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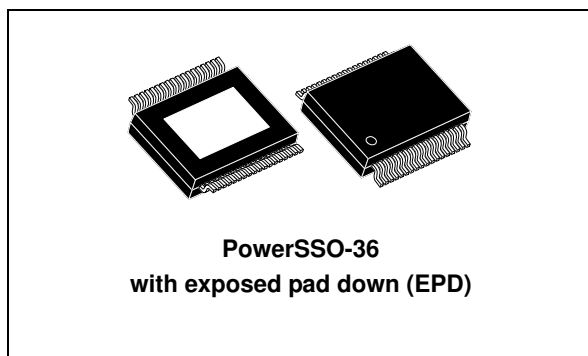
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## 2.1-channel high-efficiency digital audio system Sound Terminal®

Datasheet - production data



### Features

- Wide-range supply voltage
  - 5 V to 26 V (operating range)
  - 30 V (absolute maximum rating)
- Four power output configurations
  - 2 channels of ternary PWM (stereo mode) (2 x 30 W into 8 Ω at 22 V)
  - 3 channels - left, right using binary and LFE using ternary PWM (2.1 mode) (2 x 15 W + 1 x 30 W into 2 x 4Ω, 1 x 8 Ω at 22 V)
  - 2 channels of ternary PWM (2 x 30 W) + stereo lineout ternary)
- FFX®100 dB SNR and dynamic range
- Selectable 32 to 192 kHz input sampling rates
- I<sup>2</sup>C control with selectable device address
- Digital gain/attenuation +42 dB to -80 dB with 0.125 dB/step resolution
- Soft-volume update with programmable ratio
- Individual channel and master gain/attenuation
- Two independent DRCs configurable as a dual-band anti-clipper (B<sup>2</sup>DRC) or independent limiters/compressors
- EQ-DRC for DRC based on filtered signals
- Dedicated LFE processing for bass boosting with 0.125 dB/step resolution
- Audio presets:

- 15 preset crossover filters
- 5 preset anti-clipping modes
- Preset nighttime listening mode
- Individual channel and master soft/hard mute
- Independent channel volume and DSP bypass
- Automatic zero-detect mute
- Automatic invalid input-detect mute
- I<sup>2</sup>S input data interface
- Input and output channel mapping
- Up to 8 user-programmable biquads per channel
- 3 coefficient banks for EQ presets storing with fast recall via I<sup>2</sup>C interface
- Extended coefficient dynamic up to -4..4 for easy implementation of high shelf filters
- Bass/treble tones and de-emphasis control
- Selectable high-pass filter for DC blocking
- Advanced AM interference frequency switching and noise suppression modes
- Selectable high- or low-bandwidth noise-shaping topologies
- Selectable clock input ratio
- 96 kHz internal processing sampling rate with quantization error noise shaping for very low cutoff frequency filters
- Thermal overload and short-circuit protection embedded
- Video apps: 576 x Fs input mode supported
- Fully compatible with STA339BW, STA369BWS and STA350BW

**Table 1. Device summary**

Order code	Package	Packing
STA369BW	Power SSO-36	Tube
STA369BWTR	Power SSO-36	Tape and reel

# Contents

- 1 Description . . . . . 10**
  - 1.1 Block diagram . . . . . 11
- 2 Pin connections . . . . . 12**
  - 2.1 Connection diagram . . . . . 12
  - 2.2 Pin description . . . . . 12
- 3 Electrical specifications . . . . . 14**
  - 3.1 Absolute maximum ratings . . . . . 14
  - 3.2 Thermal data . . . . . 14
  - 3.3 Recommended operating conditions . . . . . 15
  - 3.4 Electrical specifications for the digital section . . . . . 15
  - 3.5 Electrical specifications for the power section . . . . . 16
- 4 Characterization curves . . . . . 18**
  - 4.1 Mono parallel BTL characteristics . . . . . 23
- 5 Serial audio interface . . . . . 25**
  - 5.0.1 Timings . . . . . 25
  - 5.0.2 Delay serial clock enable . . . . . 25
  - 5.0.3 Channel input mapping . . . . . 25
- 6 Processing data paths . . . . . 26**
- 7 I<sup>2</sup>C bus specification . . . . . 28**
  - 7.1 Communication protocol . . . . . 28
    - 7.1.1 Data transition or change . . . . . 28
    - 7.1.2 Start condition . . . . . 28
    - 7.1.3 Stop condition . . . . . 28
    - 7.1.4 Data input . . . . . 28
  - 7.2 Device addressing . . . . . 28
  - 7.3 Write operation . . . . . 29
    - 7.3.1 Byte write . . . . . 29
    - 7.3.2 Multi-byte write . . . . . 29

7.4	Read operation	29
7.4.1	Current address byte read	29
7.4.2	Current address multi-byte read	29
7.4.3	Random address byte read	29
7.4.4	Random address multi-byte read	29
7.4.5	Write mode sequence	30
7.4.6	Read mode sequence	30
<b>8</b>	<b>Register description</b>	<b>31</b>
8.1	Configuration register A (addr 0x00)	34
8.1.1	Master clock select	34
8.1.2	Interpolation ratio select	35
8.1.3	Thermal warning recovery bypass	35
8.1.4	Thermal warning adjustment bypass	35
8.1.5	Fault detect recovery bypass	36
8.2	Configuration register B (addr 0x01)	36
8.2.1	Serial audio input interface format	36
8.2.2	Serial data interface	37
8.2.3	Serial data first bit	37
8.2.4	Delay serial clock enable	39
8.2.5	Channel input mapping	39
8.3	Configuration register C (addr 0x02)	40
8.3.1	FFX power output mode	40
8.3.2	FFX compensating pulse size register	40
8.3.3	Overcurrent warning detect adjustment bypass	41
8.4	Configuration register D (addr 0x03)	41
8.4.1	High-pass filter bypass	41
8.4.2	De-emphasis	41
8.4.3	DSP bypass	42
8.4.4	Post-scale link	42
8.4.5	Biquad coefficient link	42
8.4.6	Dynamic range compression/anti-clipping bit	42
8.4.7	Zero-detect mute enable	43
8.4.8	Submix mode enable	43
8.5	Configuration register E (addr 0x04)	43
8.5.1	Max power correction variable	43

- 8.5.2 Max power correction ..... 43
- 8.5.3 Noise-shaper bandwidth selection ..... 44
- 8.5.4 AM mode enable ..... 44
- 8.5.5 PWM speed mode ..... 44
- 8.5.6 Distortion compensation variable enable ..... 44
- 8.5.7 Zero-crossing volume enable ..... 44
- 8.5.8 Soft-volume update enable ..... 45
- 8.6 Configuration register F (addr 0x05) ..... 45
  - 8.6.1 Output configuration ..... 45
  - 8.6.2 Invalid input detect mute enable ..... 51
  - 8.6.3 Binary output mode clock loss detection ..... 51
  - 8.6.4 LRCK double trigger protection ..... 51
  - 8.6.5 Auto EAPD on clock loss ..... 51
  - 8.6.6 IC power-down ..... 51
  - 8.6.7 External amplifier power-down ..... 52
- 8.7 Volume control registers (addr 0x06 - 0x0A) ..... 52
  - 8.7.1 Mute/line output configuration register ..... 52
  - 8.7.2 Master volume register ..... 52
  - 8.7.3 Channel 1 volume ..... 52
  - 8.7.4 Channel 2 volume ..... 53
  - 8.7.5 Channel 3 / line output volume ..... 53
- 8.8 Audio preset registers (addr 0x0B and 0x0C) ..... 54
  - 8.8.1 Audio preset register 1 (addr 0x0B) ..... 54
  - 8.8.2 Audio preset register 2 (addr 0x0C) ..... 55
  - 8.8.3 AM interference frequency switching ..... 55
  - 8.8.4 Bass management crossover ..... 55
- 8.9 Channel configuration registers (addr 0x0E - 0x10) ..... 56
  - 8.9.1 Tone control bypass ..... 56
  - 8.9.2 EQ bypass ..... 56
  - 8.9.3 Volume bypass ..... 57
  - 8.9.4 Binary output enable registers ..... 57
  - 8.9.5 Limiter select ..... 57
  - 8.9.6 Output mapping ..... 57
- 8.10 Tone control register (addr 0x11) ..... 58
  - 8.10.1 Tone control ..... 58
- 8.11 Dynamic control registers (addr 0x12 - 0x15) ..... 58

8.11.1	Limiter 1 attack/release rate	58
8.11.2	Limiter 1 attack/release threshold	58
8.11.3	Limiter 2 attack/release rate	58
8.11.4	Limiter 2 attack/release threshold	59
8.11.5	Limiter 1 extended attack threshold (addr 0x32)	62
8.11.6	Limiter 1 extended release threshold (addr 0x33)	62
8.11.7	Limiter 2 extended attack threshold (addr 0x34)	63
8.11.8	Limiter 2 extended release threshold (addr 0x35)	63
8.12	User-defined coefficient control registers (addr 0x16 - 0x26)	63
8.12.1	Coefficient address register	63
8.12.2	Coefficient b1 data register bits 23:16	63
8.12.3	Coefficient b1 data register bits 15:8	63
8.12.4	Coefficient b1 data register bits 7:0	63
8.12.5	Coefficient b2 data register bits 23:16	64
8.12.6	Coefficient b2 data register bits 15:8	64
8.12.7	Coefficient b2 data register bits 7:0	64
8.12.8	Coefficient a1 data register bits 23:16	64
8.12.9	Coefficient a1 data register bits 15:8	64
8.12.10	Coefficient a1 data register bits 7:0	64
8.12.11	Coefficient a2 data register bits 23:16	64
8.12.12	Coefficient a2 data register bits 15:8	65
8.12.13	Coefficient a2 data register bits 7:0	65
8.12.14	Coefficient b0 data register bits 23:16	65
8.12.15	Coefficient b0 data register bits 15:8	65
8.12.16	Coefficient b0 data register bits 7:0	65
8.12.17	Coefficient write/read control register	65
8.12.18	User-defined EQ	68
8.12.19	Pre-scale	68
8.12.20	Post-scale	68
8.12.21	Overcurrent post-scale	69
8.13	Variable max power correction registers (addr 0x27 - 0x28)	70
8.14	Variable distortion compensation registers (addr 0x29 - 0x2A)	70
8.15	Fault-detect recovery constant registers (addr 0x2B - 0x2C)	71
8.16	Device status register (addr 0x2D)	71
8.17	EQ coefficients and DRC configuration register (addr 0x31)	72
8.18	Extended configuration register (addr 0x36)	73

8.18.1	Dual-band DRC	73
8.18.2	EQ DRC mode	74
8.18.3	Extended post-scale range	75
8.18.4	Extended attack rate	75
8.18.5	Extended BIQUAD selector	76
8.19	EQ soft-volume configuration registers (addr 0x37 - 0x38)	76
8.20	DRC RMS filter coefficients (addr 0x39-0x3E)	77
8.21	Extra volume resolution configuration registers (address 0x3F)	78
8.22	Quantization error noise correction (address 0x48)	79
8.23	Extended coefficient range up to -4...4 (address 0x49, 0x4A)	80
8.24	Miscellaneous registers (address 0x4B, 0x4C)	81
8.24.1	Rate powerdown enable (RPDNEN) bit (address 0x4B, bit D7)	81
8.24.2	Noise-shaping on DC cut filter enable (NSHHPEN) bit (address 0x4B, bit D6)	81
8.24.3	Bridge immediate off (BRIDGOFF) bit (address 0x4B, bit D5)	81
8.24.4	Channel PWM enable (CPWMEN) bit (address 0x4B, bit D2)	82
8.24.5	Power-down delay selector (PNDLSL[2:0]) bits (address 0x4C, bit D4, D3, D2)	82
<b>9</b>	<b>Application</b>	<b>83</b>
9.1	Application scheme for power supplies	83
9.2	PLL filter schematic	83
9.3	Typical output configuration	83
<b>10</b>	<b>Package thermal characteristics</b>	<b>85</b>
<b>11</b>	<b>Package mechanical data</b>	<b>86</b>
<b>12</b>	<b>Revision history</b>	<b>88</b>

# List of tables

Table 1.	Device summary . . . . .	1
Table 2.	Pin description . . . . .	11
Table 3.	Absolute maximum ratings . . . . .	13
Table 4.	Thermal data . . . . .	13
Table 5.	Recommended operating conditions . . . . .	14
Table 6.	Electrical specifications - digital section . . . . .	14
Table 7.	Electrical specifications - power section . . . . .	15
Table 8.	Timing parameters for slave mode . . . . .	24
Table 9.	Register summary . . . . .	30
Table 10.	Master clock select . . . . .	33
Table 11.	Input sampling rates . . . . .	33
Table 12.	Internal interpolation ratio . . . . .	34
Table 13.	IR bit settings as a function of input sampling rate . . . . .	34
Table 14.	Thermal warning recovery bypass . . . . .	34
Table 15.	Thermal warning adjustment bypass . . . . .	34
Table 16.	Fault detect recovery bypass . . . . .	35
Table 17.	Serial audio input interface . . . . .	35
Table 18.	Serial data first bit . . . . .	36
Table 19.	Support serial audio input formats for MSB-first (SAIFB = 0) . . . . .	36
Table 20.	Supported serial audio input formats for LSB-first (SAIFB = 1) . . . . .	37
Table 21.	Delay serial clock enable . . . . .	38
Table 22.	Channel input mapping . . . . .	38
Table 23.	FFX power output mode . . . . .	39
Table 24.	Output modes . . . . .	39
Table 25.	FFX compensating pulse size bits . . . . .	39
Table 26.	Compensating pulse size . . . . .	39
Table 27.	Overcurrent warning bypass . . . . .	40
Table 28.	High-pass filter bypass . . . . .	40
Table 29.	De-emphasis . . . . .	40
Table 30.	DSP bypass . . . . .	41
Table 31.	Post-scale link . . . . .	41
Table 32.	Biquad coefficient link . . . . .	41
Table 33.	Dynamic range compression/anti-clipping bit . . . . .	41
Table 34.	Zero-detect mute enable . . . . .	42
Table 35.	Submix mode enable . . . . .	42
Table 36.	Max power correction variable . . . . .	42
Table 37.	Max power correction . . . . .	42
Table 38.	Noise-shaper bandwidth selection . . . . .	43
Table 39.	AM mode enable . . . . .	43
Table 40.	PWM speed mode . . . . .	43
Table 41.	Distortion compensation variable enable . . . . .	43
Table 42.	Zero-crossing volume enable . . . . .	43
Table 43.	Soft-volume update enable . . . . .	44
Table 44.	Output configuration . . . . .	44
Table 45.	Output configuration engine selection . . . . .	44
Table 46.	Invalid input detect mute enable . . . . .	51
Table 47.	Binary output mode clock loss detection . . . . .	51
Table 48.	LRCK double trigger protection . . . . .	51



Table 49.	Auto EAPD on clock loss . . . . .	51
Table 50.	IC power-down . . . . .	51
Table 51.	External amplifier power-down . . . . .	52
Table 52.	Line output configuration . . . . .	52
Table 53.	Master volume offset as a function of MV[7:0] . . . . .	53
Table 54.	Channel volume as a function of CxV[7:0] . . . . .	54
Table 55.	Audio preset gain compression/limiters selection for AMGC[3:2] = 00 . . . . .	54
Table 56.	AM interference frequency switching bits . . . . .	55
Table 57.	Audio preset AM switching frequency selection . . . . .	55
Table 58.	Bass management crossover . . . . .	55
Table 59.	Bass management crossover frequency . . . . .	55
Table 60.	Tone control bypass . . . . .	56
Table 61.	EQ bypass . . . . .	57
Table 62.	Binary output enable registers . . . . .	57
Table 63.	Channel limiter mapping as a function of CxLS bits . . . . .	57
Table 64.	Channel output mapping as a function of CxOM bits . . . . .	57
Table 65.	Tone control boost/cut as a function of BTC and TTC bits . . . . .	58
Table 66.	Limiter attack rate as a function of LxA bits . . . . .	60
Table 67.	Limiter release rate as a function of LxR bits . . . . .	60
Table 68.	Limiter attack threshold as a function of LxAT bits (AC-mode) . . . . .	61
Table 69.	Limiter release threshold as a function of LxRT bits (AC-mode) . . . . .	61
Table 70.	Limiter attack threshold as a function of LxAT bits (DRC -mode) . . . . .	62
Table 71.	Limiter release threshold as a as a function of LxRT bits (DRC-mode) . . . . .	62
Table 72.	RAM block for biquads, mixing, scaling and bass management. . . . .	69
Table 73.	Status register bits . . . . .	71
Table 74.	EQ RAM select . . . . .	72
Table 75.	Anti-clipping and DRC preset . . . . .	72
Table 76.	Anti-clipping selection for AMGC[3:2] = 01 . . . . .	72
Table 77.	Biquad filter settings . . . . .	80
Table 78.	PowerSSO-36 EPD dimensions . . . . .	86
Table 79.	Document revision history . . . . .	88

# List of figures

Figure 1. Block diagram ..... 11

Figure 2. Pin connection PowerSSO-36 (top view) ..... 12

Figure 3. Test circuit ..... 17

Figure 4. Demonstration board, 2.0 channels ..... 18

Figure 5. Mono parallel BTL schematic ..... 19

Figure 6. THD+N vs. output power ( $V_{CC} = 25\text{ V}$ , load = 6 W) ..... 20

Figure 7. THD+N vs. output power ( $V_{CC} = 18\text{ V}$ , load = 8 W) ..... 20

Figure 8. Output power vs.  $V_{CC}$  (load = 6 W) ..... 21

Figure 9. Output power vs.  $V_{CC}$  (load = 8 W) ..... 21

Figure 10. Efficiency vs. output power ( $V_{CC} = 25\text{ V}$ , load = 6 W) ..... 22

Figure 11. Efficiency vs. output power ( $V_{CC} = 25\text{ V}$ , load = 8 W) ..... 22

Figure 12. THD+N vs. output power ( $V_{CC} = 25\text{ V}$ , load = 3 W) ..... 23

Figure 13. Output power vs.  $V_{CC}$  (load = 3 W) ..... 23

Figure 14. Efficiency vs. output power ( $V_{CC} = 26\text{ V}$ , load = 3 W) ..... 24

Figure 15. Efficiency vs. output power ( $V_{CC} = 18\text{ V}$ , load = 3 W) ..... 24

Figure 16. Timing diagram for SAI interface ..... 25

Figure 17. Left and right processing - part 1 ..... 26

Figure 18. Processing - part 2 ..... 27

Figure 19. Write mode sequence ..... 30

Figure 20. Read mode sequence ..... 30

Figure 21. OCFG = 00 (default value) ..... 46

Figure 22. OCFG = 01 ..... 46

Figure 23. OCFG = 10 ..... 46

Figure 24. OCFG = 11 ..... 47

Figure 25. Output mapping scheme ..... 47

Figure 26. 2.0 channels (OCFG = 00) PWM slots ..... 48

Figure 27. 2.1 channels (OCFG = 01) PWM slots ..... 49

Figure 28. 2.1 channels (OCFG = 10) PWM slots ..... 50

Figure 29. Basic limiter and volume flow diagram ..... 60

Figure 30. B<sup>2</sup>DRC scheme ..... 73

Figure 31. EQDRC scheme ..... 75

Figure 32. Extra resolution volume scheme ..... 78

Figure 33. Biquad filter structure with quantization error noise-shaping ..... 80

Figure 34. Application scheme for power supplies ..... 83

Figure 35. Output configuration for stereo BTL mode ..... 84

Figure 36. Double-layer PCB with 2 copper ground areas and 24 via holes ..... 85

Figure 37. PowerSSO-36 power derating curve ..... 85

Figure 38. PowerSSO-36 EPD outline drawing ..... 87

# 1 Description

The STA369BW is an integrated solution of digital audio processing, digital amplifier control, and FFX-power output stage, thereby creating a high-power single-chip FFX<sup>®</sup> solution comprising high-quality, high-efficiency, and all-digital amplification.

The STA369BW is based on an FFX (fully flexible amplification) processor, a proprietary technology from STMicroelectronics. FFX is the evolution and the enlargement of ST's ternary technology: the new processor can be configured to work in ternary, binary, binary differential and phase-shift PWM modulation schemes.

The STA369BW contains the ternary, binary and binary differential implementations, a subset of the full capability of the FFX processor.

The STA369BW is part of the Sound Terminal<sup>®</sup> family that provides full digital audio streaming to the speaker, offering cost effectiveness, low power dissipation and sound enrichment.

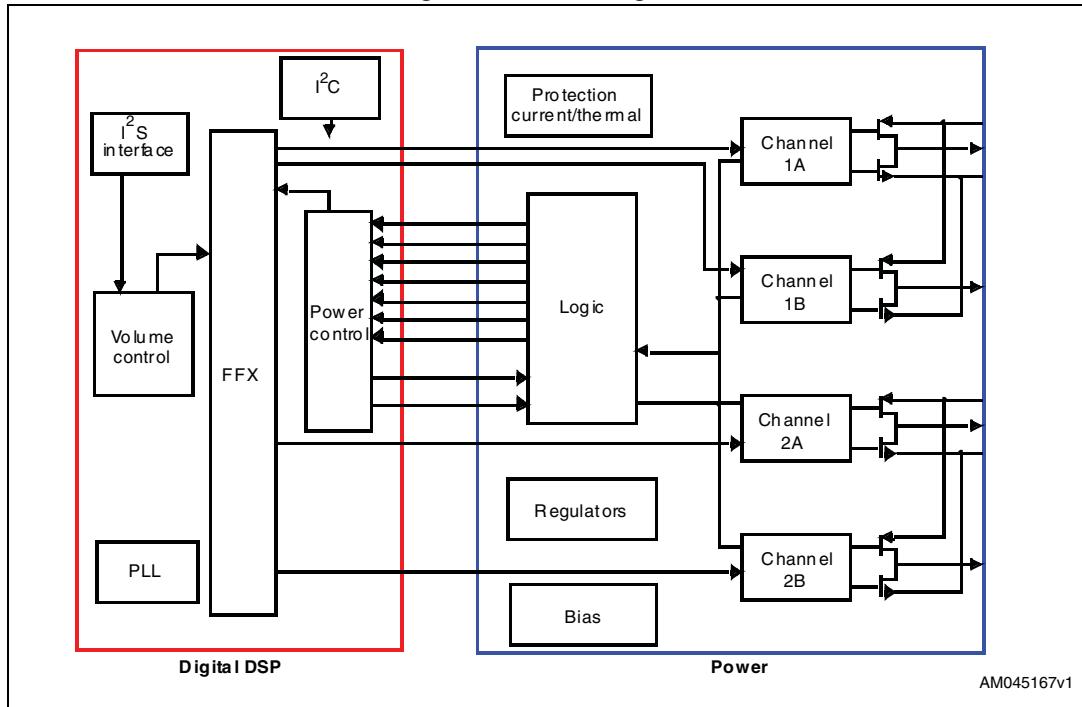
The STA369BW power section consists of four independent half-bridges. These can be configured via digital control to operate in different modes. 2.1 channels can be provided by two half-bridges and a single full-bridge, providing up to  $2 \times 15 \text{ W} + 1 \times 30 \text{ W}$  of music output power, by using standard 4 and 8  $\Omega$  speakers. Two channels can be provided by two full-bridges, providing up to  $2 \times 30 \text{ W}$ , by using standard 8  $\Omega$  speaker at 22 V. The IC can also be configured as 2.1 channels with  $2 \times 30 \text{ W}$  provided by the device and external power for FFX power drive. Please refer to the package thermal characteristics and application suggestions for more details.

Also provided in the STA369BW are a full assortment of digital processing features. This includes up to 8 programmable biquads (EQ) per channel. Special digital signal processing techniques are available in order to manage low-frequency quantization noise in case of very low frequency cutoff filter thresholds. The coefficient range  $-4..4$  allows the easy implementation of high shelf filters. Available presets allow the advantage of earlier time-to-market by substantially reducing the amount of software development needed for certain functions. This includes audio preset volume loudness, preset volume curves and preset EQ settings. There are also new advanced AM radio interference reduction modes. The dual-band DRC dynamically equalizes the system to provide speaker linear frequency response regardless of output power level. This feature independently processes the two bands, controlling dynamically the output power level in each band, thus providing better sound clarity.

The serial audio data input interface accepts all possible formats, including the popular I<sup>2</sup>S format. Three channels of FFX processing are provided. This high-quality conversion from PCM audio to FFX PWM switching waveform provides over 100 dB SNR and dynamic range.

# 1.1 Block diagram

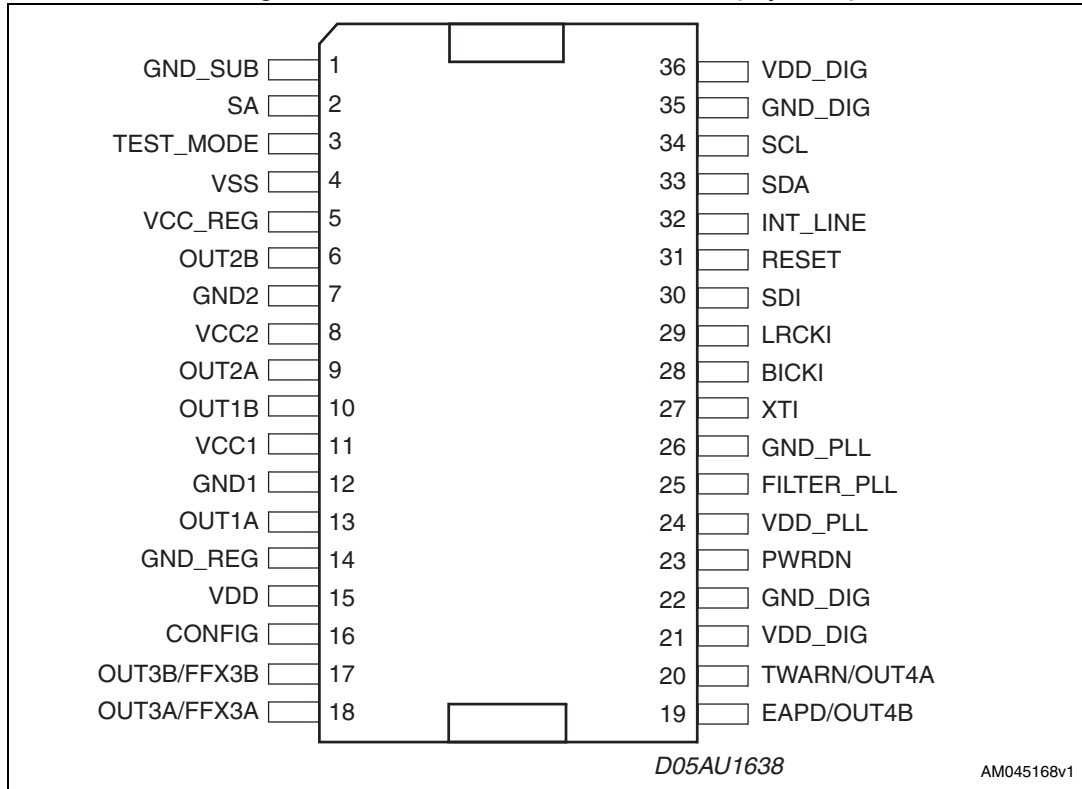
Figure 1. Block diagram



## 2 Pin connections

### 2.1 Connection diagram

Figure 2. Pin connection PowerSSO-36 (top view)



### 2.2 Pin description

Table 2. Pin description

Pin	Type	Name	Description
1	GND	GND_SUB	Substrate ground
2	I	SA	I <sup>2</sup> C select address (pull-down)
3	I	TEST_MODE	This pin must be connected to ground (pull-down)
4	I/O	VSS	Internal reference at Vcc-3.3 V
5	I/O	VCC_REG	Internal Vcc reference
6	O	OUT2B	Output half-bridge 2B
7	GND	GND2	Power negative supply
8	Power	VCC2	Power positive supply
9	O	OUT2A	Output half-bridge 2A
10	O	OUT1B	Output half-bridge 1B

Table 2. Pin description (continued)

Pin	Type	Name	Description
11	Power	VCC1	Power positive supply
12	GND	GND1	Power negative supply
13	O	OUT1A	Output half-bridge 1A
14	GND	GND_REG	Internal ground reference
15	Power	VDD	Internal 3.3 V reference voltage
16	I	CONFIG	Parallel mode command
17	O	OUT3B/FFX3B	PWM out CH3B / external bridge driver
18	O	OUT3A/FFX3A	PWM out CH3A / external bridge driver
19	O	EAPD/OUT4B	Power-down for external bridge / PWM out CH4B
20	I/O	TWARN/OUT4A	Thermal warning from external bridge (pull-up when input) / PWM out CH4A
21	Power	VDD_DIG	Digital supply voltage
22	GND	GND_DIG	Digital ground
23	I	PWRDN	Power down (pull-up)
24	Power	VDD_PLL	Positive supply for PLL
25	I	FILTER_PLL	Connection to PLL filter
26	GND	GND_PLL	Negative supply for PLL
27	I	XTI	PLL input clock
28	I	BICKI	I <sup>2</sup> S serial clock
29	I	LRCKI	I <sup>2</sup> S left/right clock
30	I	SDI	I <sup>2</sup> S serial data channels 1 and 2
31	I	RESET	Reset (pull-up)
32	O	INT_LINE	Fault interrupt
33	I/O	SDA	I <sup>2</sup> C serial data
34	I	SCL	I <sup>2</sup> C serial clock
35	GND	GND_DIG	Digital ground
36	Power	VDD_DIG	Digital supply voltage

## 3 Electrical specifications

### 3.1 Absolute maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Min	Typ	Max	Unit
V <sub>CC</sub>	Power supply voltage (VCCxA, VCCxB)	-0.3		30	V
VDD_DIG	Digital supply voltage	-0.3		4	V
VDD_PLL	PLL supply voltage	-0.3		4	
T <sub>op</sub>	Operating junction temperature	-20		150	°C
T <sub>stg</sub>	Storage temperature	-40		150	°C

**Warning:** Stresses beyond those listed in [Table 3](#) above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended operating conditions” are not implied. Exposure to AMR conditions for extended periods may affect device reliability. In the real application, power supplies with nominal values rated within the recommended operating conditions, may rise beyond the maximum operating conditions for a short time when no or very low current is sunk (amplifier in mute state). In this case the reliability of the device is guaranteed, provided that the absolute maximum ratings are not exceeded.

### 3.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Min	Typ	Max	Unit
R <sub>th j-case</sub>	Thermal resistance junction-case (thermal pad)			1.5	°C/W
T <sub>th-sdj</sub>	Thermal shutdown junction temperature		150		°C
T <sub>th-w</sub>	Thermal warning temperature		130		°C
T <sub>th-sdh</sub>	Thermal shutdown hysteresis		20		°C
R <sub>th j-amb</sub>	Thermal resistance junction-ambient <sup>(1)</sup>				

1. See [Section 10: Package thermal characteristics on page 85](#) for details.

### 3.3 Recommended operating conditions

Table 5. Recommended operating conditions

Symbol	Parameter	Min	Typ	Max	Unit
$V_{cc}$	Power supply voltage (VCCxA, VCCxB)	5		26	V
VDD_DIG	Digital supply voltage	2.7	3.3	3.6	V
VDD_PLL	PLL supply voltage	2.7	3.3	3.6	V
$T_{amb}$	Ambient temperature	-20		+85	°C

### 3.4 Electrical specifications for the digital section

Table 6. Electrical specifications - digital section

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{il}$	Low-level input current without pull-up/down device	$V_i = 0$ V		1	5	$\mu$ A
$I_{ih}$	High-level input current without pull-up/down device	$V_i = VDD\_DIG = 3.6$ V		1	5	$\mu$ A
$V_{il}$	Low-level input voltage				0.2 * VDD_DIG	V
$V_{ih}$	High-level input voltage		0.8 * VDD_DIG			V
$V_{ol}$	Low-level output voltage	$I_{ol} = 2$ mA			0.4 * VDD_DIG	V
$V_{oh}$	High-level output voltage	$I_{oh} = 2$ mA	0.8 * VDD_DIG			V
$I_{pu}$	Pull-up/down current		25	66	125	$\mu$ A
$R_{pu}$	Equivalent pull-up/down resistance			50		k $\Omega$



### 3.5 Electrical specifications for the power section

The specifications given in this section are valid for the operating conditions:  $V_{CC} = 22\text{ V}$ ,  $f = 1\text{ kHz}$ ,  $f_{sw} = 384\text{ kHz}$ ,  $T_{amb} = 25^\circ\text{ C}$  and  $R_L = 8\ \Omega$ , unless otherwise specified.

**Table 7. Electrical specifications - power section**

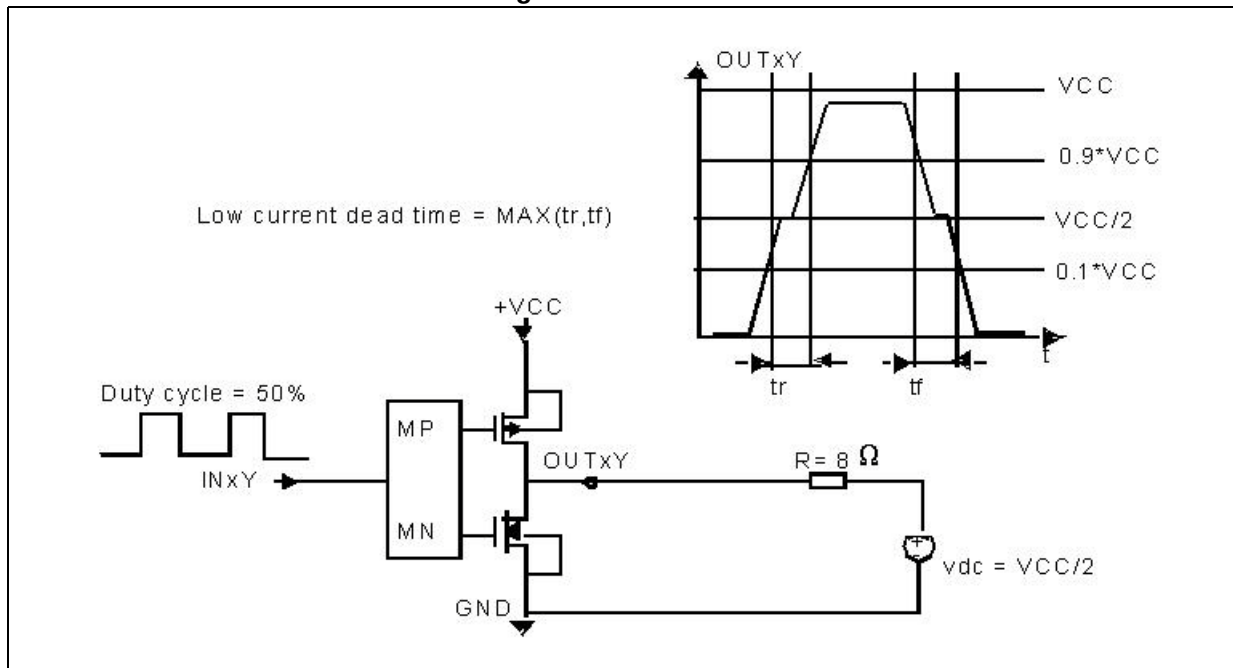
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Po	Continuous output power, BTL, ternary mode	THD = 1%		20		W
		THD = 10%		30		
	Continuous output power SE, binary mode, $R_L = 4\ \Omega$	THD = 1%		12		W
		THD = 10%		15		
R <sub>dsON</sub>	Power Pchannel/Nchannel MOSFET (total bridge)	$I_d = 1.5\text{ A}$		180	250	m $\Omega$
I <sub>dss</sub>	Power Pchannel/Nchannel leakage	$V_{CC} = 20\text{ V}$			10	$\mu\text{A}$
I <sub>LDT</sub>	Low current dead time (static)	Resistive load <sup>(1)</sup>		8	15	ns
I <sub>HDT</sub>	High current dead time (dynamic)	I load <sup>(1)</sup> = 1.5 A		15	30	ns
t <sub>r</sub>	Rise time	Resistive load <sup>(1)</sup>		10	18	ns
t <sub>f</sub>	Fall time	Resistive load <sup>(1)</sup>		10	18	ns
V <sub>cc</sub>	Supply voltage operating voltage		5		26	V
I <sub>vcc</sub>	Supply current from Vcc in power-down	PWRDN = 0		1		$\mu\text{A}$
	Supply current from Vcc in operation	PCM input signal = -60 dBfs, Switching frequency = 384 kHz, No LC filters		52	60	mA
I <sub>vdd</sub>	Supply current FFX processing (reference only)	Internal clock = 49.152 MHz		55	70	mA
I <sub>lim</sub>	Overcurrent limit	<sup>(2)</sup>	2.6	2.8		A
I <sub>sc</sub>	Short-circuit protection	Hi-Z output	3.1	3.3		A
UVL	Undervoltage protection				4.3	V
OVP	Overvoltage protection			29		V
t <sub>min</sub>	Output minimum pulse width	No load		100		ns
DR	Dynamic range			100		dB
SNR	Signal-to-noise ratio, ternary mode	A-Weighted		100		dB
	Signal-to-noise ratio binary mode			90		dB
THD+N	Total harmonic distortion + noise	FFX stereo mode, Po = 1 W f = 1 kHz		0.09		%

Table 7. Electrical specifications - power section (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$X_{TALK}$	Crosstalk	FFX stereo mode, <5 kHz One channel driven at 1 W Other channel measured		80		dB
PSRR	Power Supply Rejection Ratio	FFX stereo mode, <5 kHz VRipple01V RMS Audio input = dither only		80		dB
$\eta$	Peak efficiency, FFX mode	$P_o = 2 \times 25 \text{ W}$ into $8 \Omega$		90		%
	Peak efficiency, binary modes	$P_o = 2 \times 10\text{W}$ into $4\Omega$ + $1 \times 20\text{W}$ into $8 \Omega$		86		

1. Refer to [Figure 3: Test circuit](#).
2. Limit current if the register (OCRB [Section 8.3.3](#)) overcurrent warning detect adjustment bypass is enabled. When disabled refer to the  $I_{sc}$ .

Figure 3. Test circuit

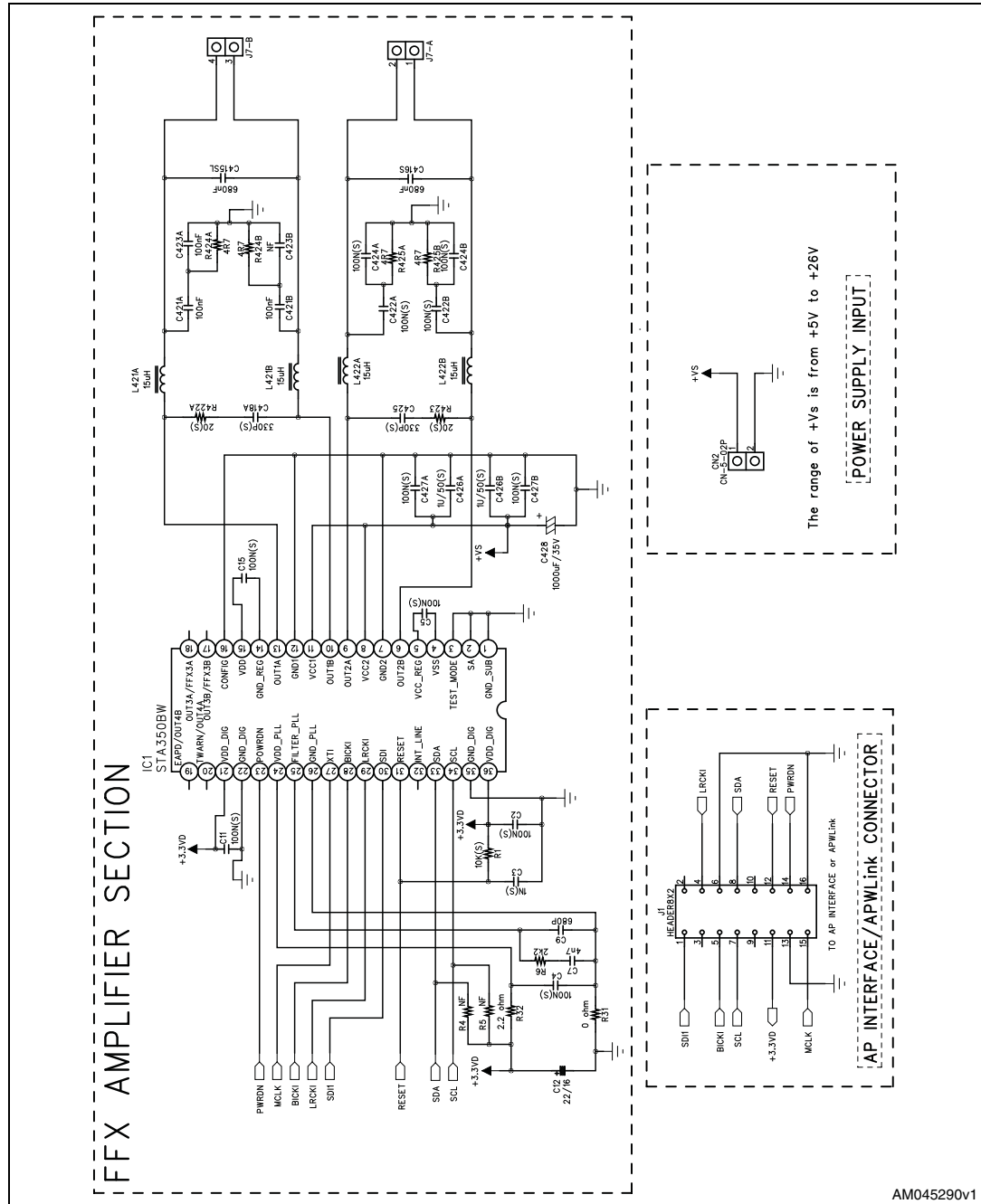


# 4 Characterization curves

The following characterization curves were made using the STA369BW demonstration board with 2.0 channels (refer to the schematic in [Figure 6](#)) under the following test conditions:

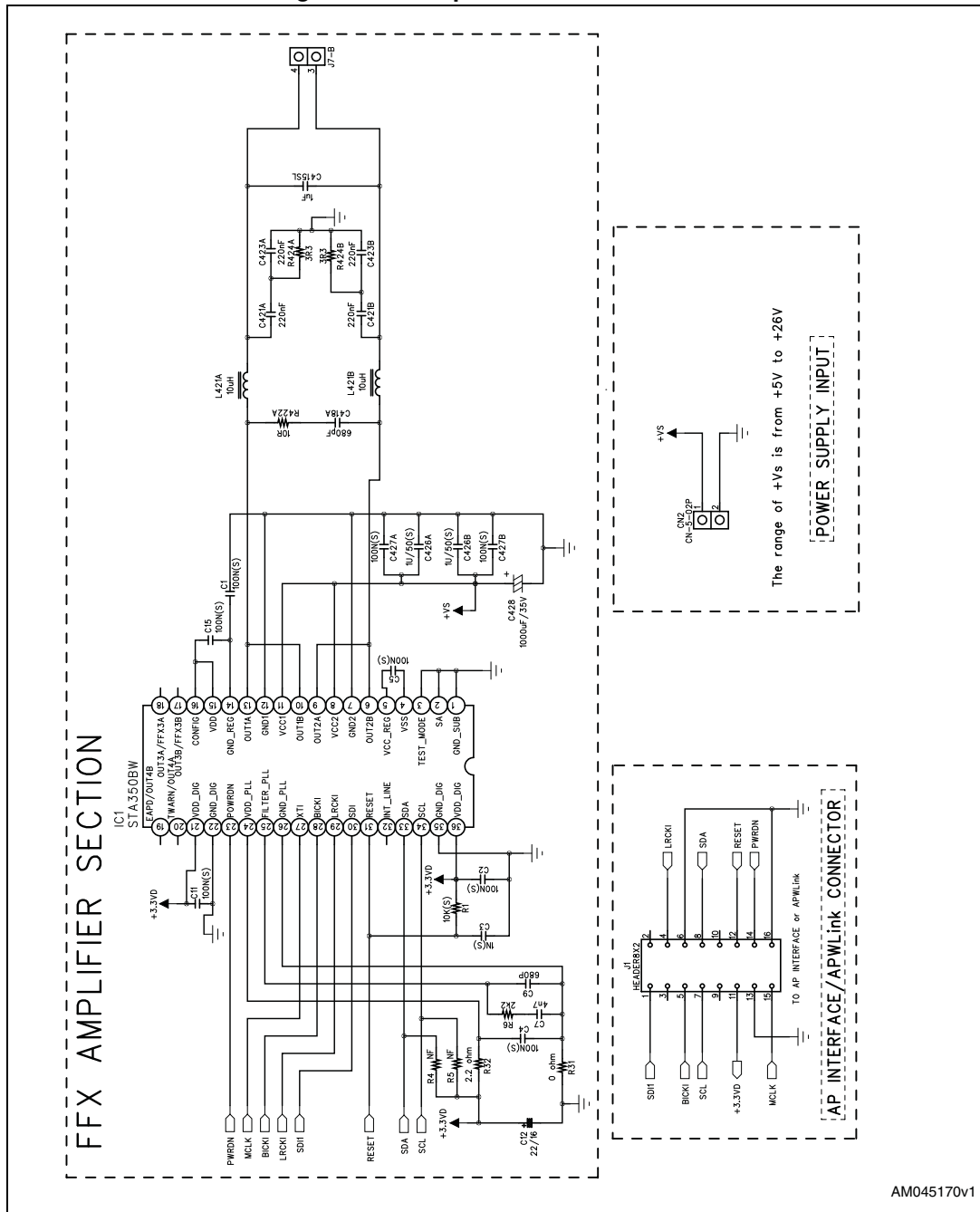
$V_{CC} = 22\text{ V}$ ,  $f = 1\text{ kHz}$ ,  $f_{SW} = 384\text{ kHz}$ ,  $T_{amb} = 25\text{ °C}$  and  $R_L = 8\text{ }\Omega$ , unless otherwise specified.

Figure 4. Demonstration board, 2.0 channels



AM045290v1

Figure 5. Mono parallel BTL schematic



AM045170v1

Figure 6. THD+N vs. output power ( $V_{CC} = 25\text{ V}$ , load =  $6\ \Omega$ )

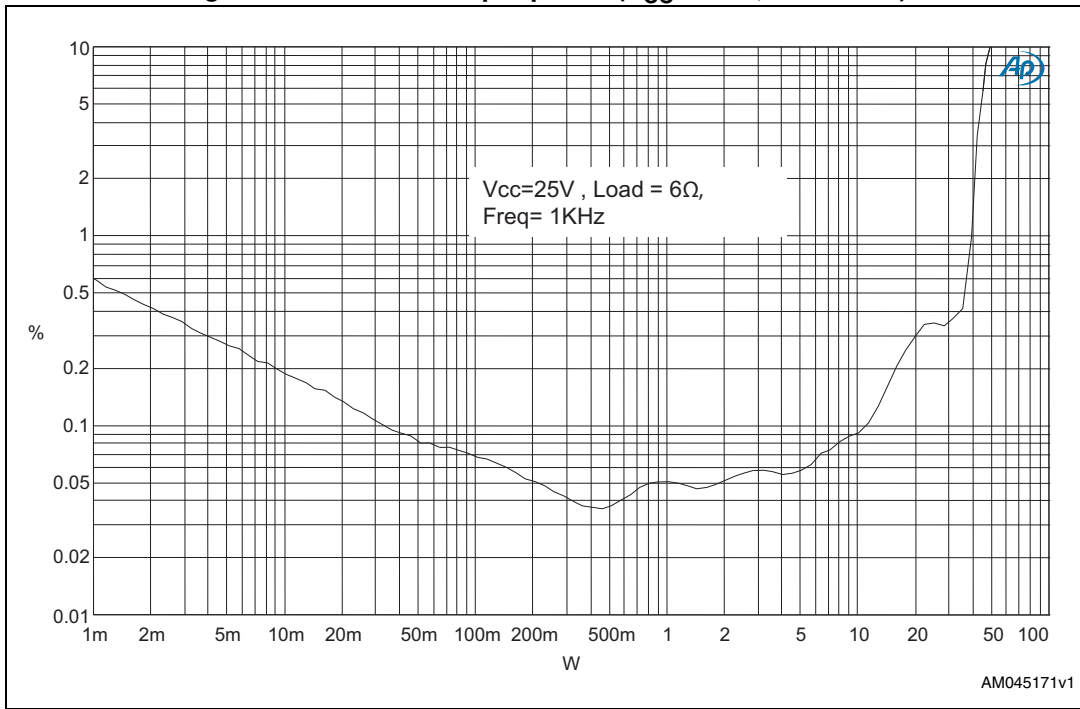


Figure 7. THD+N vs. output power ( $V_{CC} = 18\text{ V}$ , load =  $8\ \Omega$ )

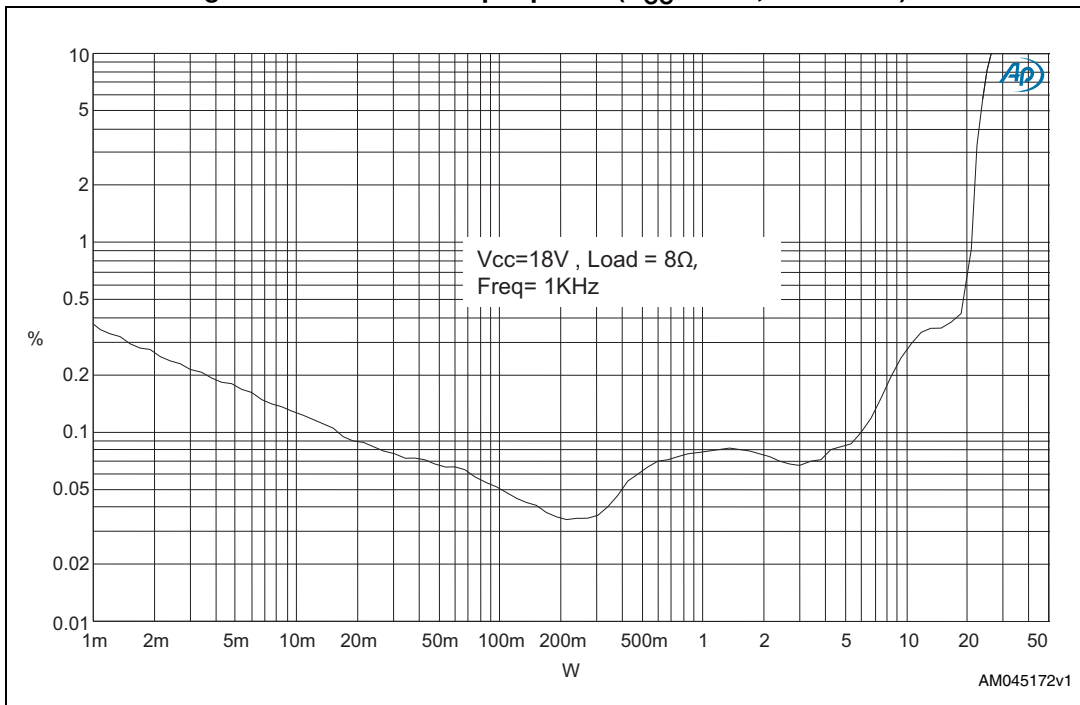


Figure 8. Output power vs.  $V_{CC}$  (load = 6  $\Omega$ )

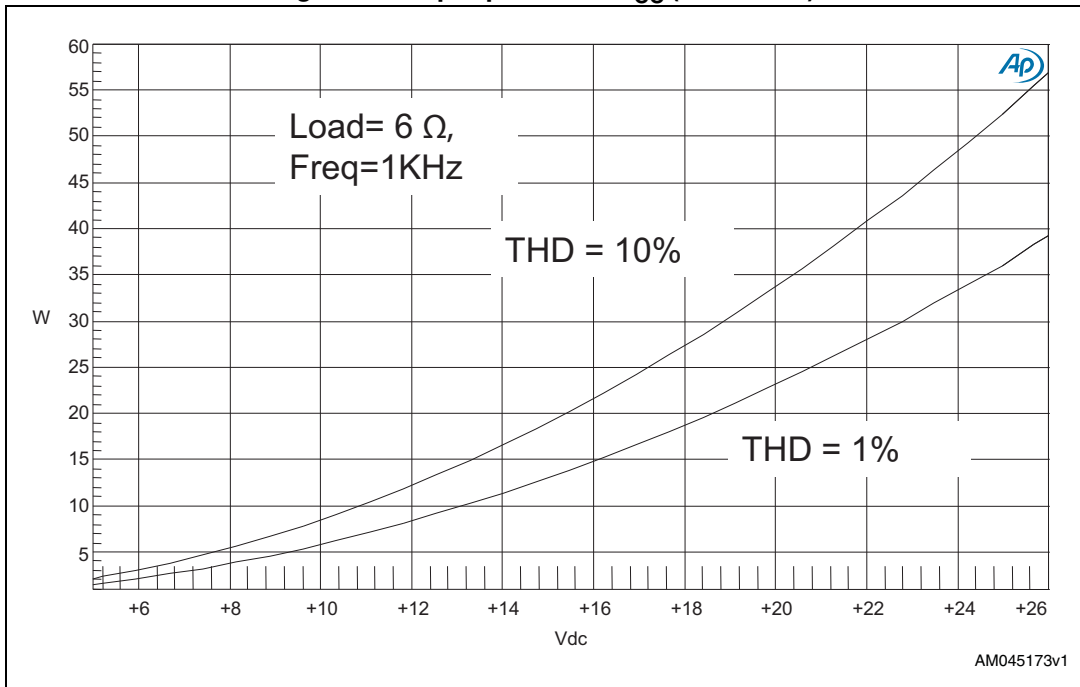


Figure 9. Output power vs.  $V_{CC}$  (load = 8  $\Omega$ )

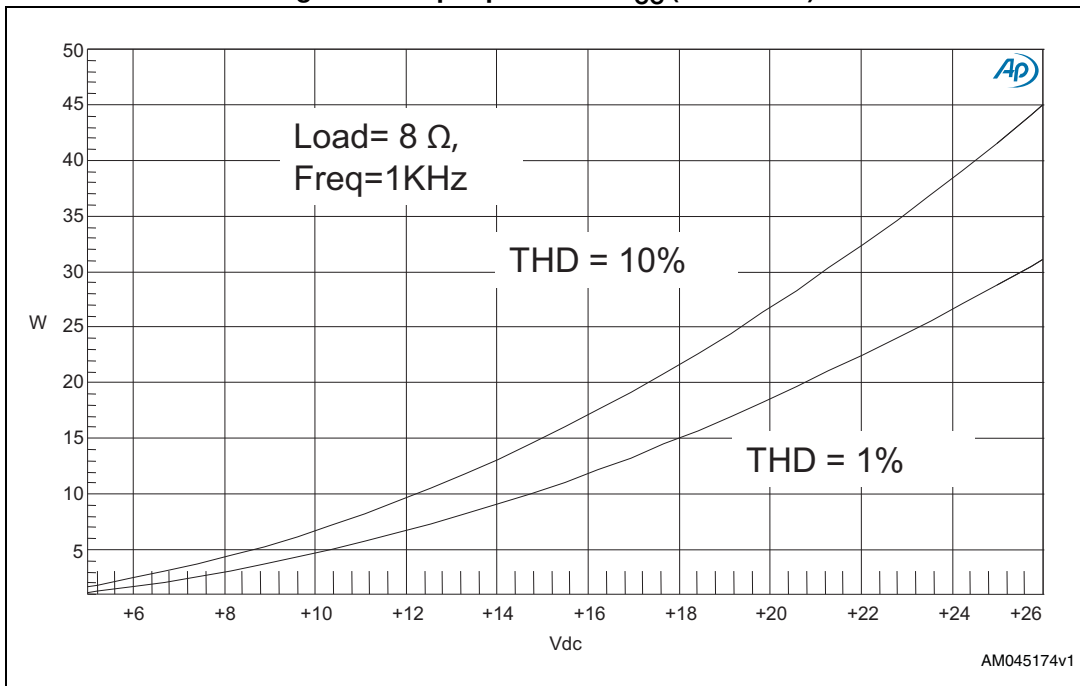


Figure 10. Efficiency vs. output power ( $V_{CC} = 25\text{ V}$ , load =  $6\ \Omega$ )

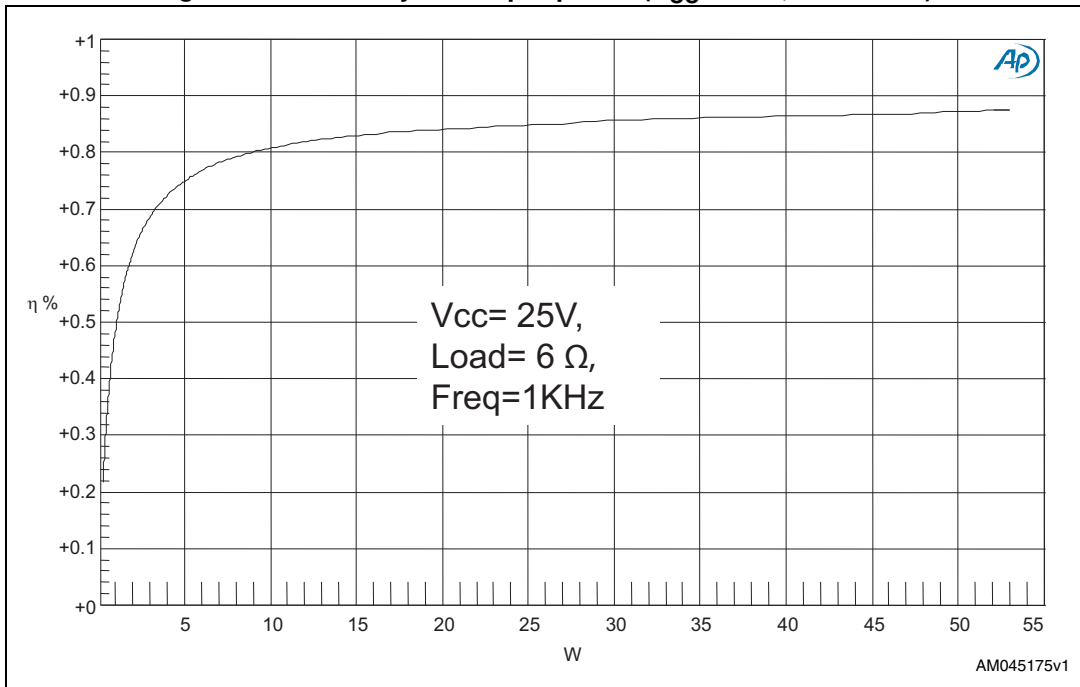
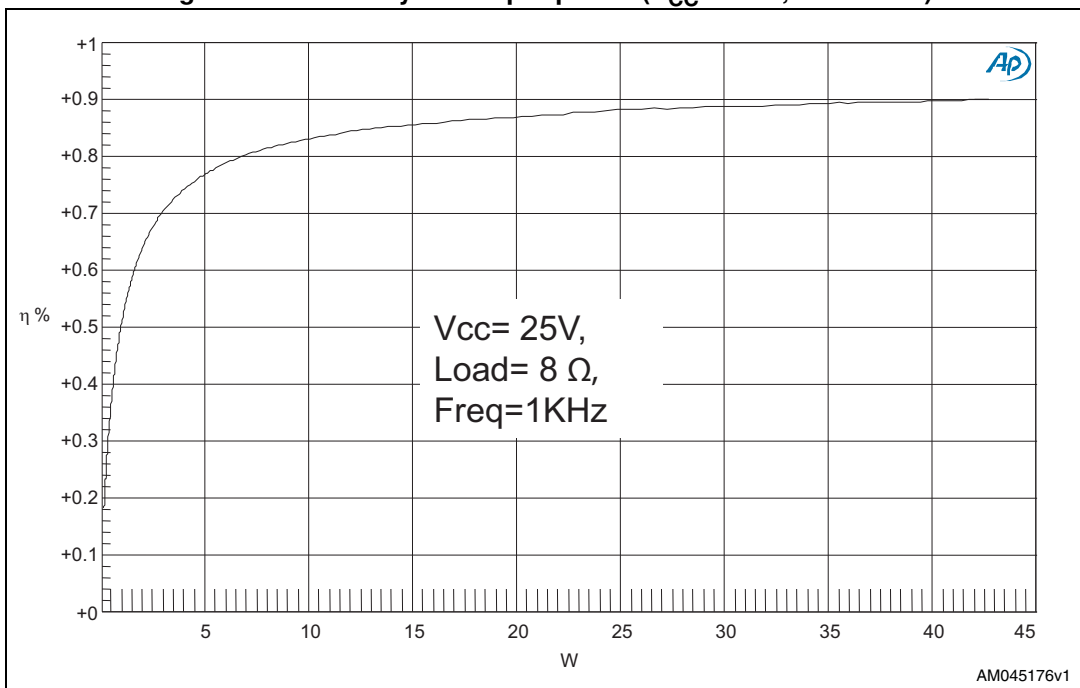


Figure 11. Efficiency vs. output power ( $V_{CC} = 25\text{ V}$ , load =  $8\ \Omega$ )



### 4.1 Mono parallel BTL characteristics

Figure 12. THD+N vs. output power ( $V_{CC} = 25\text{ V}$ , load =  $3\ \Omega$ )

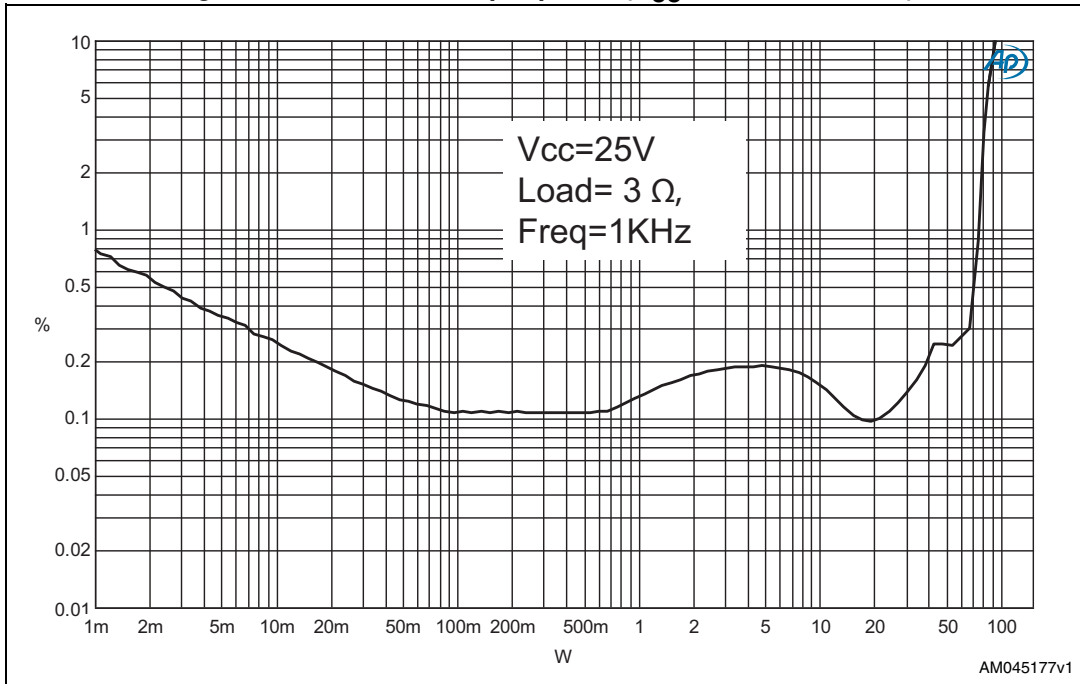


Figure 13. Output power vs.  $V_{CC}$  (load =  $3\ \Omega$ )

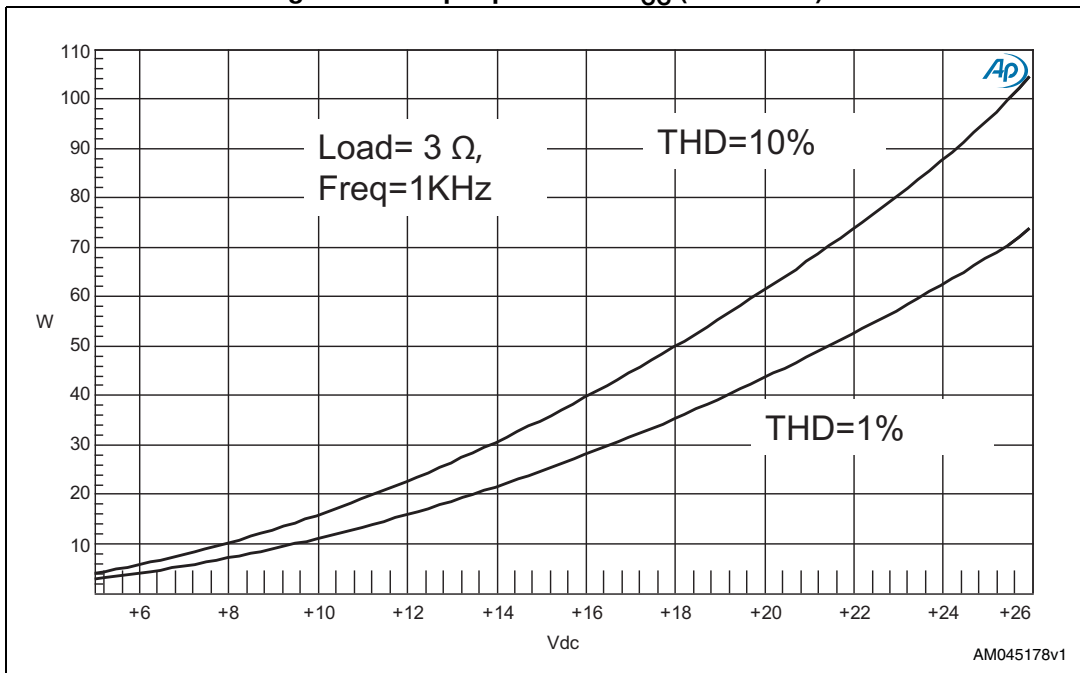




Figure 14. Efficiency vs. output power ( $V_{CC} = 26\text{ V}$ , load =  $3\ \Omega$ )

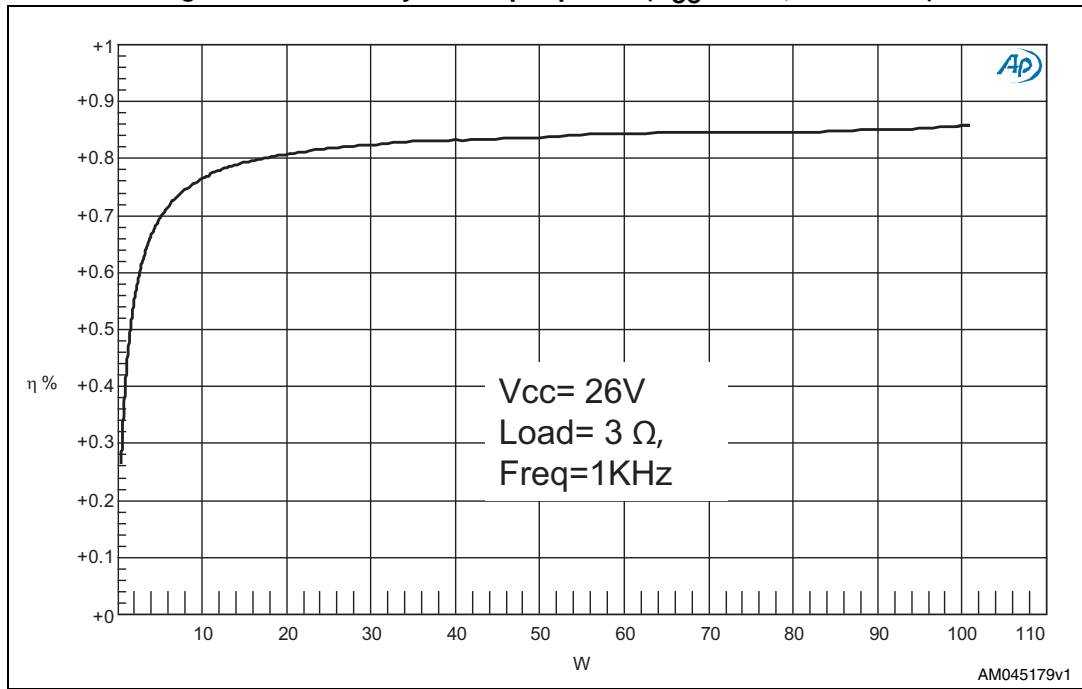
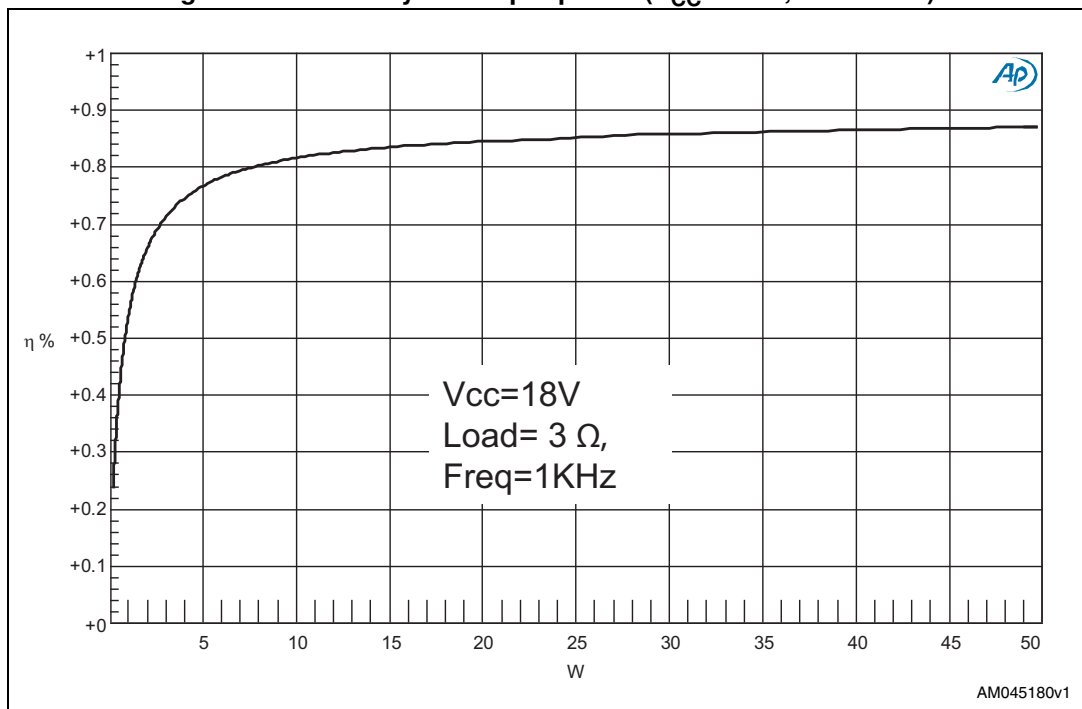


Figure 15. Efficiency vs. output power ( $V_{CC} = 18\text{ V}$ , load =  $3\ \Omega$ )



## 5 Serial audio interface

The STA369BW audio serial input interface was designed to interface with standard digital audio components and to accept a number of serial data formats. The STA369BW always acts as the slave when receiving audio input from standard digital audio components. Serial data for two channels is provided using three inputs: left/right clock LRCKI, serial clock BICKI, and serial data SDI12.

The SAI bit and the SAIFB bit are used to specify the serial data format. The default serial data format is I<sup>2</sup>S, MSB-first.

### 5.0.1 Timings

In the STA369BW the BICKI and LRCKI pins are configured as inputs and they must be supplied by the external peripheral.

Figure 16. Timing diagram for SAI interface

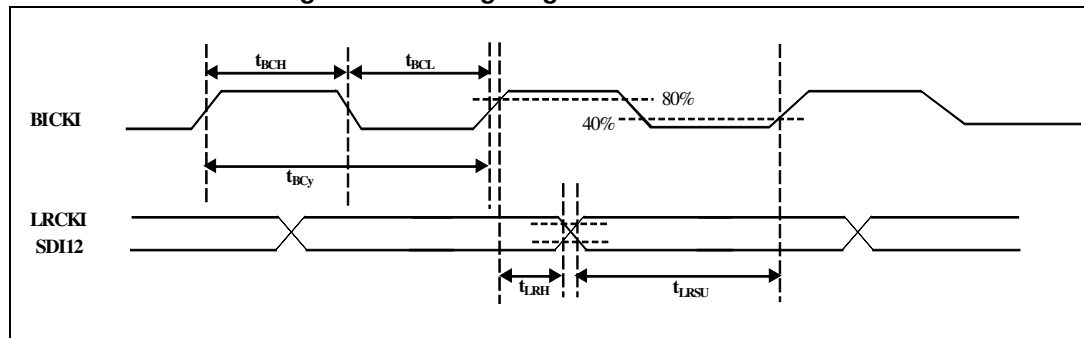


Table 8. Timing parameters for slave mode

Symbol	Parameter	Min	Typ	Max	Unit
t <sub>BCy</sub>	BICK cycle time	80	-	-	ns
t <sub>BCH</sub>	BICK pulse width high	40	-	-	ns
t <sub>BCL</sub>	BICK pulse width low	40	-	-	ns
t <sub>LRSU</sub>	LRCKI setup time to BICKI strobing edge	40	-	-	ns
t <sub>LRH</sub>	LRCKI hold time to BICKI strobing edge	40	-	-	ns
t <sub>LRJT</sub>	LRCKI Jitter Tolerance			40	ns

### 5.0.2 Delay serial clock enable

To tolerate anomalies in some I<sup>2</sup>S master devices, a PLL clock cycle delay can be added to the BICKI signal before the SAI interface.

### 5.0.3 Channel input mapping

Each channel received via I<sup>2</sup>S can be mapped to any internal processing channel via the channel input mapping registers. This allows for flexibility in processing. The default settings of these registers map each I<sup>2</sup>S input channel to its corresponding processing channel.