APPLICATION NOTE

Nordic VLSI ASA

3V to 5V DC Step up Conversion **nAN400-01**

1. General

The **nRF0433** single-chip RF transceiver [1] is designed for 5V operation. To be able to use the chip in a 3V system, a voltage-converter circuit will be needed. This document describes the design of such a step-up circuit. As shown here, the circuit is able to operate on power-supply voltages in the range 2.6 – 5.5V.

2. Circuit description

The proposed voltage converter consists of two parts. Most important is the power-supply circuitry, needed to transform the 3V to 5V to feed **nRF0433** with power. In addition, some level-shifters are needed to give valid logic levels on the digital signals in both directions.

A diagram of the complete circuit solution is shown in Figure 1. The circuit shown is designed to work for an input voltage range from 2.6V to 5.0V. In the schematic the low-voltage power is on the left side. **nRF0433** is to be connected to the right side of the schematic.

2.1. DC-DC converter circuit

A DC-DC converter IC, in this case the MAXIM MAX856 [2], does the step-up of the power supply voltage. This 8-pin IC needs only a few external components to perform a DC-DC conversion. The circuit can deliver up to 100mA on the 5V output. The conversion efficiency of the circuit is 65 – 70% when delivering 20 – 60mA to the 5V region. The corresponding current drawn from the input supply voltage can be computed using the equation:

$$I_{BAT} = \frac{5.0}{\eta \cdot V_{BAT}} \cdot I_{LOAD}$$

where

V_{BAT} = input supply voltage
I_{BAT} = current drawn from input supply voltage
η = conversion efficiency
I_{LOAD} = current drawn at the 5V output

If I_{LOAD} is in the range 20 – 60mA the current drawn from the 3V supply will be 50 – 150mA. If the input supply voltage is reduced, the current drawn from the supply will increase to maintain a constant power in watts.

For further details on the operation of the circuit, refer to the MAX856 data sheet [2] and the MAX856 Evaluation Kit manual [3].

2.2. Level-shifting circuit

A 74HCT04 IC performs the level-shifting of the logic signals from the low-voltage side to the high-voltage side. This IC has high-impedance TTL level inputs and CMOS level outputs. Therefore it can be operated with input high-levels down to 2.6V. The logic outputs of the circuit have a 5V swing. Conversion of the data out signal, DOUT', from **nRF0433** to low-voltage logic is done by a series-coupling of the resistor R1 and the schottky diode D2. Note that DOUT must not be loaded with a resistive load because R1 represents a high output impedance at this node.

2.3. Passive components

The most critical of the passive components in the circuit is the inductor L1. To keep the efficiency of the circuit high, this inductor must have low loss. In this circuit, a 15 µH Murata LQH4N inductor has been chosen. If a more expensive inductor is used, the efficiency may be increased to about 85%. The capacitor C3 should also be of the low-loss type, preferably a tantalum capacitor. For optimum efficiency, the diode D1 should have a low voltage drop. Therefore the schottky diode MBR0530T1 (Motorola) is suggested here. The inductor L2 and the capacitor C4 give an additional low-pass filtering at the 5V output. This ensures a sufficient damping of the switching noise of the MAX856. In the circuit shown in Figure 1, the output ripple is about $2mV_{P-P}$. The ceramic capacitor C3 is a decoupling of the internal voltage reference of the MAX856. The input capacitor C1 prevents switching noise from reaching the 3V supply voltage. Due to the PFM (Pulse-Frequency Modulation) operation of the MAX856, the switching frequency will vary with load, input voltage and inductor value.

3. Even lower power supply voltages

The 74HCT04 IC cannot be used in systems with logic high input voltages lower than 2.6V. Therefore, if the circuit is to be used on supply voltages below 2.6V, this part of the circuit will have to be redesigned. The 74HCT04 may be replaced by a quad-pack of comparators, for instance the National LM339M. In addition a couple of resistors will be needed to create a threshold voltage reference. Then the voltage converter can be operated down to a 2.0V supply, limited by the LM339M comparator.

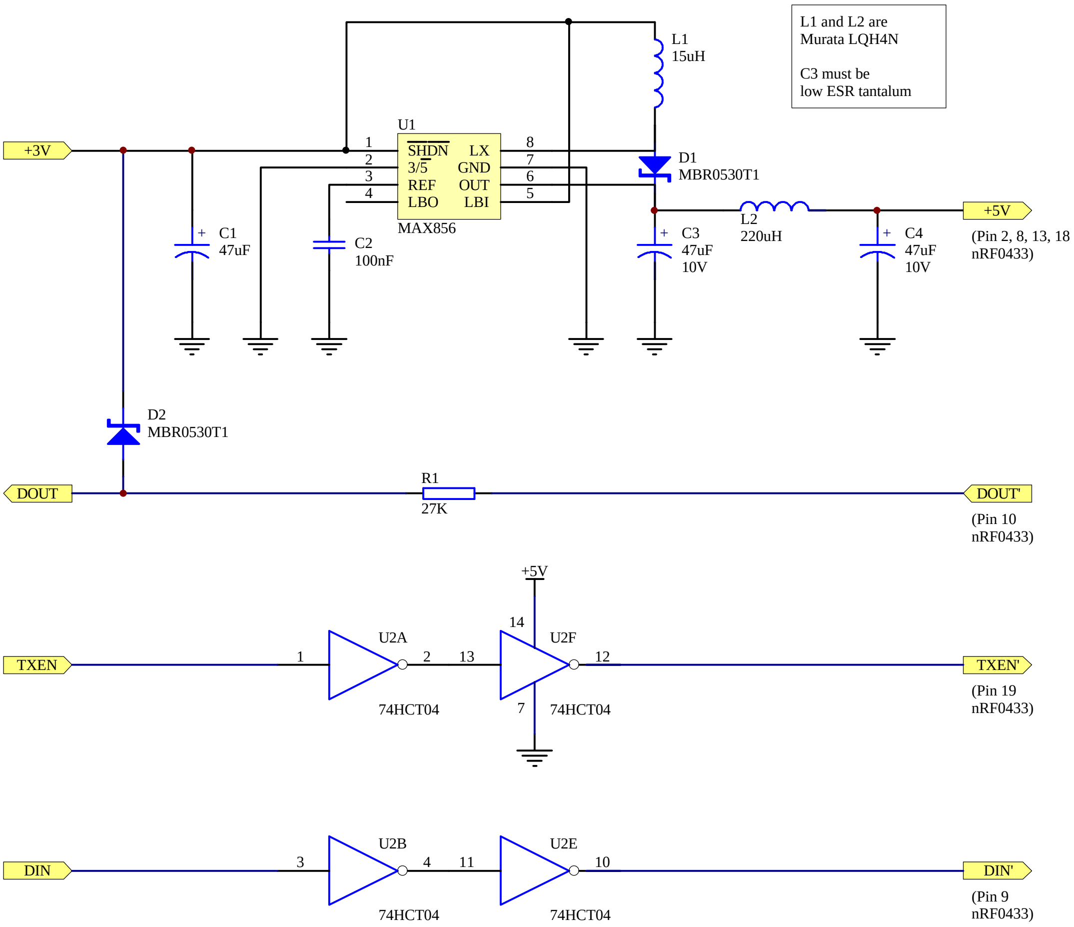

Figure 1. Circuit schematic of a voltage converter for operation of **nRF0433** in a 3V system. Left side is connected to 3V system, **nRF0433** is connected to the right side.

4. References

1. Product specification **nRF0433**, “Single chip 433MHz RF Transceiver”, Nordic VLSI ASA.
2. MAX856 datasheet, 19-0211; Rev 4; 5/96.
3. MAX856 Evaluation Kit manual, 1995.

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