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ANPS063E

TLE 472x – Family Stepper Motor Drivers

Current Control Method and Accuracy

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Automotive Power

Never stop thinking.

1. Abstract

This Application Note is intended to provide detailed technical information about the current control method that is used in Infineons stepper motor driver family TLE 472x. Special attention is paid on accuracy considerations.

2. Introduction

The TLE 472x stepper motor drivers are intended to be used for bipolar, two-phase, current-controlled stepper motors (see figure 1).

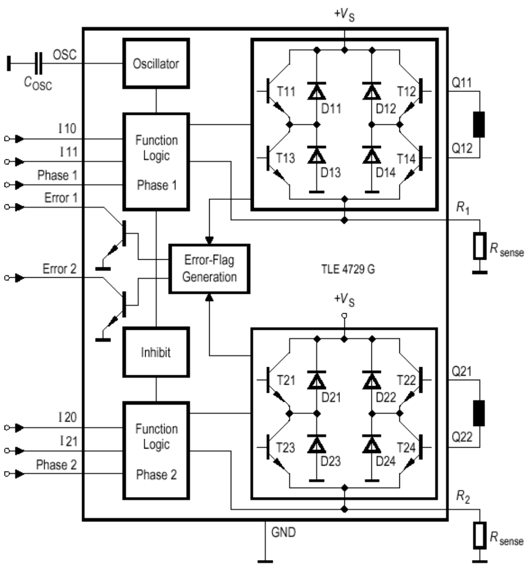


Figure1: TLE 4729 block-diagram

3. Current Control Method

In general, three different methods are used to control the current in the coil of a stepper motor:

3.1. Peak current control with fixed off-time

With this control method, the H-bridge is switched into freewheel-condition as soon as the output current reaches the desired value Itarget. The bridge remains in off-state for a fixed time toff and is switched on again automatically after toff (see figure 2). As a result, the peak value of the output current equals the desired value.

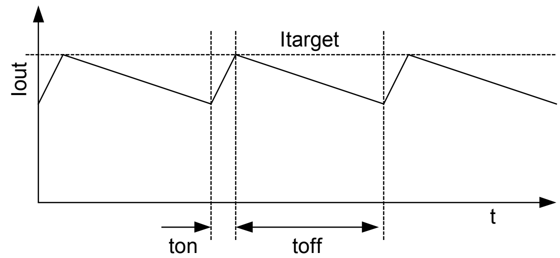


Figure 2: peak current control with constant off-time

3.2. Peak current control with fixed frequency

With this control method, the H-bridge is switched into freewheel-condition as soon as the output current reaches the desired value Itarget. In contrast to the previous method, the off-time is not fixed, but the bridge is switched ON after every time interval 1/f, f being the chopper frequency as shown in figure 3. This has the advantage that the chopper frequency is fixed, i.e. independent of the load characteristics and the supply voltage (in other words: independent of the off-time toff). **This control method is used in the TLE 472x driver family.**

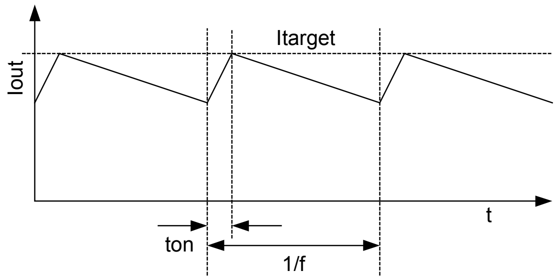


Figure 3: peak current control with fixed frequency

3.3. Mean-value current control (current-mode control).

The control methods described so far have the disadvantage that the effective, mean output current is always smaller than the desired current. By using suitable filters and comparators, it is also possible to control the current in such a manner that the mean value of the output current is equal to the desired value Itarget, as shown in figure 4.

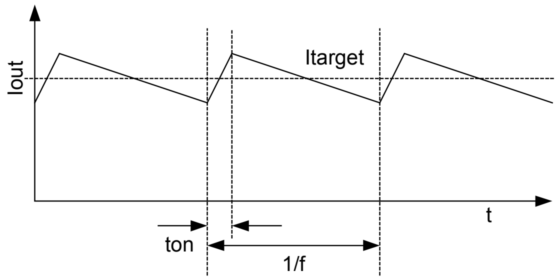


Figure 4: current-mode control

However, for this method it is necessary to adapt the filtering elements to the load characteristics, so a fully integrated IC solution is not possible. For that reason, current mode control is not implemented in the TLE 472x familly.

4. Implementation

As just described, fixed frequency peak-current control is used in the TLE 472x stepper motor driver family. As simplified schematic of the implementation is shown in figure 5.

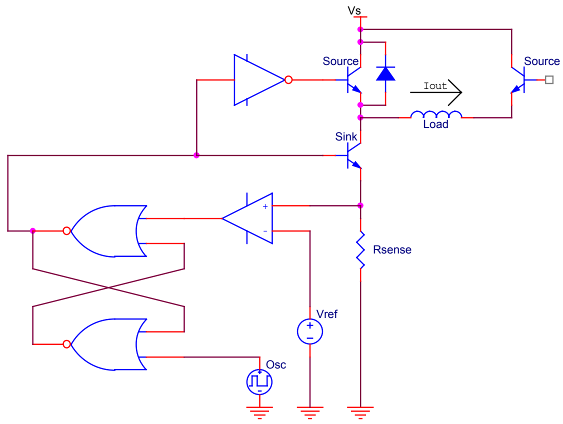


Figure 5: simplified schematic of current control implementation

The oscillator sets the NOR-latch output to high with the oscillator frequency fosc. By this, the sink-transistor is turned ON every period 1/f.

According to the input signals IXX, a reference voltage Vref is generated:

IX0	IX1	Symb.	min	typ	max	unit
H	L	Vch	40	70	100	mV
L	H	Vcs	410	450	510	mV
H	H	Vca	630	700	800	mV

This reference Voltage is compared to the drop across the sense resistor Rsense. As soon as Iout * Rsense equals Vref, the NOR-latch is set to low. This turns OFF the sink transistor, setting the H-bridge to freewheel (freewheel in source transistors).

This means that the desired output current is:

Itarget = Vref / Rsense

5. Accuracy Considerations

The accuracy of the actual output current value depends on the accuracy of :

- the internal comparator reference voltage Vref
- the external sense resistor
- the current ripple

5.1. Accuracy of Vref and Rsense

The accuracy of Vref is given in the datasheet and in above table. For Example, the Setpoint current has a nominal value of 450mV and a variation of –9% and +13%. As the output current depends linearly on Vref, the same accuracy has to be expected for the output current.

The same is true for the sense resistor. The accuracy of Rsense contributes linearly to the accuracy of Iout.

5.2. Current ripple

As explained earlier, the control method leads to an average current smaller that the desired current Itarget because the peak current is limited to Itarget. If DI is the current ripple, the average current is

Iout,mean = Itarget – DI/2

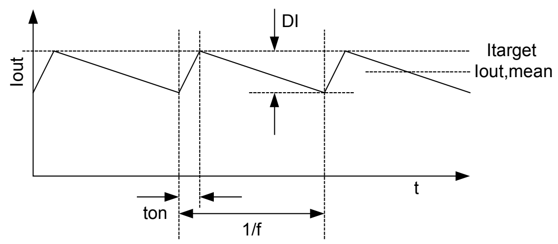
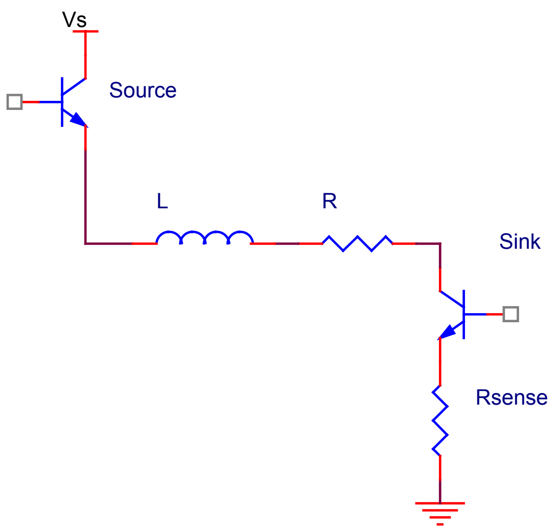


Figure 6: Current ripple, peak- and mean current

To determine, the current ripple, we have to calculate the voltage drop across the load inductivity.

5.2.1. (di/dt)charge

For the rising current slope (charging the inductivity), we have:



Vs = VsatuC + UL + R*Iout + Vsatl + Rsense*Iout.

The parameter we are interseted in is the current slew rate:

(di/dt)c = UL/L =
(Vs – VsatuC – Vsatl – Iout(R + Rsense))/L

Lets look at an example to carry out the calculation:

Vs = 12V
Rsense = 1.3Ohm
Iout = 315mA
R = 8Ohm
L = 4mH

From the datasheet, we have (using the values at Iout = 450mA):

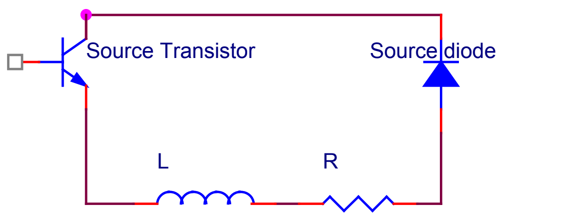
VsatuC = 1V
Vsatl = 0.3V

This leads to :

(di/dt)c = (12 – 1 - 0.3 – 2.92)V / 4mH =
1.95 A/ms

5.2.2. (di/dt)discharge

The same has now to be done for the falling current slope (discharging of the inductivity, frewheeling):



We have

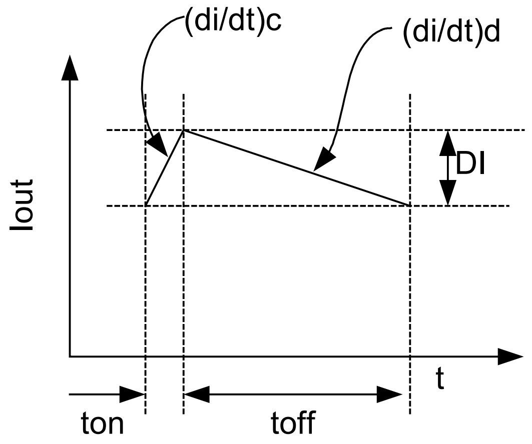
- UL = R*Iout + VFu + VsatuD,
(di/dt)d = (R*Iout + VFu + VsatuD) / L

For our example, this leads to:

(di/dt)d =
UL/L = - (2.52 + 1 + 0.3)V/4mH = **-0.96A/ms**

5.2.3. ton, toff and Ripple

Now, we can approximate toff and ton by making the approximation of constant di/dt:



ton + toff = 1/fosc,
(di/dt)c * ton = (di/dt)d * toff = DI

This leads to:

ton = (1/fosc) / [{(di/dt)c / (di/dt)d} + 1],
toff = 1/fosc – ton,
DI = (di/dt)c * ton

For our example with fosc = 25kHz, this leads to:

ton = 40µs / [{1.95 / 0.96} + 1] = **13.2µs**
toff = 40µs – ton = **26.8µs**

We see that the ON-time is much shorter than the OFF-time. The reason is that the (higher) supply-voltage is used to charge the coil, while during freewheeling only the (smaller) drops accross load resistance and power transistors contribute to the di/dt.

This finally gives us the current ripple:

DI = (di/dt)c * ton = **25.7mA**

6. Conclusion

The general method to control the output current that is used in the TLE 472x stepper motor driver family was explained. An approximative formula to determine the current ripple and thus the difference between mean output current and desired current is derived and carried out for a representative example

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