BTN7030-1EPA PWM Capabilities Application Note

Title continued

About this document

Scope and purpose

This document compiles application hints for the application of the BTN7030-1EPA, the NovalithIC™ Lite. This document must be used in conjunction with the device datasheets.

Intended audience

Developers, working with the BTN7030-1EPA.

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1 Introduction

The NovalithIC™ Lite is part of an integrated half-bridge family, suitable for driving DC motors and solenoids.

The device is a monolithic chip integrated in SMART7 technology. BTN7030-1EPA is a protected half-bridge with integrated driver, providing protection and diagnosis functions. The high side power stage is built using a N-channel vertical power MOSFET with charge pump, while the low side power stage uses no charge pump. It has an exposed pad which ensures better cooling.

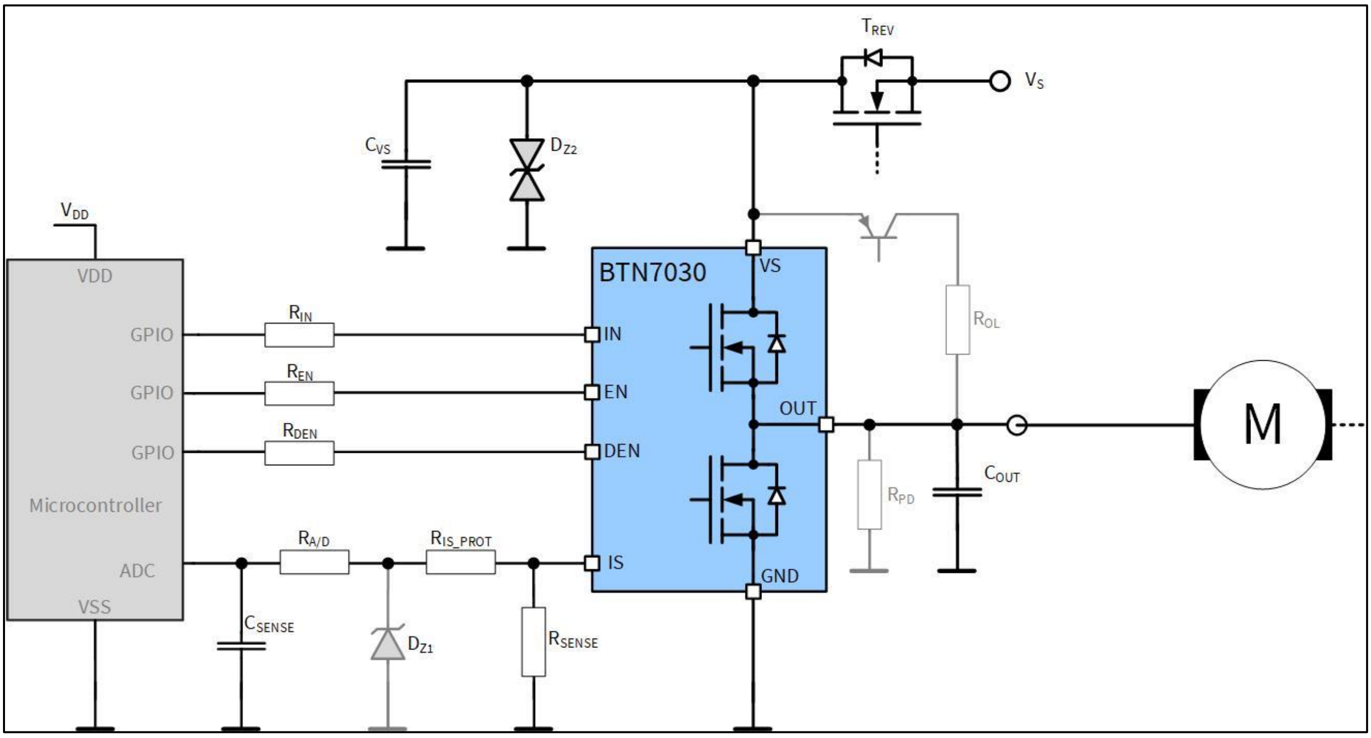

Figure 1 Application diagram

2 PWM capabilities

One of the most important topics when it comes to driving a load with a PWM signal is making sure the device is providing high performance while staying in optimal operational range. In other words this chapter will give a detailed explanation of how to calculate a duty cycle linear range when using BTN7030-1EPA device.

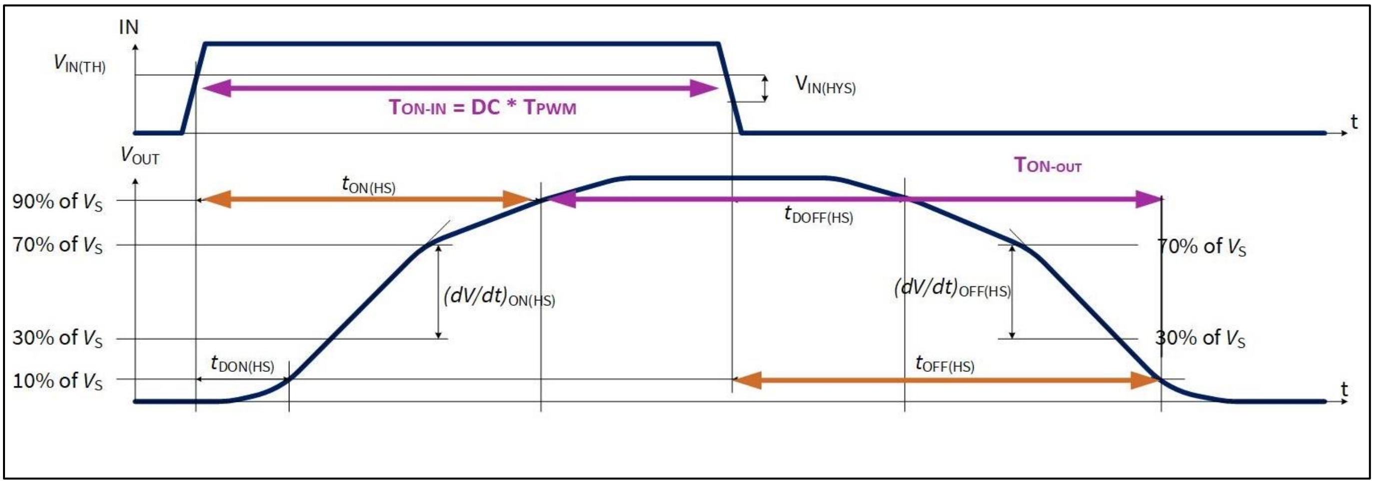

Figure 2 Switching time when load is connected to GND

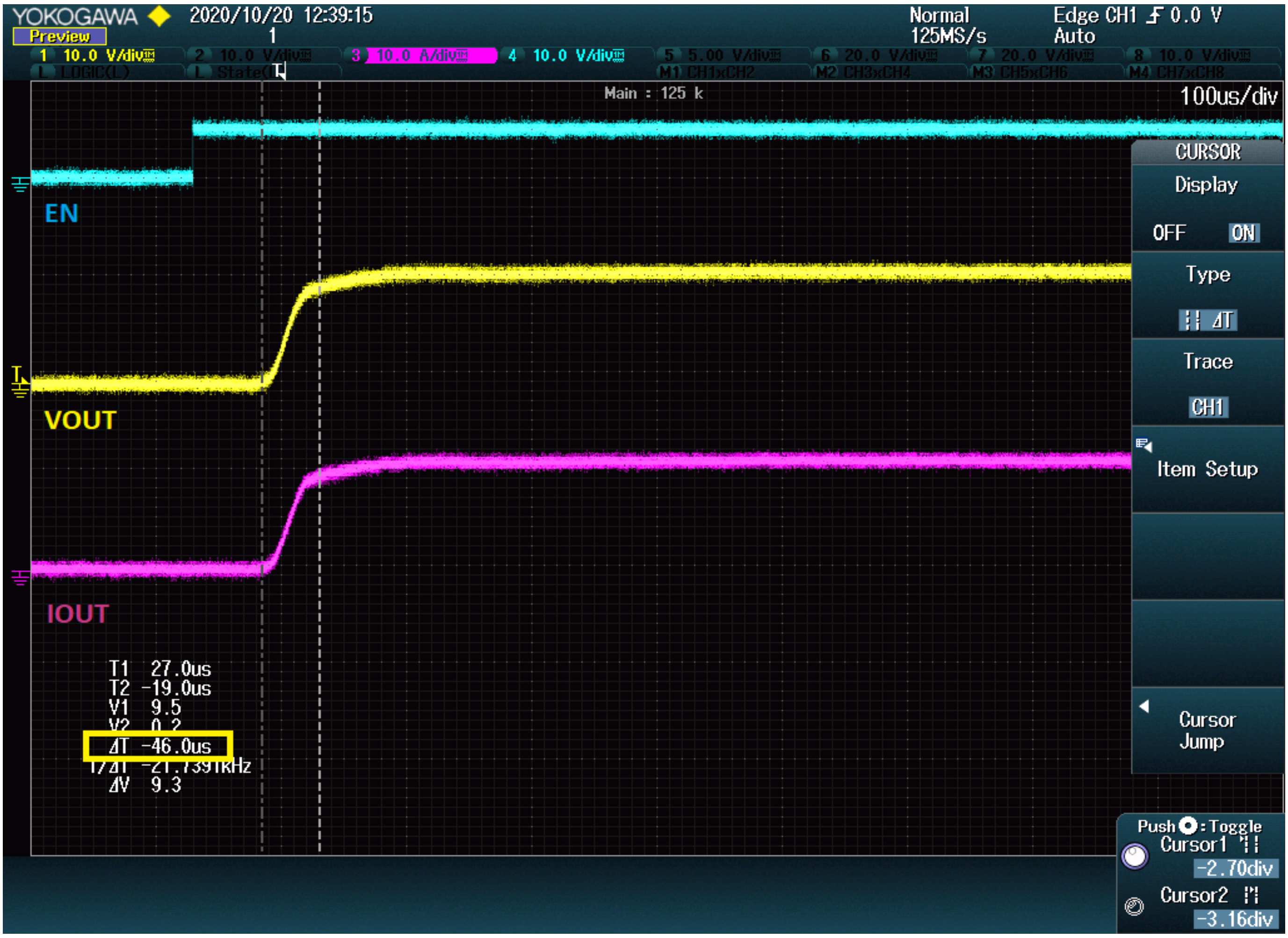

Figure 3 Rising edge when load is connected to GND and high-side switch is active

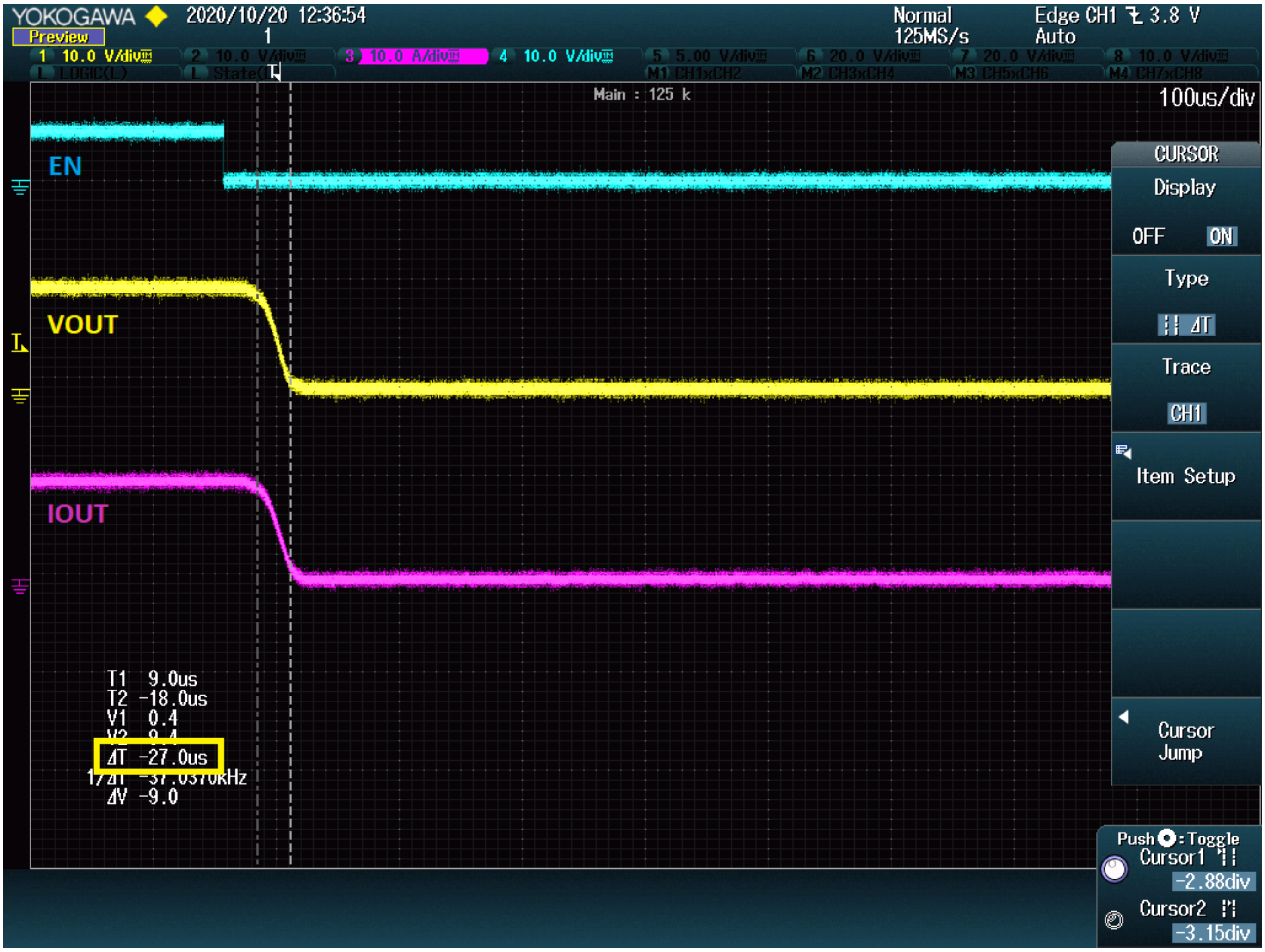

Figure 4 Falling edge when load is connected to GND and high-side switch is active

According to **Figure 2** the output duty cycle calculations are made, as the first step the output ON-time is calculated:

$$T_{ON-OUT} = T_{ON-IN} - t_{ON(HS)} + t_{OFF(HS)} = T_{ON-IN} - \left(\underbrace{t_{ON(HS)} - t_{OFF(HS)}}_{\Delta t_{SW(HS)}}\right)$$

$$T_{ON-OUT} = T_{ON-IN} - \Delta t_{SW(HS)}$$

Equation 1

Resulting duty-cycle is as follows:

$$DC_{OUT} = \frac{T_{ON-OUT}}{T_{PWM}} = \frac{T_{ON-IN} - \Delta t_{SW(HS)}}{T_{PWM}} = DC_{IN} - \underbrace{\frac{\Delta t_{SW(HS)}}{T_{PWM}}}_{DC_{offset}}$$

Equation 2

Now DC_{error} and DC_{offset} can be calculated based on datasheet parameters:

$$DC_{error} = \frac{\Delta t_{SW(HS)max} - \Delta t_{SW(HS)min}}{2 * T_{PWM}} \qquad DC_{offset} = \frac{\Delta t_{SW(HS)max} + \Delta t_{SW(HS)min}}{2 * T_{PWM}}$$

$$DC_{error} = \frac{60\ \mu s - 0\ \mu s}{2 * 5000\ \mu s} = 0{,}06 \qquad DC_{offset} = \frac{60\ \mu s + 0\ \mu s}{2 * 5000\ \mu s} = 0{,}06 = 0{,}6\%$$

Equation 3

To calculate the linear transfer function for f_{PWM} = 200 Hz and DC_{out} = 5% … 95 %, DC_{offset} needs to be added:

$$DC_{IN} = DC_{OUT} + DC_{offset} = 5{,}6\% \ldots 95{,}6\%$$

Equation 4

We can calculate the minimum and maximum T_{ON-IN} from the **Figure 2**:

$$T_{ON-IN(min)} = DC_{IN} * T_{PWM} = 0{,}056 * 5ms = 280\ \mu s$$
$$T_{ON-IN(max)} = DC_{IN} * T_{PWM} = 0{,}956 * 5ms = 4{,}78\ ms$$

Equation 5

In these corner cases timings may vary as power MOSFETs not fully charged/discharged.

In **Figure 5** DC_{out} to DC_{IN} correlation for 3 different frequencies is shown. It is important to notice in which range this transfer characteristic shows linear behavior and make sure to stay within this range while operating a BTN7030-1EPA.

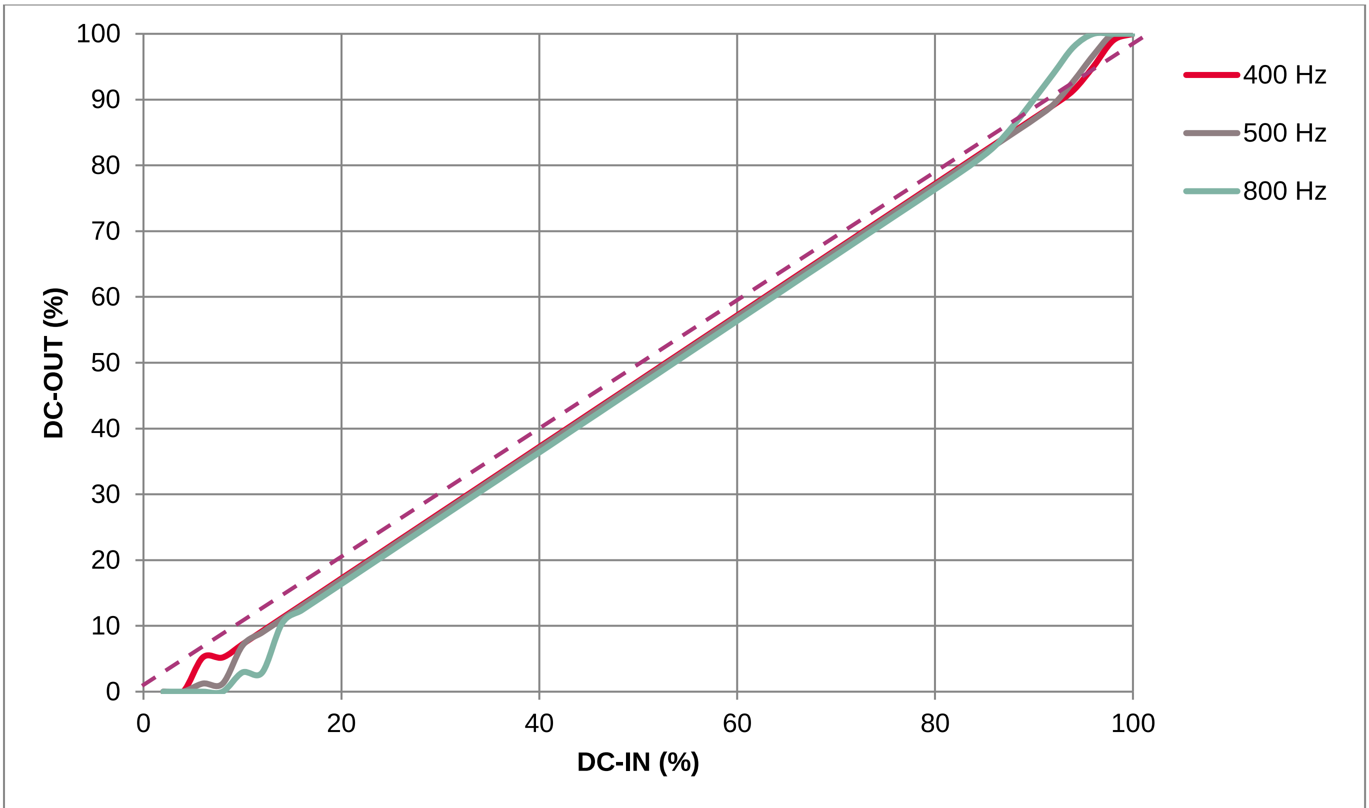

Figure 5 Duty-cycle transfer function

In case when $T_{ON\text{-}IN}$ is shorter than $t_{DON(HS)}$ there is no change in the shape of output voltage, but in case $t_{DON(HS)} < T_{ON\text{-}IN} < t_{ON(HS)}$, there is a change in the output voltage, as shown in **Figure 6** it becomes triangular.

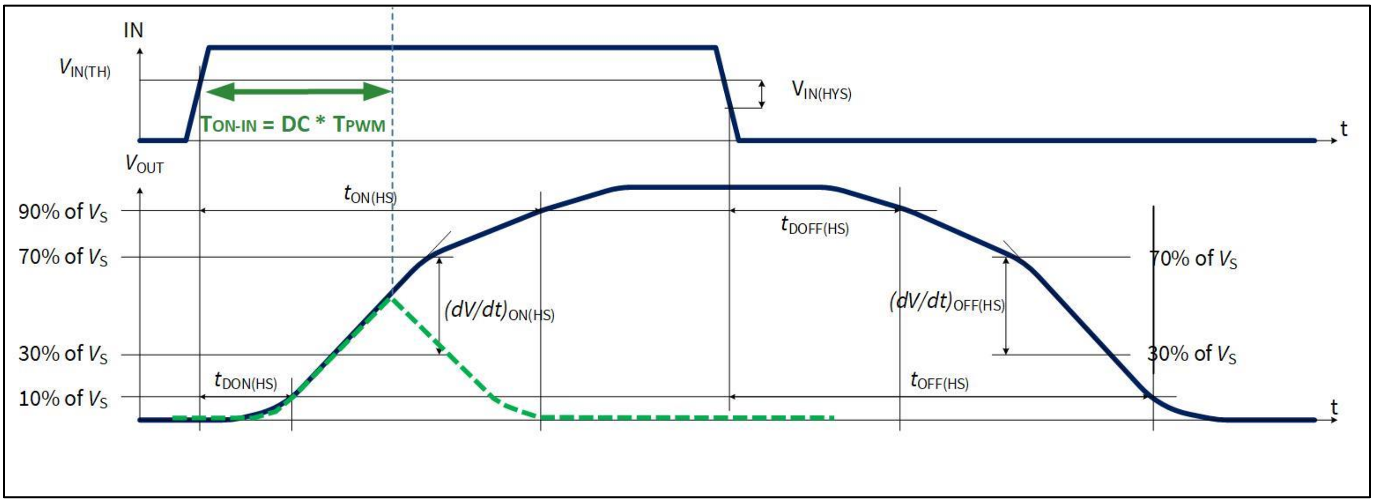

Figure 6 Output voltage shape when Duty-cycle is short

Another situation when the output voltage changes shape is shown in **Figure 7** and this happens when $t_{DOFF(HS)} < T_{OFF\text{-}IN} < t_{OFF(HS)}$, while in case $T_{OFF\text{-}IN}$ is shorter than $t_{DOFF(HS)}$ there is no change in the shape of output voltage.

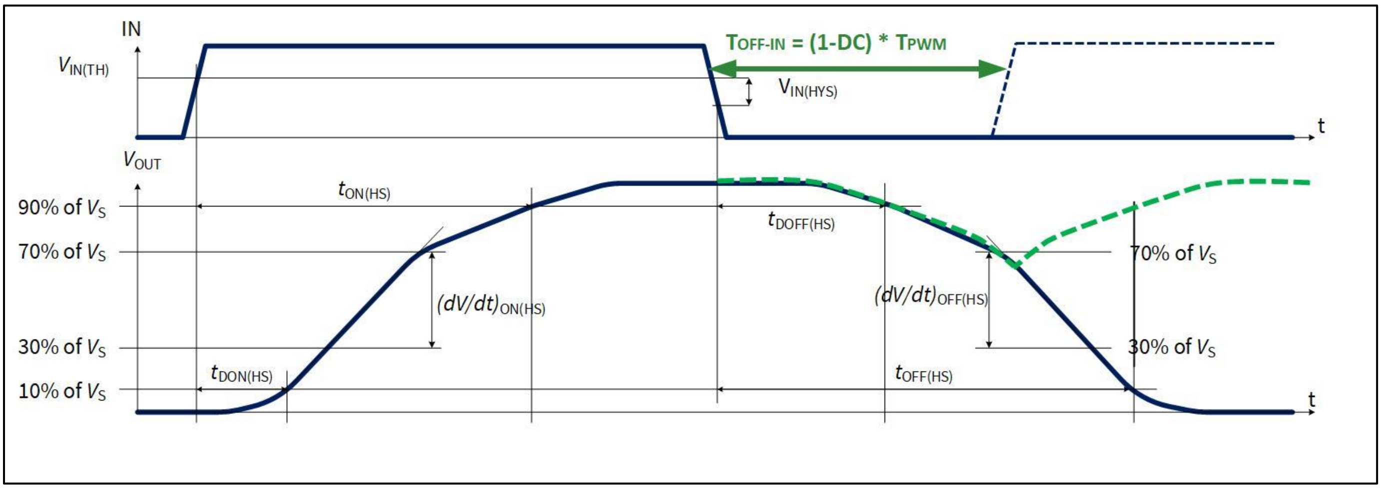

Figure 7 Output voltage shape when Duty-cycle is long

2.1 Using BTN7030-1EPA with PWM frequencies higher than 2kHz

In case a NovalithIC™ Lite device should be used in an application that requires frequencies higher than 2kHz, an H-bridge configuration of a BTN89xx and a BTN7030 device is a recommended solution. **Figure 8** shows an H-bridge configuration consisting of a BTN7030 and a BTN89xx featuring small solutions size and cost savings. BTN89xx (Novalithic™) supports PWM frequencies up to 20kHz, whereas BTN7030 (Novalithic™ Lite) selects the motor direction.This solution gives the possibility to use a NovalithIC™ device for driving frequencies up to 20kHz and NovalithIC™ Lite for motor direction selection, while saving space and costs.

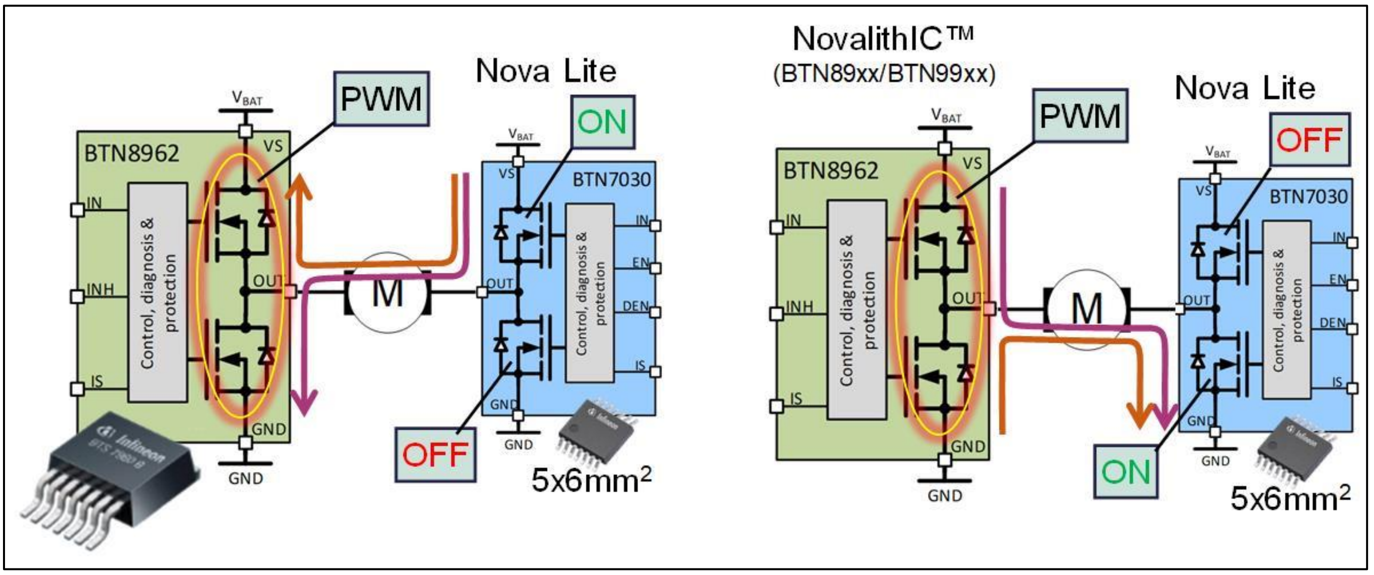

Figure 8 PWM configuration for NovalithIC™ Lite

3 Revision history

Document version	Date of release	Description of changes
1.1	2020-11-24	Oscilloscope measurements added
1.0	2020-08-28	First release

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