

## Analog Signal Input Class D Amplifier with DC-DC Converter for Piezo Speaker

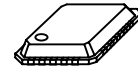
### ■ GENERAL DESCRIPTION

The **NJU8753** is an analog signal input class D power amplifier with DC-DC converter for Piezo speaker. Input part operates on 2.85V(typ) and a built-in DC-DC converter generates variable output voltage(up to 12V) with input voltage(2.6 to 4.2V). Therefore, it drives Piezo speaker with louder sound and high efficiency.

The **NJU8753** incorporates BTL amplifier, which eliminate AC coupling capacitors, capable of driving monaural Piezo speaker with simple external LC low-pass filters.

Class D operation achieves lower power operation for Piezo speaker, thus the NJU8753 is suited for battery-powered applications.

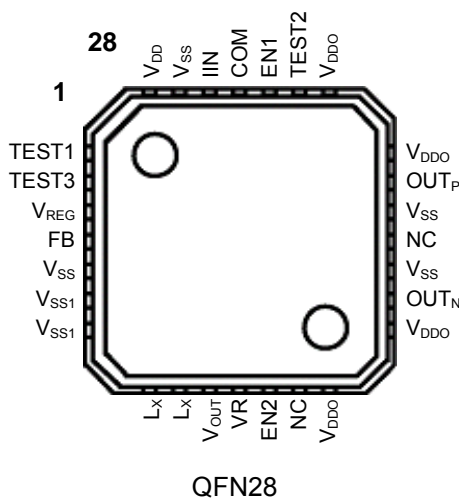
### ■ PACKAGE OUTLINE


**NJU8753KN1**

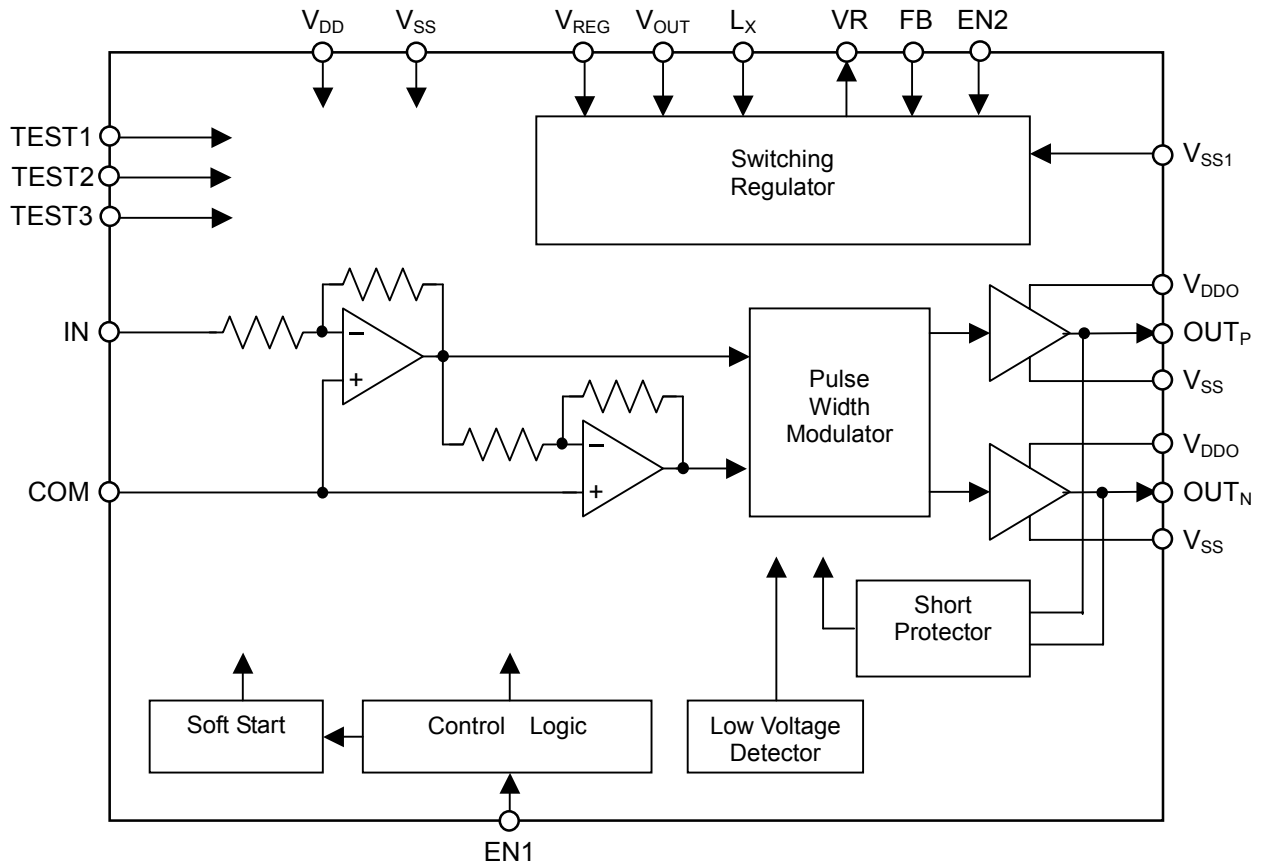
### ■ FEATURES

- Piezo Speaker Driving
- Output voltage: 8Vrms(Typ.) @ $V_{DDO}=10.0V$
- 1-channel Analog Signal Input, 1-channel BTL output
- Standby(Hi-Z),
- Built-in DC-DC Converter
- Built-in Low Voltage Detector
- Built-in Short Protector
- Operating Voltage :2.6~3.6V( $V_{DD}$ ,  $V_{REG}$ )  
:2.6~4.2V( $V_{BAT}$ )
- CMOS Technology
- Package Outline :QFN28

### ■ PIN CONFIGURATION



## ■ BLOCK DIAGRAM



## ■ PIN DESCRIPTION

No.	SYMBOL	I/O	Function
1	TEST1	I	Maker test 1 This pin must be connected to GND.
2	TEST3	I	Maker test 3 This pin must be connected to GND.
3	V <sub>REG</sub>	–	Switching regulator Power Supply : V <sub>REG</sub> =2.85V
4	FB	I	Switching regulator Feedback resistor
5	V <sub>SS</sub>	–	Power GND : V <sub>SS</sub> =0V
6,7	V <sub>SS1</sub>	–	Switching regulator Power GND : V <sub>SS1</sub> =0V
8,9	L <sub>X</sub>	I	Switching regulator voltage input
10	V <sub>OUT</sub>	–	Switching regulator Power Supply : V <sub>out</sub> =10.0V
11	VR	O	Switching regulator Output voltage
12	EN2	I	Switching regulator Standby Control High : Step-up ON Low : Standby ON This pin must be connected to V <sub>REG</sub> when step-up ON.
13	NC	–	Non connection
14, 15	V <sub>DDO</sub>	–	Output Power supply
16	OUT <sub>N</sub>	O	Negative Output
17	V <sub>SS</sub>	–	Power GND : V <sub>SS</sub> =0V
18	NC	–	Non connection
19	V <sub>SS</sub>	–	Power GND : V <sub>SS</sub> =0V
20	OUT <sub>P</sub>	O	Positive output
21, 22	V <sub>DDO</sub>	–	Output Power supply
23	TEST2	I	Maker Test 2 This pin must be connected to GND.
24	EN1	I	Power Amplifier Standby Control High : Standby OFF Low : Standby ON This pin must be connected to V <sub>DD</sub> when Standby OFF.
25	COM	–	Analog common
26	IN	I	Audio Signal Input
27	V <sub>SS</sub>	I	Power GND : V <sub>SS</sub> =0V
28	V <sub>DD</sub>	–	Power Supply : V <sub>DD</sub> =2.85V

\*Pin No.5(V<sub>SS</sub>), 6(V<sub>SS1</sub>), 7(V<sub>SS1</sub>), 17(V<sub>SS</sub>), 19(V<sub>SS</sub>), 27(V<sub>SS</sub>) should be connected at the nearest point to the IC.

\*Pin No.14(V<sub>DDO</sub>), 15(V<sub>DDO</sub>), 21(V<sub>DDO</sub>), 22(V<sub>DDO</sub>) should be connected at the nearest point to the IC.

\*Pin No.3(V<sub>REG</sub>) and 28(V<sub>DD</sub>) must be connected to V<sub>DD</sub>, when these pins are not used.

## ■ FUNCTIONAL DESCRIPTION

### (1) Signal Output

The  $OUT_P$  and  $OUT_N$  generate PWM output signals, which will be converted to analog signal via external 2nd-order or higher LC filter. A switching regulator with a high response against a voltage fluctuation is the best selection for the  $V_{DDO}$ , which are the power supply for output drivers. To obtain better THD performance, the stabilization of the power is required.

### (2) EN1

By setting the EN1 pin to "L", the standby mode is enabled. In the standby mode, the entire functions of the **NJU8753** enter a low-power state, and the output pins ( $OUT_P$  and  $OUT_N$ ) are high impedance.

### (3) Low Voltage Detector

When the power supply voltage drops down to below  $V_{DD}(\text{MIN})$ , the internal oscillation is halted for prevention to generate unwanted frequency, and the output pins ( $OUT_P$ ,  $OUT_N$ ) become in high impedance.

### (4) Step-up switching regulator

The switching regulator is used as power supply( $V_{DDO}$ ) for power amplifier of class-D. The PFM controlled switching regulator works with external components, which are coil, capacitor, Schottky-diode and resistor for Step-up voltage.

By setting the EN2 pin to "H", the step-up operation is enabled, and in case of "L", standby mode is enabled. Step-up voltage is set by internal reference voltage( $V_{REF}/2$ ) and external resistors.

The step-up voltage can be calculated by the following methods:

<Calculation of the step-up voltage>

The step-up voltage is determined by internal reference voltage( $V_{REF}$ ),  $R_1$  and  $R_2$ . (See Figure.2)

ex.  $V_{DD}=2.85V$ , Internal reference voltage( $V_{REF}$ ) =  $V_{REG}/2=1.425[V]$ ,  $R_1=2M\Omega$ ,  $R_2=330k\Omega$   
" Step-up voltage[V] =  $V_{REF} \times ((R_1+R_2)/R_2) = 1.425 \times ((2M + 330k)/330k) = 10.06[V]$  "

Note 1) Apply  $V_{REG}$  first, next  $V_{BAT}$ . Otherwise, the voltage stress may cause a permanent damage to the IC.

### (5) Short Circuit Protection

The short protector, which protects the **NJU8753** against high short-circuit current, turns off the output driver. After about 5 seconds from the protection, the NJU8753 returns to normal operation. The short protector functions at the following accidents.

- Short between  $OUT_P$  and  $OUT_N$
- Short between  $OUT_P$  and  $V_{SS}$
- Short between  $OUT_N$  and  $V_{SS}$

Note 1) The detectable current and the period for the protection depend on the power supply voltage and ambient temperature.

Note 2) The short protector is not effective for a long term short-circuit current but for an instantaneous accident. Continuous high-current may cause permanent damage to the **NJU8753**.

## ■ ABSOLUTE MAXIMUM RATINGS

(Ta=25°C)

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V <sub>DD</sub>	-0.3 ~ +4.0	V
	V <sub>REG</sub>	-0.3 ~ +4.0	V
	V <sub>DDO</sub>	-0.3 ~ +15.0	V
L <sub>X</sub> Input Voltage	V <sub>LX</sub>	-0.3 ~ +15.0	V
FB Input Voltage	V <sub>FB</sub>	-0.3 ~ +4.0	V
Input Voltage	V <sub>in</sub>	-0.3 ~ V <sub>DD</sub> +0.3	V
Operating Temperature	T <sub>opr</sub>	-40 ~ +85	°C
Storage Temperature	T <sub>stg</sub>	-40 ~ +125	°C
Power Dissipation	P <sub>D</sub>	640*	mW

\* : Mounted on a glass epoxy PCB(50mm x 50mm x 1.6mm).

Note 1) All voltage are relative to “V<sub>SS</sub>= 0V” reference.

Note 2) The LSI must be used inside of the “Absolute maximum ratings”. Otherwise, a stress may cause permanent damage to the LSI.

Note 3) De-coupling capacitors for V<sub>DD</sub>(Pin 28)-V<sub>SS</sub>(Pin 27), V<sub>REG</sub>(Pin 3)-V<sub>SS</sub>(Pin 5) and L<sub>X</sub>(Pin 8,9)-V<sub>SS</sub>(Pin 17,18,19) should be connected for stable operation.

## ■ ELECTRICAL CHARACTERISTIC

(Ta=25°C, V<sub>DD</sub>=V<sub>REG</sub>=2.85V, V<sub>BAT</sub>=3.7V, V<sub>DDO</sub>=10V, V<sub>SS</sub>=0V, V<sub>SS1</sub>=0V,  
TEST1=TEST2=TEST3=0V, EN1=EN2=2.85V,

Input Signal=1kHz, Input Signal Level=150mVrms, Frequency Band=20Hz~20kHz,  
Load Impedance=2.0μF 2nd-order 11.5kHz LC Filter(Q=0.72))

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	Note
V <sub>DD</sub> Supply Voltage	V <sub>DD</sub>		2.6	2.85	3.6	V	
V <sub>REG</sub> Supply Voltage	V <sub>REG</sub>		2.6	2.85	3.6	V	
V <sub>BAT</sub> Input Voltage	V <sub>BAT</sub>		2.6	3.7	4.2	V	
V <sub>DDO</sub> Supply Voltage	V <sub>DDO</sub>		8.0	10.0	12.0	V	
Input Impedance	Z <sub>IN</sub>	IN pin	-	20	-	KΩ	
Voltage Gain	A <sub>V</sub>		-	31	-	dB	
Output THD	THD	Input Signal Level =200mVrms	-	0.05	0.08	%	4
Maximum Output	V <sub>o</sub>	Output THD=10%	-	8.0	-	Vrms	
S/N	SN	A weight	-	80	-	dB	4
Operating Current(Standby)	I <sub>ST</sub>	EN1=EN2=0V	-	-	1	μA	
Operating Current (No signal input)	I <sub>SS</sub>	No-load operating No Signal Input	-	10	15	mA	
Input Voltage	V <sub>IH</sub>	EN1, EN2 pins	0.7V <sub>DD</sub>	-	V <sub>DD</sub>	V	
	V <sub>IL</sub>	EN1, EN2 pins	0	-	0.3V <sub>DD</sub>	V	
Input Leakage Current	I <sub>LK</sub>	EN1, EN2 pins	-	-	±1.0	μA	
Switching regulator Oscillating Frequency	f <sub>OSC</sub>		220	300	380	kHz	
Switching regulator Maximum Load Current	I <sub>OUT</sub>	Step-up Voltage =10.0V V <sub>OUT</sub> = 10.0V X 95%	50	-	-	mA	
Switching regulator Load Stability	ΔV <sub>OUT</sub>	Step-up Voltage =10.0V I <sub>OUT</sub> =10mA~50mA	-	100	-	mV	

Note 4) Test system of the output THD and S/N

The output THD and S/N are tested in the system shown in Figure 1, where a 2nd-order LC LPF and another filter incorporated in an audio analyzer are used.

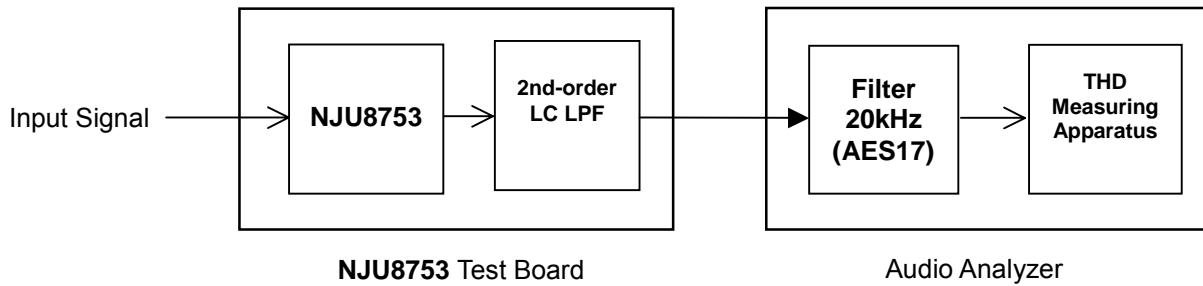


Figure 1. Output THD and S/N Test System

2nd-order LC LPF : Refer to "Typical Application Circuit"  
Filters : 22Hz HPF + 20kHz LPF(AES17)  
(with the A-Weight filter for S/N and Dynamic-range tests)

## ■ TYPICAL APPLICATION CIRCUIT

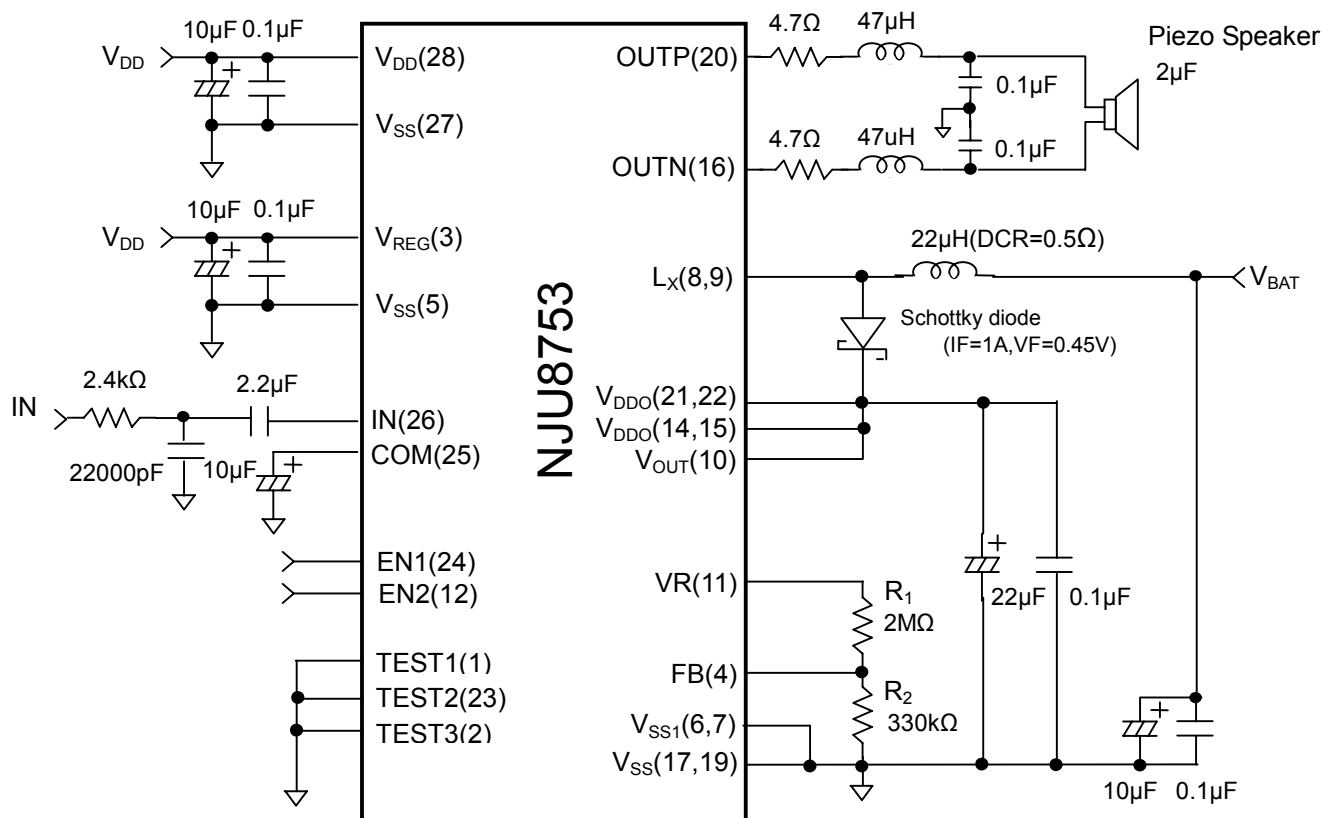


Figure 2. Application Circuit example

- Note 5) De-coupling capacitors must be connected between each power supply pin and GND. The capacity value should be adjusted on the application circuit and the operation temperature. It may malfunction if capacity value is small.
- Note 6) The power supply for  $V_{DDO}$  require fast driving response performance such as a switching regulator for better THD. THD performance becomes worse by ripple if the capacity of De-coupling capacitors is small.
- Note 7) The above circuit shows only application example and does not guarantee the any electrical characteristics. Therefore, please test the circuit carefully to fit your application. The cutoff frequency of the LC filter influences the quality of sound. The Q factor of the LC filter must be less than "1". Otherwise, the operating current increase when the frequency of input signal is closed to the cutoff frequency.
- Note 8) The transition time for EN1 and EN2 signals must be less than 100µs. Otherwise, a malfunction may be occurred.
- Note 9) (1)-(28) indicates pin number.

[CAUTION]  
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