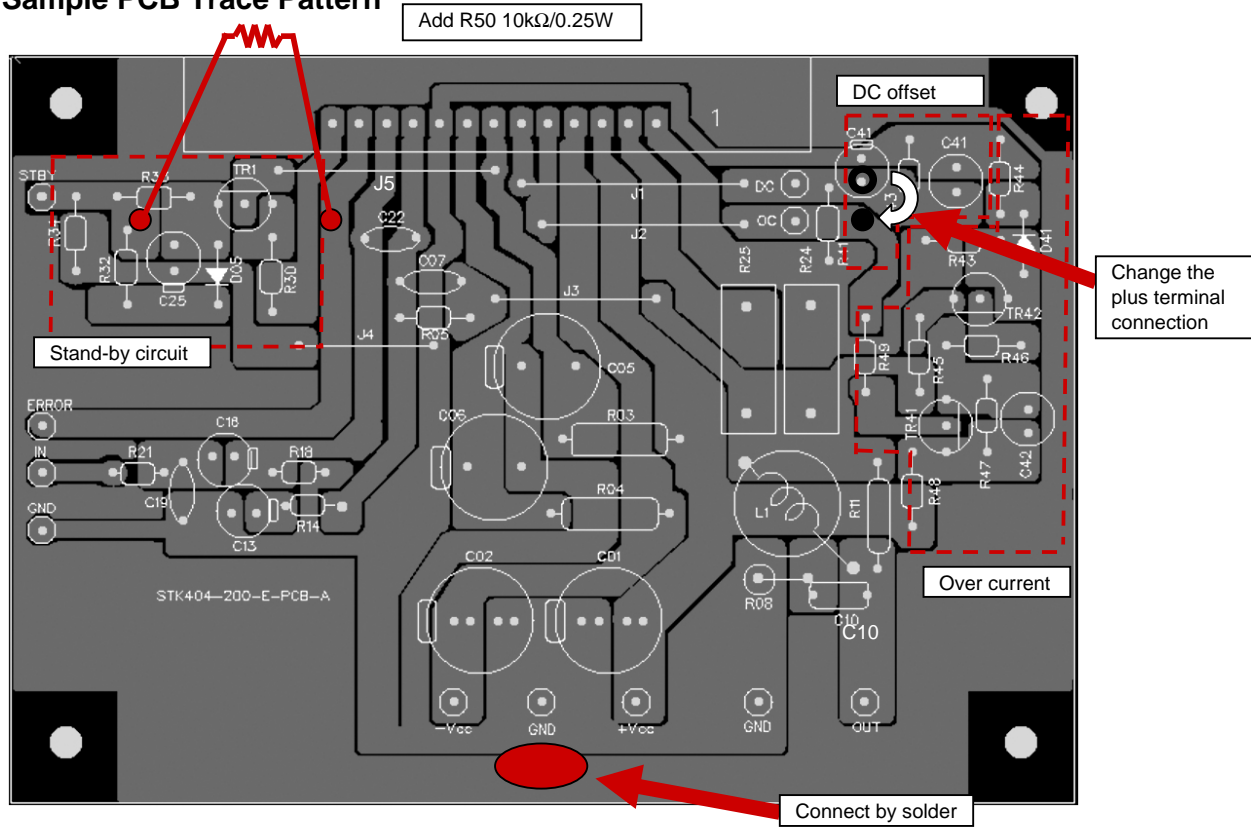
## Pin Description

| Pin No. | Pin name |   | Function  |
|---------|----------|---|---|
| 1       | STBY     | I | Standby terminal<br>H: Operation mode, L: Standby mode  |
| 2       | ERROR    | O | Error signal output in protection mode (open collector)<br>H: Operation mode, L: Protection mode (shutdown) |
| 3       | IN       | I | Input signal terminal   |
| 4       | NF       | I | NF signal input terminal  |
| 5       | SUB/GND  | G | Ground terminal, circuit ground and sub-ground  |
| 6       | -PRE     | V | Negative power supply for predriver   |
| 7       | +PRE     | V | Positive power supply for predriver   |
| 8       | DC       | I | DC offset detection signal input<br>L: Protection disabled, H: Protection enabled (system shutdown)         |
| 9       | OC       | I | Overcurrent detection signal input<br>L: Protection disabled, H: Protection enabled (system shutdown)       |
| 10      | -VCC     | P | Negative power supply for power   |
| 11      | +VCC     | P | Positive power supply for power   |
| 12      | OUT-     | O | Negative output terminal (emitter of PNP power transistor)  |
| 13      | OUT+     | O | Positive output terminal (emitter of NPN power transistor)  |

Recommended External Parts

| Symbol   | Recommended Value | Description  | Larger than Recommended Value   | Smaller than Recommended Value                   |
|----------|-------------------|--|---|--|
| R03, R04 | 100Ω/1W           | Ripple filtering resistors (Use of fusing resistors is desirable. Used with C05 and C06 to form a ripple filter.)  | Decrease in through current at high frequencies.                                | Increase in through current at high frequencies. |
| R05      | 56kΩ              | Virtually determines the input impedance.  | VN offset (Ensure R05=R18 when changing.)                                       |  |
| R08      | 4.7Ω/1W           | Oscillation prevention resistor  | -   | -  |
| R11      | 4.7Ω              | Noise suppression resistor   | -   | -  |
| R14      | 1.8kΩ             | Used with R18 to determine the voltage gain VG. (VG should desirably be determined by the R14 value.)  | It may oscillate (Vg<30dB)  | None   |
| R18      | 56kΩ              | Used with R14 to determine the voltage gain VG.  | -   | -  |
| R21      | 1kΩ               | Input filtering resistor   | -   | -  |
| R24, R25 | 0.22Ω±10%, 5W     | Output emitter resistors (Use of cement resistor is desirable)   | Decrease in maximum output power  | It may cause thermal-runaway.                    |
| R30      | Remarks *4        | A resistor must be used such that the voltage at the Stand-by pin (pin 1) does not exceed the maximum rating.  |   |  |
| C01, C02 | 100μF/100V        | Oscillation prevention capacitors.<br>• Insert the capacitors as close to the IC as possible to decrease the power impedance for reliable IC operation (use of electrolytic capacitors are desirable). | -   | -  |
| C05, C06 | 100μF/100V        | Decoupling capacitors.<br>Eliminate ripple components that pass into the input side from the power line. (Used with R03 and R04 to form a ripple filter.)  | Increase in ripple components that pass into the input side from the power line |  |
| C07      | 3pF               | Oscillation prevention capacitor   | It may oscillate  |  |
| C10      | 0.1μF             | Oscillation prevention capacitor   | It may oscillate  |  |
| C13      | 22μF/10V          | NF capacitor<br>(Changes the low cutoff frequency; $ex/f_L=1/2\pi\cdot C13\cdot R14$ )   | Increase in low-frequency voltage gain, with higher pop noise at power-on.      | Decrease in low-frequency voltage gain           |
| C16      | 2.2μF/50V         | Input coupling capacitor (block DC current)  | -   | -  |
| C19      | 470pF             | Input filter capacitor (Used with R21 to form a filter that suppresses high-frequency noises.)   | -   | -  |
| C22      | 100pF             | Oscillation prevention capacitor   | It may oscillate.   |  |
| L01      | 3μH               | Oscillation prevention inductance  | None  | It may oscillate.                                |

Sample PCB Trace Pattern

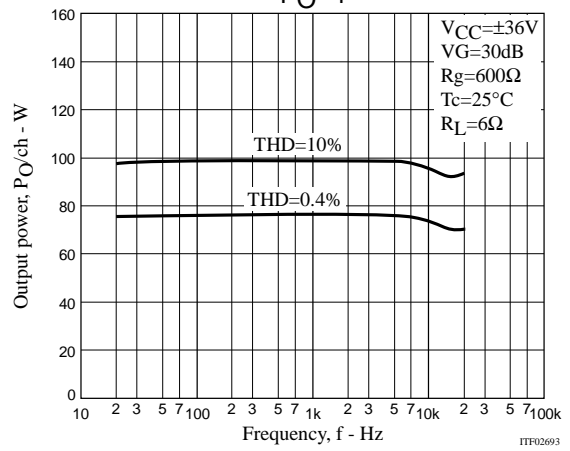
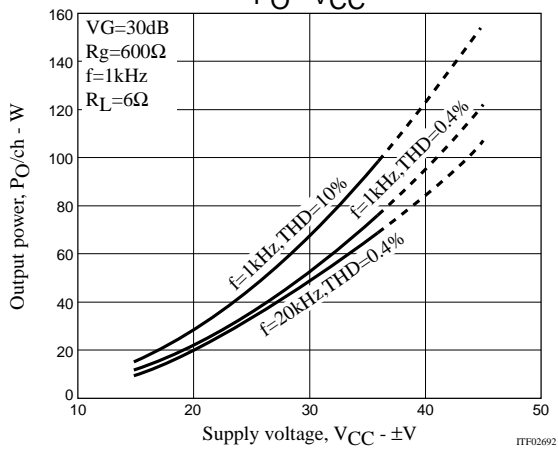
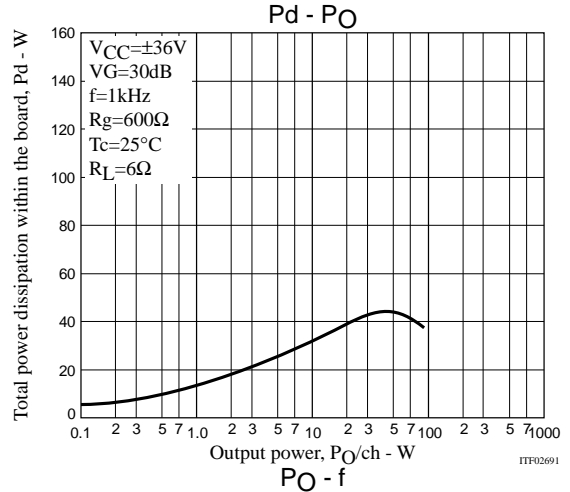
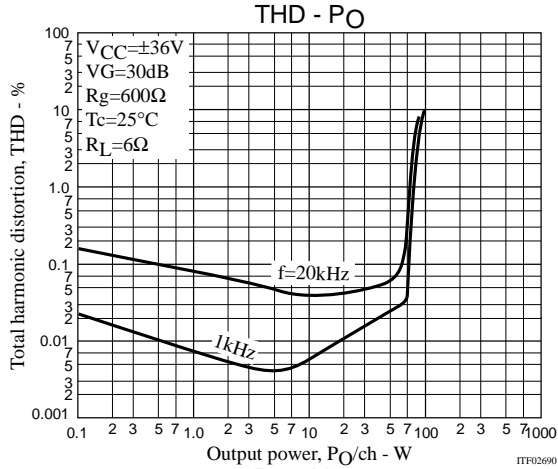


## STK404-200-E

### Parts List

| PCB No.             | Parts         | Rating          |                |
|---------------------|---------------|-----------------|----------------|
| R03, R04            | 100Ω, 1W      | ERG1SJ101       |                |
| R05                 | 56kΩ, 1/6W    | RN16S563FK      |                |
| R18                 | 56kΩ, 1/6W    | RN16S563FK      |                |
| R08                 | 4.7Ω, 1W      | ERX1SJ4R7       |                |
| R11                 | 4.7Ω, 1/4W    | RN14S4R7FK      |                |
| R14                 | 1.8kΩ, 1/6W   | RN16S182FK      |                |
| R21                 | 1kΩ, 1/6W     | RN16S102FK      |                |
| R24, R25            | 0.22Ω±10%, 5W | BPR56CFR22J     |                |
| C01, C02, C05, C06  | 100μF, 100V   | 100MV100HC      |                |
| C07                 | 3pF           | DD104-63B3R0K50 |                |
| C10                 | 0.1μF, 100V   | ECQ-V1H104JZ    |                |
| C13                 | 10μF, 10V     | 10MV10HC        |                |
| C16                 | 2.2μF, 50V    | 50MV2R2HC       |                |
| C19                 | 470pF         | DD104-63B471K50 |                |
| C22                 | 100pF         | DD104-63B101K50 |                |
| L01                 | 3μH           |                 |                |
| Stand-by            | R30           | 5.6kΩ, 1/6W     | RN16S152FK     |
|                     | R32           | 1kΩ, 1/6W       | RN16S102FK     |
|                     | R33           | 3.3kΩ, 1/6W     | RN16S332FK     |
|                     | R34           | 2.2kΩ, 1/6W     | RN16S222FK     |
|                     | C25           | 33μF, 10V       | 10MV33HC       |
|                     | D05           | -               | GMB01 (Ref.)   |
|                     | TR1           | -               | 2SC2362 (Ref.) |
| Over Current        | TR41          |                 | 2SA1016 (Ref.) |
|                     | TR42          |                 | 2SC2362 (Ref.) |
|                     | C42           | -               | -              |
|                     | C43           | 2.2μF, 10V      | 10MV2R2HC      |
|                     | D41           |                 | GMB01 (Ref.)   |
|                     | R43           | 220Ω, 1/6W      | RN16S221FK     |
|                     | R44           | 1.8kΩ, 1/6W     | RN16S182FK     |
|                     | R45           | Jumper          | -              |
|                     | R46           | 15kΩ, 1/6W      | RN16S153FK     |
|                     | R47           | 5.1kΩ, 1/6W     | RN16S152FK     |
|                     | R48           | 15kΩ, 1/6W      | RN16S153FK     |
| R49                 | 47kΩ, 1/6W    | RN16S473FK      |                |
| DC offset           | R41           | 33kΩ, 1/6W      | RN16S333FK     |
|                     | R42           | 10kΩ, 1/6W      | RN16S103FK     |
|                     | C41           | 33μF, 10V       | 10MV33HC       |
| J01, 02, 03, 04, 05 | Jumper        |                 |                |

Evaluation Board Characteristics



[Thermal Design Example for STK404-200-E ( $R_L=6\Omega$ )]

The thermal resistance,  $\theta_{c-a}$ , of the heat sink for total power dissipation,  $P_d$ , within the hybrid IC is determined as follows.

Condition 1: The hybrid IC substrate temperature,  $T_c$ , must not exceed  $125^\circ\text{C}$ .

$$P_d \times \theta_{c-a} + T_a < 125^\circ\text{C} \dots\dots\dots (1)$$

$T_a$ : Guaranteed ambient temperature for the end product

Condition 2: The junction temperature,  $T_j$ , of each power transistor must not exceed  $150^\circ\text{C}$ .

$$P_d \times \theta_{c-a} + P_d/N \times \theta_{j-c} + T_a < 150^\circ\text{C} \dots\dots\dots (2)$$

$N$ : Number of power transistors

$\theta_{j-c}$ : Thermal resistance per power transistor

However, the power dissipation,  $P_d$ , for the power transistors shall be allocated equally among the number of power transistors.

The following inequalities result from solving equations (1) and (2) for  $\theta_{c-a}$ .

$$\theta_{c-a} < (125 - T_a)/P_d \dots\dots\dots (1)'$$

$$\theta_{c-a} < (150 - T_a)/P_d - \theta_{j-c}/N \dots\dots\dots (2)'$$

Values that satisfy these two inequalities at the same time represent the required heat sink thermal resistance.

When the following specifications have been stipulated, the required heat sink thermal resistance can be determined from formulas (1)' and (2)'.

- Supply voltage  $V_{CC}$
- Load resistance  $R_L$
- Guaranteed ambient temperature  $T_a$

[Example]

When the IC supply voltage,  $V_{CC}=\pm 36\text{V}$  and  $R_L$  is  $6\Omega$ , the total power dissipation,  $P_d$ , within the hybrid IC, will be a maximum of  $43\text{W}$  at  $1\text{kHz}$  for a continuous sine wave signal according to the  $P_d$ - $P_o$  characteristics.

For the music signals normally handled by audio amplifiers, a value of  $1/8P_{O \text{ max}}$  ( $P_{O \text{ max}}=7.5\text{W}$ ) is generally used for  $P_d$  as an estimate of the power dissipation based on the type of continuous signal. (Note that the factor used may differ depending on the safety standard used.)

This is:

$$P_d \approx 30\text{W} \quad (\text{when } 1/8P_{O \text{ max}} = 7.5\text{W}, P_{O \text{ max}} = 60\text{W}).$$

The number of power transistors in audio amplifier block of these hybrid ICs,  $N$ , is 2, and the thermal resistance per transistor,  $\theta_{j-c}$ , is  $1.7^\circ\text{C/W}$ . Therefore, the required heat sink thermal resistance for a guaranteed ambient temperature,  $T_a$ , of  $50^\circ\text{C}$  will be as follows.

From formula (1)'  $\theta_{c-a} < (125 - 50)/32$   
 $< 2.34$

From formula (2)'  $\theta_{c-a} < (150 - 50)/32 - 1.7/2$   
 $< 1.49$

Therefore, the value of  $1.49^\circ\text{C/W}$ , which satisfies both of these formulae, is the required thermal resistance of the heat sink.

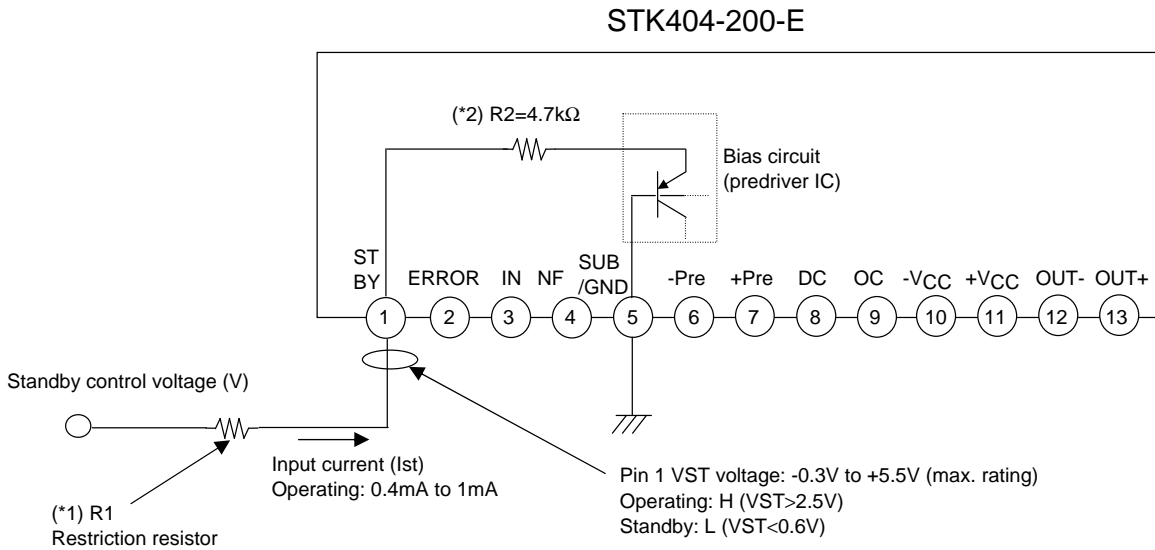
Note that this thermal design example assumes the use of a constant-voltage power supply, and is therefore not a verified design for any particular user's end product.



**Applications**

Standby circuit

Use the current limiting resistor R1 (\*1) so that the voltage applied to the Stand-by pin (pin #1) does not exceed the maximum rating voltage.

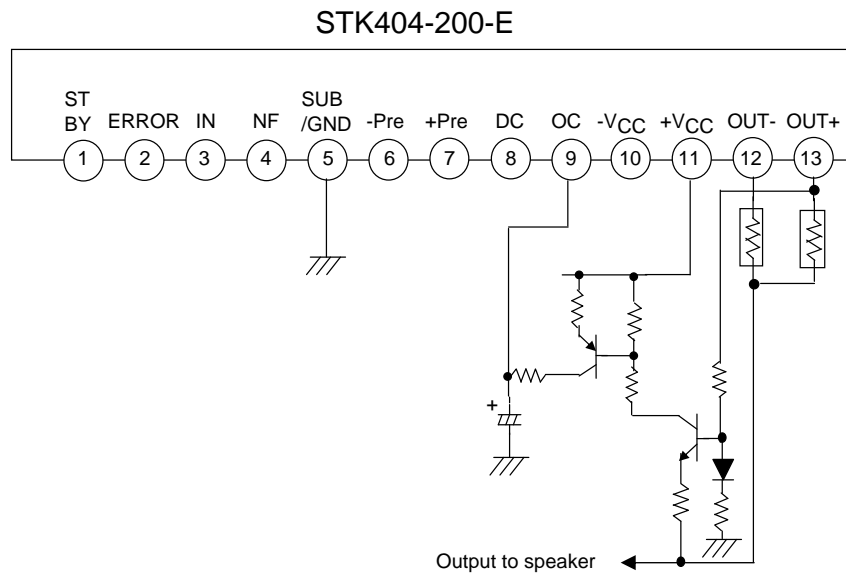


This pin has a function to release the latch when it is set to the ground level.

**Overcurrent Protection Circuit**

Overcurrent protection is activated if  $V_{OC} \approx 0.5V$  (typ) is applied to OC (#9). The HIC shuts down (latch mode) and the state of the error pin switches from high to low. The (open collector output) latch mode is cleared by setting the pin to the ground level.

**Sample Application Circuit**



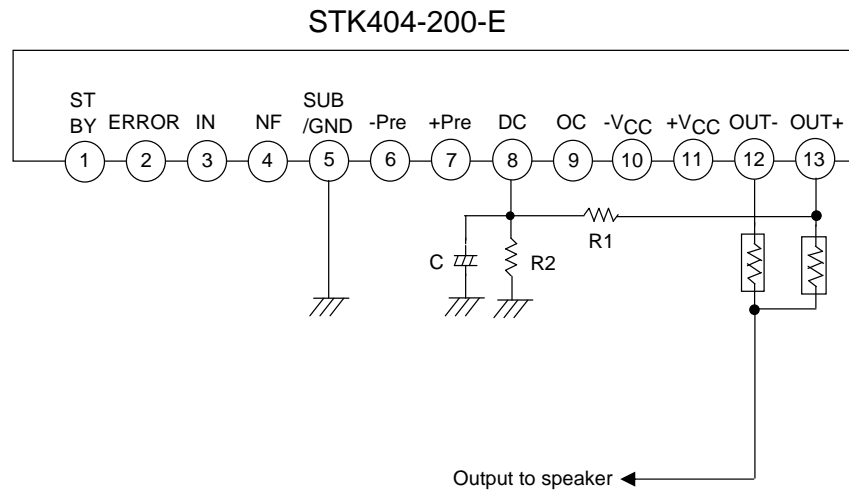
\* See "Application Circuit" for recommended values.

### DC Offset Detector Circuit

DC offset protection is activated if  $V_{DC}(+)$  or  $V_{DC}(-) \approx 0.5V$  (typ) is applied to DC (#8). The HIC shuts down and the state of the error pin switches from high to low. The (open collector output) latch mode is cleared by setting the pin to the ground level.

Set the protection level with the voltage dividing resistors R1 and R2 and determine the time constant value of C so that the IC will not malfunction when generating the audio signals.

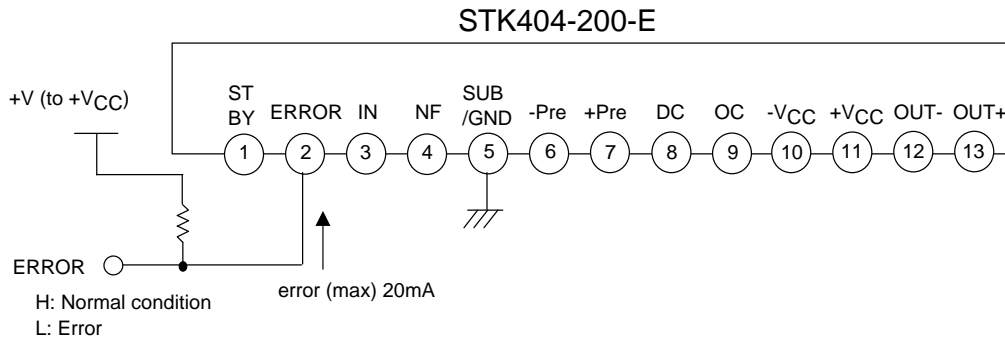
### Sample Application Circuit



\* Please refer to “13.Application circuit” about recommended Value.

### Error Indicator (Open Collector)

The state of the ERROR pin (#2) switches from high to low (open collector output) when a protection circuit is activated.



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