MONO AUTOMOTIVE CLASSD AUDIO AMPLIFIER

Advance Information
July 2016

GENERAL DESCRIPTION

The IS32AP2120 is a mono Class D audio amplifier, ideal for use in automotive emergency call (eCall), telematics, instrument cluster, and infotainment applications. The device can deliver 5.8W into 8Ω speaker at less than 1% THD+N from a 12V power supply. The wide operating voltage range and excellent efficiency make the device ideal for start-stop support or running from a backup battery when required.

APPLICATIONS

- Automotive emergency call (eCall) amplifier
- Telemetric systems
- Instrument cluster systems
- Infotainment audio

FEATURES

- 4.5V to 24V operating range
- Mono BTL digital power amplifier
- Loudspeaker power(with AGC) from 12V supply
  - 5.8W/CH in to 8Ω @1% THD+N
  - 7W/CH into 8Ω @10% THD+N
  - 9W/CH in to 4Ω @1% THD+N
  - 10.2W/CH into 4Ω @10% THD+N
- Up to 90% efficiency
- Differential analog input
- 70dB power supply rejection ratio (PSRR)
- Dynamic temperature control prevents chip from over heating
- AGC (Automatic Gain Control) control function
- Protection and monitoring functions:
  - Short-circuit protection
  - Output DC level detection while music is playing
  - Over temperature protection
  - Over and under voltage protection
- Thermally enhanced eTSSOP-16 package
- AEC-Q100 Qualified (pending)
- -40°C to +125°C ambient temperature range

TYPICAL APPLICATION CIRCUIT

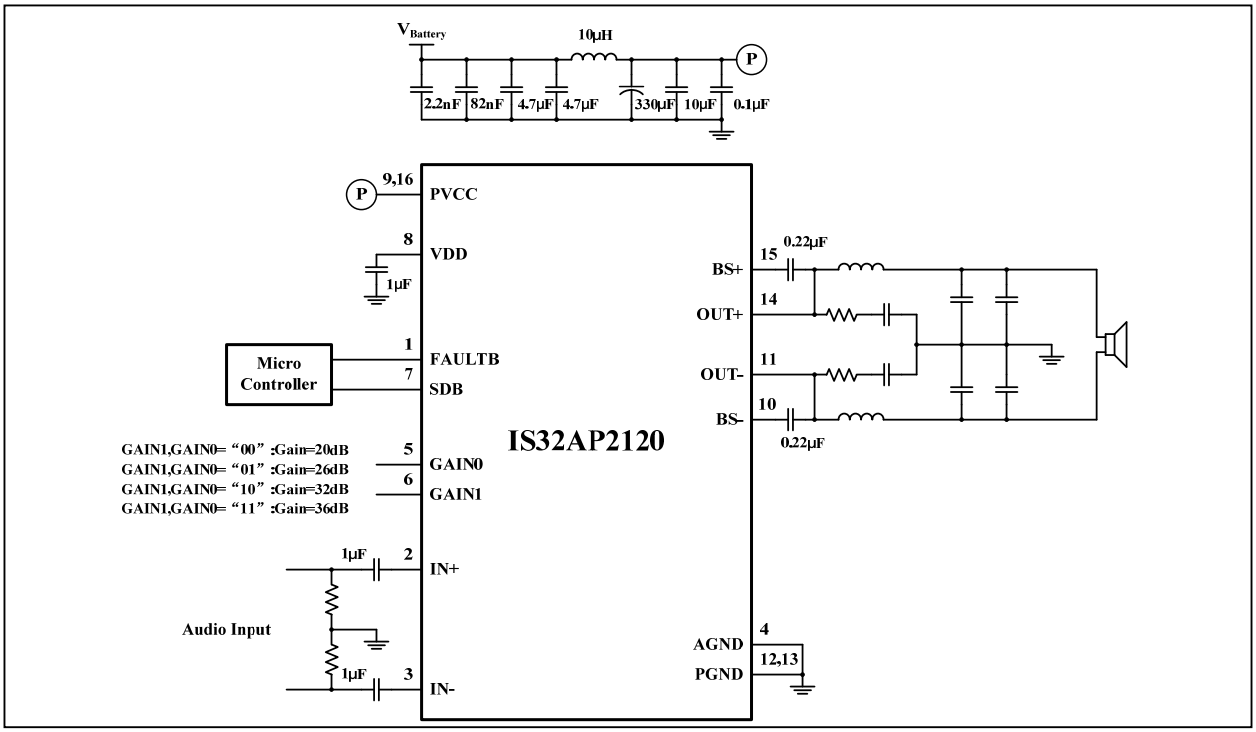
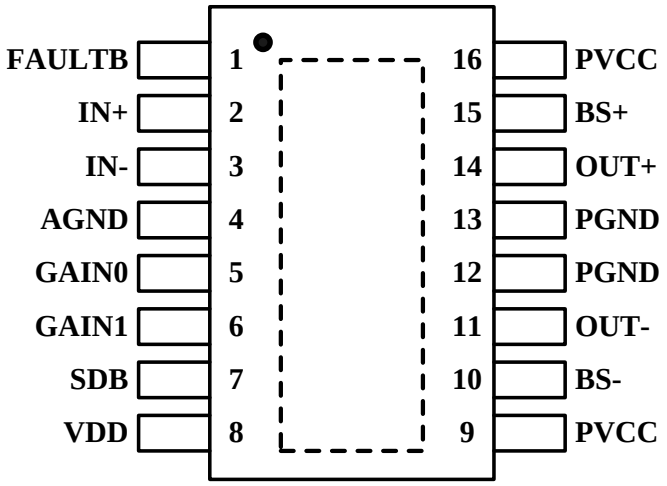


Figure 1 Typical Application Circuit

PIN CONFIGURATION

Package	Pin Configuration (Top View)
eTSSOP-16	

PIN DESCRIPTION

No.	PIN	DESCRIPTION
1	FAULTB	Active-low open-drain output used to report faults.
2	IN+	Non-inverting analog input.
3	IN-	Inverting analog input.
4	AGND	Ground.
5	GAIN0	Output gain control pin.
6	GAIN1	Output gain control pin.
7	SDB	Active-low SDB pin (no internal pull-up or pull-down).
8	VDD	Internal 5V voltage.
9,16	PVCC	Power supply.
10	BS-	Bootstrap for negative-output high-side FET.
11	OUT-	Negative output for channel.
12,13	PGND	Ground.
14	OUT+	Positive output for channel.
15	BS+	Bootstrap for positive-output high-side FET.
	Thermal Pad	Connect to GND.

ORDERING INFORMATION

Automotive Range: -40°C To +125°C

Order Part No.	Package	QTY
IS32AP2120-ZLA3-TR IS32AP2120-ZLA3	eTSSOP-16, Lead-free	2500/Reel 96/Tube

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (Unless otherwise noted) (Note 1).

Supply voltage, V_{CC} (Relative to GND)	-0.3V ~ +30V
Supply voltage ramp rate, V_{CC_RAMP}	15V/ms
For SDB pin (Relative to GND)	-0.3V ~ +5V
For IN+, IN- pins (Relative to GND)	-0.3V ~ +6.5V
DC current on VCC, GND and OUTx pins, I_{CC}, I_O	±4A
Maximum current, on all input pins, I_{IN_MAX} (Note 2)	±1mA
Maximum sink current for open-drain pins, I_{IN_ODMAX}	7mA
Junction-to-ambient thermal resistance, θ_{JA}	39.4°C/W
Storage temperature range, T_{STG}	-55°C ~ +150°C
ESD (HBM) ESD (CDM)	±2kV ±0.8kV

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Note 2: See Application Information section for information on analog input voltage and ac coupling.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{CC}	Supply voltage range relative to GND. Includes AC transients, requires proper decoupling.(Note 3)		4.5	12	24	V
V_{CC_RIP}	Maximum ripple on VCC	V_{CC}<8V			1	V_{PP}
V_{SD_H}	SDB pin input voltage for logic-level high		2			V
V_{SD_L}	SDB pin input voltage for logic-level low				0.7	V
T_A	Ambient temperature		-40		125	°C
R_L	Load impedance range	When using low impedance loads, do not exceed overcurrent limit.	3.4	4	16	Ω
R_{PU}	External pull-up resistor range	Resistor connected between open-drain logic output and V_{DD} supply	10		50	kΩ

RECOMMENDED OPERATING CONDITIONS (CONTINUE)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
C_{VCC}	External capacitor on VCC pin, typical value ±20% (Note 3)			10		μF
C_{VDD}	External capacitor on the BYP pin, typical value ±10%			1		μF
C_{IN}	External capacitance to analog input pin in series with input signal			1		μF
C_{BSP}	External boostrap capacitor, typical value ±20%			220		nF

Note 3: See the Power Supply section.

Note 4: Signal input for full unclipped output with gains of 36dB, 32dB, 26dB, and 20dB

Note 5: Maximum recommended input voltage is determined by the gain setting.

ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{CC} = 12V, R_L = 8Ω, P_O = 1W/CH, AES17 filter (unless otherwise noted).

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Operating Current						
I_{CC}	VCC idle current	In play mode, no audio present		16		mA
I_{SD}	VCC shutdown current	SDB mode, V_{MUTE}=0V		5	20	μA
Output Power						
P_O	Output power per channel With AGC	8Ω, THD≤1%,1kHz,T_A=25°C		5.8		W
		8Ω, THD=10%,1kHz,T_A=25°C		7		
		4Ω, THD≤1%,1kHz,T_A=25°C		9		
		4Ω, THD=10%,1kHz,T_A=25°C		10.2		
η	Power efficiency	8Ω, P_O=6W (THD=10%)		88		%
Audio Performance						
V_{NO}	Noise voltage at output	Gain=20dB, zero input, and A-weighting		80		μV
CMRR	Common-mode rejection ratio	f=1kHz, 100mVrms referenced to GND, Gain=20dB		63		dB
PSRR	Power supply rejection ratio	V_{CC}=12VDC+1Vrms, f=1kHz		70		dB
THD+N	Total harmonic distortion+noise	P_O=1W, f=1kHz		0.15		%
f_S	Switching frequency			400		kHz
Gain	Voltage gain (V_{OUT}/V_{IN})	Source impedance=0Ω, P_O=1W	19	20	21	dB
			25	26	27	
			31	32	33	
			35	36	37	

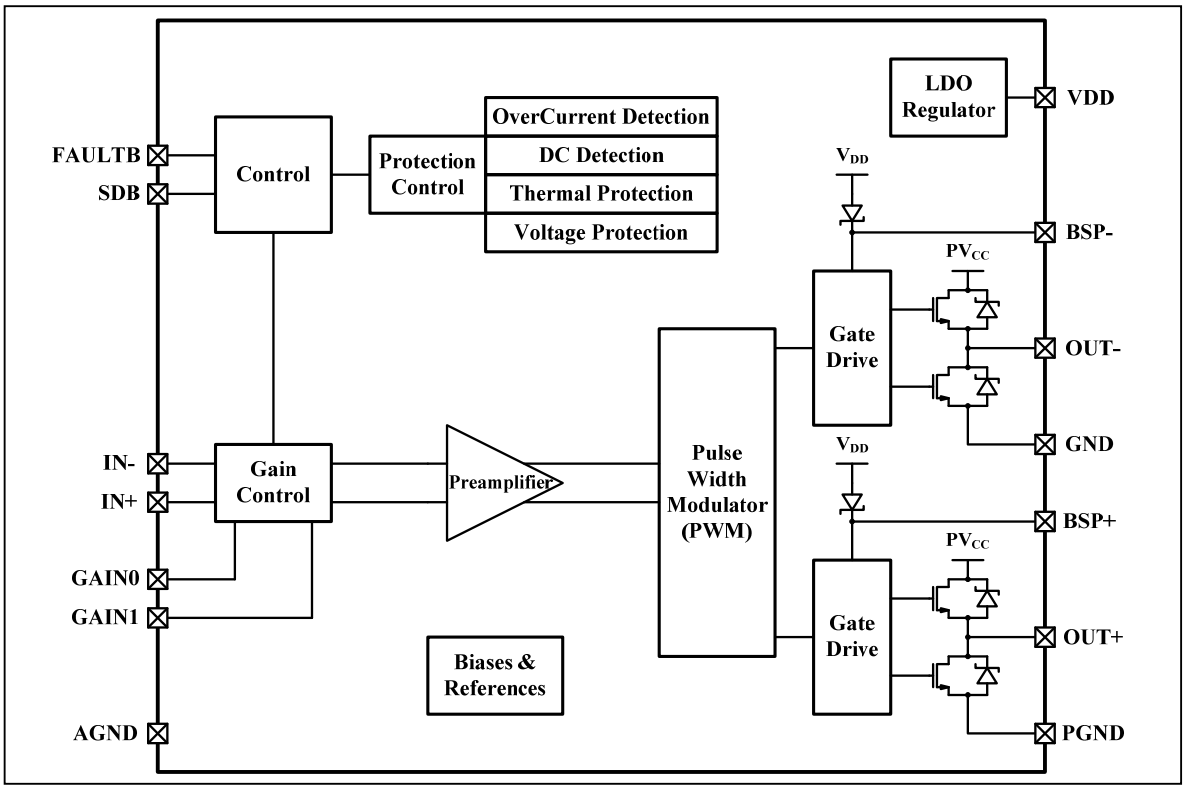
ELECTRICAL CHARACTERISTICS (CONTINUE)

T_A = 25°C, V_{CC} = 12V, R_L = 8Ω, P_O = 1W/CH, AES17 filter (unless otherwise noted).

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
PWM Output Stage						
R_{FET}	FET drain-to-source resistance	T_J=25°C		500		mΩ
V_{OFFSET}	Output offset voltage	Zero input signal, Gain=20dB		±5		mV
VCC Over Voltage Protection						
V_{OV_SET}	VCC over voltage shutdown set		27	28	29	V
V_{OV_HYS}	VCC over voltage shutdown hysteresis			0.6		V
VCC Under voltage Protection						
V_{UV_SET}	VCC under voltage shutdown set		3.6	4	4.4	V
V_{UV_HYS}	VCC under voltage shutdown hysteresis			0.25		V
VDD						
V_{VDD}	VDD pin voltage		4.5	5	5.5	V
Over Temperature (OT) Protection						
T_{OT_SD}	Junction temperature for over temperature shutdown			170		°C
T_{OT_HYS}	Junction temperature for over temperature hysteresis			20		°C
Over Current (OC) Shutdown Protection						
I_{MAX}	Maximum current (Peak output current)			3.5		A
SDB Pin						
I_{SDB}	SDB pin current			0.1	0.2	μA
DC Detect						
V_{DC}	DC detect threshold			2.9		V
t_{DC}	DC detect step response time				700	ms
Fault Report						
V_{OH_FAULT}	FAULTB pin output voltage for logic high	External 47Ω pull up resistor to 3.3V	2.4			V
V_{OL_FAULT}	FAULTB pin output voltage for logic low				0.5	V

Note 6: Guaranteed by design.

FUNCTIONAL BLOCK DIAGRAM



APPLICATION INFORMATION

OVERVIEW

The IS32AP2120 is a mono digital audio amplifier, ideal for use in automotive emergency call (eCall), telematics, instrument cluster, and infotainment applications. The device provides up to 6W into 8Ω at less than 10% THD+N from a 12V automotive battery. The wide operating voltage range and excellent efficiency make the device ideal for start-stop support or running from a backup battery when required.

ANALOG AUDIO INPUT AND PREAMPLIFIER

The differential input stage of the amplifier cancels common-mode noise that appears on the inputs. For a differential audio source, connect the positive lead to IN+ and the negative lead to IN-. The inputs must be ac-coupled to minimize the output dc-offset and ensure correct ramping of the output voltages. For good transient performance, the impedance seen at each of the two differential inputs should be the same.

The gain setting impacts the input level of GAIN0 and GAIN1 pins. See Table 1 for typical values.

Table 1 Gain Setting

Gain	GAIN1,GAIN0
20dB	00
26dB	01
32dB	10
36dB	11

PULSE-WIDTH MODULATOR (PWM)

The PWM converts the analog signal from the preamplifier into a switched signal of varying duty cycle. This is the critical stage that defines the Class-D architecture. In the IS32AP2120, the modulator is an advanced design with high bandwidth, low noise, low distortion, and excellent stability.

The pulse-width modulation scheme allows increased efficiency at low power. Each output is switching from 0V to VCC. The OUT+ and OUT- pins are in phase with each other with no input, so that there is little or no current in the speaker. The duty cycle of OUT+ is greater than 50% and OUT- is less than 50% for positive output voltages. The duty cycle of OUT- is greater than 50% and that of OUT+ is less than 50% for negative output voltages. The voltage across the load is at 0V through most of the switching period, reducing power loss.

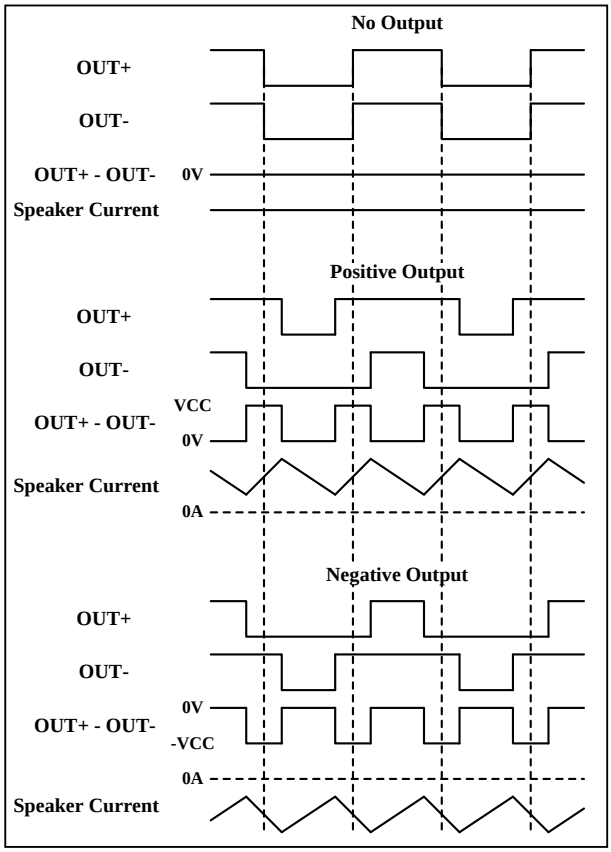


Figure 2 BD Mode Modulation

GATE DRIVE

The gate driver accepts the low-voltage PWM signal and level shifts it to drive a high-current, full-bridge, power FET stage. The device uses proprietary techniques to optimize EMI and audio performance.

POWER FETS

The BTL output comprises four matched N-channel FETs for high efficiency and maximum power transfer to the load.

HARDWARE CONTROL PINS

There are three discrete hardware pins for real-time control and indication of device status.

FAULTB pin: This active-low open-drain output pin indicates the presence of a fault condition which requires the device to go into the Hi-Z mode. On assertion of this pin, the device has protected itself and the system from potential damage.

SDB pin: Assertion of this active-low pin sends the device goes into a complete shutdown, limiting the current draw.

PROTECTION AND MONITORING

Undervoltage (UV) - The undervoltage (UV) protection detects low voltages on VCC. In the event of an undervoltage condition, the device will assert the FAULTB pin.

Overvoltage (OV) - OV protection detects high voltages on VCC. If VCC reaches the overvoltage threshold, the device will assert the FAULTB pin.

Overcurrent Shutdown (OCSD) - The overcurrent shutdown forces the output into Hi-Z. The device will assert the FAULTB pin.

DC Detect - This circuit checks for a DC offset continuously during normal operation at the output of the amplifier. If a DC offset occurs, the device will assert the FAULTB pin. Note that the DC detection threshold follows VCC changes.

Overtemperature Shutdown (OTSD) - The device shuts down when the die junction temperature reaches the overtemperature threshold. The device will assert the FAULTB pin. Recovery is automatic when the temperature returns to a safe level.

AGC (AUTOMATIC GAIN CONTROL) CONTROL FUNCTION

This is the function to control the output in order to obtain a maximum output level without distortion when an excessive input is applied which would otherwise cause clipping at the differential signal output. That is, with the AGC function, IS32AP2120 lowers the gain of the digital amplifier to an appropriate value so as not to cause clipping at the differential signal output.

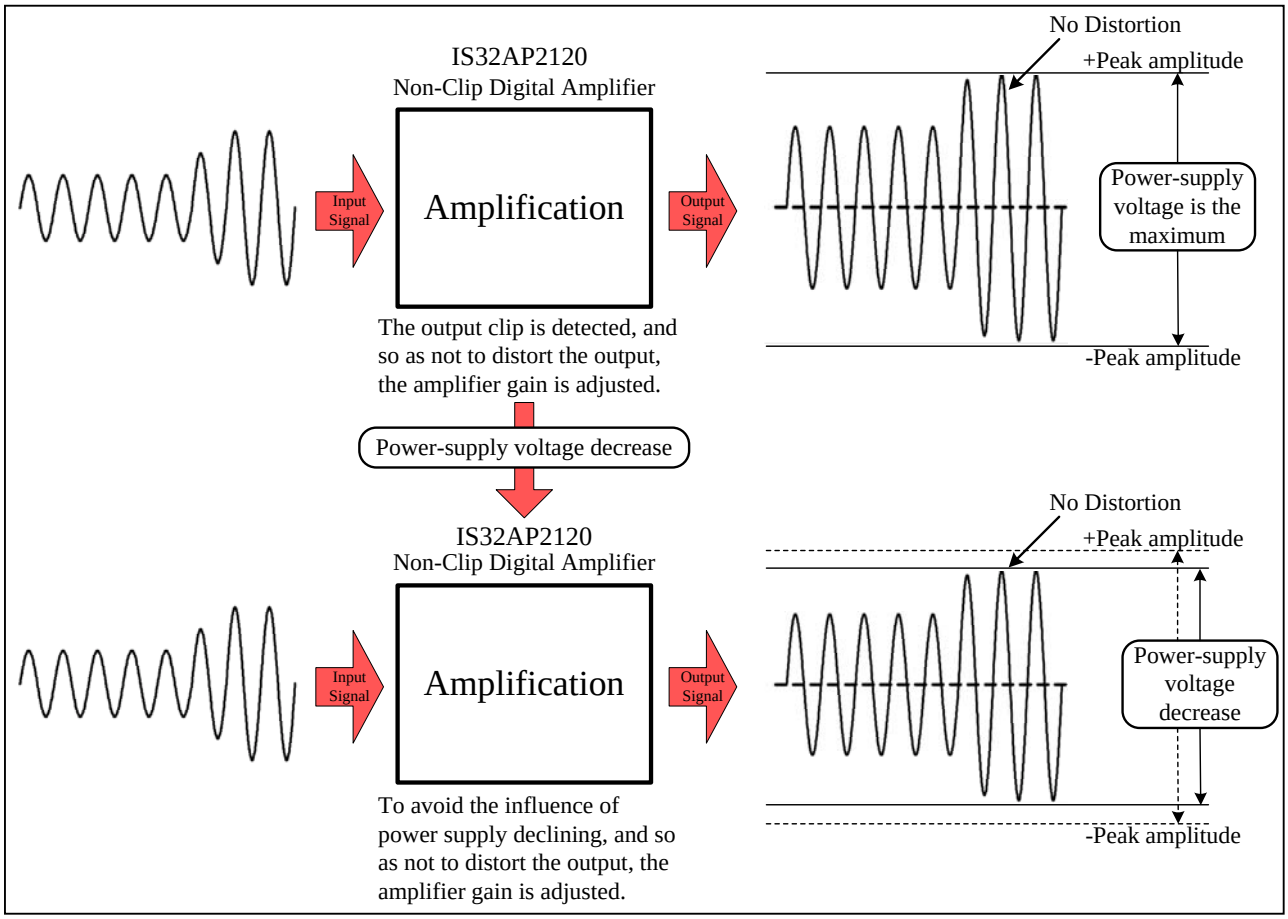


Figure 3 Operation Outline of Clip-less Function

The attack time and the release time of AGC control as below Table 1). The attack time is a time interval that gain falls from no AGC attenuation to target attenuation with a big signal input enough. And the Release Time is a time from target attenuation to no AGC attenuation.

Table 1 Attack Time and Release Time

Attack Time	Release Time
5ms	2.0s

With the AGC function of IS32AP2120, the optimum output power can be obtained along with the minimal distortion. The Figure 4 shows the outcome of AGC function.

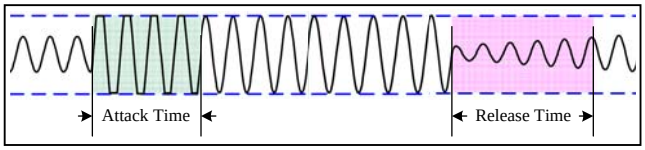


Figure 4 AGC Function ON

SPREAD SPECTRUM FUNCTION

The spread spectrum function eliminates the need for output filters, ferrite beads or chokes. In spread spectrum mode, the switching frequency varies randomly by 16% about a 400kHz center frequency, reducing the wideband spectral contend, improving EMI emissions radiated by the speaker and associated cables and traces. Where a fixed frequency Class-D exhibits large amounts of spectral energy at multiples of the switching frequency, the spread spectrum architecture of the IS32AP2120 spreads that energy over a larger bandwidth. The cycle-to-cycle variation of the switching period does not affect the audio reproduction, efficiency, or PSRR.

DYNAMIC TEMPERATURE CONTROL (DTC)

The DTC function is designed to protect the loudspeaker from over heating. As the junction temperature is higher than OT_W, the gain of amplifier will decrease step by step every 0.25s. Finally, as the junction temperature is lower than OT_R, the attenuated gain steps will be released step by step every 0.5s. If DTC can't suppress the temperature and the temperature reach to the OT trip point (170°C), the amplifier will be shutdown. The OT hysteresis temperature equals to OT_R. Typically, OT_W is 160°C and OT_R is 145°C.

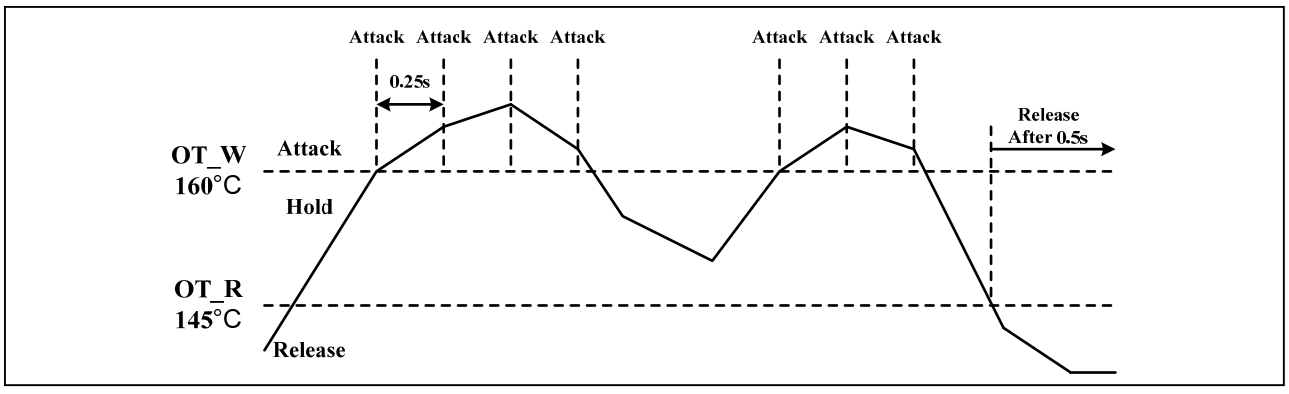
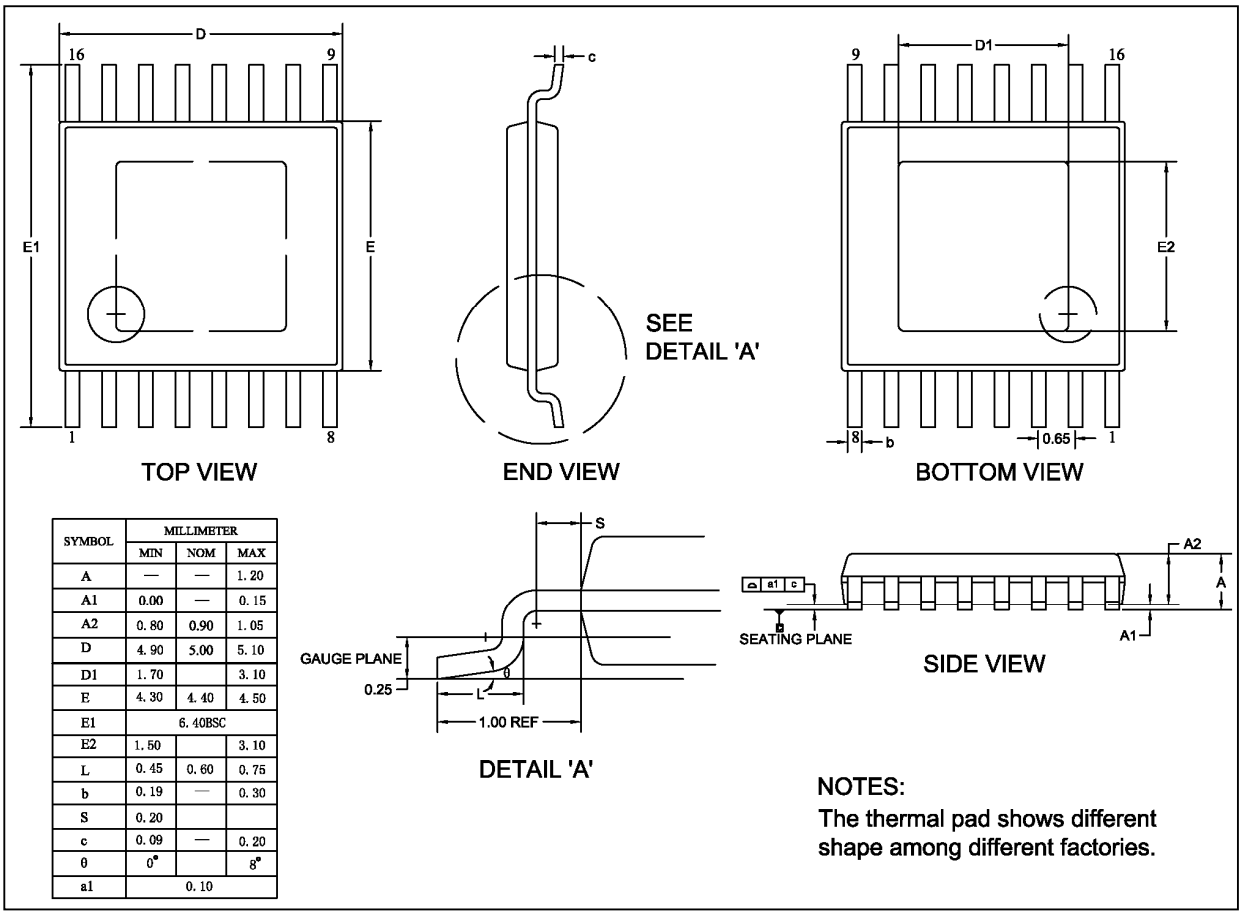


Figure 5 Dynamic Temperature Control Function

PACKAGE INFORMATION

eTSSOP-16



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.00	—	0.15
A2	0.80	0.90	1.05
D	4.90	5.00	5.10
D1	1.70		3.10
E	4.30	4.40	4.50
E1	6.40BSC		
E2	1.50		3.10
L	0.45	0.60	0.75
b	0.19	—	0.30
S	0.20		
c	0.09	—	0.20
θ	0°		8°
a1	0.10		