New multilevel ‘PKN H8®’ amplifier topology breaks the barriers of signal quality, conversion efficiency of conventional Class-D amplifiers

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***Abstract*- This paper presents a new type of switching amplifier circuitry based on a modified Multilevel Inverter for high power and accuracy AC signal reproduction with wide bandwidth, way beyond the upper audio range. The proposed circuit has improved efficiency, less EMI disturbance and reduced cooling requirements compared to the conventional Class-D amplifiers. PKN H8® circuit is suitable for high power audio amplifiers, brings improved signal quality and has very good pulse response with full reactive load capability yet higher reliability and compactness.**

Multilevel converter & switching amplifier (MI) technology has been here for a while, it has unique application areas where high quality AC signal reproduction is mandatory at elevated power levels such as traction drives or power distribution networks from couple of KW up to hundreds of MW range. Unfortunately the popular MI circuits are too bulky, complex and costly to use them in a professional amplifier. Knowing the benefits of the MI technology We have made significant R&D effort to optimize and extend the conventional MI circuitry to be suitable as end stage of a high-power professional amplifier.

H8 basic simplified power circuit and its corresponding control waveforms are displayed on *fig1.* Fully symmetrical arrangement of the circuit is clearly visible. Eight power devices (Q1-Q8) are driven by carefully aligned multiphase PWM signals equally distributed in a time period by 90° phase shift. The internal Voltage levels of the switching cells are maintained by H8 level control circuitry, it samples actual Voltage values of level nodes, balancing the level clamping capacitors (C3, C5, C7, C8) in perfect symmetry by limited intervention of individual PS/PWM. The output passive low-pass filter has been composed by L1, L2, T2 inductors and C1, C2, C4 capacitors. Due to the increased effective switching frequency as well as reduced ripple current the size of the filter is lot more compact than 2 or 3 level Class-D amplifier. The output analog signal (OUT1,2) is directly measured on the point of load after the passive filter this way eliminating the non-linearity and load dependent frequency response of the filter network. The MI circuits needs start-up support at on time when the level clamping capacitors are not equally charged, initial charging up function is realized by switchable R1, Q6 pre-charger which is bypassed by Q5 during normal operation.

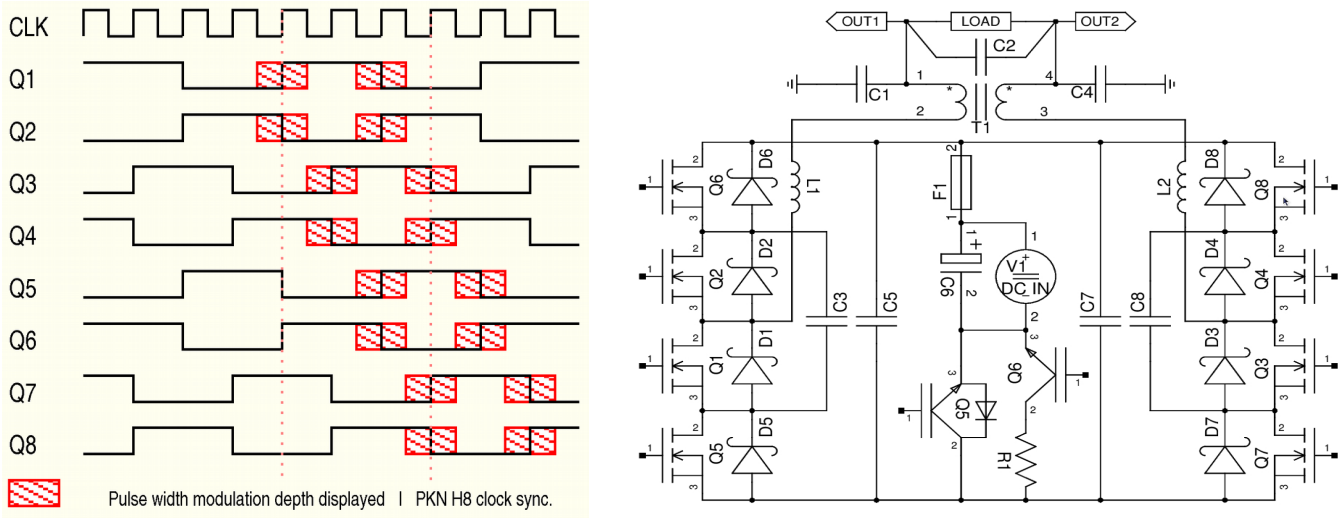

fig1. PKN H8 basic simplified circuit (power devices) and corresponding switching sequence

Comparing the conventional 2 level Class-D amplifier to the H8, here we have eight power processing elements instead of two. While the Voltage stress of switching devices exceed $2 * V_{out}$ in the Class-D, the H8 circuit has just sightly above $0.5 * V_{out}$ which is a four times improvement. It is well known fact that the operational frequency of 2 level Class-D amplifier can not be increased without limits due excessive switching losses, even using the best and fastest available WBG power semiconductors. By reducing the Voltage stress of the power switches, it also reducing their dissipated heat losses greatly. Moreover distributing these losses across eight power devices the reliability of power conversion part is greatly improved. From the other point of view the power of four switching cells are inherently added therefore H8 circuit is suitable for much higher power range, referred to the same power semiconductors realized of a Class-D power stage.
The multilevel switching strategy with just a fraction of high dV/dt switch node steps has huge positive impact on the EMI performance too. Smaller output filter requirement and less heat dissipation need smaller footprint of passive components so despite the 4-5 times more complex active circuitry the power vs. size barriers of Class-D amplifier technology exceeded. Reduced output filter together with the multiphase PKN H8 modulation strategy allows lot higher bandwidth of control for the output, this way producing much nicer and accurate load waveform than Class-D. Fixed frequency operation, possible sample rates well over 1000KS/s are easily achievable without the penalty of loss of efficiency due excessive switching losses at high frequency (above 500KHz). Large signal bandwidth and slew rates of pulse response are at least twice of useful frequency range compared to Class-D, this way bringing closer H8 technology to the best signal accuracy but very inefficient linear amplifiers than any other efficient switching solution.