

# DIGITAL TRILEVEL DT4800/6800

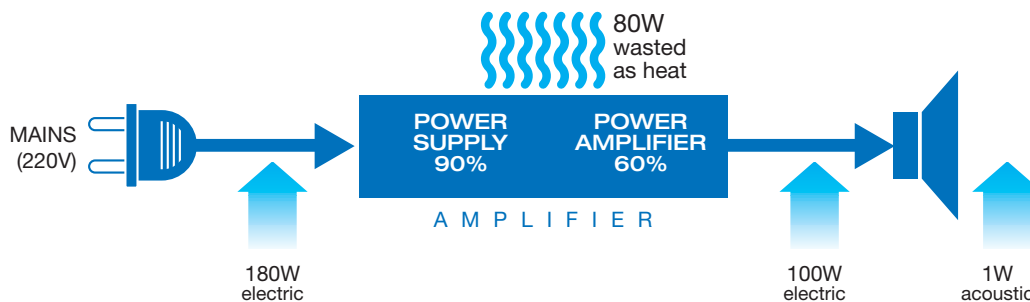
## “All the power all the time”

### WHY LIGHTWEIGHT AMPLIFIERS?

#### Blame it on the loudspeakers

The loudspeaker is a component with very low efficiency, it barely reaches 1%. Since its invention in the twenties, its basic technology has remained practically unchanged. The power amplifier is responsible of amplifying the audio signal to sufficiently high voltages to move the loudspeaker voice coil and thus produce the desired acoustic sound pressure.

Following model shows the power distribution in a typical audio system:



In order to obtain 1 acoustic Watt, one needs an amplifier delivering 100 electric Watt at its output. In a conventional amplifier, these 100 electric Watt are obtained out of 180 W. The system wastes 80W alone in heat dissipation, which represents 45%.

The efficiency shortcomings of loudspeakers are evidenced by these figures. Additionally, the high output power the amplifier has to deliver to deal with the loudspeaker limitation together with its reduced efficiency will mean considerable heat dissipation losses. Bulky heat sinks and oversized power supplies become strictly necessary if satisfactory operation is desired.

Technological difficulties and the associated high costs that come together when trying to increase the efficiency of traditional loudspeakers have motivated that technological evolution has been focused on power amp design. "Put the blame on the loudspeakers"

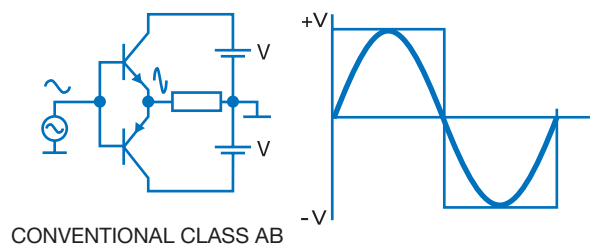
#### More and more Watt... Where is the limit?

In the mid eighties, a 500W amplifier (per channel, on 4 Ohm) was considered a very powerful amplifier. Today, this honour goes to a 2000 Watt model. The reasons for this power escalation are beyond the scope of this document, so let's assume it's simply a fact that nobody can predict where the power limit really is. Some manufacturers even advertise 4000W devices. The fact that the main purchase factor is the cost per Watt, together with the fact that output power ratings depend on numerous factors which are difficultly measurable even by professional users has lead to great confusion and speculation about these ratings. The consequence is an authentic "power race". Nevertheless, the market demand for more and more Watt is a reality that forces manufacturers to increase the efficiency of power amplifiers, which were becoming more and more heavy with traditional technologies that wasted significant amounts of energy as heat.

### DIFFERENT SOLUTIONS: ADVANTAGES AND DRAWBACKS

#### Class AB

This is the traditional amplifying technology. Durable, tested, reliable but heavy. It's efficiency can reach 60%. ECLER's SPM TECHNOLOGY has an efficiency of 75%.



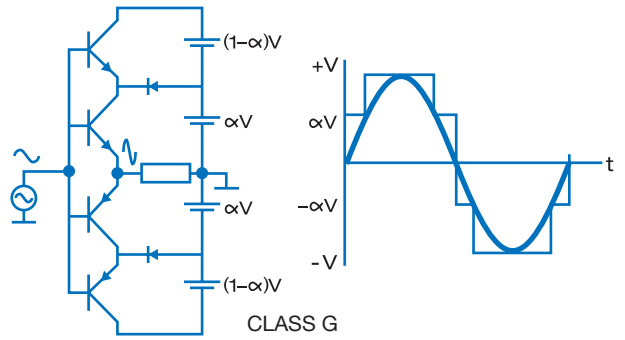
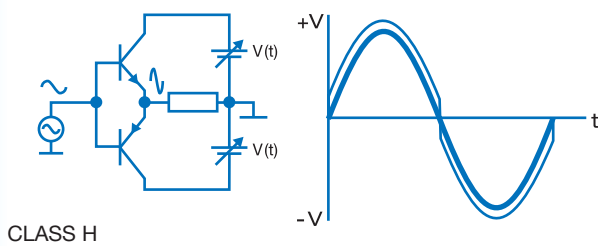
CONVENTIONAL CLASS AB

## Class G and H

This configuration increases efficiency from 60% to 75% for class G and up to 85% for class H.

However, the weight reduction is not too spectacular, as it rates at about 30%.

In class AB amplifiers, the power supply must constantly deliver the full power range, from  $-V$  to  $+V$ . The amplified audio signal will travel between these values. In class G and class H amplifiers, the supply voltage "follows" the audio signal. Class G does that in discreet steps, while Class H adjusts supply voltage linearly and extensively.



## Class D

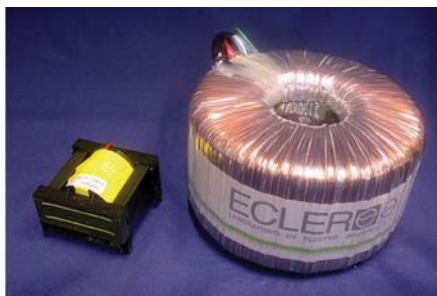
Efficiency rises spectacularly, it can be higher than 90%. Weight can be reduced around 30%. The heat sink can be 6 times smaller than on a conventional amp with similar output power. Theoretically, the digital solution is thus the best, but on the other hand digital amplifier technology is quite complex, its reliability is under question and its audio qualities have many disbelievers. These are important reasons that have delayed until today the logical path to follow.

## SWITCH-MODE POWER SUPPLIES MEET PROFESSIONAL AUDIO

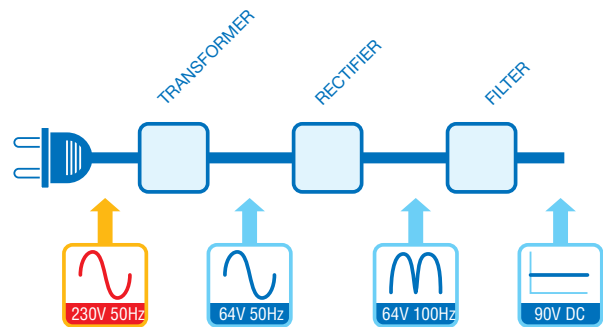
Switch-mode power supplies are very common in our daily life and have become an imperative solution when it comes to reduce weight. Therefore, when combined with any of the amplifier classes described earlier, important weight reduction can be achieved, which range from the most extended solution: switch-mode power supply + Class AB (50% weight reduction) to switch-mode power supply + Class D, which additionally reduces weight another 30%.

A conventional high power amplifier with conventional power supply weighting 30kg will slim down to 15 kg by using a switch-mode power supply and finally weight only 10 kg if class D is employed (30% reduction).

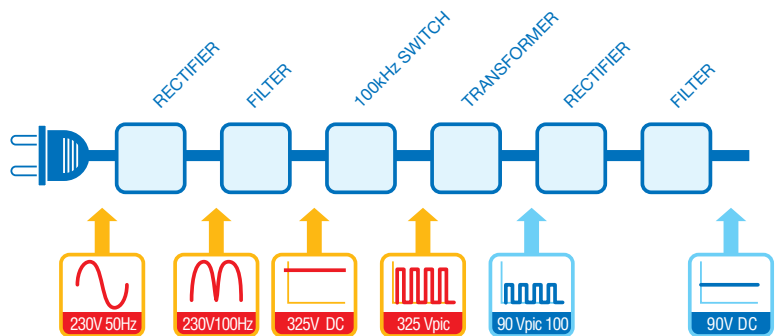
Switch-mode power supplies base their operation on high frequency: "The high frequency miracle".



The small transformer operating at 90kHz is able to provide twice the power (3000 W) as the big one operating at 50 Hz.



STANDARD POWER SUPPLY



SWITCHING POWER SUPPLY

Comparison of block diagrams between a conventional power supply and a switch-mode power supply

## ECLERs SOLUTION: TRILEVEL TECHNOLOGY DIGITAL AMPLIFIERS

300+300W PWM Prototype (1987)



In 1987, ECLERs engineers built their first prototype of a 300 + 300 WRMS digital PWM amplifier. This research branch was then abandoned due to the non-existence of electronic components which could stand tall to the requirements of this approach. Research later focused on the SPM TECHNOLOGY project (Award for technological innovation in 1997 by Catalonian regional government) and whose first commercial incarnation as an amplifier saw light in 1989. The limited availability of sufficiently reliable components and their high costs due to their exclusivity were the main handicaps during the early stages of digital amplifier design.

Nevertheless, the PWM87 project made clear two things: The technical viability and the downsides of this promising development path, reliability and audio quality. In 1999, ECLERs R&D Department restarts the project in a greatly more favourable environment thanks to technological advancements in the area of electronic components during the last decade.

The goal: To neutralize and even convert the two main drawbacks of digital amplification technology into advantages, effectively creating a very lightweight but extremely powerful amp that sound like an analogue counterpart and even is more reliable than any conventional power amp.

The PWM87 project has finally crystallized into the DIGITAL TRILEVEL technology which stands for a very lightweight digital amplifier concept. ECLERs lightweight amplifiers employ a regulated switch-mode power supply with PFC (Power Factor Correction) together with two TRILEVEL technology digital amplifiers. ECLERs R&D engineers have developed innovative solutions in both devices obtaining as a result a lightweight amplifier that sounds like an analogue equivalent and is capable of delivering all its output power all the time. This last aspect in particular represents an important step taken by ECLER for the consolidation of this technology.

DT6800: The first 2 x 3300WRMS /2 Ohm digital amplifier with "all the power all the time" operation that sounds like an analogue amp.

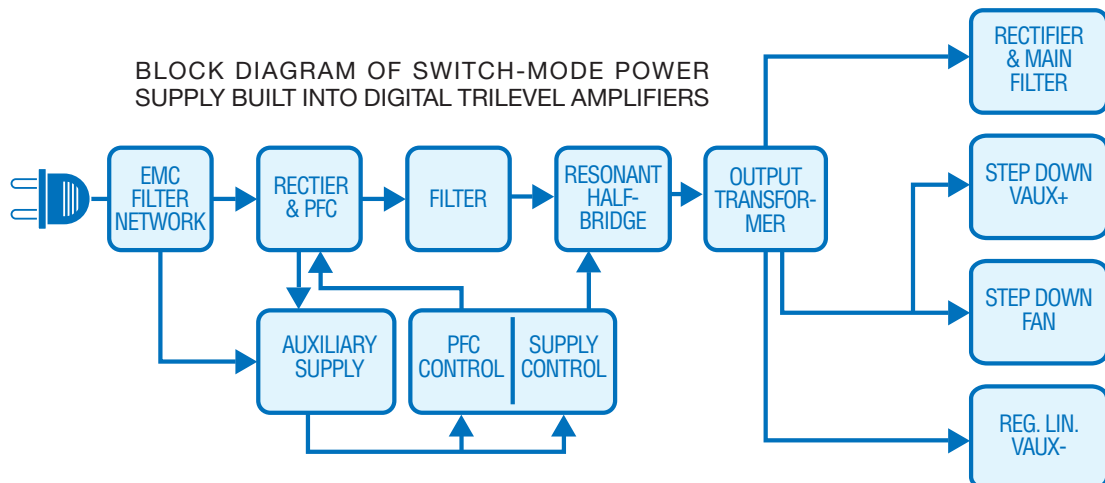


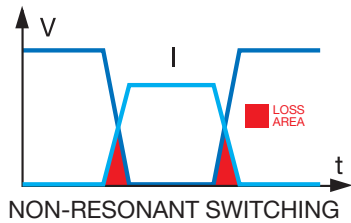
### THE POWER SUPPLY INSIDE THE DIGITAL TRILEVELS: THE DT'S ENGINE IS A QUITE SPECIAL SWITCH-MODE POWER SUPPLY

The mission of a power supply is to adapt alternate current taken from mains supply to the adequate direct current voltages needed in each amplifier. Furthermore should it physically isolate the device from mains supply to avoid electrical shocks on touching the unit, according to safety regulations.

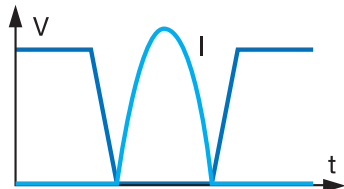
Even the best amplifier can miserably fail if the power supply can't stand up to its requirements.

The switch-mode power supply built into the DT amplifiers has a resonant structure, is stabilized and features PFC: "a real competition engine"

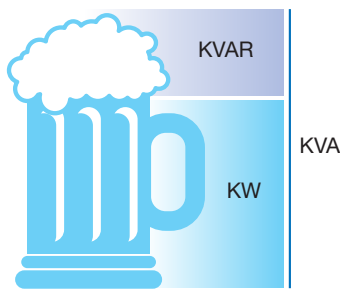
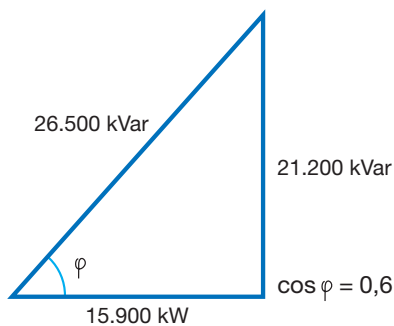




NON-RESONANT SWITCHING



RESONANT SWITCHING



## RESONANT STRUCTURE

A resonant type electronic structure minimizes energy losses. Its efficiency is clearly very high, over 90%.

Its high efficiency involves reduced weight and volume. The transformer size can be reduced as operating frequency can be increased if the power device switches during periods when current equals zero.

Heat sinks can be smaller too, as heat dissipation losses are reduced to a bare minimum.

The resonant electronic structure reduces EMI, Electromagnetic interference.

Finally, thanks to this circuit, reliability is increased for two reasons: The series LC structure - protecting against short circuits - and less stress on the switching power device.

## STABILIZED

The power supply delivers constant voltage for the digital amplification modules across a wide range of mains supply variations from 180 to 265 VAC. As a consequence of this feature, output power becomes independent from mains supply voltage.

## BUILT-IN PFC (POWER FACTOR CORRECTION)

The PF (Power factor) is an indication of how well a certain circuit makes use of electrical energy taken from the electrical network. It's the quotient of the useful power consumption (measured in W) divided by the total power consumption (measured in VA).

Mathematically, it's the cosine of the phase angle between the applied voltage and the current drawn by a circuit. (PF = cos φ).

Consider a system formed by 10 power amps (with a maximum power consumption of 2650 for each amp) which have a PF=0,6. In order to obtain 15.900 W of useful power, the system must draw 26.500 VA electric energy from mains, as:

$$PF = \frac{W}{VA} = \frac{15.900}{26.500} = 0,6$$

This concept can be understood by using a "technical metaphor" consisting of a beer glass where beer is the useful power you drink and the foam is the reactive (or returned) power. The real consumption you pay for is the sum of both, but in the end, the "useful" beer is only the liquid and not the foam.

Many electronic devices don't make good use of electric energy because their PF is far from unity. The problem gets worse if power consumption is large. To avoid waste of energy, a so-called PFC circuit is included inside the Digital Trilevels, which forces the device to get energy with a PF near 1. In practice, the user may connect more amplifier units to the same power line or power generator, hire a smaller power generator or even significantly reduce electric consumption costs in fixed installations.

But there are still more advantages of PFC inside a power amplifier: The mains waveform is sinusoidal at a frequency of 50 Hz and 230VRMS. The current consumption of a device connected to mains supply should ideally be sinusoidal, too. However, many devices don't show that type of consumption, but rather as short peaks, specially those devices that rectify AC and filter that signal with high capacity electrolytics. These current peaks introduce interference in mains voltage. A PFC corrects the current consumption of a device so it is sinusoidal.

Regulations (not valid yet for pro audio) impose the use of PFC in high-consumption devices.

## HIGH EFFICIENCY STRUCTURE

While the efficiency of stabilized linear power supplies, whose main characteristics are excellent regulation and heavy weight, merely reaches 50%, the efficiency of the switch-mode power supply built into the Digital Trilevels rises up to 92%.

## HIGH RELIABILITY

The tough world of live touring needs extremely robust and reliable products. Ask your service technician about all that can be found inside a power amp after thousands of miles of touring. Here at ECLER we perfectly know about all kinds of things found inside amps and therefore the DT's power supplies are shortable. Today, few amplifiers feature shortable power supplies.

## REAL POWER, NOT PEAK VALUES

If sound quality is a key factor and additionally all the output power is required all the time, the "engine" should be well prepared for such a task. The switch-mode power supply inside the DT's is engineered so that the maximum power is available on every moment continuously, and not only during short periods of time.

## ECLER'S DIGITAL AMPLIFIER: DIGITAL TRILEVEL TECHNOLOGY

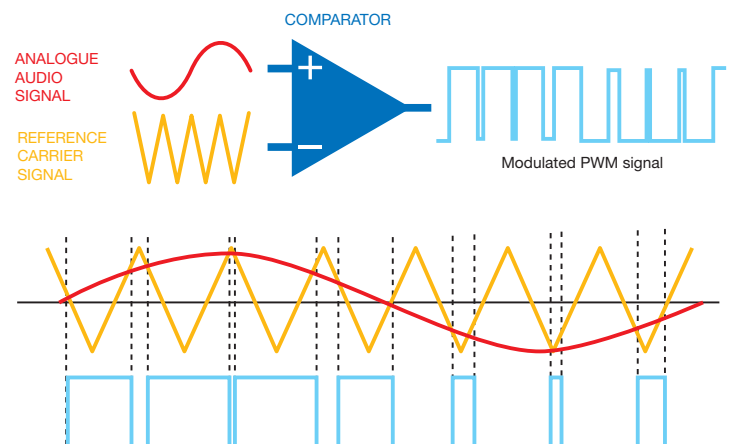
### PWM MODULATION

Many methods exist for encoding an analogue signal to pulses. One of the most commonly used is known as PWM (Pulse Width Modulation), where the amplitude of the audio signal is represented by the pulse duration of a constant frequency digital signal.

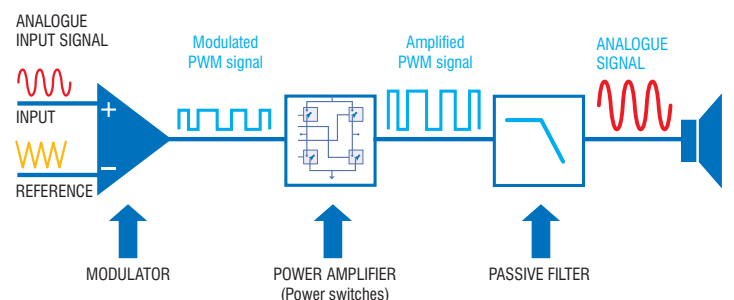
The electronic circuit that performs this modulation consists of a simple comparator, as shown on following diagram. Here you can observe the carrier signal, which is a constant amplitude triangular waveform at several times higher frequency than the highest input signal frequency.

To obtain the amplified signal at the output, one simply has to increase the amplitude of the modulated PWM pulses with a pair of power switches (MOSFETs). These are controlled by the same low voltage PWM signal and are configured so that energy from the power supply is directly passed to the input of the filter. This last device reconstructs the suitably amplified analogue signal. The power losses in the devices that perform amplification are very small as ideally, when switched on, no heat dissipation occurs thanks to their internal resistance around milliohms. ( $W = V \times I = 0$ ).

Conversely, when switched off, resistance is several megaohms large.



### PWM AMPLIFIER



## AMPLIFIER WITH BD-TYPE TRILEVEL MODULATOR

The digital amplifier class described above is known as AD and is characterized by:

On absence of signal at the input, the pulse duration equals exactly half square wave period. The term AD has been coined precisely by this fact, as D stands for a digital type system and A means that during absence of audio signal, modulating signal still exists, the same behaviour as on analogue class A amplifiers. Signal at the input of the filter takes two levels: high level "1", corresponding to the positive supply rail and low level "0", corresponding to the negative supply rail.

Class BD is instead characterized by:

On absence of signal at the input, no output pulses appear at all. The acronym BD is coined by direct similarity with analogue class B amplifiers. The PWM waveform at the amplifier's output can have three levels:

- If no audio signal is present, no pulses appear (level "0", corresponding to ground).
- During positive cycles of the modulating audio signal, positive pulses "+1" appear, corresponding to the positive supply voltage +Vs.
- During negative cycles of the modulating audio signal, negative pulses "-1" appear, corresponding to the negative supply voltage -Vs.

In order to realize a class BD amplifier, it is mandatory to use two modulators and a bridged configuration in the power stage. A class BD amplifier consists in fact of two class AD modules. The load is connected to outputs 1 and 2 through the filter in a floating configuration.

These are the voltages that can be measured at different points of the diagram as a function of time.

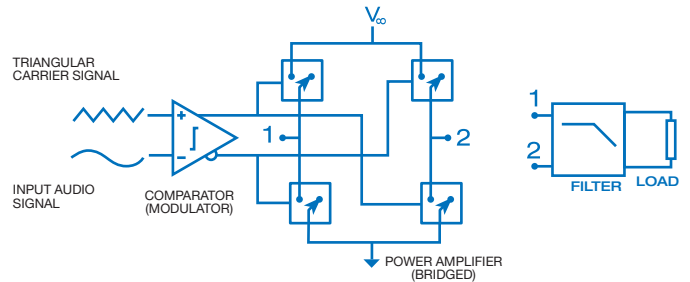
The resulting pulse train (last diagram) has interesting properties:

Its effective frequency is twice that of the reference signal. The higher the frequency, the better the filter will attenuate unwanted frequencies and the less residual ripple will exist, thus directly affecting audio quality.

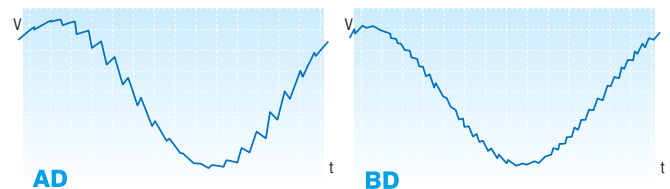
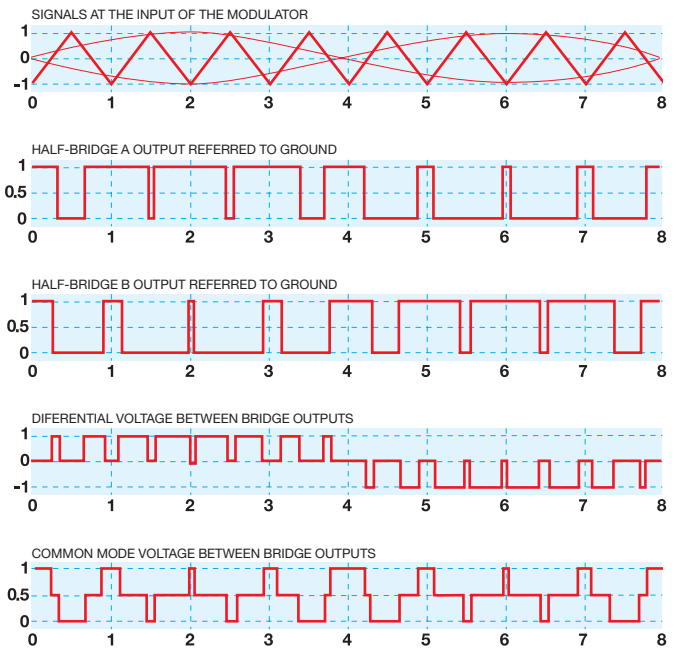
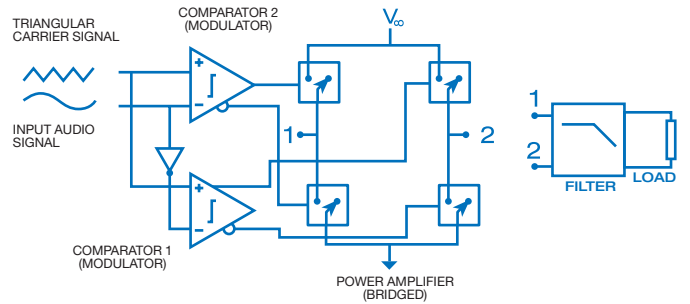
The existence of both positive and negative pulses (TRILEVEL Modulation) means that the effective amplitude of the pulse signal is half that of a class AD Modulation, further decreasing residual ripple content.

These two facts signify a 18 dB improvement during the filtering of the modulated signal using the same passive filter. Residual ripple is 8 times smaller, significantly improving audio quality.

Class AD amplifier implemented with bridged power stage



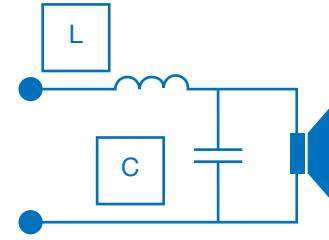
Class BD amplifier implemented with bridged power stage



Residual ripple comparison between both modulation systems

### THE DT's OUTPUT FILTER

This last device is responsible of reconstructing the analogue audio signal. As it has to deal with high power signals, this filter must be built using passive components (resistors, inductors and condensers). Resistors, however, should never be used in series with the loudspeaker load to avoid losses. Therefore, its topology is a LC filter designed to optimize frequency response variation as a function of load impedance variation.



2nd ORDER PASSIVE FILTER

### THE FIRST LOWWEIGHT AMPLIFIER CAPABLE OF DELIVERING ALL THE POWER AL THE TIME

Traditionally, audio amplifiers have been engineered to operate with continuous audio signals across a frequency range of 20 Hz to 20 kHz. In practice, however, they are used to amplify musical signals which are quite differently shaped than pure sinusoidal signals (musical usage philosophy).

Output power of amplifiers is usually specified for a sinusoidal input signal whose peak voltage should be carefully chosen so that the amplifier is at the threshold of clipping. The RMS value nothing more than an equivalent level after averaging the signal in time. Being a sine wave a repetitive waveform, its RMS value stays the same, making design process and comparison with other equipment easier.

The behaviour of a musical signal is though totally unpredictable (it can only be studied statistically). The RMS value of music changes as a function of sampling time. A statistical examination carried out on many musical fragments of different styles demonstrates that:

Duration of musical fragments	Equivalent level compared to a sinewave signal of the same peak amplitude (*)	Necessary output power for reproducing the RMS amplitude of music (relative to output power for reproducing sinewaves)
1 ms	VRMS sine signal	Wmax
10 ms	0,75 x VRMS sine signal	0,56 x Wmax
100 ms	0,56 x VRMS sine signal	0,32 x Wmax
1 s	0,42 x VRMS sine signal	0,18 x Wmax
10 s	0,31 x VRMS sine signal	0,1 x Wmax

(\*) To obtain the equivalent RMS Value, the RMS values of many fragments of a same piece of music are measures and later averaged for the whole length of the piece.

As conclusion: If we consider a sufficiently long time period (10 sec, last row), the RMS value of the music signal is one third (0,31) that of a equivalent sinusoidal signal which had the same peak amplitude. And the power delivered by the power amplifier is one tenth (0,1) of the maximum.

However, one cannot use an amplifier that delivers one tenth of the maximum power, as it would be unable to output more power during music peaks. The question becomes evident:

How long are musical peaks and how much power do they require?

Following table has the answer, showing output power of the amplifier as a function of time period:

Output power	1000W	562W	320W	180W	100 W
Time	1 ms	10ms	100ms	1s	>10s

As can be seen, an amplifier of only 100 W could be able to deliver 1000 W in the short time period of one thousandth of a second. Based on this principle, each manufacturer should determine:

- Maximum deliverable output power during a certain time period.
- What kind of maximum output power reduction to impose as a function of time to avoid risks.
- How large should the continuous power (RMS) be, trying to achieve a compromise that "fools" the ear.

A criterion often used by various manufacturers is 200 ms for delivering maximum output power and 1/3 of maximum power for continuous operation.

Continuous power is rarely published due to the difficulties in measuring it (protections jump in when smelling problems) and frequently output power for very short time periods (impulsional) is indicated as continuous. If semiconductors, heat sinks, transformers, etc. are chosen as for a smaller power amplifier, signal compression devices and radical protections must step in. All this translates into reliability grade and clearly affects audio quality.

Following table summarizes criteria for both operating philosophies.

	"ALL THE POWER ALL THE TIME" PHILOSOPHY	"MUSICAL USAGE" PHILOSOPHY
THEORETICAL AMPLIFIER APPLICATION FIELD	Amplifier for professional audio applications.	Amplifier for reproducing musical signals.
MAIN DESIGN AND COMPONENT SELECTION CRITERIA	Reliability and sound.	Minimum weight, volume and cost.
COMPONENT DIMENSIONING	For continuous operation. No critical components.	As if it were a lower power amplifier. Critical components.
TIME PERIOD DELIVERING FULL SPECIFIED OUTPUT POWER	Theoretically indefinitely. Depends on heatsink in practice.	Depends on dimensioning of critical components.
OUTPUT POWER REDUCTION AS A FUNCTION OF TIME	Not applicable unless saving on heatsink (ECLER's case)	Indispensable for protecting critical components.
OPERATION WITH SINUSOIDAL SIGNALS	No problem.	Dangerous. Protections must take care.
CONSEQUENCES	Good reproduction of musical dynamics. Professional reliability. Dependable power measurements.	Bad reproduction of musical dynamics ("sagging"). No professional reliability. Dependable power measurements can't be done.

ECLER's DT amplifiers have been engineered with "all the power all the time" philosophy.

## ECLER's DIGITAL TRILEVEL AMPS FOR ANY USE?

Until now, we have delved into technological intimacies of DT amplifiers. All features exposed in this document lead us to that question. Finally a digital amplifier exists whose audio quality and reliability is perfectly comparable to the most reputable analogue power amps in the pro audio world. Its advantages, that go beyond low weight, exceptional efficiency and reduced thermal stress, make this option fit in a wide range of installations and events.

Digital technology furthermore opens a universe of possibilities yet to arrive.

Don't compromise! Amplify digitally with all the power all the time.



## ECLER DIGITAL TRILEVEL POWER AMPLIFIERS

### Main features

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- First high performance "all the power all the time" amplifier.
- 3320 W per channel on 2 Ohm (Model DT6800) in only 9,8 kg.
- Resonant structure stabilized switch-mode power supply with PFC (Power Factor Correction).
- Trilevel Technology class BD digital amplification.
- High End audio performance.
- Low distortion, comparable to an analogue amplifier.
- Temperature controlled progressive "Back to Front" cooling system takes air from the rear and throws it out at the front panel. Thermal management system.
- Effective protection systems that do not affect audio quality with status indicators.
- VCA-controlled autogain protection system (Analogue Autogain Signal Processor) and intelligent variable threshold anticlip protection that adapts to the incoming type of transient peak.
- Built-in subsonic filter.
- Robust, road tested. It has been certified to pass norm EN 60068-2-6:1995, level 5M3 as described on IEC 60721-3-5:1997. (Norm related to equipment to be transported by road through routes in bad conditions.)



*Vibration test*



- Tropicalized printed circuit boards, for use in salty or extremely humid environments.
- Sealable gain controls.
- Nominal gain can be adjusted at the back panel with micro-switches (1V, 32 dB, 26 dB, 24 dB).
- Electronically balanced XLR-3 input connectors.
- XLR-3 stack output connectors for interconnection with additional power amps.
- Complies with EMC (Electromagnetic Compatibility) regulations.

### LABORATORY OUTPUT POWER MEASUREMENTS

	DT4800			DT 6800		
	8Ω	4Ω	2Ω	8Ω	4Ω	2Ω
Maximum RMS Output Power per channel 0,3% THD, 1 kHz *	700W	1320W	2350W	960W	1794W	3320W

\* Maximum RMS Output power remain constant even in heavy use situations and is independent from warm up time.

### TECHNICAL CHARACTERISTICS DT 6800 - 4800

Frequency response (-1dB / -3dB)	10Hz÷35KHz
High pass filter (-3dB)	~20Hz
THD+Noise @ 1kHz Full Pwr.	<0,05%
Imd. Dist. 50Hz & 7kHz, 4:1	<0,03%
TIM 100	<0,04%
S+N/N 20Hz-20kHz @ 1W/4W	>85dB
Damping factor 1kHz @ 8ohms	>350
Channel crosstalk @ 1kHz	>65dB
Input connector	XLR3 balanced
Input CMRR/ref. Max. PWR	>60dB
Input Sensitivity / Impedance	0dBV/10kHz
Signal present indicator	-40dB
Output connectors	Speak-on
Mains 230V AC	
Power consumption (max.Out)	3.650 VA (2700VA 4800)
Dimensions Panel	482.6x88mm
Depth	458mm
Weight	9.8 Kg.

All the characteristics are subject to variation due to production tolerances. ECLER SA reserves the right to make changes or improvements in manufacturing or design that may affect specifications.