



SANYO Semiconductors

## DATA SHEET

# STK433-040-E — Thick-Film Hybrid IC 2-channel class AB audio power IC, 40W+40W

## Overview

The STK433-040-E is a hybrid IC designed to be used in 40W × 2ch class AB audio power amplifiers.

## Applications

- Audio power amplifiers.

## Features

- Pin-to-pin compatible outputs ranging from 30W to 60W.
- Can be used to replace the STK433-200 series (3-channel) due to its pin compatibility.
- Miniature package (47.0mm × 25.6mm × 9.0mm)
- Output load impedance:  $R_L = 6\Omega$  to  $4\Omega$  supported
- Allowable load shorted time: 0.3 second
- Allows the use of predesigned applications for standby and mute circuits.

## Series Models

	STK433-030-E	STK433-040-E	STK433-060-E	STK433-070-E
Output 1 (10%/1kHz)	30W×2 channels	40W×2 channels	50W×2 channels	60W×2 channels
Output 2 (0.4%/20Hz to 20kHz)	20W×2 channels	25W×2 channels	35W×2 channels	40W×2 channels
Max. rated $V_{CC}$ (quiescent)	±34V	±38V	±46V	±50V
Max. rated $V_{CC}$ (6Ω)	±32V	±36V	±40V	±44V
Max. rated $V_{CC}$ (4Ω)	±26V	±30V	±33V	±37V
Recommended operating $V_{CC}$ (6Ω)	±21V	±24V	±27V	±29V
Dimensions (excluding pin height)	47.0mm×25.6mm×9.0mm			

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## Specifications

**Absolute Maximum Ratings** at  $T_a = 25^\circ\text{C}$  (excluding rated temperature items),  $T_c = 25^\circ\text{C}$  unless otherwise specified

Parameter	Symbol	Conditions	Ratings	Unit
Maximum quiescent supply voltage 0	$V_{CC \text{ max (0)}}$	When no signal	$\pm 38$	V
Maximum supply voltage 1	$V_{CC \text{ max (1)}}$	$R_L \geq 6\Omega$	$\pm 36$	V
Maximum supply voltage 2	$V_{CC \text{ max (2)}}$	$R_L = 4\Omega$	$\pm 30$	V
Minimum operating supply voltage	$V_{CC \text{ min}}$		$\pm 10$	V
Pin 13 input voltage	$V_{ST \text{ max}}$		-0.3 to +5.5	V
Thermal resistance	$\theta_{j-c}$	Per power transistor	4.2	$^\circ\text{C/W}$
Junction temperature	$T_{j \text{ max}}$	Both the $T_{j \text{ max}}$ and $T_c \text{ max}$ conditions must be met.	150	$^\circ\text{C}$
IC substrate operating temperature	$T_c \text{ max}$		125	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-30 to +125	$^\circ\text{C}$
Allowable load shorted time *4	$t_s$	$V_H = \pm 24\text{V}$ , $R_L = 6\Omega$ , $f = 50\text{Hz}$ , $P_O = 25\text{W}$ , 1-channel active	0.3	s

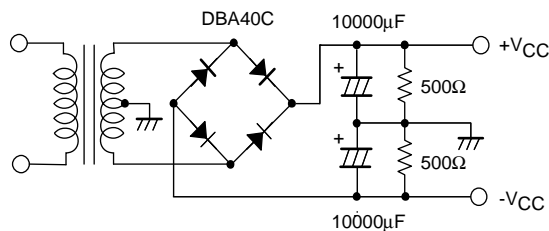
**Operating Characteristics** at  $T_c = 25^\circ\text{C}$ ,  $R_L = 6\Omega$ ,  $R_g = 600\Omega$ ,  $V_G = 30\text{dB}$ , non-inductive load  $R_L$ , unless otherwise specified

Parameter	Symbol	Conditions *2					Ratings			unit
		$V_{CC}$ (V)	f (Hz)	$P_O$ (W)	THD (%)		min	typ	max	
Output power *1	$P_O (1)$	$\pm 24$	20 to 20k		0.4		23	25		W
	$P_O (2)$	$\pm 24$	1k		10			40		
	$P_O (3)$	$\pm 20$	1k		1	$R_L = 4\Omega$		25		
Total harmonic distortion *1	THD (1)	$\pm 24$	20 to 20k	5.0					0.4	%
	THD (2)	$\pm 24$	1k					0.02		
Frequency characteristics *1	$f_L, f_H$	$\pm 24$		1.0		+0 -3dB	20 to 50k			Hz
Input impedance	$r_i$	$\pm 24$	1k	1.0				55		k $\Omega$
Output noise voltage *3	$V_{NO}$	$\pm 29$				$R_g = 2.2\text{k}\Omega$			1.0	mVrms
Quiescent current	$I_{CCO}$	$\pm 29$				No loading	20	45	70	mA
Standby current	$I_{CST}$	$\pm 29$							1	mA
Output neutral voltage	$V_N$	$\pm 29$					-70	0	+70	mV
Pin 13 voltage when standby ON	$V_{ST \text{ ON}}$	$\pm 24$				Standby			0.6	V
Pin 13 voltage when standby OFF	$V_{ST \text{ OFF}}$	$\pm 24$				Operating	2.5			V

[Remarks]

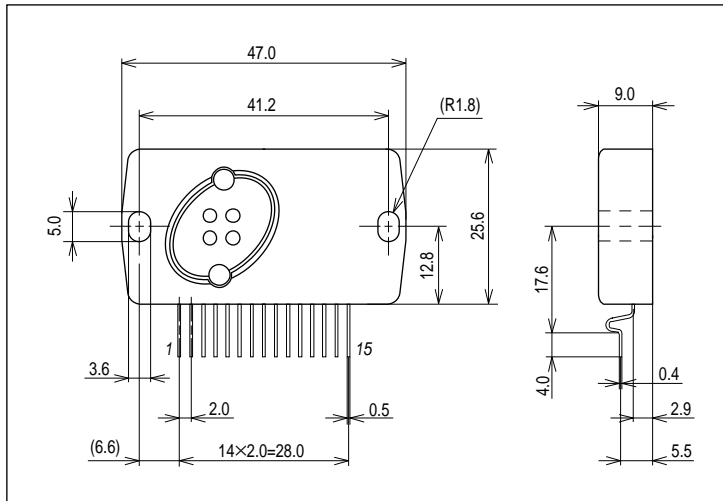
- \*1: For 1-channel operation
- \*2: Unless otherwise specified, use a constant-voltage power supply to supply power when inspections are carried out.
- \*3: The output noise voltage values shown are peak values read with a VTVM. However, an AC stabilized (50Hz) power supply should be used to minimize the influence of AC primary side flicker noise on the reading.
- \*4: Use the transformer power supply circuit shown in the figure below for allowable load shorted time measurement.
- \* The  $-V_{CC}$  (pin 1) line must be at the lowest level under any circumstances.
- \* Thermal design must be implemented based on the conditions under which the customer's end products are expected to operate on the market.
- \* A thermoplastic adhesive is used to adhere the case.

Designated transformer power supply (MG-200 equivalent)

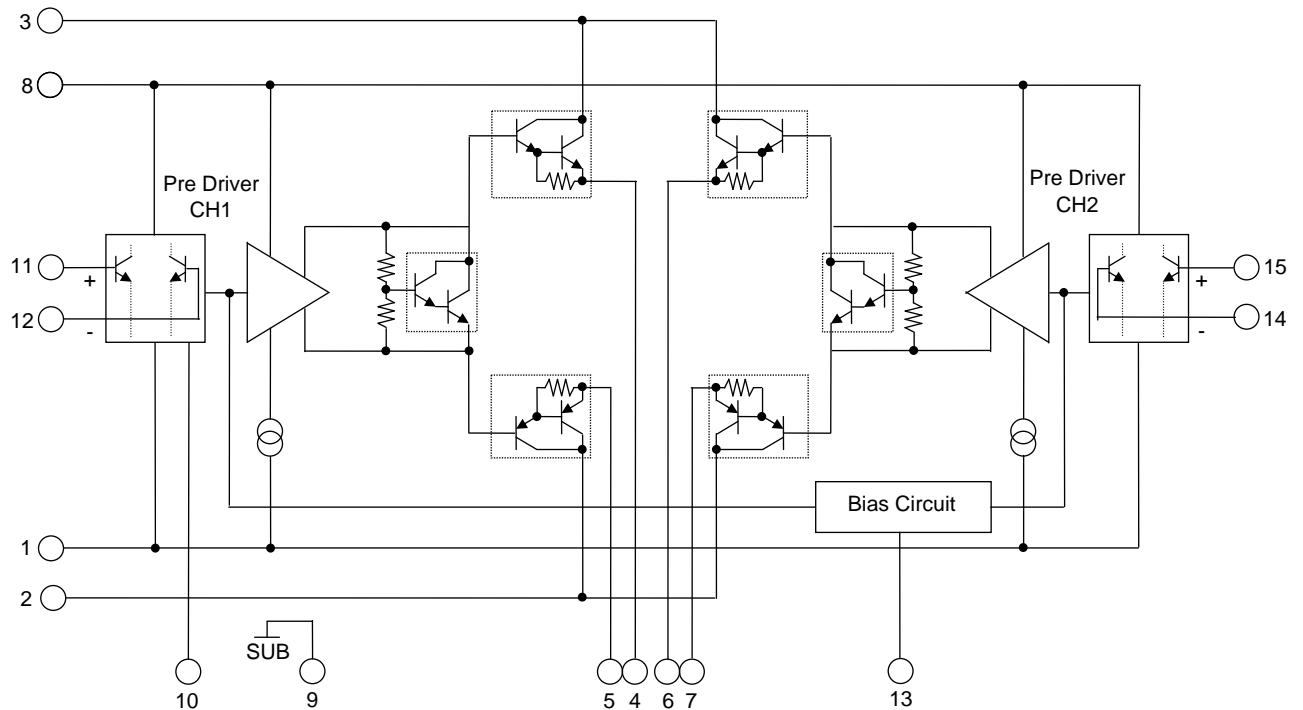


## Package Dimensions

unit:mm (typ)



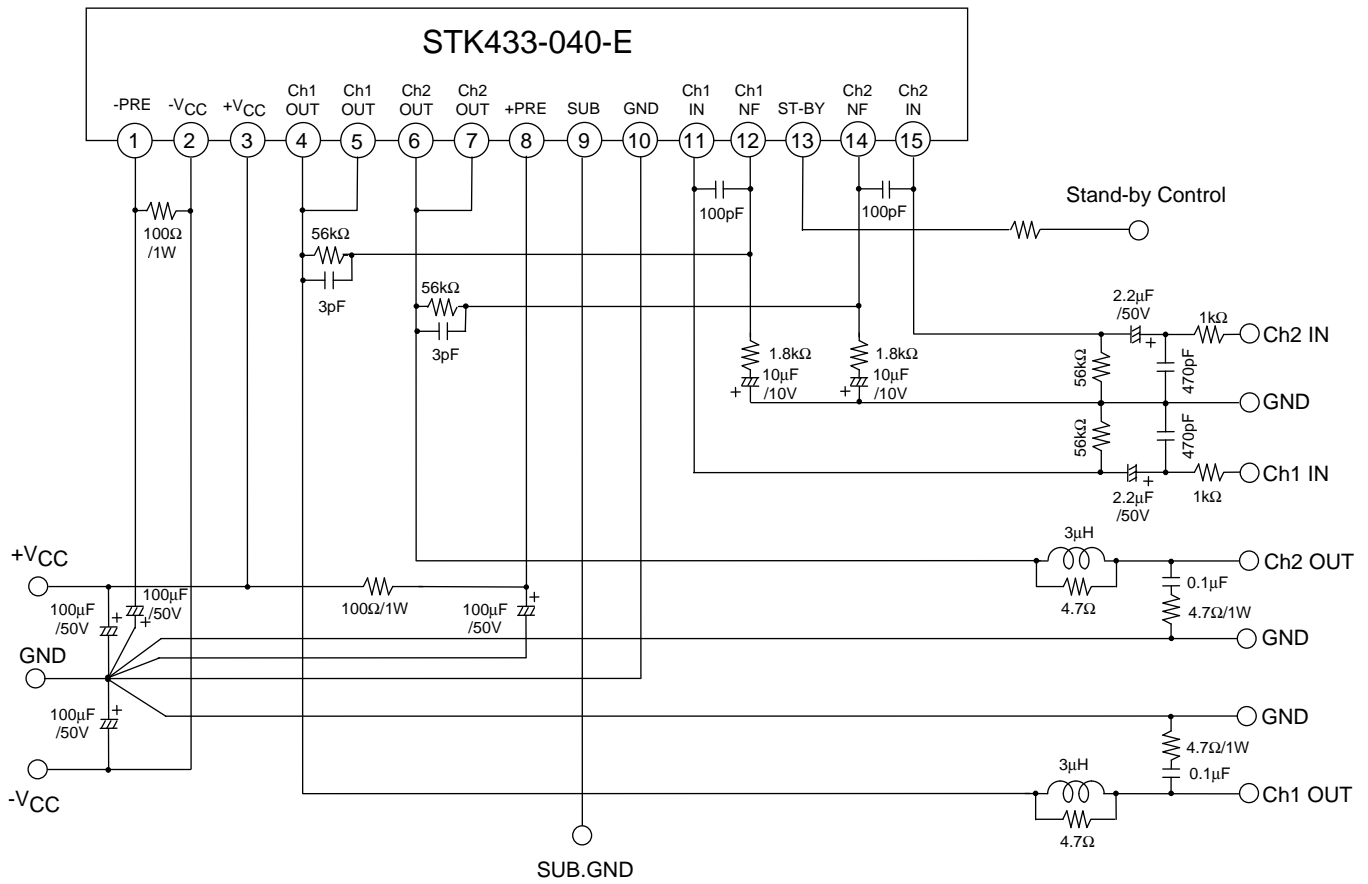
## Internal Equivalent Circuit



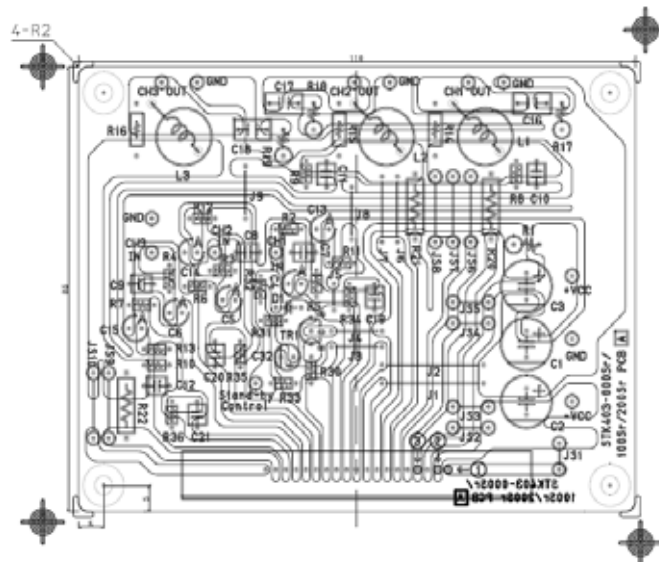
# STK433-040-E

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## Application Circuit Example



## Sample PCB Trace Pattern



# STK433-040-E

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## STK433-000/-200/STK403-100Sr PCB PARTS LIST

PCB Name: STK403-000Sr/100Sr/200Sr PCBA

Location No. (*3)	PARTS	RATING	Component	
			STK433-030/-040	STK433-060/-070
			STK433-230/-240	STK433-260/-270
				STK403-090 to130
Hybrid IC#1 Pin Position	-	-	①	
R01	ERG1SJ101	100Ω, 1W	enable	
R02, R03 (R4)	RN16S102FK	1kΩ, 1/6W	enable	
R05, R06, R08, R09 (R7, R10)	RN16S563FK	56kΩ, 1/6W	enable	
R11, R12 (R13)	RN16S182FK	1.8kΩ, 1/6W	enable	
R14, R15 (R16)	RN14S4R7FK	4.7Ω, 1/4W	enable	
R17, R18 (R19)	ERX1SJ4R7	4.7Ω, 1W	enable	
R20, R21 (R22)	ERX2SJR22	0.22Ω, 2W	short	enable
C01, C02, C03	100MV100HC	100μF, 100V	enable	
C04, C05 (C06)	50MV2R2HC	2.2μF, 50V	enable (*1)	
C07, C08 (C09)	DD104-63B471K50	470pF, 50V	enable	
C10, C11 (C12)	DD104-63CJ030C50	3pF, 50V	enable (*2)	
C13, C14 (C15)	10MV10HC	10μF, 10V	enable (*1)	
C16, C17 (C18)	ECQ-V1H104JZ	0.1μF, 50V	enable	
C19, C20 (C21)	DD104-63B***K50	***pF, 50V	100pF	
R34, R35 (R36)	RN16S302FK	3kΩ, 1/6W	Short	
L01, L02 (L3)	-	3μH	enable	
Stand-By Control Circuit	Tr1	2SC2274 (Reference)	VCE≥50V, IC≥10mA	
	D1	GMB01 (Reference)	Di	
	R30	RN16S512FK	5.1kΩ, 1/6W	
		RN16S103FK	13kΩ, 1/6W	
	R31	RN16S333FK	33kΩ, 1/6W	
	R32	RN16S102FK	1kΩ, 1/6W	
	R33	RN16S202FK	2kΩ, 1/6W	
	C32	10MV33HC	33μF, 10V	
J1, J2, J3, J4, J5, J6, J8, J9	-	-	enable	
J7, JS2, JS3, JS4, JS5, JS7 JS8, JS9	-	-	-	
JS6, JS10	-	-	enable	
JS1	-	-	enable	

(\*1) Capacitor mark “A” side is “-” (negative).

(\*2) STK433-200Sr (3ch) is 8pF use.

(\*3) Location No.( ) parts is STK433-200Sr (3ch) only use.

# STK433-040-E

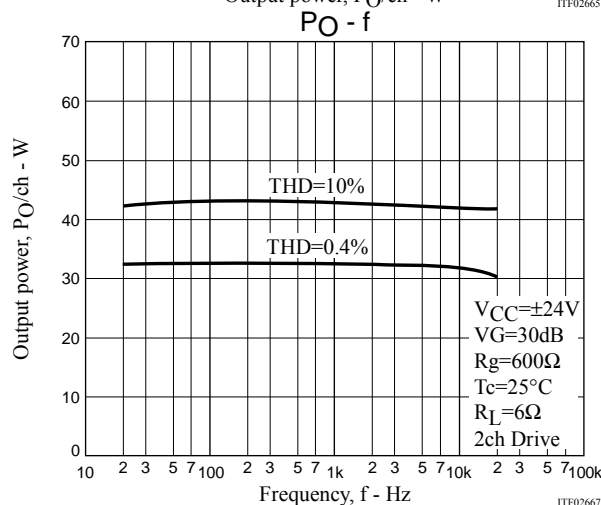
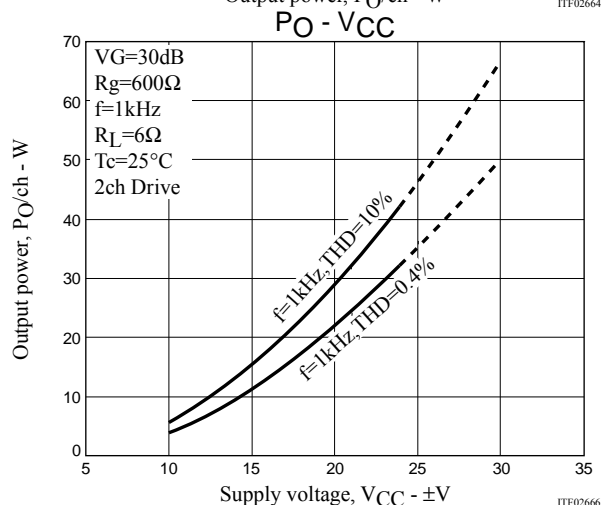
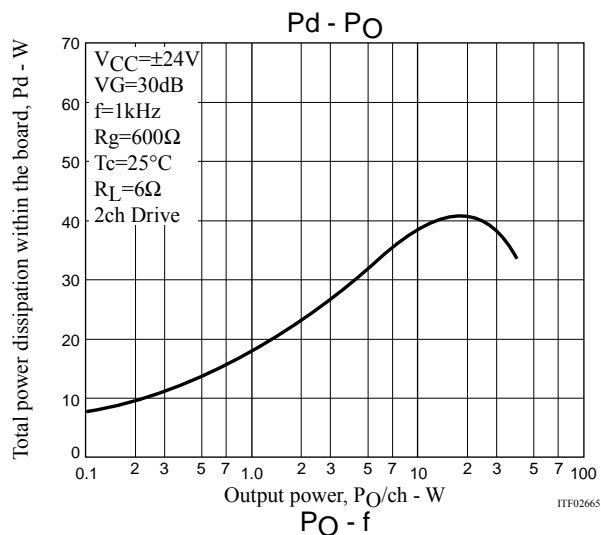
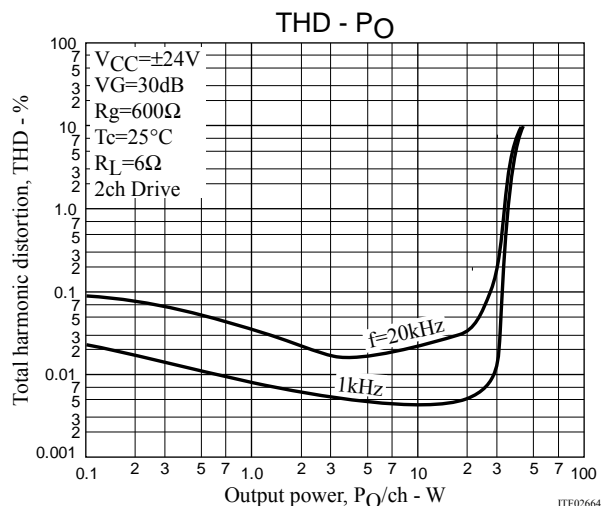
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## Pin Assignments

[STK433-000/-100/-200Sr & STK415/416-100Sr Pin Layout]

2-channel class-AB																123456789101112131415														
2-channel class AB/2.00mm																														
STK433-030-E 30W/JEITA <b>STK433-040-E 40W/JEITA</b> STK433-060-E 50W/JEITA STK433-070-E 60W/JEITA  STK433-090-E 80W/JEITA STK433-100-E 100W/JEITA STK433-120-E 120W/JEITA STK433-130-E 150W/JEITA			-	-	+	O	O	O	O	+		I	N	S	N	I														
		P	V	V	U	U	U	U	P	S	G	N	F	T	F	N														
		R	C	C	T	T	T	T	R	U		/	/	A	/	/														
		E	C	C	/	/	/	/	E	B	D	C	C	N	C	C														
					C	C	C	C		•		H	H	D	H	H														
					H	H	H	H		G		1	1		2	2														
					1	1	2	2		N				B																
3-channel class-AB			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19									
		3-channel class AB/2.00mm																												
		STK433-230A-E 30W/JEITA STK433-240A-E 40W/JEITA STK433-260A-E 50W/JEITA STK433-270-E 60W/JEITA			-	-	+	O	O	O	O	+		I	N	S	N	I	I	N	O	O								
				P	V	V	U	U	U	U	P	S	G	N	F	T	F	N	N	N	F	U	U							
				R	C	C	T	T	T	T	R	U		/	/	A	/	/	/	/	T	T								
				E	C	C	/	/	/	/	E	B	D	C	C	N	C	C	C	C	/	/								
							C	C	C	C		•		H	H	D	H	H	H	H	C	C								
			1	1	2	2		G		1	1		2	2	3	3	3	3	3											
			+	-	+	-		N				B		Y			+	-												
2-channel class-H				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19								
2-channel class H/2.00mm																														
STK415-090-E 80W/JEITA STK415-100-E 90W/JEITA STK415-120-E 120W/JEITA STK415-130-E 150W/JEITA STK415-140-E 180W/JEITA		+	-	+	-	-	-	+	O	O	O	O	+		I	N	S	N	I											
		V	V	O	O	P	V	V	U	U	U	U	P	S	G	N	F	T	F	N										
		L	L	F	F	R	H	H	T	T	T	T	R	U		/	/	A	/	/										
				F	F	E			/	/	/	/	E	B	D	C	C	N	C	C										
				S	S				C	C	C	C		•		H	H	D	H	H										
		E	E				H	H	H	H		G		1	1		2	2												
		T	T				1	1	2	2		N				B														
							+	-	+	-		D				Y														
3-channel class-H				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23				
3-channel class H/2.00mm																														
STK416-090-E 80W/JEITA STK416-100-E 90W/JEITA STK416-120-E 120W/JEITA STK416-130-E 150W/JEITA		+	-	+	-	-	-	+	O	O	O	O	+		I	N	S	N	I	I	N	O	O							
		V	V	O	O	P	V	V	U	U	U	U	P	S	G	N	F	T	F	N	N	F	U	U						
		L	L	F	F	R	H	H	T	T	T	T	R	U		/	/	A	/	/	/	T	T							
				F	F	E			/	/	/	/	E	B	D	C	C	N	C	C	C	/	/							
				S	S				C	C	C	C		•		H	H	D	H	H	H	C	C							
		E	E				H	H	H	H		G		1	1		2	2	3	3	3	3								
		T	T				1	1	2	2		N				B				+	-									

# Evaluation Board Characteristics



[Thermal Design Example for STK433-040-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  $125^\circ C$ .

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

$T_a$ : Guaranteed ambient temperature for the end product

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

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

$N$ : 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  $\theta_{c-a}$ .

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

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

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,  $V_{CC}$ , is  $\pm 24V$  and  $R_L$  is  $6\Omega$ , the total power dissipation,  $P_d$ , within the hybrid IC, will be a maximum of  $41W$  at  $1kHz$  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  $1/8P_O$  max 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:

$$P_d \approx 31.8W \quad (\text{when } 1/8P_O \text{ max.} = 5.0W, P_O \text{ max.} = 40W).$$

The number of power transistors in audio amplifier block of these hybrid ICs,  $N$ , is 4, and the thermal resistance per transistor,  $\theta_{j-c}$ , is  $4.2^\circ C/W$ . Therefore, the required heat sink thermal resistance for a guaranteed ambient temperature,  $T_a$ , of  $50^\circ C$  will be as follows.

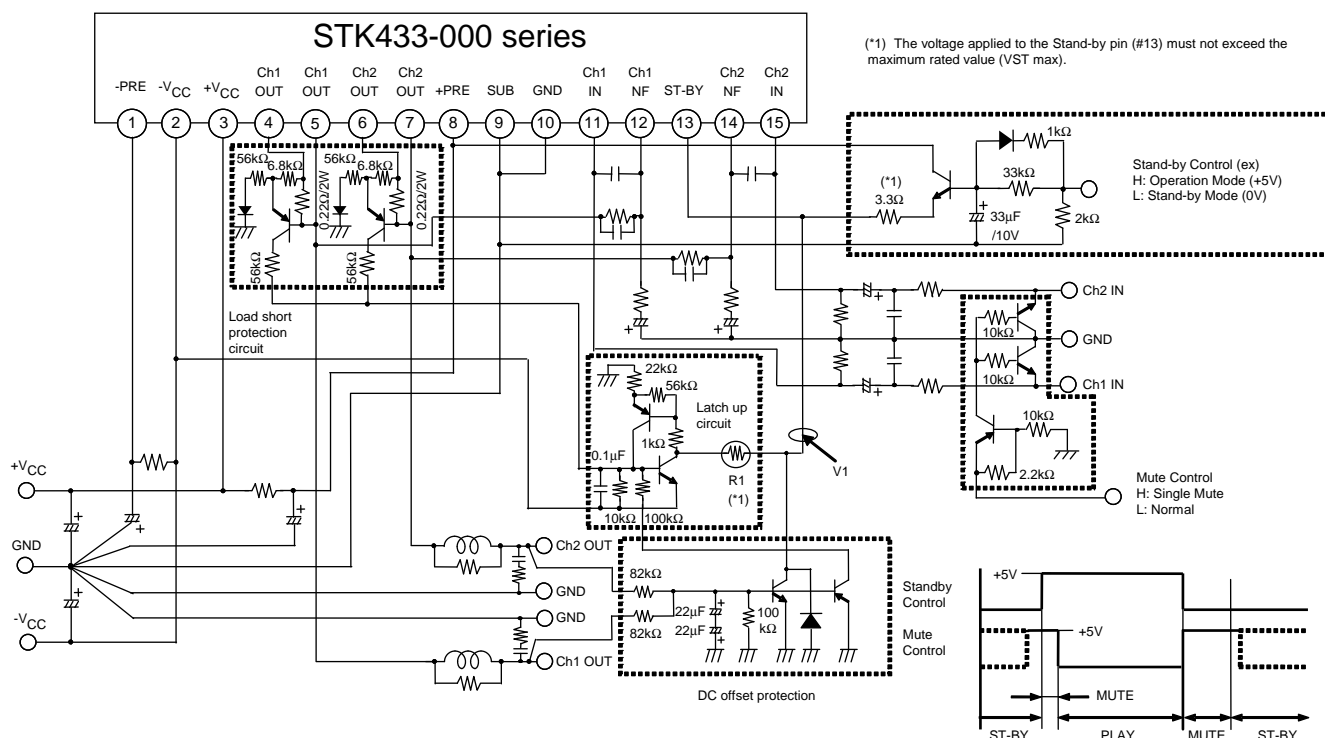
$$\begin{aligned} \text{From formula (1)'} \quad \theta_{c-a} &< (125 - 50)/31.8 \\ &< 2.36 \end{aligned}$$

$$\begin{aligned} \text{From formula (2)'} \quad \theta_{c-a} &< (150 - 50)/31.8 - 4.2/4 \\ &< 2.09 \end{aligned}$$

Therefore, the value of  $2.09^\circ C/W$ , 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.

## STK433-000 Series Standby Control, Mute Control, Load-short Protection & DC offset Protection application

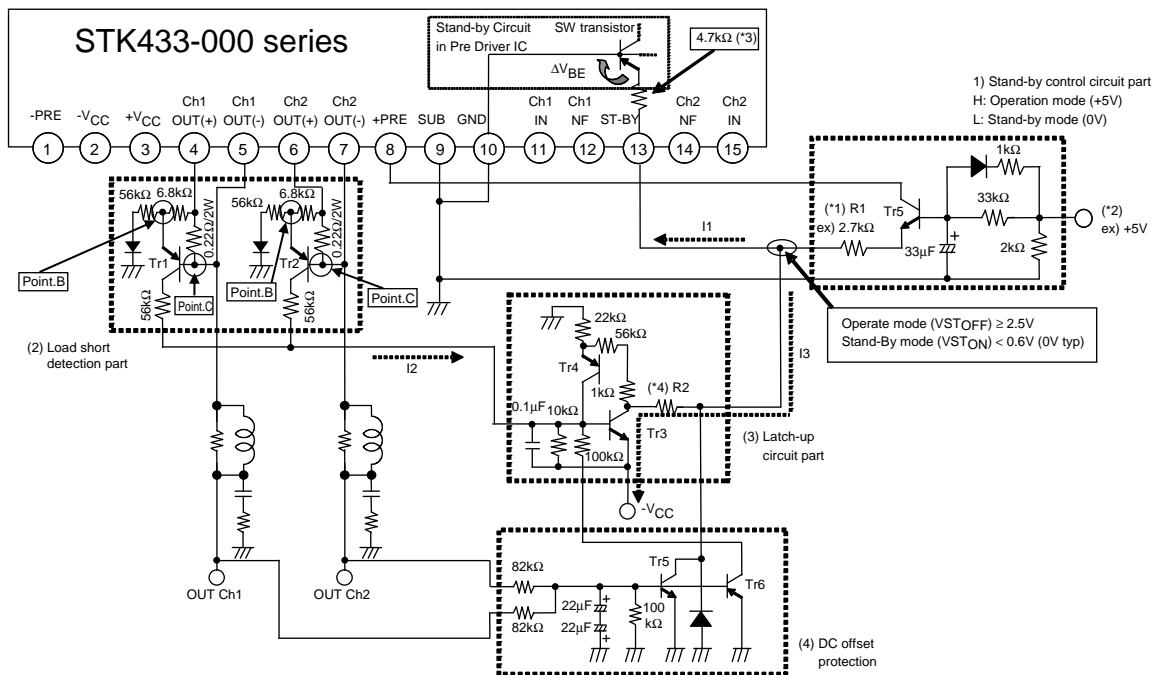


(\*1) R1 is changed depending on the power-supply voltage (-V<sub>CC</sub>).

Please set resistance (R1) to become "V1 = 0V" by the following calculation types.



# STK433-000 Series Application Explanation



The protection circuit application for the STK433-000sr consists of the following blocks (blocks (1) to (4)).

- (1) Standby control circuit block
- (2) Load short-circuit detection block
- (3) Latch-up circuit block
- (4) DC voltage protection block

## 1) Standby control circuit block

Concerning pin 13 reference voltage VST

### <1> Operation mode

The switching transistor of the predriver IC turns on when the pin 13 reference voltage, VST, becomes greater than or equal to 2.5V, placing the amplifier into the operation mode.

Example: When VST (min.) = 2.5V

I1 is approximately equal to 0.40mA since  $VST = (*2) \times IST + 0.6V \rightarrow 2.5V = 4.7k\Omega \times IST + 0.6V$ .

### <2> Standby mode

The switching transistor of the predriver IC turns off when the pin 13 reference voltage, VST, becomes lower than or equal to 0.6V (typ. 0V), placing the amplifier into the standby mode.

Example: When VST = 0.6V

I1 is approximately equal to 0mA since  $VST = (*2) \times IST + 0.6V \rightarrow 0.6V = 4.7k\Omega \times IST + 0.6V$ .

### (\*1) Limiting resistor

Determine the value of R1 so that the voltage VST applied to the standby pin (pin 13) falls within the rating (+2.5V to 5.5V (typ. 3.0V)).

(\*2) The standby control voltage must be supplied from the host including microcontrollers.

(\*3) A 4.7kΩ limiting resistor is also incorporated inside the hybrid IC (at pin 13).

2) Load short-circuit detection block

Since the voltage between point B and point C is less than 0.6V in normal operation mode ( $V_{BE} < 0.6V$ ) and TR1 (or TR2) is not activated, the load short-circuit detection block does not operate.

When a load short-circuit occurs, however, the voltage between point B and point C becomes larger than 0.6V, causing TR1 (or TR2) to turn on ( $V_{BE} > 0.6V$ ), and current I2 to flows.

3) Latch-up circuit block

TR3 is activated when I2 is supplied to the latch-up circuit.

When TR3 turns on and current I3 starts flowing, VST goes down to 0V (standby mode), protecting the power amplifier.

Since TR3 and TR4 configure a thyristor, once TR3 is activated, the IC is held in the standby mode.

To release the standby mode and reactivate the power amplifier, it is necessary to set the standby control voltage (\*2) temporarily low (0V). Subsequently, when the standby control is returned to high, the power amplifier will become active again.

(\*4) The I3 value varies depending on the supply voltage. Determine the value of R2 using the formula below, so that

I1 is equal to or less than I3.

$$I1 \leq I3 = V_{CC}/R2$$

4) DC offset protection block

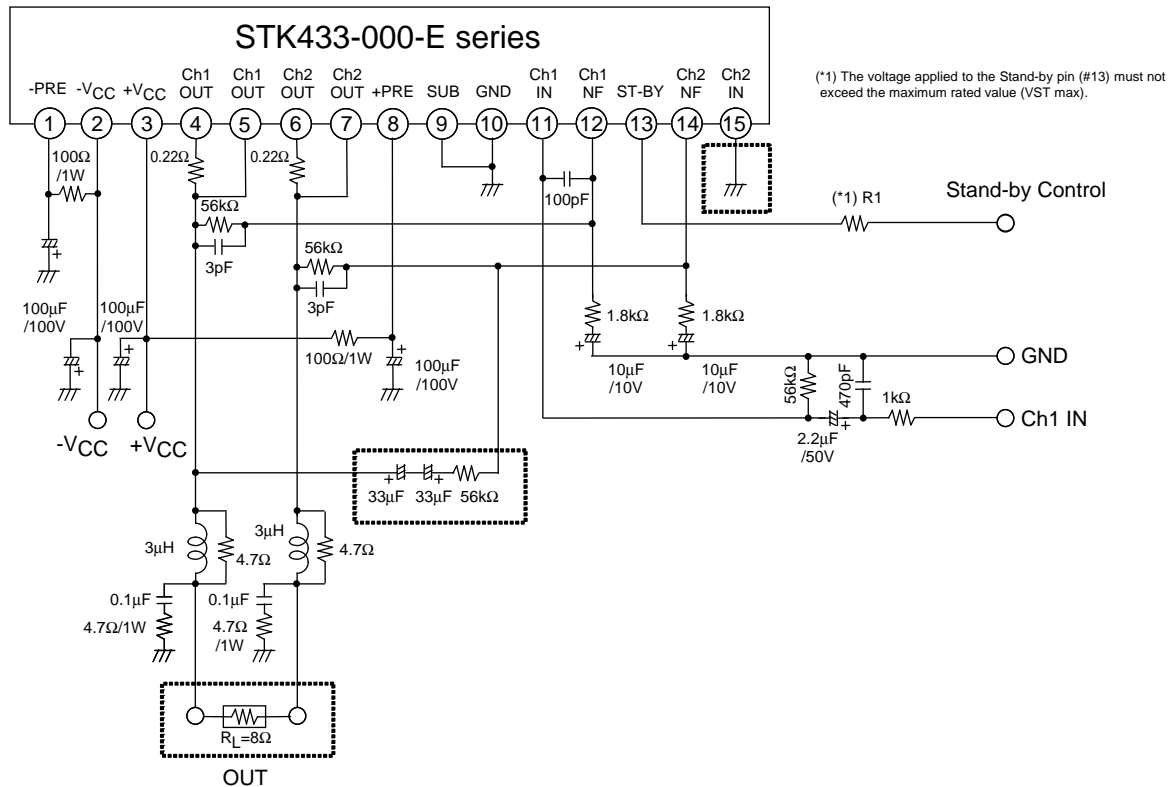
The DC offset protection circuit is activated when  $\pm 0.5V$  (typ) voltage is applied to either "OUT CH1" or "OUT CH2," and the hybrid IC is shut down (standby mode).

To release the IC from the standby mode and reactivate the power amplifier, it is necessary to set the standby control voltage temporarily low (0V).

Subsequently, when the standby control is returned to high (+5V, for example), the power amplifier will become active again.

The protection level must be set using the 82k $\Omega$  resistor. Furthermore, the time constant must be determined using 22 $\mu$ /22 $\mu$  capacitors to prevent the amplifier from malfunctioning due to the audio signal.

## STK433-000 Series BTL Application



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