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ภาคผนวก

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ไอซี TDA 4814



Michael Herfurth

TDA 4814 – Integrated Circuit for Sinusoidal Line Current Consumption

Components at present available from semiconductor manufacturers allow to build more powerful switched-mode power supplies and motor controls run from line supply. So far the piece-wise method of rectifying line voltage by means of pulse-width modulation at higher frequencies has been widely used, as it offers high efficiency and a reduction in the size of inductive components.

Many applications for TDA 4814 integrated control circuit

Switched-mode devices cause interference which should not exceed the limits laid down in standards (VDE 0871) for the frequency range above 10 kHz. As a result of rectification and subsequent capacitor smoothing, harmonics are produced by a pulsed capacitor's charge currents. As these harmonics may affect other loads, limit values are prescribed for certain devices. Here, for example, household appliances (VDE 0838) and ballasts for fluorescent lamps (VDE 0712) are relevant. Apart from such regulations governing harmonic content, the power factor is becoming more important in the assessment of devices. The power factor indicates the ratio of active and apparent power drawn. While electrical interferences are

the major concern when harmonic content is considered, the power factor is a measure of supply system load and supply system safety. A growing demand for so-called wide-range power supplies for input ac voltages of 90 to 250 V (without changeover) produces a strong need for a new approach to existing design concepts. Modified solutions lead to the same requirements as mentioned above. Against this background the TDA 4814 IC has been developed. This IC utilizes an efficient control method to operate a boost converter in a way that allows an almost sinusoidal current to be drawn from the single-phase line supply and a stabilized dc voltage to be provided at the output. Hence the harmonic content as well as the apparent power consumption are kept fairly small

Sufficient sinusoidal current drawn from the line requires an appropriate control method

A converter capable of continuously transforming the input voltage over a

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wide range is necessary for the job. Then, only a flyback converter or related boost and boost/buck converters are required (Fig. 1). For the application described here the boost converter is ideal as a switching transistor of only 500 V off-state voltage is needed while a minimum dielectric strength of 800 V is required for the remaining converter types. Losses due to loose coupling of turns or stray inductances are eliminated. Only a choke is necessary with one lead connected to the output voltage by a free-wheel diode. The output voltage is equal to the off-state voltage load of the transistor. In the demagnetization phase the choke is fed from the input voltage. Thus a large amount of the input current bypasses the switching transistor and flows directly to the output via the free-wheel diode. For all these reasons the boost converter is the system best suited to obtain high efficiency (Fig. 2). The operational mode is the next step to be defined. If the transistor switches on again before the free-wheel diode ceases conduction, approximately trapezoidal currents occur in the semiconductor. Reverse diode current resulting from delays in the blocking ability of the free-wheel diode might cause trouble. A much more convenient operational mode allows the diode current to reach zero before the transistor is switched on again. Hence triangular currents are produced in the semiconductor devices without any inverse diode currents. Relative to fixed-frequency operation, free oscillation utilizing the inherent dynamics of the system obviates dead times and accompanying transients, finally, resulting in a reduced current load of the component (Fig. 4). The physical relationship of current and voltage characteristics occurring at the boost converter (Table and Fig. 3) form the groundwork of the control method described here. The mean input current per cycle is exact half the peak value of the choke current. With these peak values lying on a curve which is proportional to the input voltage, the input converter acts like a resistance to the line after smoothing. To provide optimum control of the boost converter the current through the semiconductor switch is sensed by a shunt resistor. The measured current is equal to the peak choke current at the turn-off

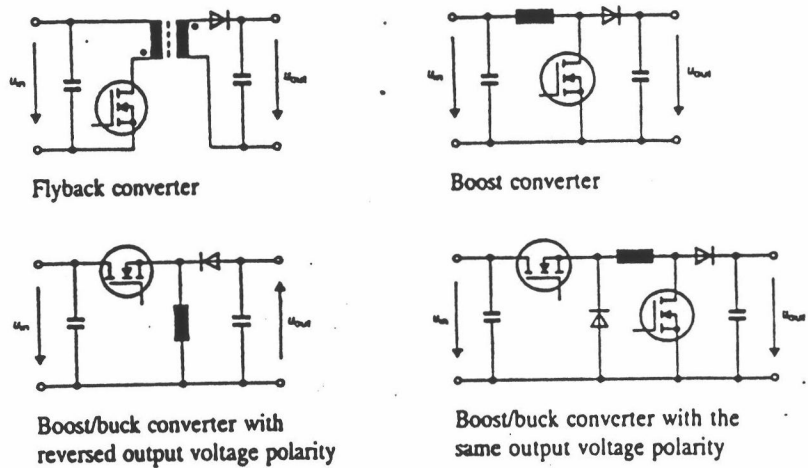


Fig. 1 Converter types for wide-range transformation

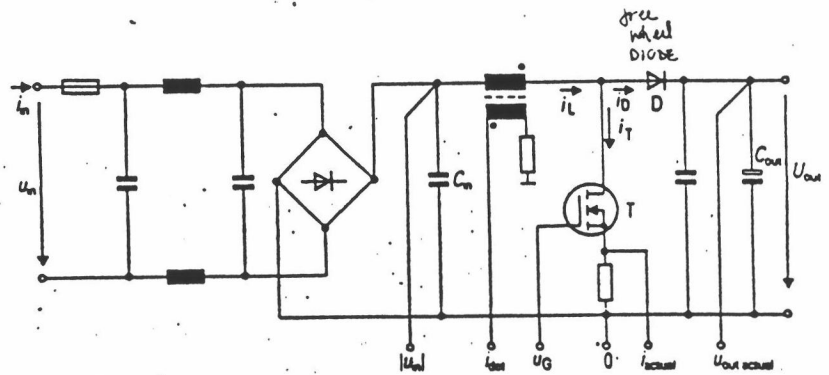


Fig. 2 Boost converter used as active harmonic filter

Handwritten note: Boost converter efficiency 90%

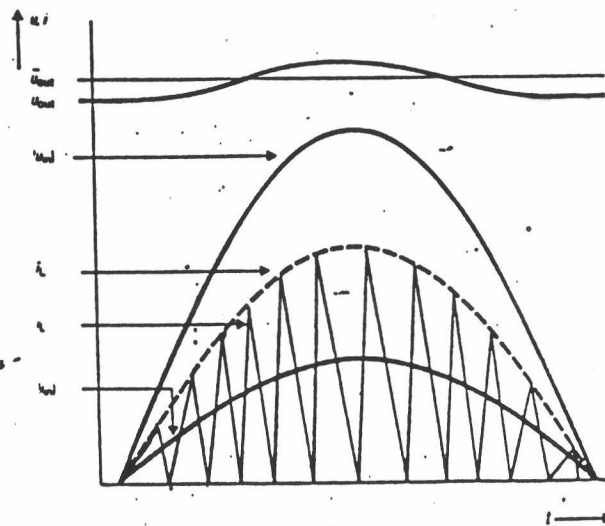


Fig. 3 Operation of active harmonic filter shown as current and voltage characteristics over a half-wave of line frequency

point of the SIPMOS transistor. A comparator blocks the transistor at the exact instant when the peak choke current reaches a given nominal value. A multiplier delivers the nominal value from the waveform of the input voltage and the amplitude of the controller output voltage (Fig. 5). The transistor is blocked until the current through the choke and the boost converter diode have dropped to zero. We now have to make clear how the zero crossing of the diode current is detected. Monitoring the voltage u_L at the boost converter choke has proved to be an interference-free and low-cost method. The voltage at the choke changes polarity depending on the operating state: The charge period with the transistor switched on is characterized by negative polarity on the output terminal of the choke, while the discharge period with the transistor blocked, gives positive polarity at the same terminal. After the discharge period is finished the voltage across the choke returns to zero or overshoots may generate negative polarity on the output side again. This change of polarity is picked up by induction in an auxiliary winding on the choke and processed in the control logic circuit (Figs. 2 and 4).

TDA 4814 performance

This device has a conditioning circuit for the internal power supply. It allows standby operation with very low current consumption, a hysteresis between enable and switch-off levels, an input voltage limiter and internal voltage stabilization.

These facilities ensure reliable starting and allow supply from a current source. The output driver is intended to drive a SIPMOS transistor directly. Both the capacitive input impedance and keeping the gate level at zero potential in standby operation by an internal 10-kΩ-resistor are taken into account. Possible effects on the output driver by line inductances or capacitive couplings via SIPMOS transistor Miller capacitance are limited by diodes connected to ground and supply voltage. SIPMOS transistors are ideal as power switches in active harmonic filters because of features such as low driver power, no second breakdown and controllability even of extremely

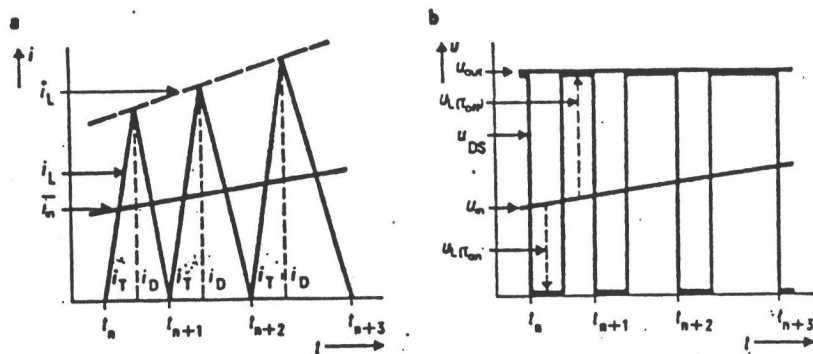


Fig. 4 Current (a) and voltage (b) in Fig. 2 circuit over several clock cycles u_L = voltage at the choke)

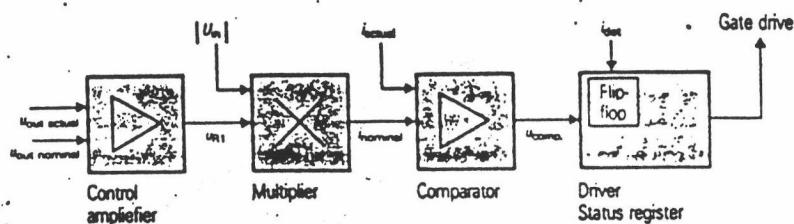
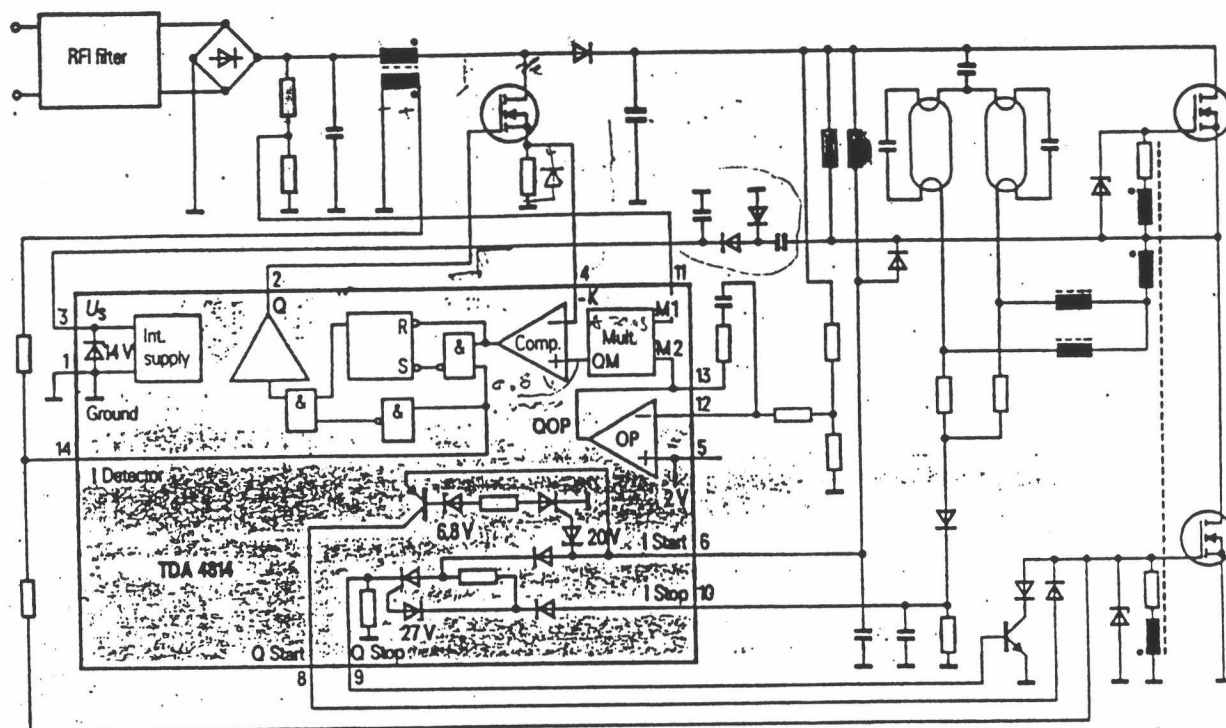


Fig. 5 Control principle of the active harmonic filter

Basic equations	Symbols
(1) $i_L = u_{in} \frac{1}{L} t_{on}$	u_{in} Input voltage
(2) $t_{off} = \frac{i_L \cdot L}{u_{out} - u_{in}}$	u_{out} Output voltage
(3) $T = t_{on} + t_{off}$	\bar{u}_{in} Mean input current, time-dependent.
(4) $u_{out} = u_{in} \frac{T}{T - t_{on}}$	i_L Peak choke current, time-dependent.
(5) $\bar{i}_{in} \approx \frac{1}{T} \left(\frac{i_L \cdot t_{on}}{2} + \frac{i_L \cdot t_{off}}{2} \right)$	L Choke inductance
(6) $\bar{i}_{in} = \frac{1}{2} i_L$	T Cycle time (variable)
	t_{on} On time
	t_{off} Off time

Table Physical interrelations with the control method



Remark: Kindly note that the Siemens AG holds patents on electronic ballast for fluorescent lamps described in the article »New electronic control gear« by A. Kröning, P. Krummel published in »Siemens Energy and Automation«, Vol. VII, No. 2, March/April 1985, page 102 to 104

Fig. 6 Circuit of an electronic ballast for fluorescent lamps using active harmonic filter and TDA 4814

short switching times – all of which are most useful in this application. The output driver is controlled by detector input and current comparator. The detector output highly resistive in the operating state reacts on hysteresis-determined voltage levels. To keep down the amount of circuitry required, clamping diodes are provided which allow control by a current source:

The operating state of the boost converter choke is sensed via the detector input. H-level means that the choke discharges and the output driver is inhibited. Furthermore, H-level sets a flip-flop which stores the switch-off instruction of the current comparator to reduce susceptibility to interference. On discharge the choke voltage reverses and the detector input is set to L-level, thus enabling the output driver. With transistor switched on the voltage drop measured at the shunt resistor is equal to the actual choke current. The current comparator blocks the output driver when

the nominal peak value of the choke current given by the multiplier output is reached. This state is maintained in the flip-flop until H-level appears at the detector input which takes over the hold function and resets the flip-flop. Operating states might occur without any useful detector signal. This is the case with magnetic saturation of the choke and when the input voltage approaches or exceeds the output voltage as, for example, during switch-on. The driver remains inhibited for the flip-flop due to the absent set signal. So it is a good idea to couple an additional trigger signal to the detector input. The trigger signal can be derived from the subsequent lamp generator, a SMPS control device or, if neither is available, from the start circuit designed as a pulse generator in the TDA 4814. The trigger signal level should be so low that with standard operation the signal from the detector winding dominates. The multiplier delivers the presettable nominal value for the

current comparator. This is done by multiplying the input voltage, which determines the nominal voltage waveform sensed at the resistance divider, and the output voltage of the control amplifier, which affects the nominal amplitude rather than its waveform. The task of the control amplifier is to stabilize the output dc voltage of the active harmonic filter in the event of load and input voltage changes. To this purpose a 2-V reference voltage is provided in the IC. The way the input current is fed to the output capacitor superimposes a ripple voltage at twice line frequency onto the output voltage with line operation. The ripple voltage cannot be compensated without altering the current drawn from the desired waveform. The ripple voltage amplitude is only reduced by increasing the smoothing capacitance. An appropriate filter keeps the ripple content of the output voltage from the control amplifier input to avoid unintended modulation. On the other hand, a change of state has

to be recognized early which is in sharp contrast to the ripple voltage suppression. Filter circuits with selectable ripple frequency suppression have proved suitable. However, these sometimes require adaptation to different line frequencies. Other methods work on the control amplifier gain when the output voltage reaches tolerance limits. Regardless of line frequency, unintended modulation by the ripple voltage is obviated in this way. In addition to these functions to control a boost converter employed as an active harmonic filter in the described operating mode, the TDA 4814 integrated circuit contains a start and stop circuit. Both functions operate independently of the harmonic control but with the same ground potential.

The start circuit acts externally like a diac. A highly resistive, charged capacitor connected to the start input is discharged via the start output when a threshold voltage of about 20 V is reached. This function starts, for example, the lamp generator of an electronic ballast or generates auxiliary trigger signals for the detector input. To avoid a negative potential at the start input which may cause failure, it is a good idea to place a diode in the line to the gate when using the TDA 4814 in an electronic ballast for fluorescent lamps.

The stop circuit acts externally like a thyristor. If the voltage at the stop input exceeds a threshold of about 27 V a thyristor is triggered and this connects stop input and stop output via a resistor. Furthermore, start input and stop output are connected via a diode. This function is utilized in an electronic ballast to charge in a delayed manner a capacitor connected to the stop input from a voltage proportional to the lamp voltage. If the fluorescent lamp does not trigger within a presettable time the capacitor is discharged via the stop output. A small-signal transistor switches off the lamp generator by short-circuiting gate and ground. As with the start output, a diode should be placed in the collector path of the small signal transistor to prevent negative potential at the stop output by the transistor's base-collector diode.

The start input is likewise short-circuited via an internal link. Only when falling below the hold current (e.g. interruption of supply voltage) the thyristor is stop-

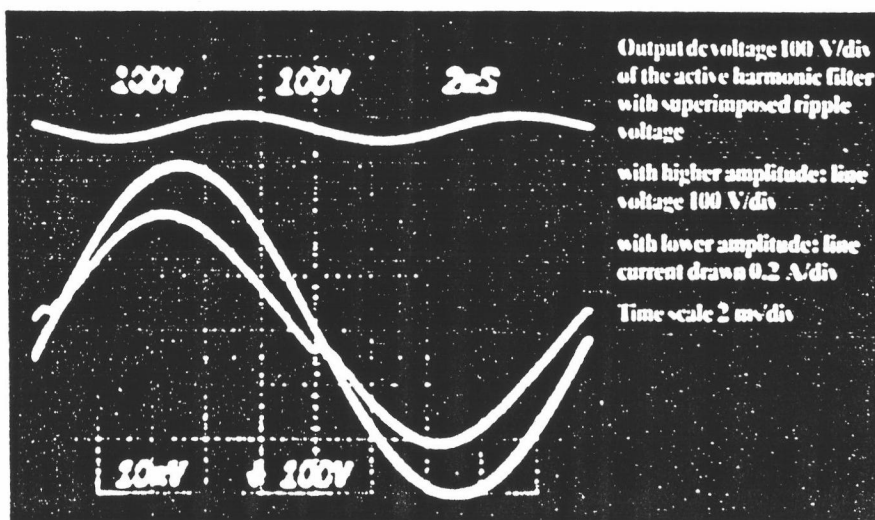


Fig. 7 Line voltage and line current drawn with an electronic ballast for a 50-W fluorescent lamp

ped and the stop function is released. In other applications this stop function may also be used as overvoltage protection. Here the stop input is fed directly from a resistance divider.

A typical application of the TDA 4814 IC is in electronic ballasts for

fluorescent lamps (Fig. 6). The schematic diagram shows the IC functions and their connections in an electronic ballast. Supply voltage and supply current of a ballast for a 50-W fluorescent lamp using an active harmonic filter controlled by a TDA 4814 are shown in Fig. 7.

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ภาคผนวก ข

ข้อดี/ข้อเสียของบัลลัสต์อิเล็กทรอนิกส์

ข้อดีของบัลลัสต์อิเล็กทรอนิกส์

1. หลอดให้แสงสม่ำเสมอมากขึ้น ไม่สามารถสังเกตเห็นการกะพริบที่ชั่วหลอดได้ด้วยตาเปล่า จึงช่วยลดผลสโตรโบสโคปิก (stroboscopic effect) ของความถี่ต่ำได้
2. ในบัลลัสต์อิเล็กทรอนิกส์รุ่นที่ไม่ต้องใช้สตาร์ทเตอร์ ก็จะไม่มีปัญหาสตาร์ทเตอร์เสีย
3. ช่วยประหยัดพลังงานได้ เพราะ บัลลัสต์จ่ายกำลังให้หลอดลดลง และมีสูญเสียพลังงานในบัลลัสต์ลดลง
4. ช่วยยืดอายุหลอดได้ เพราะ หลอดได้รับกำลังลดลง
5. หลอดจุดติดเร็วทันที (quick start) ไม่สามารถสังเกตเห็นการกะพริบระหว่างการจุดหลอดได้ (flicker-free starting) และอาจไม่สามารถสังเกตเห็นการกะพริบเนื่องจากหลอดเสื่อม (flicker-free operation)
6. ใช้ได้กับแรงดันของแหล่งจ่ายในช่วงกว้าง

ข้อเสียของ บัลลัสต์อิเล็กทรอนิกส์

1. เป็นการยากที่จะเลือกใช้บัลลัสต์อิเล็กทรอนิกส์ ให้ถูกต้องเหมาะสมอย่างแท้จริง การดูเพียงคำโฆษณาของผู้ขายจะไม่สามารถให้ข้อเปรียบเทียบได้ดีพอว่าบัลลัสต์อิเล็กทรอนิกส์นั้นแตกต่างจากบัลลัสต์อิเล็กทรอนิกส์ยี่ห้ออื่นอย่างไร ดีหรือไม่ดีอย่างไร
2. บัลลัสต์อิเล็กทรอนิกส์ อาจทำให้เกิดการรบกวนทางสนามแม่เหล็ก โดยผ่านทางตัวกล่อง หรือทางสายต่อลงดินและ หากว่าวงจรบัลลัสต์อิเล็กทรอนิกส์นั้น ไม่มีวงจรกรองที่ดีก็อาจจะมีกระแสรั่ว (leakage current) ที่เกิดจากการรบกวนจากความถี่สูง หรือ จากฮาร์โมนิกจากบัลลัสต์
3. บัลลัสต์อิเล็กทรอนิกส์มีอุปกรณภายในมากกว่าบัลลัสต์แมกเนติก จึงทำให้ความเชื่อถือได้มีค่าต่ำกว่า และอายุการใช้งานของบัลลัสต์สั้นกว่า

ประวัติผู้เขียน

นาย กิตติ สุขุดมตันติ จบการศึกษาชั้นอุดมศึกษา จาก คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย สาขาวิศวกรรมไฟฟ้า ในปีการศึกษา 2533 และเข้าศึกษาต่อในหลักสูตรวิศวกรรมศาสตรมหาบัณฑิตที่จุฬาลงกรณ์มหาวิทยาลัย เมื่อปี 2534 ปัจจุบันเป็นวิศวกรอิสระ

