H-Bridge for Servo Drives TLE 4206

Due to the high traffic density prevailing in Europe, control of headlight beam length in motor vehicles is a mandatory requirement. However …

What is Beam Length Control?

The purpose of beam length control is to prevent dazzling of oncoming traffic by headlights which are set too high. Such a situation can arise if the back of a car is so heavily loaded that the vehicle is no longer horizontal. When the vehicle position goes back to normal, the headlights must be returned to their original position in order to maintain optimum illumination of the road ahead.

How does Servo Control Work?

The driver sets the reference value for the headlights on a potentiometer on the dashboard. The headlights are moved by a DC motor. A feedback potentiometer is connected to the motor shaft in such a way that rotation of the shaft varies the value of resistance and can thus be measured. The key component of the control circuit is the TLE 4206 chip, which contains:

- a full-bridge circuit (H bridge) for controlling the motor, and
- the complete logic necessary for comparing the reference value with the feedback value.

The motor is driven until these two values, i.e. the reference value and the feedback value, are virtually equal.

Figure 1 shows the basic structure.

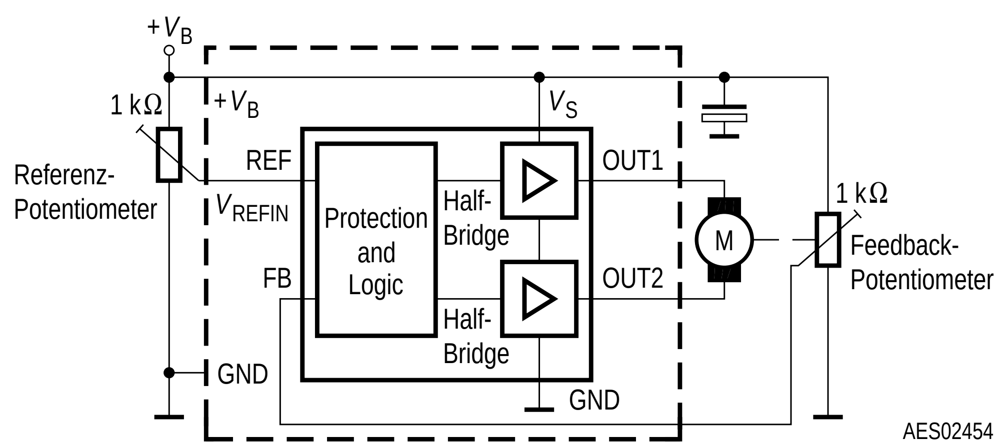

Figure 1 Basic Structure

Problems with the Servo Principle?

A headlight assembly has a certain mass. Obviously, the braking of this mass can either be carried out abruptly, involving high mechanical stress, or more gently over a period of time. If braking of the motor were not to start until the time when reference and feedback value are the same, the motor would always overshoot. However, if the duration of the braking process is known, braking can be applied in such a way that the headlights always stop exactly in the target position. This region between braking and stopping is referred to as the **deadband**.

In any closed-loop control circuit, a problem arises when the difference between reference and feedback signal becomes zero. Oscillations can occur at the zero transition due to the fact that the two signals can never be exactly equal. The control system and hence the servo motor would thus be continuously in operation. In order to avoid this, a degree of **hysteresis** is introduced between reference and feedback signal, i.e. the servo motor is actuated only if the signal from the reference potentiometer differs from the feedback signal by at least the amount of the hysteresis.

Figure 2 explains the concept of deadband and hysteresis.

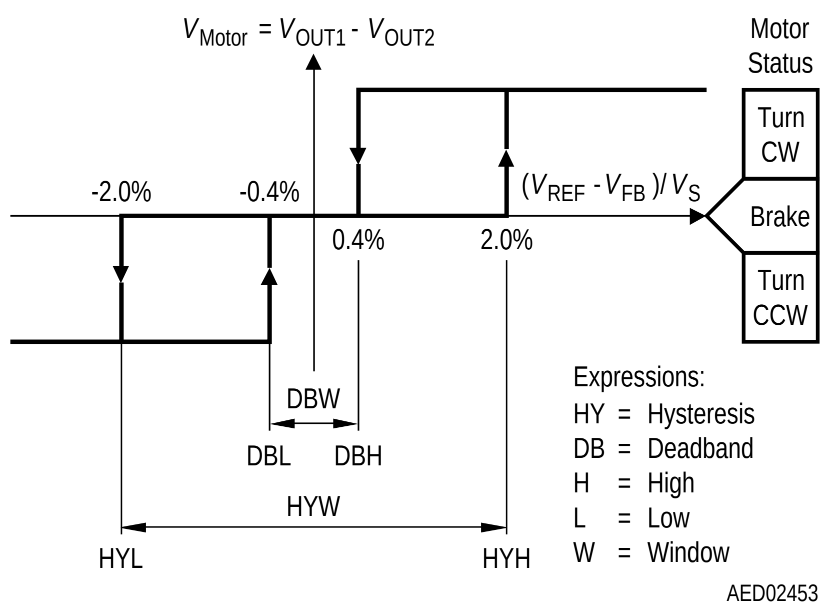

Figure 2 Deadband and Hysteresis

What is the TLE 4206 Capable of?

The **TLE 4206** has been integrated in the bipolar technology **DOPL** (**do**uble-isolated **p**ower **l**ine), which permits high-performance implementation of accurate analog control systems. The voltage regulators from SIEMENS also use this technology.

An now for the application circuit (see **Figure 3**).

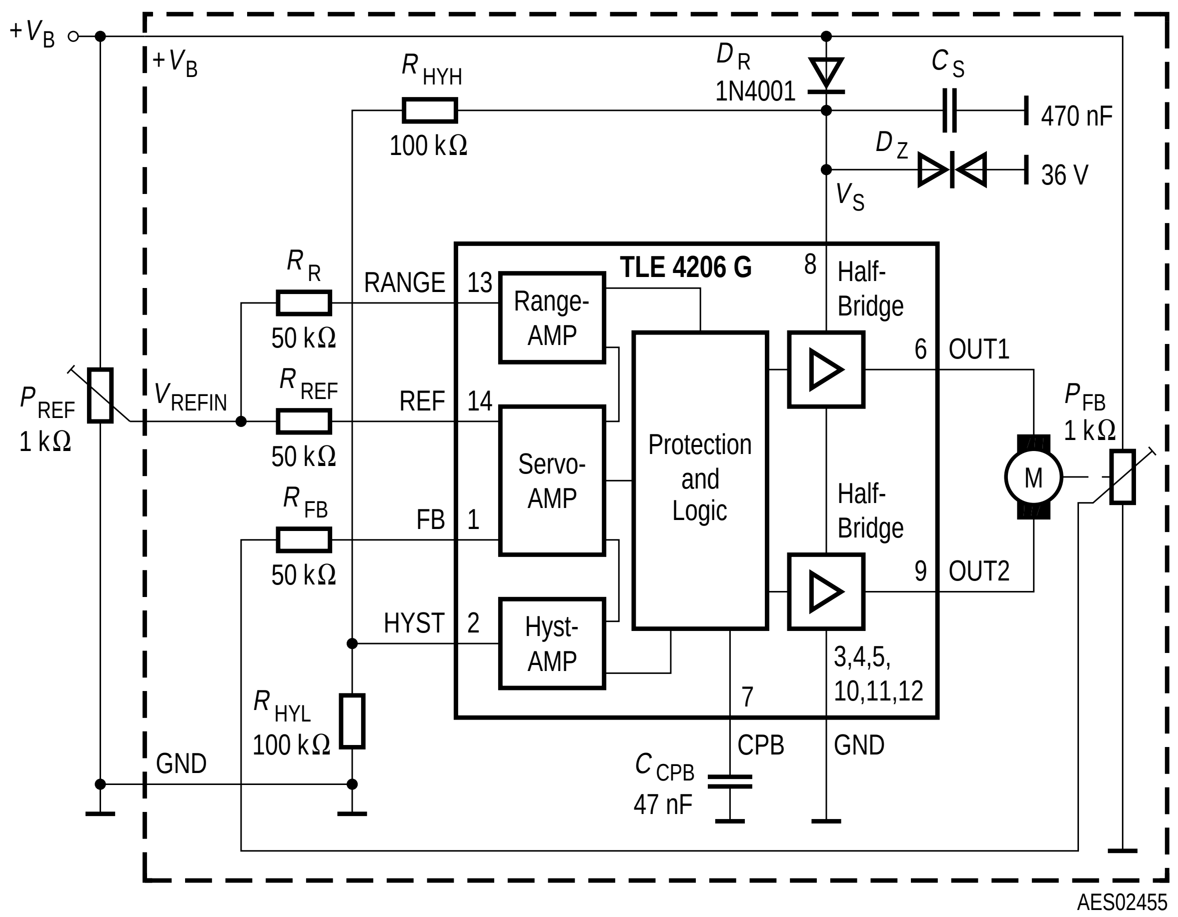

Figure 3 Application Circuit for TLE 4206

The previously mentioned inputs Reference (REF) and Feedback (FB) each have a series resistance of the same value connected to them. If the ratio between the two resistances R_{REF} and R_{FB} is changed, angle amplification is obtained.

For example:

If the resistance R_{FB} is twice the value of resistance R_{REF}, the change at the feedback potentiometer must likewise be twice that occurring at the reference potentiometer. This in turn can only be achieved by the motor doubling the setting angle. The big advantage for the customer here is that the same type of potentiometer can be used for any type of car, whether big or small, and that the setting angles can be adapted simply by changing the resistances R_{REF} and R_{FB}.

The hysteresis can be set at input HYST. If the two resistances R_{HYH} and R_{HYL} are equal, the hysteresis window is located symmetrically at 50 ± 2% relative to the supply voltage.

The position of the window can be adapted by varying the ratio of R_{HYH} to R_{HYL}. The size of the window can be adjusted by changing the ratio of the hysteresis resistances to the resistances R_{REF} on the one hand and R_{FB} on the other. For example, if the resistances R_{HYH} and R_{HYL} are both halved, the window doubles in size, i.e. to 50 ± 4%. The internal circuit for the logic inputs is shown in **Figure 4**.

Just in case

If the potentiometer or the connecting leads are damaged, uncontrolled movements of the servo motor must not occur. Dazzling of oncoming traffic resulting from such a fault could have disastrous consequences. For this reason, two additional switch-off thresholds V_{OFFL} and V_{OFFH} have been introduced. The corresponding window comparator is hidden behind the RANGE input and has a low threshold of 0.4 V. If the voltage V_{REFIN} falls below 0.4 V, which will be the case if the reference potentiometer is shorted to ground, the motor will be switched off.

If there is a short between the reference potentiometer and V_B, the upper threshold of the window comparator is activated and switches the motor off. The upper threshold V_{OFFH} is the supply voltage V_S of the IC. The polarity protection diode DR with its forward voltage drop of typically 0.7 V ensures that the upper threshold is then precisely 0.7 V lower than the battery voltage V_B.

The following calculation shows how efficiently the setting range of the potentiometer is utilized in spite of this safety requirement:

$$\frac{V_{OFFH} - V_{OFFL}}{V_B} = \frac{V_B - 0.7\ \text{V} - 0.4\ \text{V}}{V_B}$$

At a battery voltage V_B of 13.2 V, the ratio is 0.92. This means that 92% of the setting range is utilized.

The resistance connected to the RANGE input is simply a series resistor, which has the task of limiting the input current in the event of a fault producing a short between the potentiometer connection and V_B.

Electrolytic Capacitor “Designed out”

In a motor control circuit, the supply voltage must normally be buffered by means of an electrolytic capacitor, so that sufficient energy is available and the voltage does not collapse when the motor is started. In servo control, collapse of the voltage is particularly critical because reference and feedback values are being compared. This problem will be briefly explained in the following (see **Figure 5**).

If the setting of the reference potentiometer is changed in a way which reduces the reference voltage, the motor starts as soon as the lower hysteresis threshold is reached. The high startup current of the motor causes the supply voltage to the motor and to the application circuit to collapse. The reference voltage, however, does not collapse, because of the distance between the reference potentiometer and the application circuit.

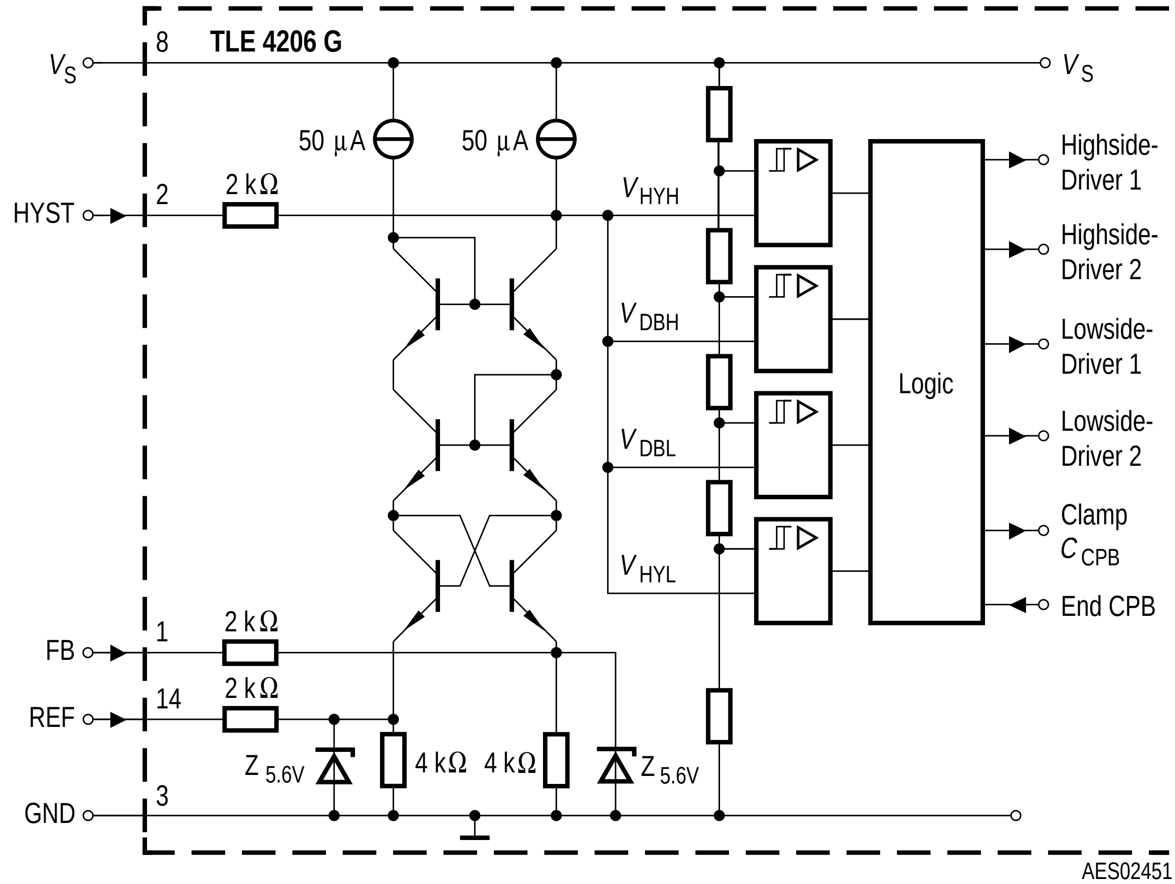

Figure 4 Input Logic Circuit

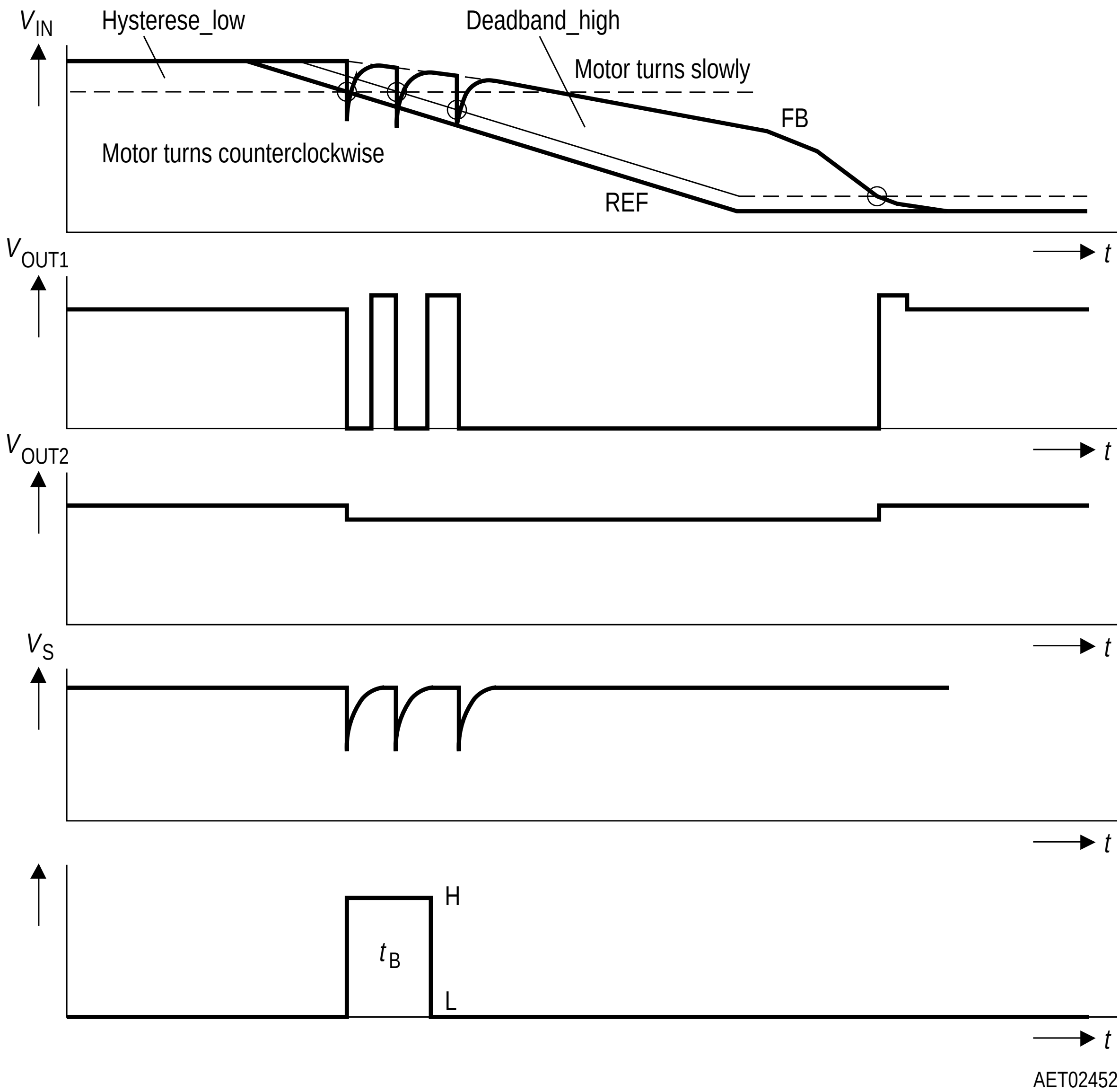

Figure 5 Explanation of Current-Peak Blanking

This leads to the problem that for a short period, the voltage from the feedback potentiometer will be equal to the reference voltage, the differential control drive voltage becomes zero and the motor stops again. When the supply voltage has recovered, a differential control voltage appears again and the motor restarts. This starting and stopping could go on forever if the motor current remained too low to move the mechanical structure.

The **current-peak blanking** feature makes it possible to blank out (disable) the comparison of the reference value with the feedback value for a period of time which can be programmed by means of an external capacitor. The time period required depends on the time constant of the motor and on the time it takes for the supply voltage to recover to a sufficient level.

The capacitor C_{CPB} is used to program a monostable trigger circuit. Whilst the motor is halted, the capacitor is clamped to ground potential. It is then charged with a constant current of 6.5 µA. When the voltage at the capacitor goes beyond the threshold of 5.7 V, the comparison between reference and feedback value is activated again. The blanking time can be calculated as follows:

$$t = \frac{C \times U}{I} = \frac{C \times 5.7\ \mathrm{V}}{6.5\ \mu\mathrm{A}} = 0.88\frac{\mathrm{ms}}{\mathrm{nF}}$$

For a capacitor C_{CPB} with a value of 47 nF, the blanking time is 40 ms. The blanking feature allows the buffer capacitor, which is usually a large and expensive electrolytic capacitor of several tens of µF, to be replaced by a small and cheaper ceramic capacitor of 470 nF.

If the feature is not used, the capacitor C_{CPB} can be omitted. Pin 7 (CPB) can remain open.

Full Power …

In the TLE 4206, the output stages are short-circuit protected and current-limited to typ. 0.8 A. In addition, **SOA** (**s**afe **o**perating **a**rea) limits are maintained over the full voltage range. Both current and voltage drop across the output transistors are monitored for this purpose. Another feature of the output stages is saturation control of the output transistors. The dissipation of the entire chip is thereby optimally matched to the output power. The circuit structure is given in **Figure 6**, showing output stage 1 as an example.

The servo motor is also protected against overvoltage. For example, if the supply voltage exceeds a value of 22 V, the **OVLO** (**ov**ervoltage **lo**ckout) is activated. The output stages are switched off and are automatically switched on again when the supply voltage is safe. The device itself has a withstand voltage of 45 V.

Not only the Internal Performance …

The package represents another innovation. In its external dimensions it conforms to the standard P-DSO-14.

Actually, however, an enhanced-power package is used for the TLE 4206.

A total of six pins, three on each side, are connected directly to the chip carrier. The thermal coupling between pins and chip is thus considerably better than with the thin bondings normally used (see **Figure 7**).

Thermic simulation for an ambient temperature of 150 °C and a dissipation of 1.5 W has proven that this package has a thermal resistance of only 25 K/W (see **Figure 8**).

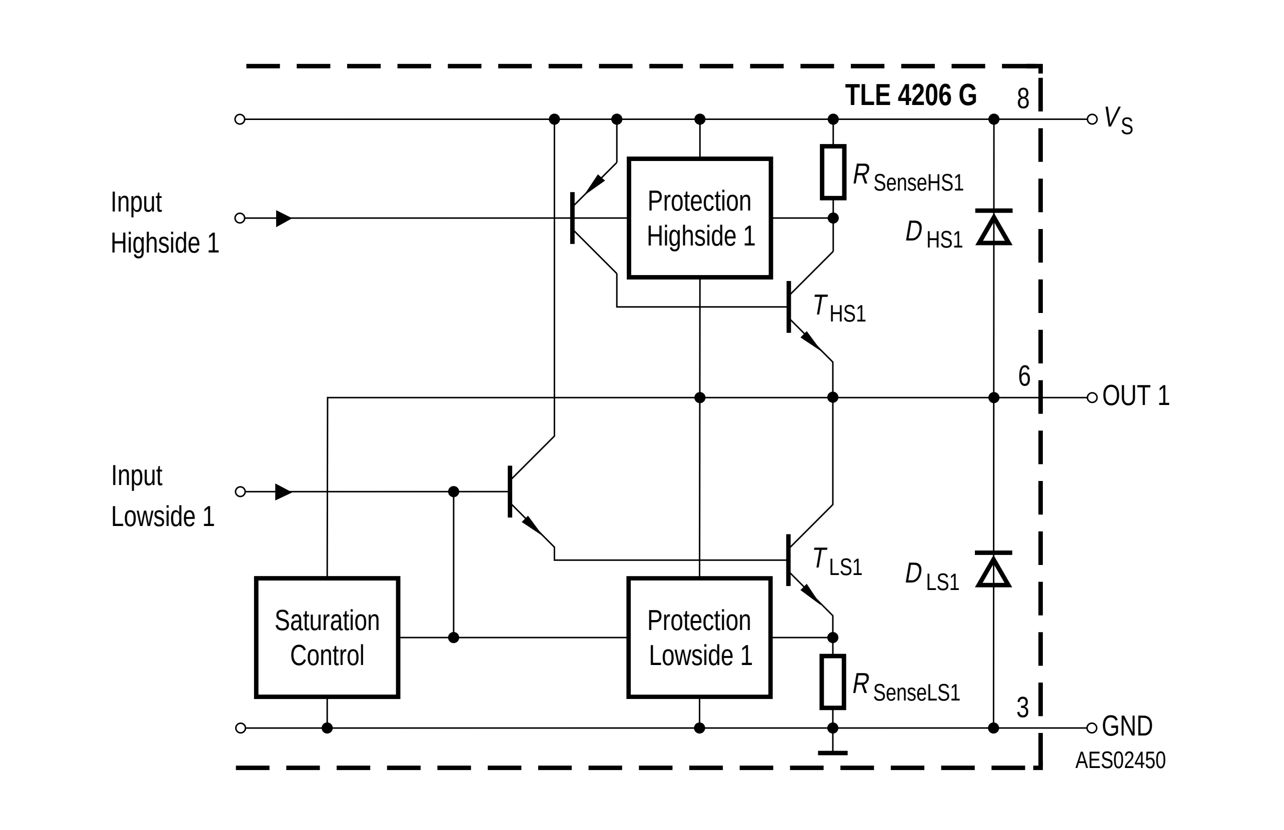

Figure 6 Structure of the Output Stage

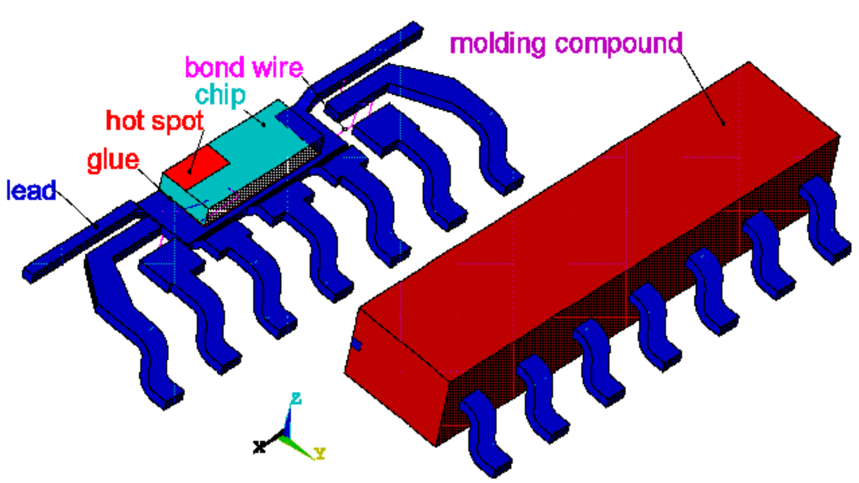

Figure 7 Fenite Elements Model

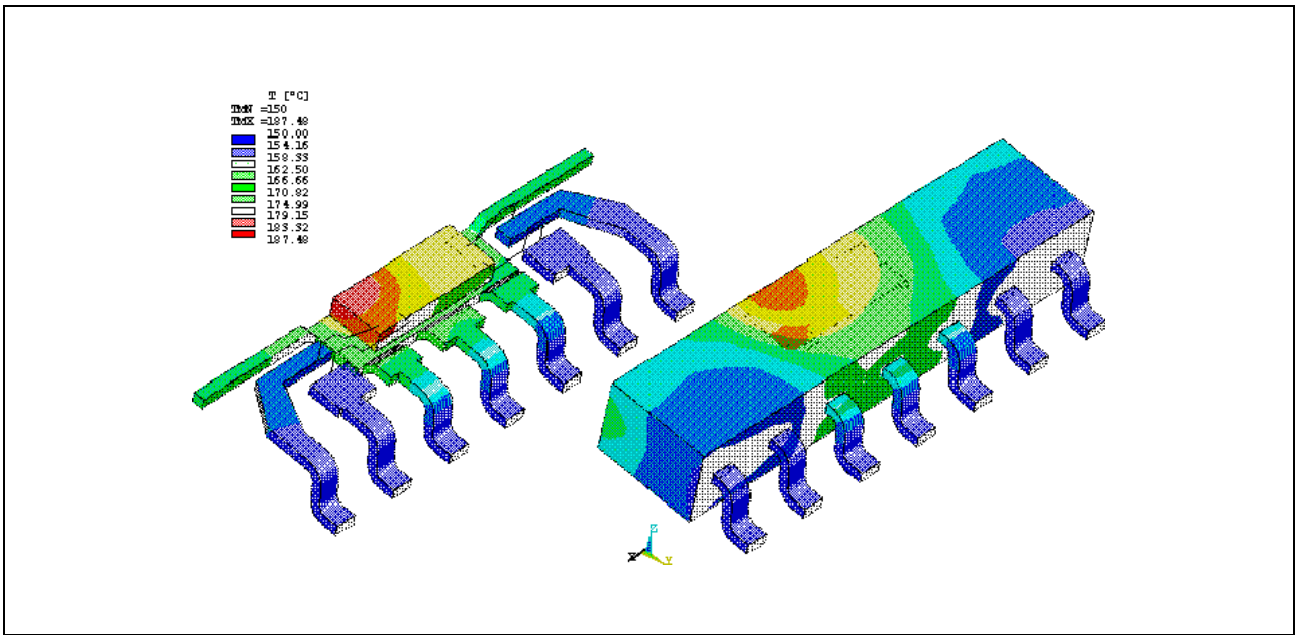

Figure 8 Thermic Simulation with P_V = 1.5 W shows R_{thJPin} = 25 K/W

It is thus possible to operate the device at a temperature of 125 °C, which would apply if the device were mounted in the headlight itself. A separate package for the application is not necessary. The device itself has a temperature shutdown operating at typically 175 °C.

The **TLE 4206** is, of course, also available in a P-DIP-16 package.

Finally, it can be said that because of its flexibility, the **TLE 4206** can be used in any application. With its power package, which permits operation at maximum ambient temperatures, and with its short-circuit-proof inputs and outputs, the device is ideally suited for automotive applications.

Ordering-Code:

TLE 4206G	Q67006-A9299	P-DSO-14-4
TLE 4206	Q67000-A9303	P-DIP-16-5