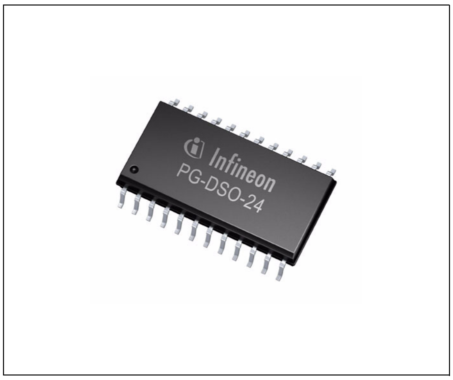
**2-Phase Stepper-Motor Driver** **TLE4726G**

## Bipolar IC

## Overview

### Features

- 2× 0.75 A / 50 V outputs
- Integrated driver, control logic and current control (chopper)
- Fast free-wheeling diodes
- Low standby-current drain
- Full, half, quarter, mini step




**PG-DSO-24-13**

| Type | Ordering Code | Package |
|---|---|---|
| TLE4726G | On Request | PG-DSO-24-13 |

### Description

TLE4726G is a bipolar, monolithic IC for driving bipolar stepper motors, DC motors and other inductive loads that operate on constant current. The control logic and power output stages for two bipolar windings are integrated on a single chip which permits switched current control of motors with 0.75 A per phase at operating voltages up to 50 V.

The direction and value of current are programmed for each phase via separate control inputs. A common oscillator generates the timing for the current control and turn-on with phase offset of the two output stages. The two output stages in a full-bridge configuration have integrated, fast free-wheeling diodes and are free of crossover current. The logic is supplied either separately with 5 V or taken from the motor supply voltage by way of a series resistor and an integrated Z-diode. The device can be driven directly by a microprocessor with the possibility of all modes from full step through half step to mini step.

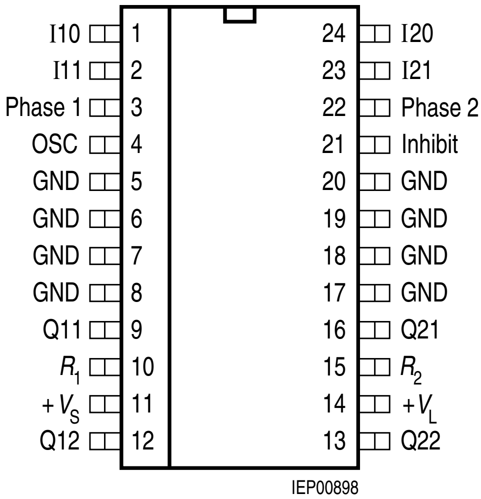



**Figure 1 Pin Configuration** (top view)

## Pin Definitions and Functions

| Pin No. | Function |
|---|---|
| 1, 2, 23, 24 | **Digital control inputs IX0, IX1** for the magnitude of the **current** of the particular phase.<br><br>**IX1** / **IX0** / **Phase Current** / **Example of Motor Status**:<br>H / H / 0 / No current<br>H / L / 1/3 $I_{max}$ / Hold<br>L / H / 2/3 $I_{max}$ / Set<br>L / L / $I_{max}$ / Accelerate<br><br>typical $I_{max}$ with $R_{sense}$ = 1 Ω: 750 mA |
| 3 | **Input Phase 1**; controls the current through phase winding 1. On H-potential the phase current flows from Q11 to Q12, on L-potential in the reverse direction. |
| 5, 6, 7, 8, 17, 18, 19, 20 | **Ground**; all pins are connected internally. |
| 4 | **Oscillator**; works at approx. 25 kHz if this pin is wired to ground across 2.2 nF. |
| 10 | **Resistor** $R_1$ for sensing the current in phase 1. |
| 9, 12 | **Push-pull outputs Q11, Q12** for phase 1 with integrated free-wheeling diodes. |
| 11 | **Supply voltage**; block to ground, as close as possible to the IC, with a stable electrolytic capacitor of at least 10 µF in parallel with a ceramic capacitor of 220 nF. |
| 14 | **Logic supply voltage**; either supply with 5 V or connect to + $V_S$ across a series resistor. A Z-diode of approx. 7 V is integrated. In both cases block to ground directly on the IC with a stable electrolytic capacitor of 10 µF in parallel with a ceramic capacitor of 100 nF. |
| 13, 16 | **Push-pull outputs Q22, Q21** for phase 2 with integrated free-wheeling diodes. |
| 15 | **Resistor** $R_2$ for sensing the current in phase 2. |
| 21 | **Inhibit input**; the IC can be put on standby by low potential on this pin. This reduces the current consumption substantially. |
| 22 | **Input phase 2**; controls the current flow through phase winding 2. On H-potential the phase current flows from Q21 to Q22, on L potential in the reverse direction. |

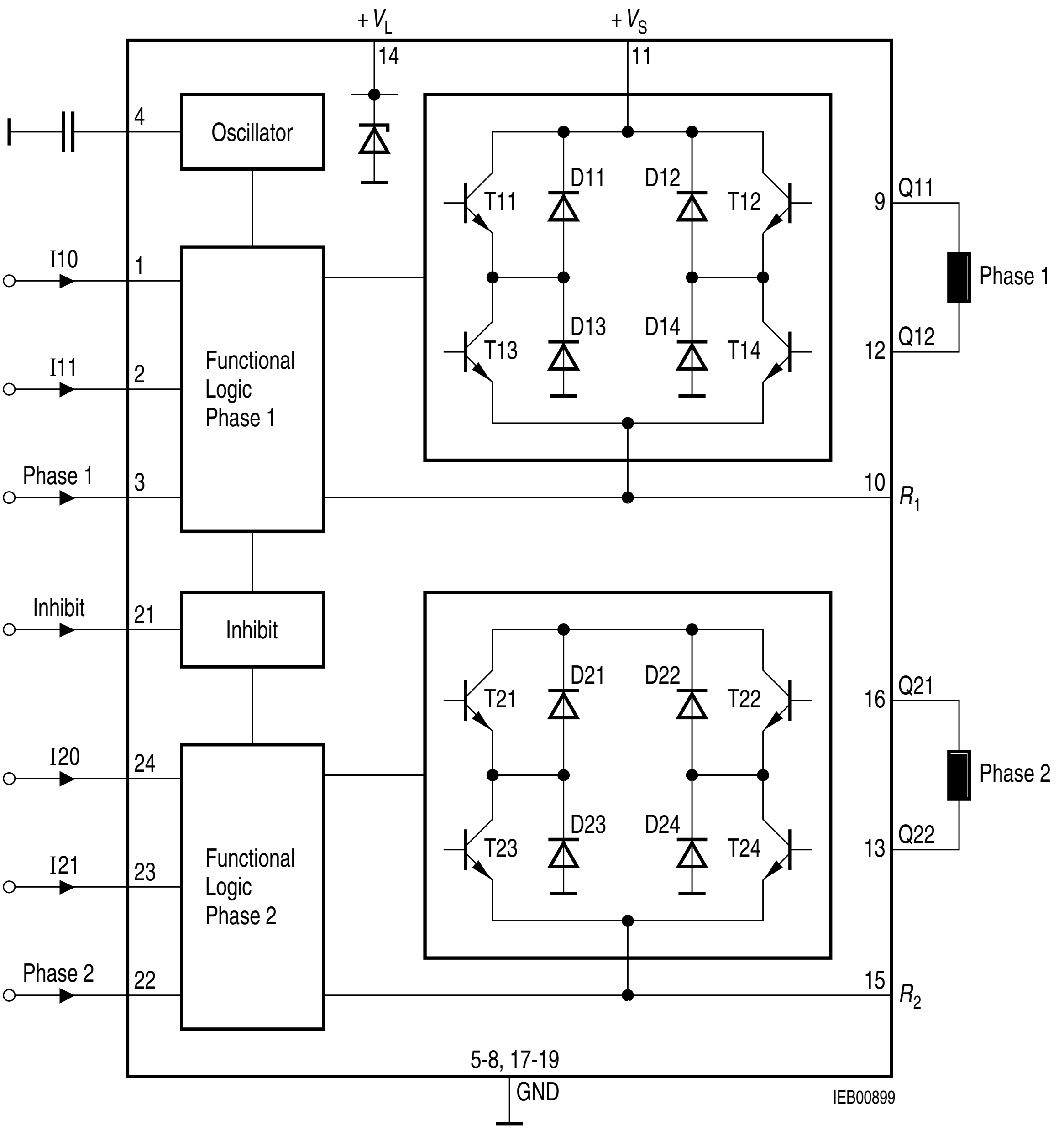



**Figure 2 Block Diagram**

### Absolute Maximum Ratings

$T_A$ = – 40 to 125 °C

| Parameter | Symbol | Limit Values | | Unit | Remarks |
|---|---|---|---|---|---|
| | | min. | max. | | |
| Supply voltage | $V_S$ | 0 | 52 | V | – |
| Logic supply voltage | $V_L$ | 0 | 6.5 | V | Z-diode |
| Z-current of $V_L$ | $I_L$ | – | 50 | mA | – |
| Output current | $I_Q$ | – 1 | 1 | A | – |
| Ground current | $I_{GND}$ | – 2 | 2 | A | – |
| Logic inputs | $V_{Ixx}$ | – 6 | $V_L$ + 0.3 | V | $I_{XX}$ ; Phase 1, 2; Inhibit |
| $R_1$, $R_2$, oscillator input voltage | $V_{RX}$, $V_{OSC}$ | – 0.3 | $V_L$ + 0.3 | V | – |
| Junction temperature | $T_j$<br>$T_j$ | –<br>– | 125<br>150 | °C<br>°C | –<br>max. 10,000 h |
| Storage temperature | $T_{stg}$ | – 50 | 125 | °C | – |

***Note:** Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## Operating Range

| Parameter | Symbol | Limit Values | | Unit | Remarks |
|---|---|---|---|---|---|
| | | min. | max. | | |
| Supply voltage | $V_S$ | 5 | 50 | V | – |
| Logic supply voltage | $V_L$ | 4.5 | 6.5 | V | without series resistor |
| Case temperature | $T_C$ | – 25 | 110 | °C | measured on pin 5 $P_{diss}$ = 2 W |
| Output current | $I_Q$ | – 800 | 800 | mA | – |
| Logic inputs | $V_{IXX}$ | – 5 | $V_L$ | V | $I_{XX}$ ; Phase 1, 2; Inhibit |

## Thermal Resistances

| | | | | | |
|---|---|---|---|---|---|
| Junction ambient | $R_{th\ ja}$ | – | 75 | K/W | PG-DSO-24-13 |
| Junction ambient (soldered on a 35 µm thick 20 cm² PC boar copper area) | $R_{th\ ja}$ | – | 50 | K/W | PG-DSO-24-13 |
| Junction case | $R_{th\ jc}$ | – | 15 | K/W | measured on pin 5 PG-DSO-24-13 |

*Note: In the operating range, the functions given in the circuit description are fulfilled.*

## Characteristics

$V_S$ = 40 V; $V_L$ = 5 V; – 25 °C ≤ $T_j$ ≤ 125 °C

| Parameter | Symbol | Limit Values | | | Unit | Test Condition |
|---|---|---|---|---|---|---|
| | | min. | typ. | max. | | |
| **Current Consumption** | | | | | | |
| from + $V_S$ | $I_S$ | – | 0.2 | 0.5 | mA | $V_{inh}$ = L |
| from + $V_S$ | $I_S$ | – | 16 | 20 | mA | $V_{inh}$ = H $I_{Q1/2}$ = 0, $I_{XX\ =\ L}$ |
| from + $V_L$ | $I_L$ | – | 1.7 | 3 | mA | $V_{inh}$ = L |
| from + $V_L$ | $I_L$ | – | 18 | 25 | mA | $V_{inh}$ = H $I_{Q1/2}$ = 0, $I_{XX\ =\ L}$ |

**Characteristics** (cont'd)
$V_S$ = 40 V; $V_L$ = 5 V; – 25 °C ≤ $T_j$ ≤ 125 °C

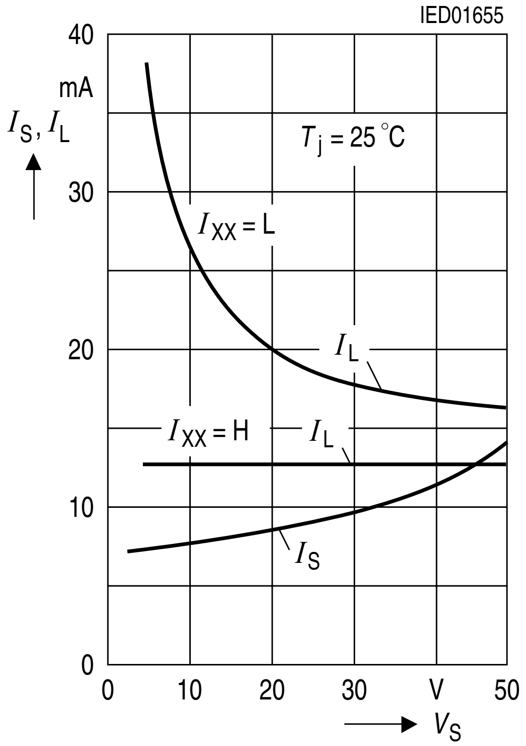
| Parameter | Symbol | Limit Values | | | Unit | Test Condition |
|---|---|---|---|---|---|---|
| | | min. | typ. | max. | | |
| **Oscillator** | | | | | | |
| Output charging current | $I_{OSC}$ | – | 110 | – | µA | – |
| Charging threshold | $V_{OSCL}$ | – | 1.3 | – | V | – |
| Discharging threshold | $V_{OSCH}$ | – | 2.3 | – | V | – |
| Frequency | $f_{OSC}$ | 18 | 25 | 40 | kHz | $C_{OSC}$ = 2.2 nF |
| **Phase Current Selection**<br>**Current Limit Threshold** | | | | | | |
| No current | $V_{sense\ n}$ | – | 0 | – | mV | IX0 = H; IX1 = H |
| Hold | $V_{sense\ h}$ | 200 | 250 | 300 | mV | IX0 = L; IX1 = H |
| Setpoint | $V_{sense\ s}$ | 420 | 540 | 680 | mV | IX0 = H; IX1 = L |
| Accelerate | $V_{sense\ a}$ | 700 | 825 | 950 | mV | IX0 = L; IX1 = L |
| **Logic Inputs**<br>**($I_{X1}$ ; $I_{X0}$ ; Phase x)** | | | | | | |
| Threshold | $V_I$ | 1.4 (H→L) | – | 2.3 (L→H) | V | – |
| L-input current | $I_{IL}$ | – 10 | – | – | µA | $V_I$ = 1.4 V |
| L-input current | $I_{IL}$ | – 100 | – | – | µA | $V_I$ = 0 V |
| H-input current | $I_{IH}$ | – | – | 10 | µA | $V_I$ = 5 V |
| **Standby Cutout (inhibit)** | | | | | | |
| Threshold | $V_{Inh}$ (L→H) | 2 | 3 | 4 | V | – |
| Threshold | $V_{Inh}$ (H→L) | 1.7 | 2.3 | 2.9 | V | – |
| Hysteresis | $V_{Inhhy}$ | 0.3 | 0.7 | 1.1 | V | – |
| **Internal Z-Diode** | | | | | | |
| Z-voltage | $V_{LZ}$ | 6.5 | 7.4 | 8.2 | V | $I_L$ = 50 mA |

**Characteristics** (cont'd)
$V_S$ = 40 V; $V_L$ = 5 V; – 25 °C ≤ $T_j$ ≤ 125 °C

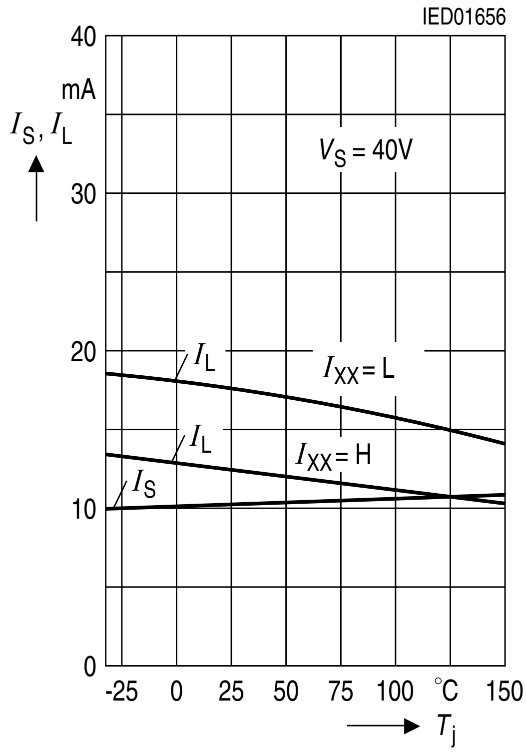
| Parameter | Symbol | Limit Values | | | Unit | Test Condition |
|---|---|---|---|---|---|---|
| | | min. | typ. | max. | | |
| **Power Outputs** | | | | | | |
| **Diode Transistor Sink Pair (D13, T13; D14, T14; D23, T23; D24, T24)** | | | | | | |
| Saturation voltage | $V_{satl}$ | – | 0.3 | 0.6 | V | $I_Q$ = – 0.5 A |
| Saturation voltage | $V_{satl}$ | – | 0.5 | 1 | V | $I_Q$ = – 0.75 A |
| Reverse current | $I_{Rl}$ | – | – | 300 | µA | $V_Q$ = 40 V |
| Forward voltage | $V_{Fl}$ | – | 0.9 | 1.3 | V | $I_Q$ = 0.5 A |
| Forward voltage | $V_{Fl}$ | – | 1 | 1.4 | V | $I_Q$ = 0.75 A |
| **Diode Transistor Source Pair (D11, T11; D12, T12; D21, T21; D22, T22)** | | | | | | |
| Saturation voltage | $V_{satuC}$ | – | 0.9 | 1.2 | V | $I_Q$ = 0.5 A; charge |
| Saturation voltage | $V_{satuD}$ | – | 0.3 | 0.7 | V | $I_Q$ = 0.5 A; discharge |
| Saturation voltage | $V_{satuC}$ | – | 1.1 | 1.4 | V | $I_Q$ = 0.75 A; charge |
| Saturation voltage | $V_{satuD}$ | – | 0.5 | 1 | V | $I_Q$ = 0.75 A; discharge |
| Reverse current | $I_{Ru}$ | – | – | 300 | µA | $V_Q$ = 0 V |
| Forward voltage | $V_{Fu}$ | – | 1 | 1.3 | V | $I_Q$ = – 0.5 A |
| Forward voltage | $V_{Fu}$ | – | 1.1 | 1.4 | V | $I_Q$ = – 0.75 A |
| Diode leakage current | $I_{SL}$ | – | 1 | 2 | mA | $I_F$ = – 0.75 A |

*Note: The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at $T_A$ = 25 °C and the given supply voltage.*

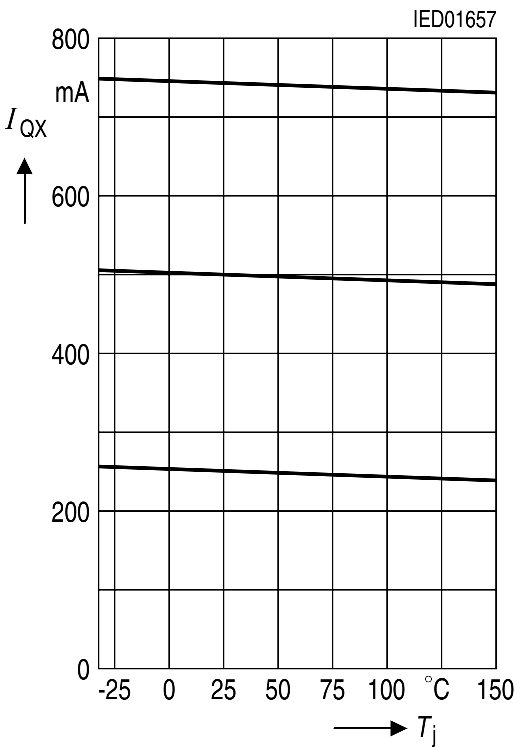
## Quiescent Current $I_S$, $I_L$ versus Supply Voltage $V_S$




## Quiescent Current $I_S$, $I_L$ versus Junction Temperature $T_j$



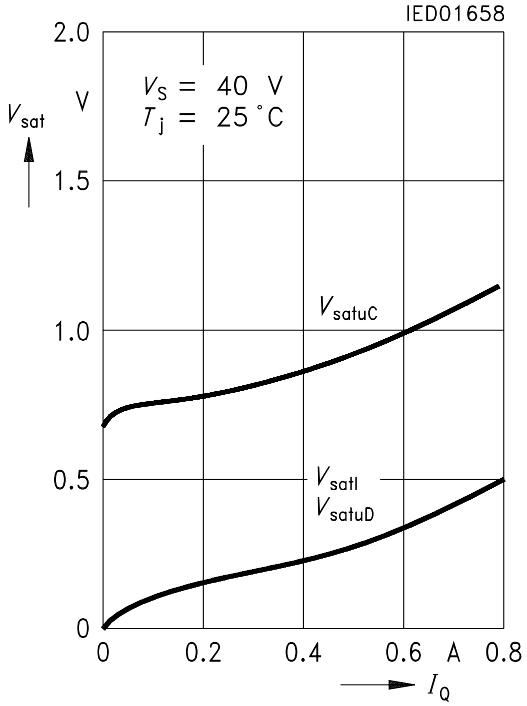

## Output Current $I_{QX}$ versus Junction Temperature $T_j$



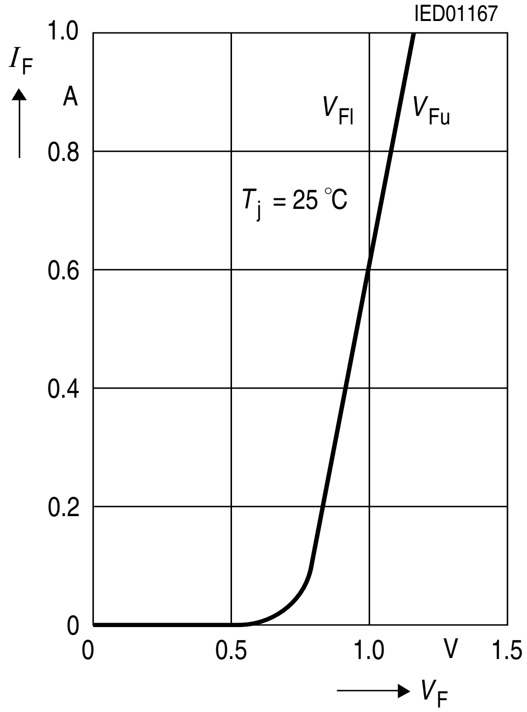

## Operating Condition:

$V_L$ = 5 V
$V_{Inh}$ = H
$C_{OSC}$ = 2.2 nF
$R_{sense}$ = 1 Ω
Load: L = 10 mH
$R$ = 2.4 Ω
$f_{phase}$ = 50 Hz
mode: fullstep

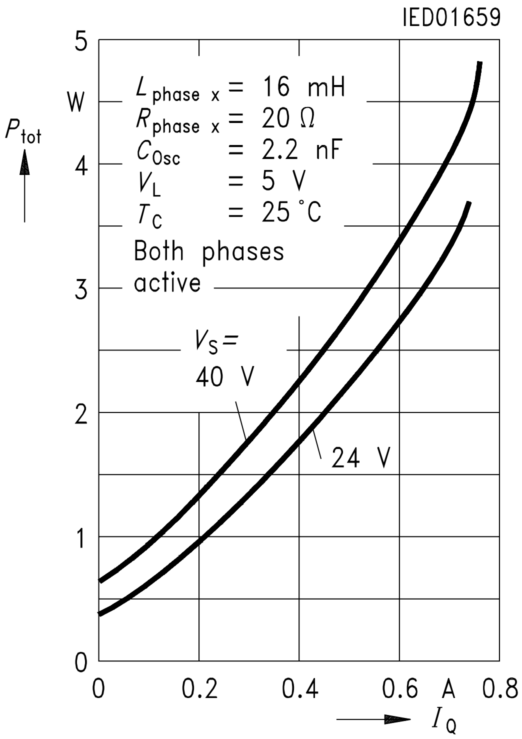
### Output Saturation Voltages $V_{sat}$ versus Output Current $I_Q$



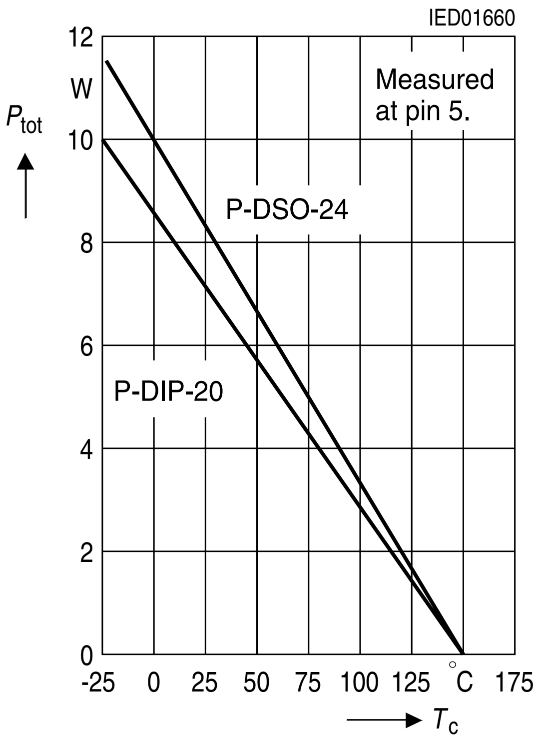

### Forward Current $I_F$ of Free-Wheeling Diodes versus Forward Voltages $V_F$



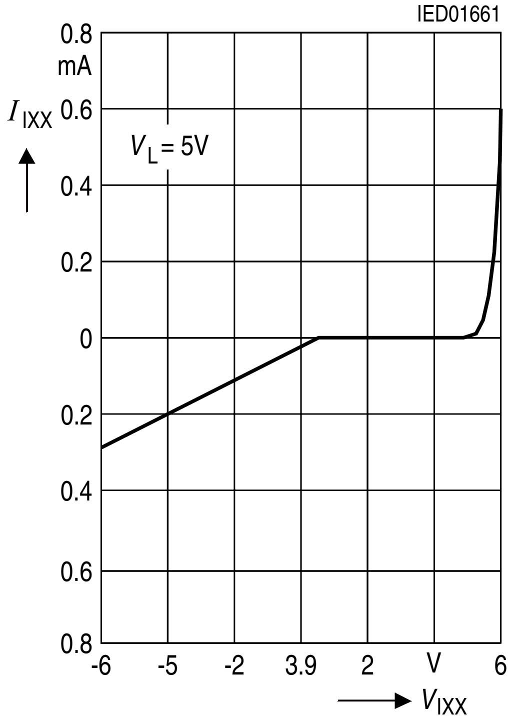

### Typical Power Dissipation $P_{tot}$ versus Output Current $I_Q$ (Non Stepping)



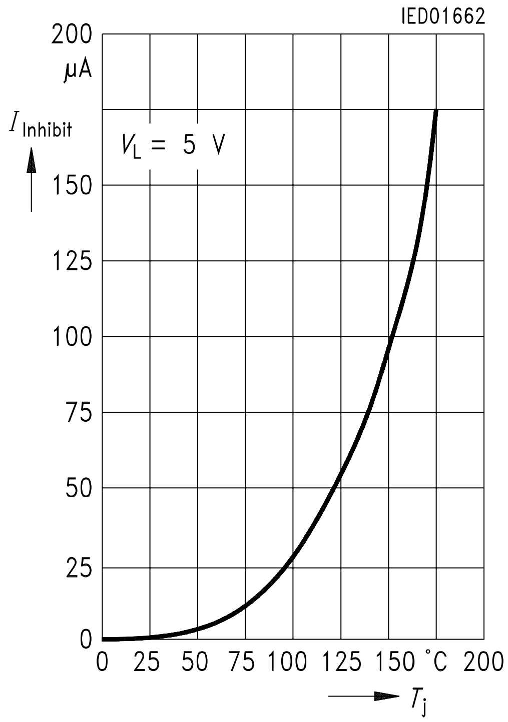

### Permissible Power Dissipation $P_{tot}$ versus Case Temperature $T_C$



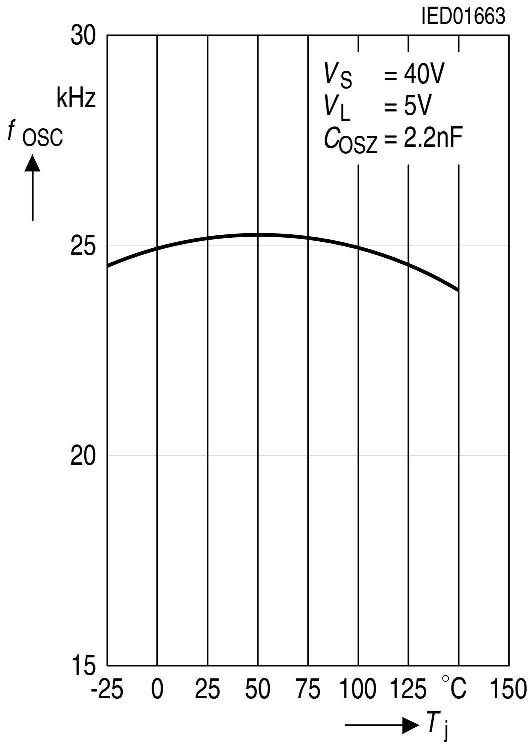
## Input Characteristics of $I_{xx}$, Phase X, Inhibit




## Input Current of Inhibit versus Junction Temperature $T_j$




## Oscillator Frequency $f_{OSC}$ versus Junction Temperature $T_j$



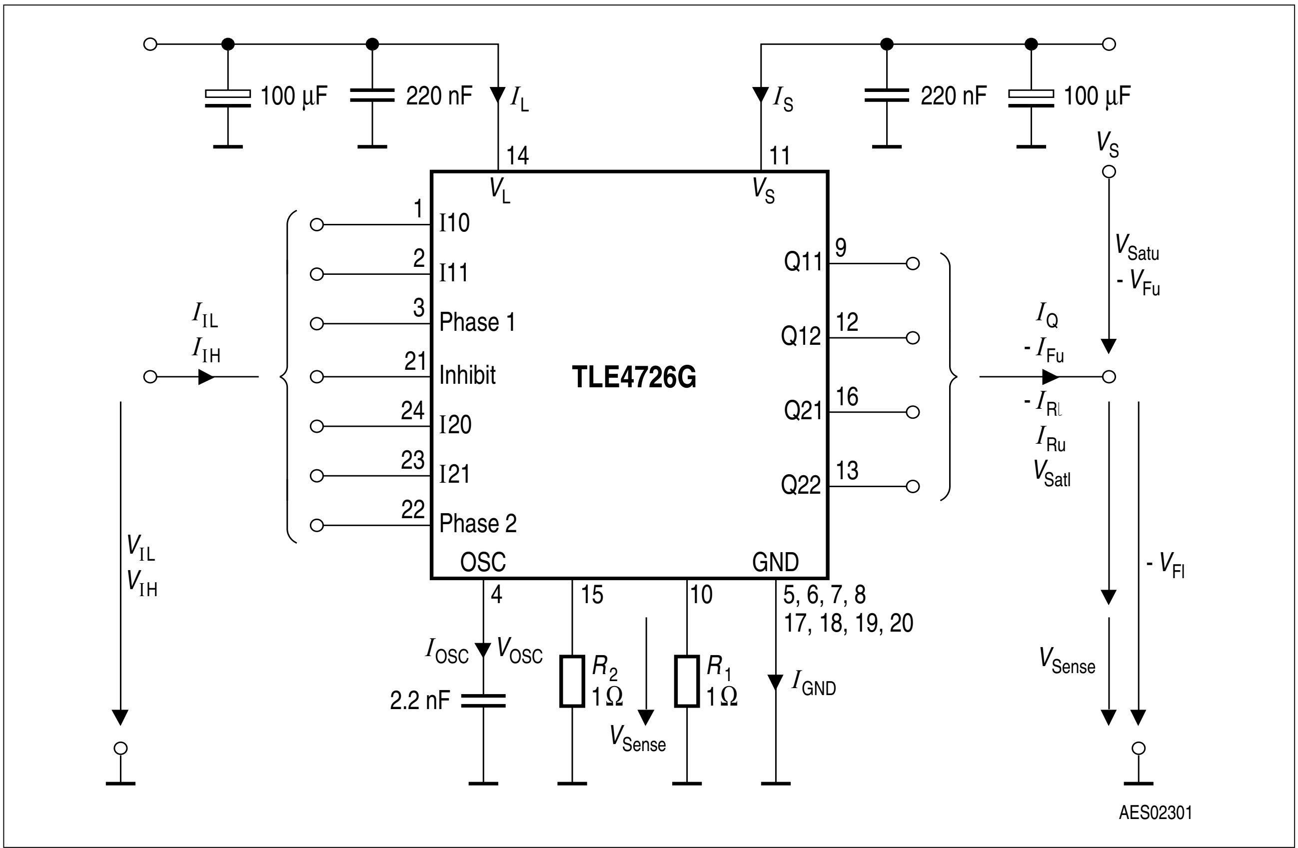



**Figure 3 Test Circuit**

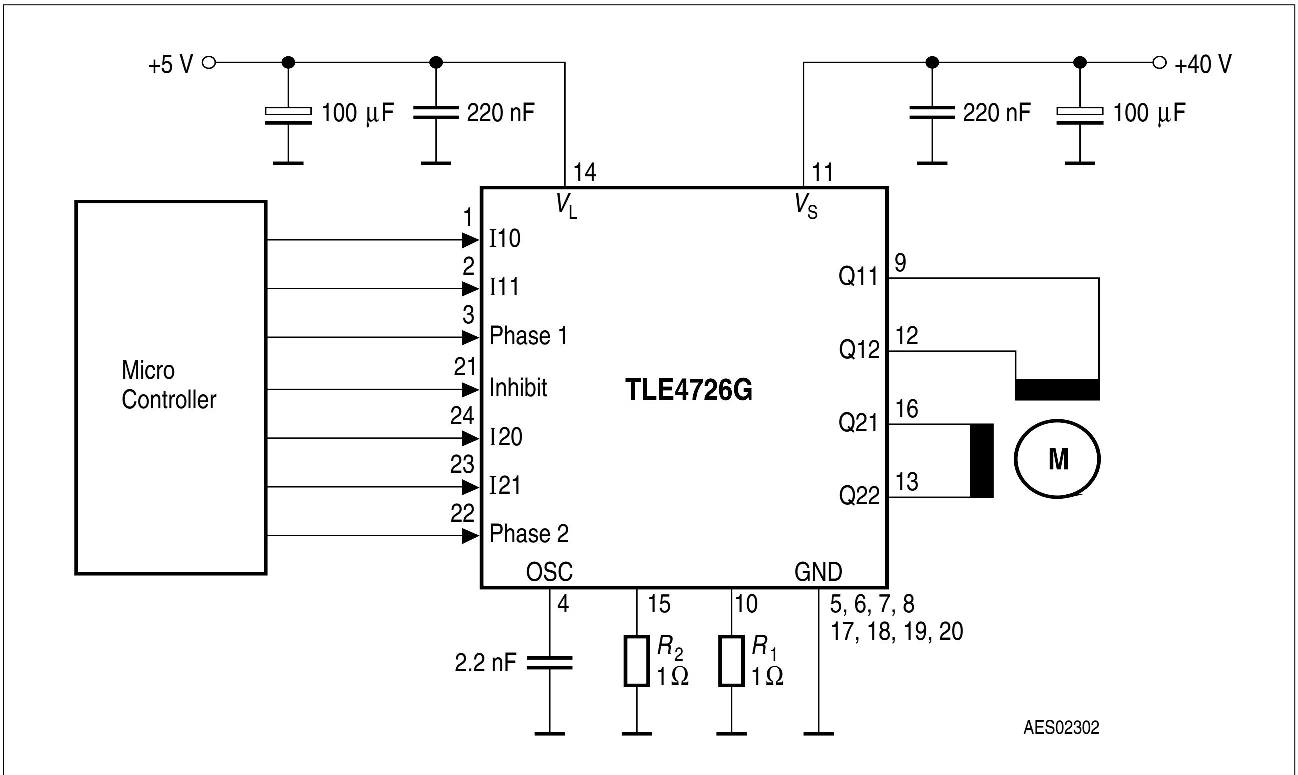



**Figure 4 Application Circuit**

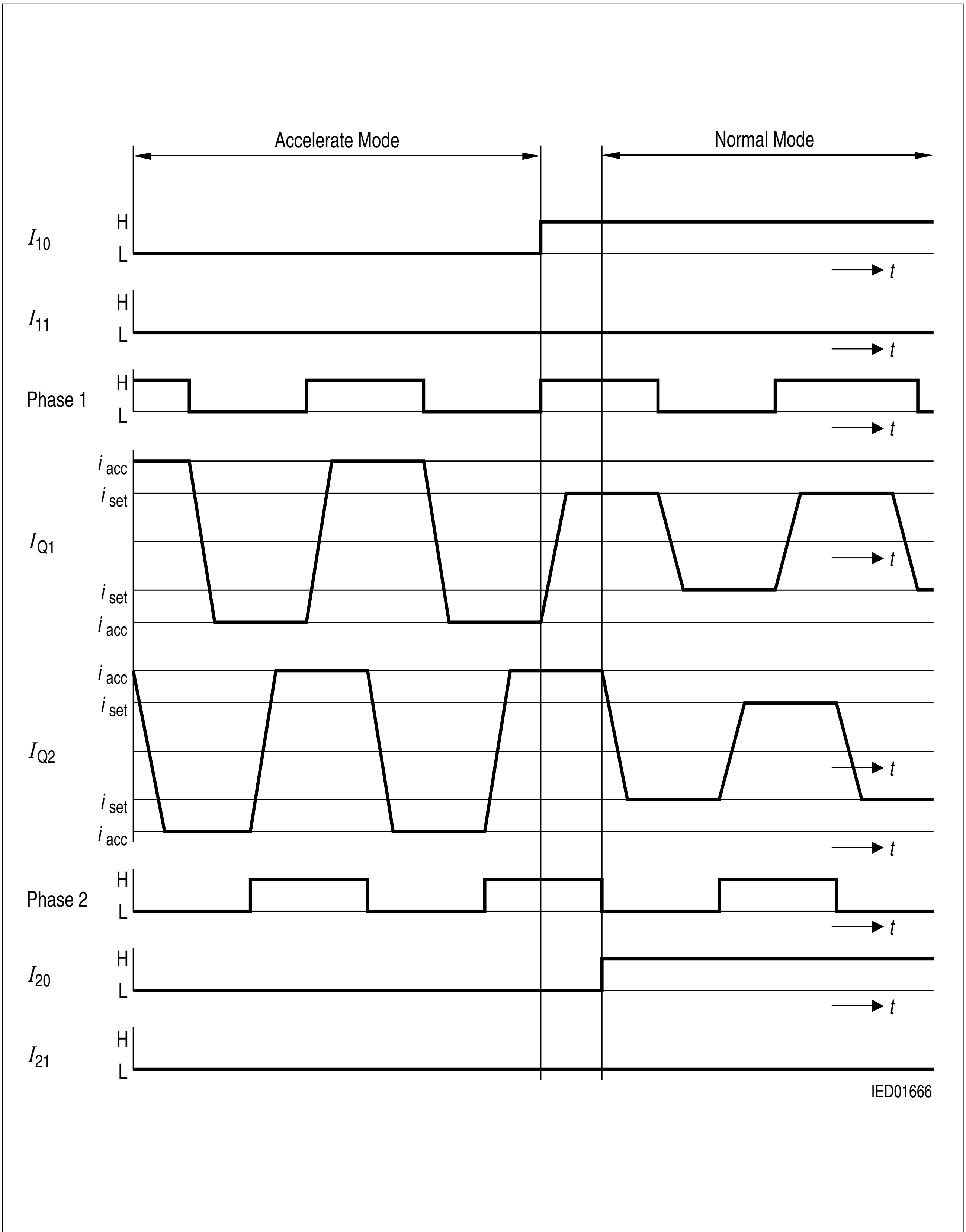



**Figure 5 Full-Step Operation**

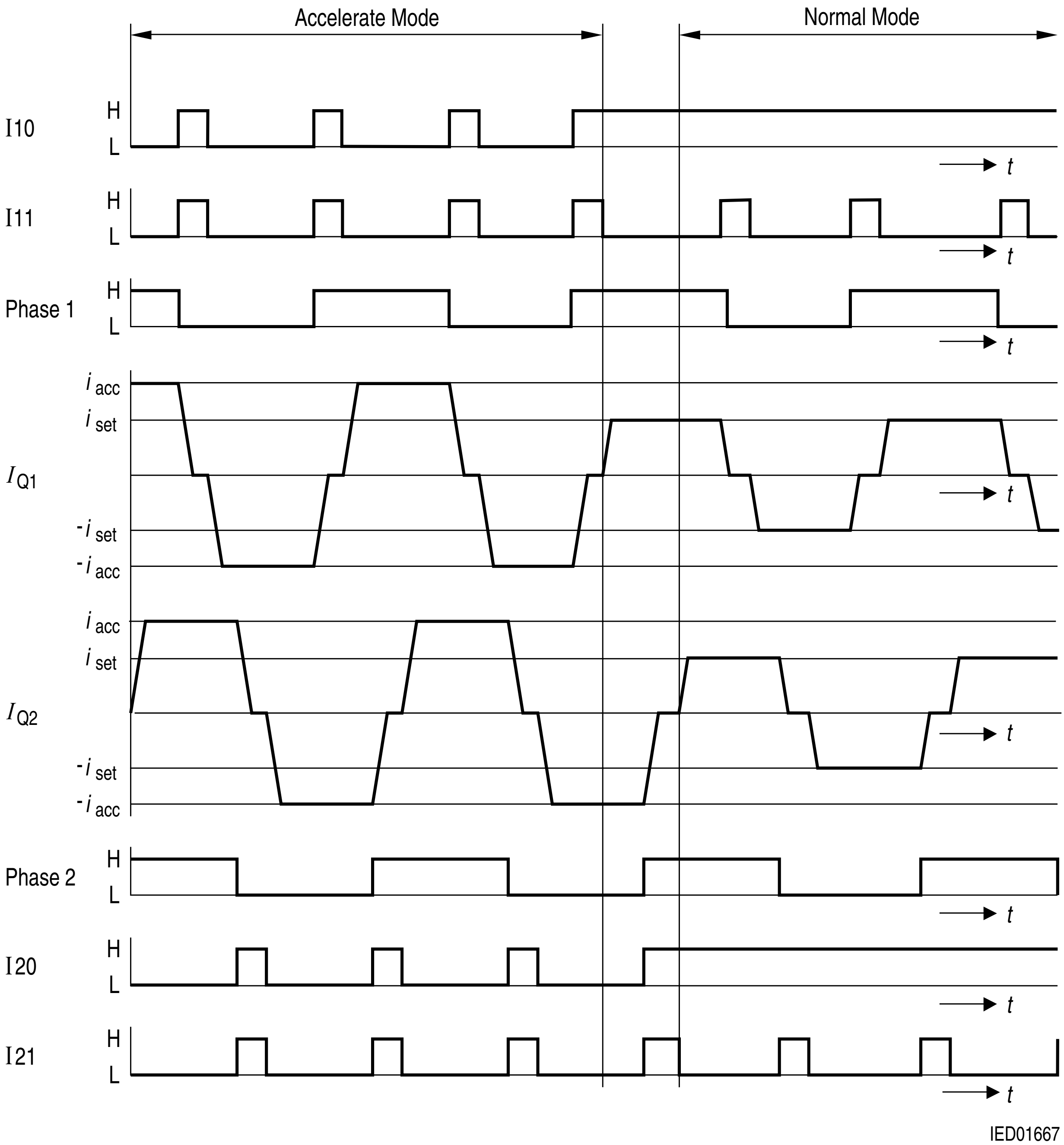



**Figure 6 Half-Step Operation**

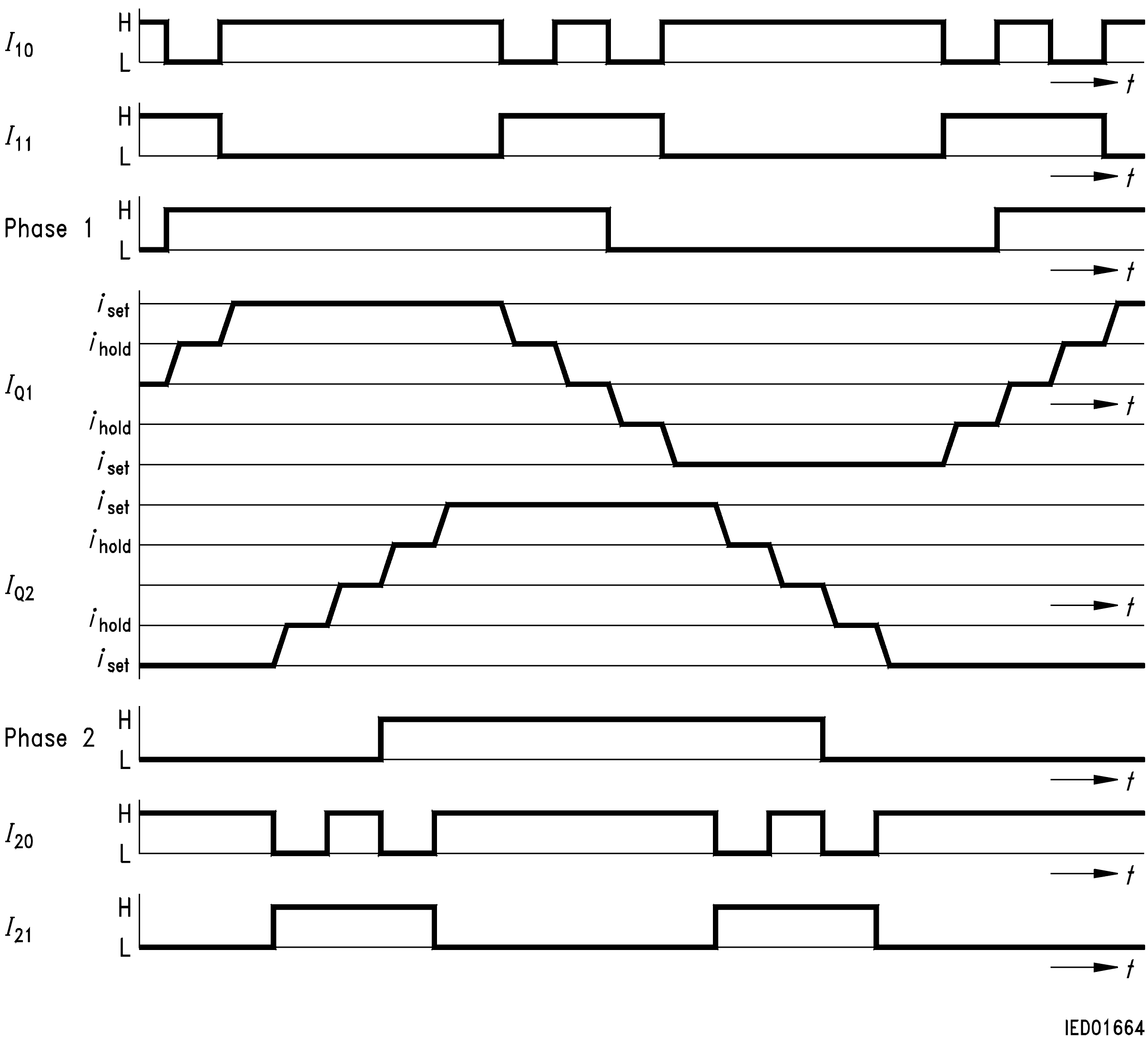



**Figure 7 Quarter-Step Operation**

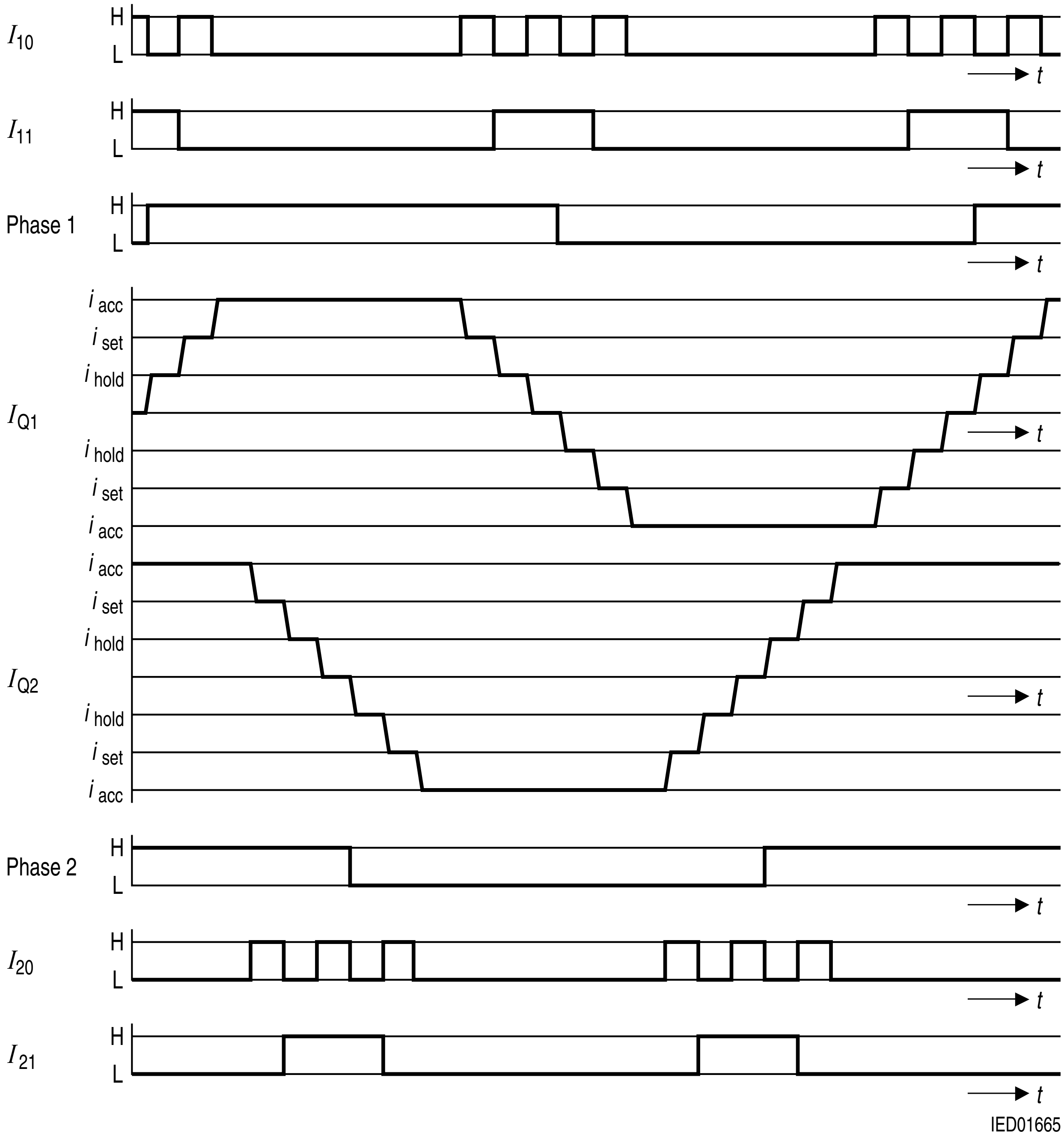
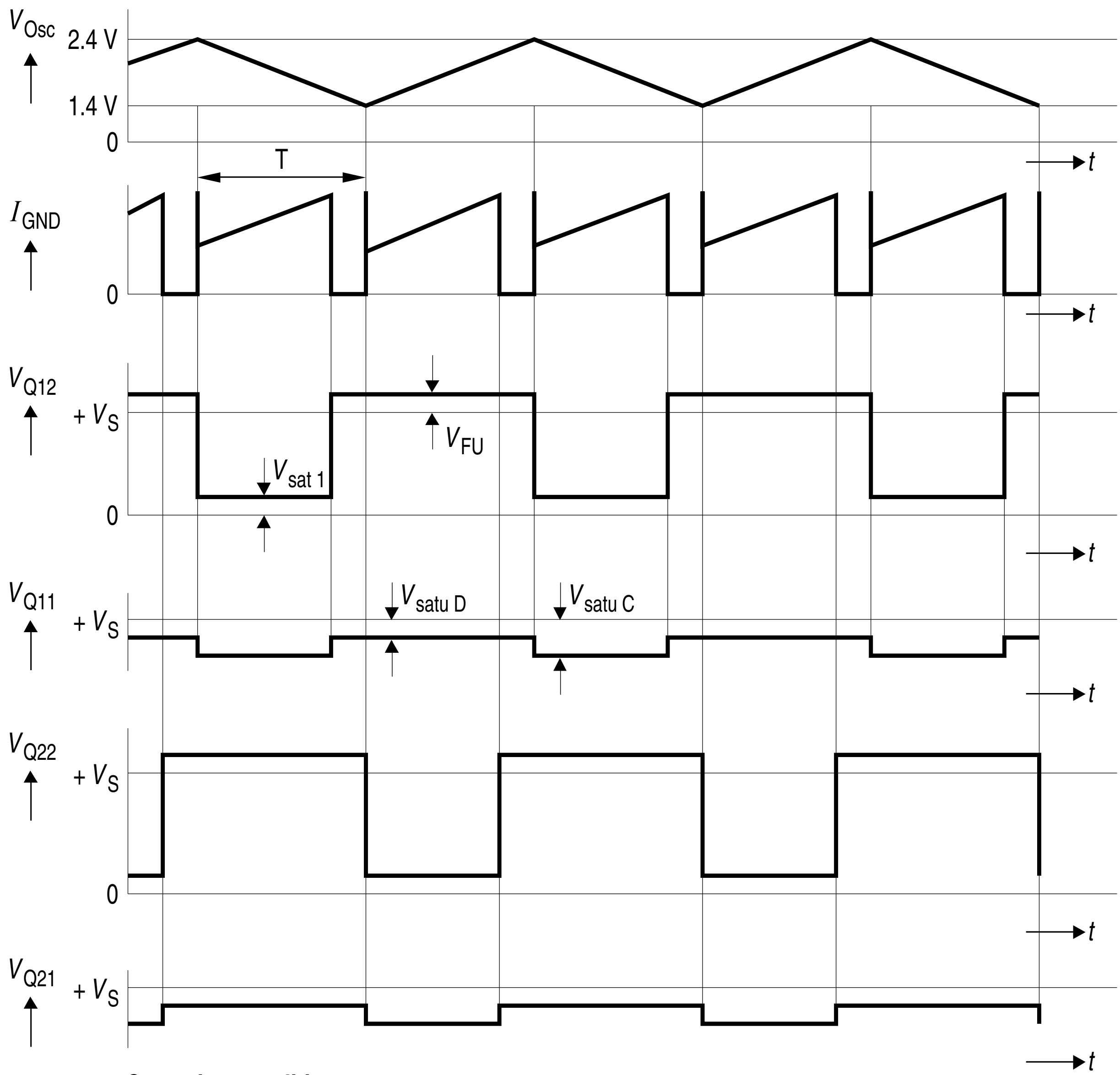



**Figure 8 Mini-Step Operation**




**Operating conditions:**

$V_S$ = 40 V
$V_L$ = 5 V
$L_{phase\ x}$ = 10 mH
$R_{phase\ x}$ = 20 Ω
$V_{phase\ x}$ = H
$V_{Inhibit}$ = H
$V_{xx}$ = L

IED01177

**Figure 9 Current Control**

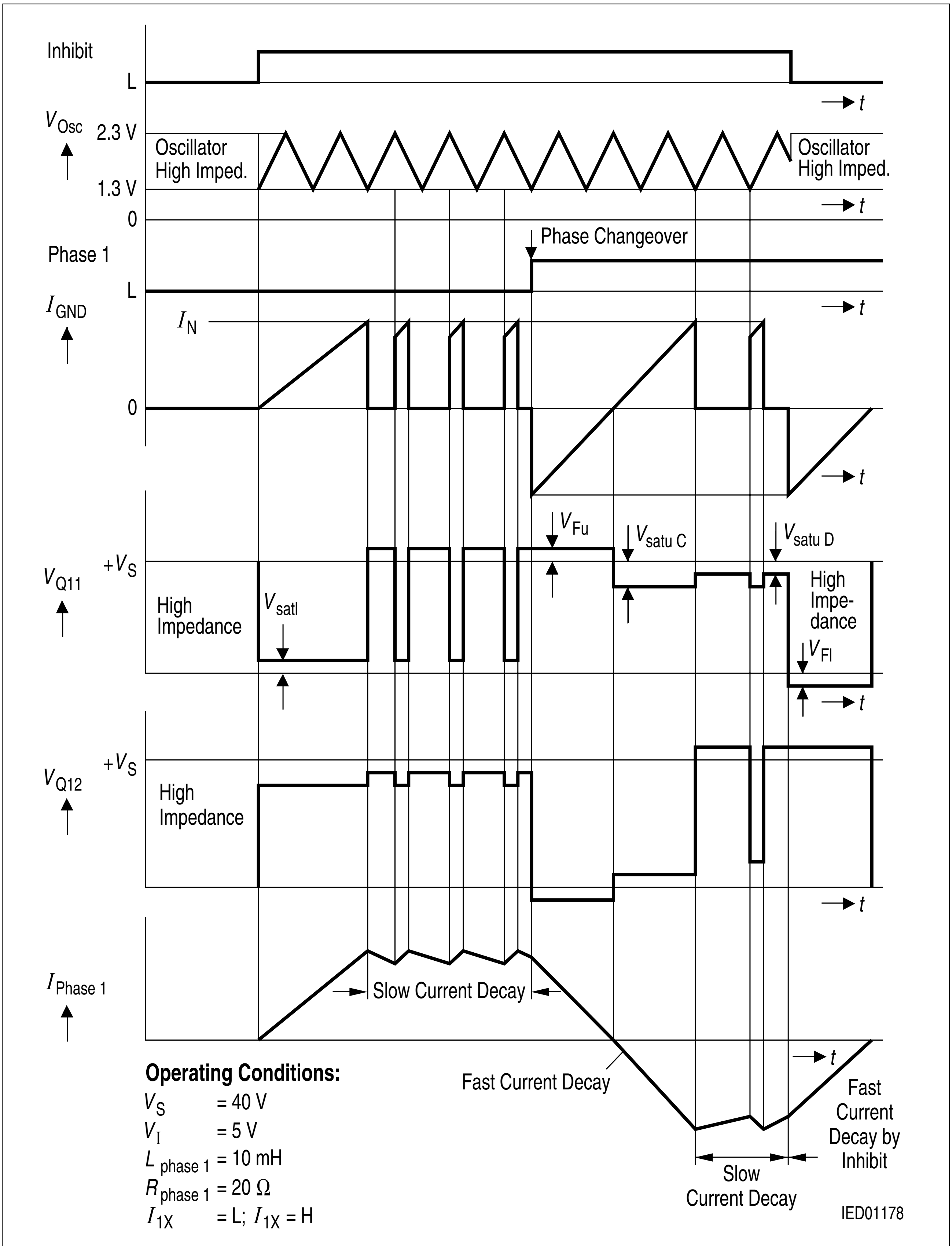



**Figure 10 Phase Reversal and Inhibit**

## Calculation of Power Dissipation

The total power dissipation $P_{tot}$ is made up of

**saturation losses** $P_{sat}$ (transistor saturation voltage and diode forward voltages),
**quiescent losses** $P_q$ (quiescent current times supply voltage) and
**switching losses** $P_s$ (turn-ON / turn-OFF operations).

The following equations give the power dissipation for chopper operation without phase reversal. This is the worst case, because full current flows for the entire time and switching losses occur in addition.

$$P_{tot} = 2 \times P_{sat} + P_q + 2 \times P_s$$

where

$$P_{sat} \cong I_N \{ V_{satl} \times d + V_{Fu} (1 - d) + V_{satuC} \times d + V_{satuD} (1 - d) \}$$

$$P_q = I_q \times V_S + I_L \times V_L$$

$$P_S \cong \frac{V_S}{T} \left\{ \frac{i_D \times t_{DON}}{2} + \frac{i_D + i_R \times t_{ON}}{4} + \frac{I_N}{2} t_{DOFF} + t_{OFF} \right\}$$

$I_N$ = nominal current (mean value)
$I_q$ = quiescent current
$i_D$ = reverse current during turn-on delay
$i_R$ = peak reverse current
$t_p$ = conducting time of chopper transistor
$t_{ON}$ = turn-ON time
$t_{OFF}$ = turn-OFF time
$t_{DON}$ = turn-ON delay
$t_{DOFF}$ = turn-OFF delay
$T$ = cycle duration
$d$ = duty cycle $t_p/T$
$V_{satl}$ = saturation voltage of sink transistor (T3, T4)
$V_{satuC}$ = saturation voltage of source transistor (T1, T2) during charge cycle
$V_{satuD}$ = saturation voltage of source transistor (T1, T2) during discharge cycle
$V_{Fu}$ = forward voltage of free-wheeling diode (D1, D2)
$V_S$ = supply voltage
$V_L$ = logic supply voltage
$I_L$ = current from logic supply

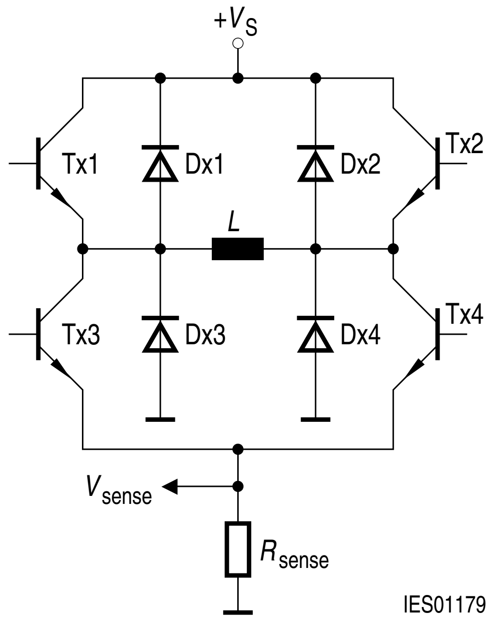



**Figure 11**

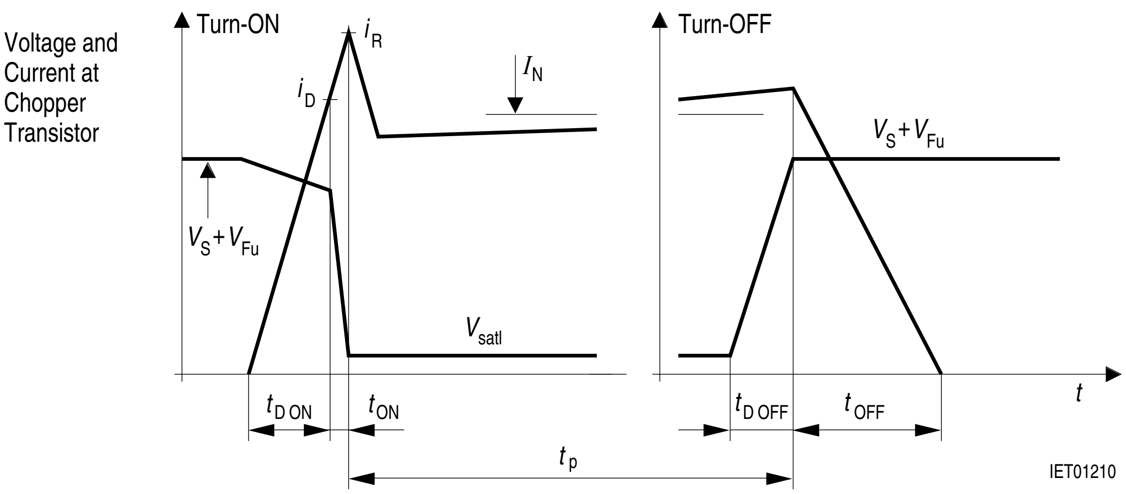



**Figure 12**

## Application Hints

The TLE726G is intended to drive both phases of a stepper motor. Special care has been taken to provide high efficiency, robustness and to minimize external components.

## Power Supply

The TLE726G will work with supply voltages ranging from 5 V to 50 V at pin $V_S$. As the circuit operates with chopper regulation of the current, interference generation problems can arise in some applications. Therefore the power supply should be decoupled by a 0.22 µF ceramic capacitor located near the package. Unstabilized supplies may even afford higher capacities.

## Current Sensing

The current in the windings of the stepper motor is sensed by the voltage drop across $R_1$ and $R_2$. Depending on the selected current internal comparators will turn off the sink transistor as soon as the voltage drop reaches certain thresholds (typical 0 V, 0.25 V, 0.5 V and 0.75 V); ($R_1$ , $R_2$ = 1 Ω). These thresholds are neither affected by variations of $V_L$ nor by variations of $V_S$ .

Due to chopper control fast current rises (up to 10 A/µs) will occur at the sensing resistors $R_1$ and $R_2$ . To prevent malfunction of the current sensing mechanism $R_1$ and $R_2$ should be pure ohmic. The resistors should be wired to GND as directly as possible. Capacitive loads such as long cables (with high wire to wire capacity) to the motor should be avoided for the same reason.

## Synchronizing Several Choppers

In some applications synchrone chopping of several stepper motor drivers may be desireable to reduce acoustic interference. This can be done by forcing the oscillator of the TLE726G by a pulse generator overdriving the oscillator loading currents (approximately ± 100 µA). In these applications low level should be between 0 V and 1 V while high level should be between 2.6 V and $V_L$ .

## Optimizing Noise Immunity

Unused inputs should always be wired to proper voltage levels in order to obtain highest possible noise immunity.

To prevent crossconduction of the output stages the TLE4726G uses a special break before make timing of the power transistors. This timing circuit can be triggered by short glitches (some hundred nanoseconds) at the Phase inputs causing the output stage to become high resistive during some microseconds. This will lead to a fast current decay during that time. To achieve maximum current accuracy such glitches at the Phase inputs should be avoided by proper control signals.

**Thermal Shut Down**

To protect the circuit against thermal destruction, thermal shut down has been implemented. To provide a warning in critical applications, the current of the sensing element is wired to input Inhibit. Before thermal shut down occurs Inhibit will start to pull down by some hundred microamperes. This current can be sensed to build a temperature prealarm.

# 1 Package Outlines

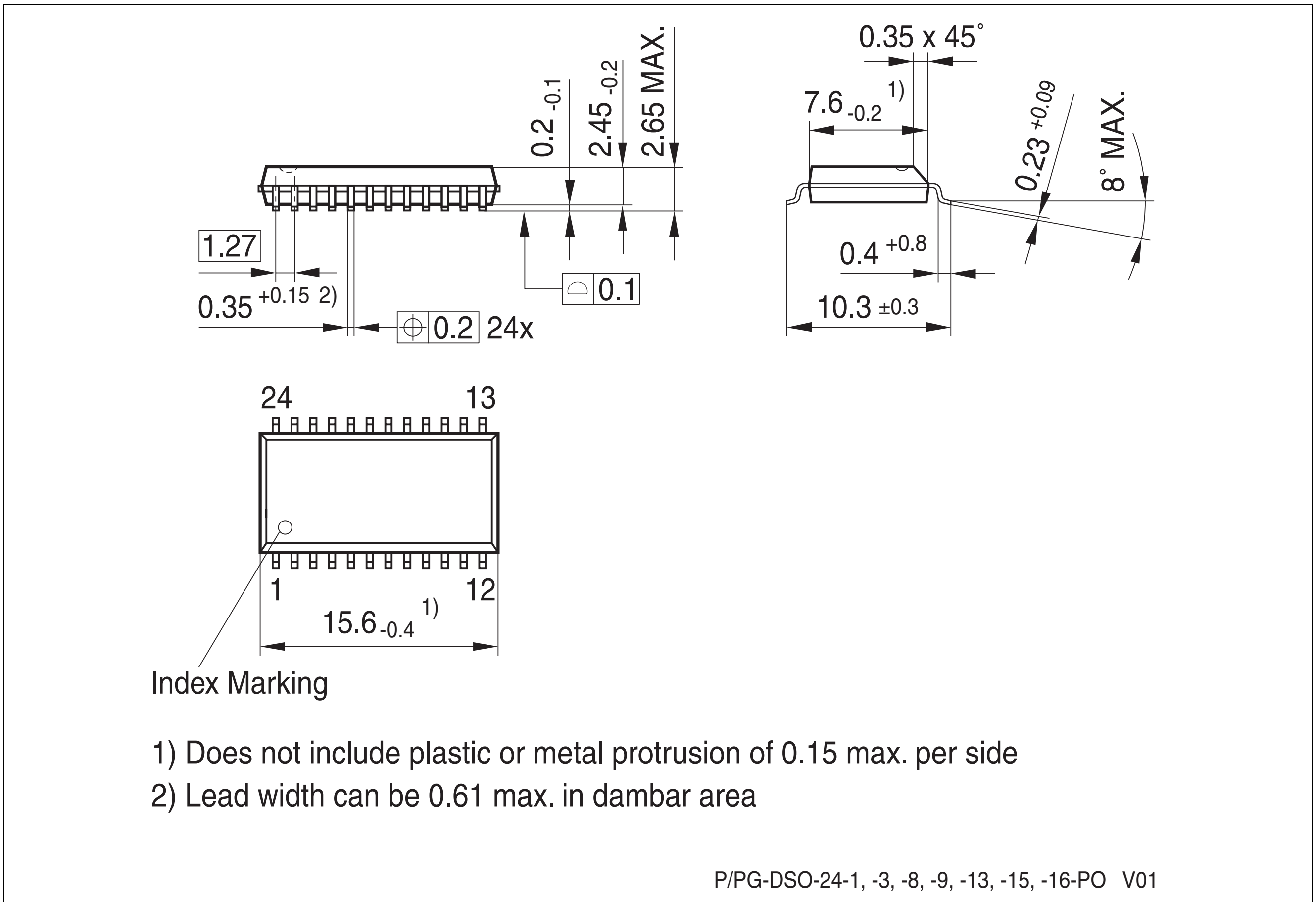



**Figure 1 PG-DSO-24-13**

**Green Product (RoHS compliant)**

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

For further information on alternative packages, please visit our website:
**http://www.infineon.com/packages**.

Dimensions in mm

## 2 Revision History

| Revision | Date | Changes |
|---|---|---|
| 1.1 | 2008-06-17 | Initial version of RoHS-compliant derivate of TLE4726<br>Page 1: AEC certified statement added<br>Page 1 and 23: added RoHS compliance statement and Green product feature<br>Page 1 and 23: Package changed to RoHS compliant version<br>Page 24-25: added Revision History, updated Legal Disclaimer |

**Edition 2008-01-04**

**Published by**
**Infineon Technologies AG**
**81726 Munich, Germany**



**Legal Disclaimer**

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics. With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation, warranties of non-infringement of intellectual property rights of any third party.

**Information**

For further information on technology, delivery terms and conditions and prices, please contact the nearest Infineon Technologies Office (**www.infineon.com**).

**Warnings**

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office.

Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

单击下面可查看定价，库存，交付和生命周期等信息

[>>Infineon(英飞凌)]