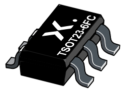


NXF6505A-Q100; NXF6505B-Q100

Low-noise 1.2 A transformer driver for isolated power supplies

Rev. 1 — 14 March 2024 | Objective data sheet

1. General description

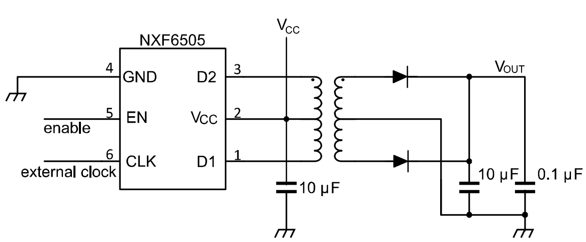
The NXF6505A/B-Q100 is a specialized push-pull transformer driver that is designed to deliver low noise and low EMI for isolated power supplies in small form factors. This driver is capable of driving low-profile, center-tapped transformers from a 2.25 V to 5 V DC power supply, while achieving ultra-low noise and EMI through the use of slew rate control and Spread Spectrum Clocking (SSC).

The NXF6505A/B-Q100 comprises an oscillator and a gate drive circuit that produces complementary output signals to drive ground-referenced N-channel power switches. To ensure start-up under heavy loads, the device includes two 1.2 A Power-MOSFET switches. Additionally, the switching clock can be provided externally for precise placement of switcher harmonics or when operating with multiple transformer drivers.

The NXF6505A/B-Q100 also features internal protection features such as current limiting, under-voltage lockout, thermal shutdown, and break-before-make circuitry, ensuring the device operates within safe limits. The device also includes a soft-start feature that prevents high inrush current during power-up with large load capacitors.

The NXF6505A-Q100 includes a 160 kHz internal oscillator for applications that need to minimize emissions, while the NXF6505B-Q100 has a 420 kHz internal oscillator for applications that require higher efficiency and smaller transformer. The NXF6505A/B-Q100 is available in a small 6 pin SOT8061-1 package and is characterized for operation within a temperature range of -55 °C to 125 °C.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.



2. Features and benefits

- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
  - Specified from -55 °C to +125 °C
- Push-pull driver for transformers
- Wide input voltage range: 2.25 V to 5.5 V
- High output drive: 1.2 A at 5 V supply
- Low R_{ON} 0.2 Ω maximum at 5 V supply
- Optimized for low EMI
- Spread Spectrum Clocking (SSC)
- Internal switching frequency:
  - for NXF6505A-Q100: 160 kHz)
  - for NXF6505B-Q100: 420 kHz)
- Synchronization of multiple devices with external clock input
- Slew-rate control
- 1.7 A current limit
- Enable pin to put device in low shutdown current: <1 µA
- Thermal shutdown
- Small 6 pin SOT8061-1 package
- Soft-start to reduce In-rush current
- ESD protection:
  - HBM: ANSI/ESDA/JEDEC JS-001 class 3A exceeds 6000 V
  - CDM: ANSI/ESDA/JEDEC JS-002 class C3 exceeds 1500 V

3. Applications

- Isolated power supply for CAN, RS-485, RS-422, RS-232, SPI, I²C, low-power LAN
- Low-noise isolated USB supplies
- Process control
- Telecom supplies
- Radio supplies
- Distributed supplies
- Medical instruments
- Precision instruments
- Low-noise filament supplies
- Isolated power supplies for automotive (Q100)
  - Traction inverter and motor control
  - DC-DC converter
  - Battery management system
  - On-board charger

4. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
NXF6505ADA-Q100	-55 °C to +125 °C	TSOT23-6	<tbd>	SOT8061-1
NXF6505BDA-Q100	-55 °C to +125 °C	TSOT23-6	<tbd>	SOT8061-1

5. Marking

Table 2. Marking

Type number	Marking code
NXF6505ADA-Q100	<tbd>
NXF6505BDA-Q100	<tbd>

6. Functional diagram

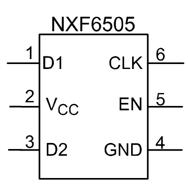


Fig. 1. Logic symbol

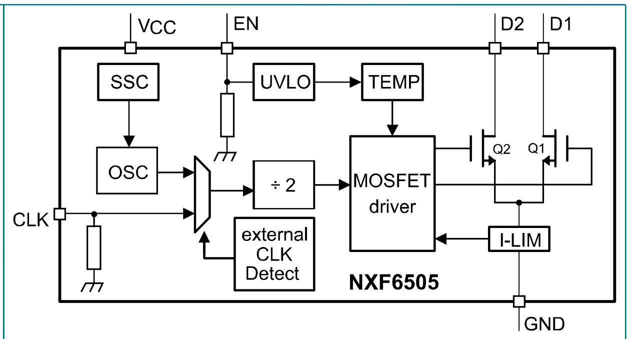


Fig. 2. Functional diagram

TBD

NFX6505B + Wurth 78931812512
V_{CC} = 5 V

Fig. 49. Output voltage versus load current

TBD

NFX6505B + Wurth 78931812512
V_{CC} = 5 V

Fig. 50. Efficiency versus load current

TBD

NFX6505B + Wurth 78931812515
V_{CC} = 5 V

Fig. 51. Output voltage versus load current

TBD

NFX6505B + Wurth 78931812515
V_{CC} = 5 V

Fig. 52. Efficiency versus load current

TBD

NFX6505B
(1) V_{CC} = 2.25 V
(2) V_{CC} = 5.5 V

Fig. 53. Frequency versus ambient temperature

TBD

NFX6505B
(1) V_{CC} = 2.25 V
(2) V_{CC} = 5.5 V

Fig. 54. Supply current versus external frequency

TBD

Fig. 55. Waveform showing the NFX6505 switching from external to internal clock

15. Application information

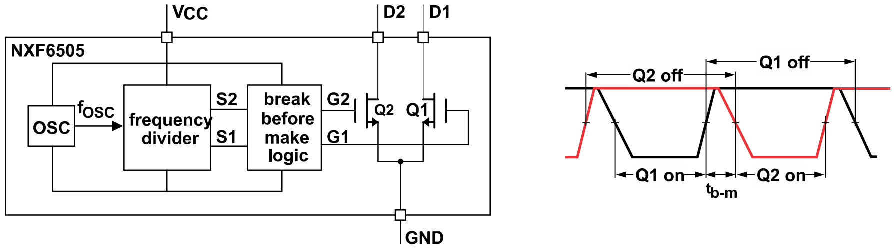


Fig. 56. Block diagram and output timing with break-before-make action

The NXF6505-Q100 is a driver for transformers that has been specifically designed for isolated DC-DC converters with a push-pull topology. It has been created with a focus on being cost-effective and having a small form-factor. The device features an oscillator that is responsible for feeding a gate-drive circuit. The gate-drive circuit consists of a frequency divider and break-before-make ($t_{b\text{-}m}$) logic, which together produce two complementary output signals that switch the output transistors on and off alternately. An asynchronous divider divides the output frequency of the oscillator and provides two complementary output signals, S1 and S2, with a 50% duty cycle. The break-before-make logic inserts a dead-time between the high-pulses of the two signals. The resulting signals, G1 and G2, provide the gatedrive signals for the output transistors Q1 and Q2. In order to prevent shorting out both ends of the primary, both signals must be low and both transistors must be high-impedance during a short time period before either one of the gates can assume logic high. This brief interval is known as the break-before-make time and is illustrated in Fig. 56.

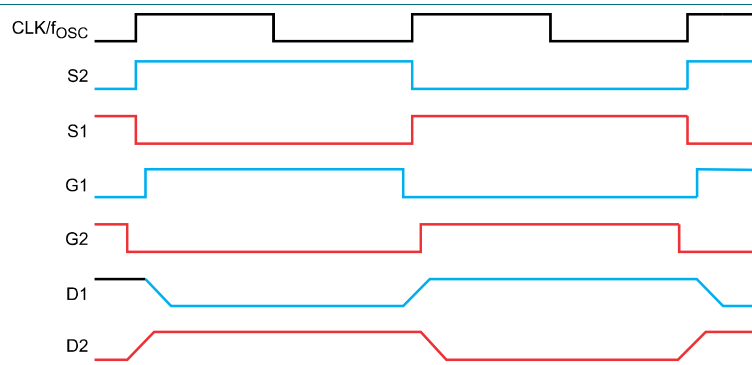


Fig. 57. Output signal waveforms

15.1. Typical Application

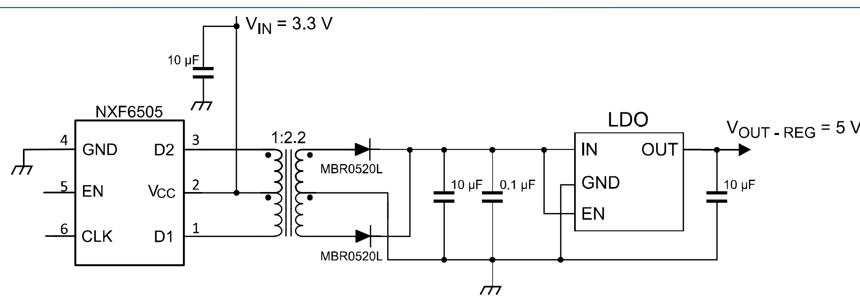


Fig. 58. NXF6505-Q100 typical application schematic

Design requirements

For this design example, use the parameters listed in Table 10 as design parameters.

Table 10. Design parameters

Parameters	Values
Input voltage range	3.3 V ± 3%
Output voltage	5 V
Maximum load current	100 mA

Detailed design procedure

These guidelines for selecting components are focused on creating a push-pull converter that is efficient and capable of handling high current drive. It's important to note that the output voltage of an unregulated converter drops significantly across a wide range of load currents. **Figure 1** and **Figure 11** illustrate this characteristic curve, which demonstrates that the voltage difference between minimum and maximum loads exceeds the range of a transceiver's supply. To ensure a stable, load-independent power supply while maximizing efficiency, we strongly recommend implementing a low dropout regulator (LDO). **Figure 47** depicts the final converter circuit, and **Figure 2** and **Figure 12** display the measured output voltage and efficiency characteristics for both regulated and unregulated outputs.

Drive capability

The transformer driver is intended for low-power push-pull converters that have input and output voltages ranging from 2.25 V to 5.5 V. Although it's feasible to create converter designs with higher output voltages, it's important to exercise caution to prevent primary currents from exceeding the device's specified current limits when using higher turns ratios.

Diode selection

To maximize the voltage output of a converter, it's important for a rectifier diode to have low-forward voltage. In high-frequency switching applications like the NXF6505-Q100, a diode with a short recovery time is also necessary. Schottky diodes fulfill both requirements and are highly recommended for push-pull converter designs. For low-voltage applications with ambient temperatures up to 85 °C, the affordable MBR0520L Schottky rectifier is a great option with a typical forward voltage of 275 mV at 100 mA forward current. If higher output voltages such as ±10 V are needed, the MBR0530 is a better choice with a higher DC blocking voltage of 30 V. However, lab tests have shown that at temperatures above 100 °C, the above Schottky diodes experience a significant increase in leakage currents. This can cause thermal runaway and the output voltage of the rectifier to collapse. To prevent this, use low-leakage Schottky diodes like RB168MM-40 for ambient temperatures exceeding 85 °C.

TBD

Fig. 59. Diode forward characteristics for MBR0520L

TBD

Fig. 60. Diode Forward Characteristics for MBR0530L

Capacitor selection

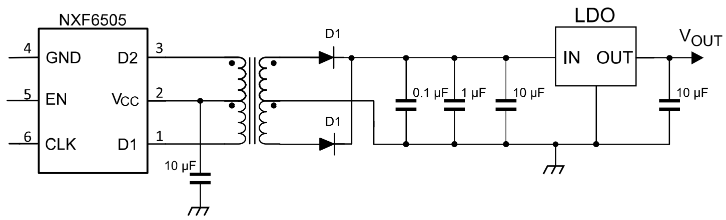


Fig. 61. Regulated output for stable supplies and high current load

The converter circuit shown in Fig. 61 employs multi-layer ceramic chip (MLCC) capacitors as its capacitors. For proper functioning of the high-speed CMOS ICs, a bypass capacitor within 10 nF to 100 nF range is required. The input bulk capacitor, located at the center-tap of the primary, is responsible for supporting high currents during fast switching transients. For minimal ripple, it is recommended to use a 1 µF to 10 µF capacitor. In a 2-layer PCB design with a dedicated ground plane, this capacitor should be positioned near the primary center-tap to reduce trace inductance. In a 4-layer board design, where low-inductance reference planes are available for ground and VIN, the capacitor can be placed at the entrance of the board. Two parallel vias should be used to ensure low-inductance paths for each connection to a reference plane or to the primary center-tap. To smooth out the output voltage, a bulk capacitor should be placed at the rectifier output. A capacitor with a value of 1 µF to 10 µF is recommended. Although not always necessary, using a small capacitor with a value of 47 nF to 100 nF at the regulator input can improve the regulator’s transient response and noise rejection.The LDO output capacitor is used to buffer the regulated output for subsequent isolator and transceiver circuitry. The choice of output capacitor depends on the LDO stability requirements, as stated in the data sheet. However, in most cases, a low-ESR ceramic capacitor within the 4.7 µF to 10 µF range is sufficient to meet these requirements.

Transformer selection

In order to avoid transformer saturation, the V-t product should exceed the highest V-t product generated by the device. The device's maximum voltage output is determined by adding 10% to the nominal converter input. The primary voltage should not exceed this maximum value for more than half the period of the lowest frequency specified for the input voltage. As a result, the minimum V-t product required for the transformer can be calculated by:

$$V \times t_{min} \geq V_{IN-max} \times \frac{T_{max}}{2} = \frac{V_{IN-max}}{2 \times f_{min}}$$

Equation 1

Assuming a 5 V supply, and considering the values of f_{min} as 138 kHz for NXF6505A-Q100 and 363 kHz for NXF6505B-Q100, the minimum V-t products can be obtained by applying the equation above, resulting in:

$$V \times t_{min} \geq \frac{5.5\,V}{2 \times 138\,kHz} = 20\,V\mu s$$

for NXF6505A-Q100, and

$$V \times t_{min} \geq \frac{5.5\,V}{2 \times 363\,kHz} = 7.6\,V\mu s$$ for NXF6505B-Q100.

Low-power center-tapped transformers typically have common V-t values that fall within the range of 22 Vµs to 150 Vµs, and they usually have a standard footprint size of 10 mm x 12 mm. However, for transformers specifically intended for PCMCIA applications, V-t values as low as 11 Vµs can be obtained, and their footprint is significantly smaller at 6 mm x 6 mm. While the device can drive any of these transformers in terms of V-t values, there are other critical factors that must be taken into account before deciding on the most suitable transformer, such as isolation voltage, transformer wattage, and turns ratio.

16. Package outline

17. Abbreviations

Table 12. Abbreviations

Acronym	Description
CDM	Charged-Device Model
CMOS	Complementary Metal Oxide Semiconductor
EMI	Electromagnetic Interference
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
UVLO	Undervoltage Lockout
SSC	Spread Spectrum Clocking
HBM	Human Body Model
ESD	ElectroStatic Discharge
MLCC	Multi-Layer Ceramic Capacitors
tbd	To Be Determined

18. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NXF6505_Q100 v.1	20240314	Objective data sheet	-	-

19. Legal information

Data sheet status

Document status [1][2]	Product status [3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the internet at https://www.nexperia.com.

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