User manual for NAC1080 development

NAC1080

About this document

Scope and purpose

This document describes the evaluation kit for Infineon's NAC1080 near-field communication (NFC) tag-side controller with the integrated H-bridge intended for passive smart lock applications. The kit has all the necessary components to enable a quick start to the development of the electrical part of a passive smart lock.

Intended audience

This document is intended for hardware design engineers who want to develop or improve the electrical part of smart lock systems.

Table of contents

1 Introduction

This evaluation kit is a tool for engineers who want to use NAC1080 to develop smart locks. NAC1080 is a NFC tag-side controller which combines in one device the functions of energy harvesting, NFC and motor control. NAC1080 is based on a 32-bit Arm® Cortex®-M0 processor core operating at a CPU frequency of 28 MHz. Standard peripheral modules such as UART, SPI and 32 kHz RTC are included.

The development kit consists of the evaluation board EVAL_NAC1080, packages of firmware and software examples with the related documentation, two PCB antenna designs and one mini DC motor. With the QR code printed on the shipping box it is possible to register the board at www.infineon.com to get access to all related documents and code examples. The following packages will be available after the registration:

- Stand-alone motor control firmware with source code (two versions)
- Firmware development SDK (without source code)
- Mobile application development SDK for iOS and Android (without source code)
- Lock demo firmware to work with mobile demo app (two versions, binary file without source code)
- Lock demo mobile application for Android (APK file)
- PCB layout files for two different antenna designs
- Evaluation board schematic and PCB layout files

The evaluation board EVAL_NAC1080 has two functional areas – the NAC1080 microcontroller area and antenna area. The perforated profile is implemented on the borders of the areas, so that they can be separated from each other if needed – for instance, to test the system with other antennas. The evaluation kit can be configured for passive or active mode.

2 Use of the evaluation kit in passive mode

Passive mode means that NAC1080 IC does not require any external wired connected power supply and the energy needed to supply the IC can be harvested wirelessly from the NFC field generated by the NFC reader. Part of the harvested energy can be stored in the dedicated storage capacitor (C7 or C10) located on the board to enable operations with the mini motor needed for the smart lock system. The evaluation board supports testing and development of different methods to rotate the motor – simple one-step movement, one-step movement with external boost-buck or multi-step method.

Table 1 shows the configuration of the board for different methods and gives a short description of each method. For more detailed information about the methods see application note **NFC passive lock implementation with NAC1080**. The installed firmware supports simple one-step and multi-step methods, and switching between them is available via the mobile application software. By default the firmware is configured for simple one-step movement. To use one-step movement with the external boost-buck circuit method – other firmware (which is available on the Infineon webpage after the evaluation board registration) must be programmed and the jumper setting on the evaluation board needs to be changed as detailed in Table 1.

Table 1 Configuration of the evaluation board for different methods of motor rotation

Method name	Simple one-step movement	One-step movement with external boost-buck circuit	Multi-step movement
Method description	One-step motor movement. Energy required to rotate the motor is stored in an external energy storage capacitor at once. Charge the external energy storage capacitor to reach the voltage clamping level first, then discharge the capacitor to rotate the motor. Connect an external energy storage capacitor to the IC VCC_HB output pin to store the harvested energy. Voltage across the capacitor is limited by NAC1080 clamping voltage: max. 3.6 V.	One-step motor movement. Energy required to rotate the motor is stored in the energy storage capacitor at once. The working principle is the same as the “simple one-step movement”, but the voltage across the energy storage capacitor is increased. A sequence of a boost and a buck converter is required. Voltage across the energy storage capacitor steps up to 15 V using a discrete boost circuit. A buck converter reduces the voltage back to 3.3 V to supply the H-bridge of NAC1080.	Stepwise motor movement. Energy required to rotate the motor is permanently harvested during motor movement. An energy storage capacitor is still required because the motor usually consumes more power than can be harvested at a certain point of time. This method controls the motor turn-on and turn-off operating points with the specified time interval or with the given VCC_HB voltage threshold. Voltage across the energy storage capacitor is limited by NAC1080 clamping voltage: max 3.6 V. Implemented as a number of charging-moving cycles. One cycle description: the capacitor starts to charge when the NFC energy harvesting is available and the motor is switched off. After the capacitor voltage reaches the required voltage level (V_{ON}), the H-bridge turns on and the motor starts to rotate. When the voltage drops down to V_{OFF}, the motor is switched off. Such cycles are repeated until the required rotation angle is reached.

(table continues...)

Table 1 **(continued) Configuration of the evaluation board for different methods of motor rotation**

Advantages and disadvantages	Pros: Easy to implement, only energy storage capacitor is required. Cons: The large capacitor (several mF) might be required to reach the target rotation angle. Normally system operates only during NFC presence. To extend the operation for some time a circuit with the backup energy storage has to be implemented (see **NFC passive lock implementation with NAC1080** application note).	Pros: Large amount of energy is stored in high-voltage capacitor which could provide energy for multiple motor motions like 90°C forward followed by 90°C backwards motor rotation. Cons: Additional cost and space for boost and buck stages. Longer capacitor charging time.	Pros: Reduced energy waste, small capacitor size can be achieved. Con: The system is functional only during NFC presence.
Evaluation board configuration	JP4:OFF, JP5:OFF, JP6:ON, JP7:OFF, JP13:OFF, JP14:OFF; with the backup energy storage: JP4:ON, JP5:1-2ON, JP6:OFF, JP7:OFF, JP13:OF, JP14:OFF	JP4:OFF, JP5:2-3ON, JP6:OFF, JP7:ON, JP13:ON, JP14: ON;	JP4:OFF, JP5:OFF, JP6:ON, JP7:OFF, JP13:OFF, JP14: OFF;

The evaluation board has a general purpose LED1 connected to GPIO2, which can be used for firmware debugging purposes. The meaning of the LED1 indication for the installed firmware code example is described in chapter 12.

Table 2 shows the parameters of a 3 V 60mA mini DC motor which is part of the evaluation kit. This is the *OT-10GP7L* geared motor from the company *Once Top Motor* www.oncetop.com.

Table 2 **Parameters of the mini DC motor**

Parameter	Value
Type	DC with gear, gear ratio 1:171
Rated voltage	3.0 V DC
Rotation	CCW
Output speed	75 ±5 RPM
Nominal load current	0.02 A max.
Stall current	0.26 A max.
Stall torque	160 g.cm min.

(table continues...)

Table 2 (continued) Parameters of the mini DC motor

Rated torque	38 ±5 g.cm
Rated current	0.06 A max.
Rated speed	61 ±10 percent RPM
Shaft diameter	8 mm

3 Use of the evaluation kit in active mode

Although the evaluation board is designed for passive smart lock systems it can also be used in active mode. In this case NAC1080 must be supplied from an external power supply, which must be connected to the VCC pin (pin header JP3, pins 1, 2 or 3). The VCC input voltage range is defined in Table 4. An energy storage capacitor on the VCC_HB pin is not needed. If H-bridge is used, connect the VCC_HB pin to the VCC pin; otherwise leave the VCC_HB pin open. In active mode the NFC works but the energy is normally not harvested from the NFC field. To avoid the conflict of two power sources in case of NFC field presence – the NFC field should not present at the moment when NAC1080 is powering up from VCC– that is, a reader (a cell phone) has to be removed from the antenna of the evaluation board at the moment of NAC1080 startup and in this case the IC keeps the supply status (active mode) until the next power-down cycle. Table 3 shows the configuration of jumpers on the evaluation board for active mode.

Table 3 Configuration of jumpers for active mode

JP4	Off
JP5	2 to 3: on
JP6	Off
JP7	Off
JP13	Off
JP14	Off

4 Photo of the evaluation board

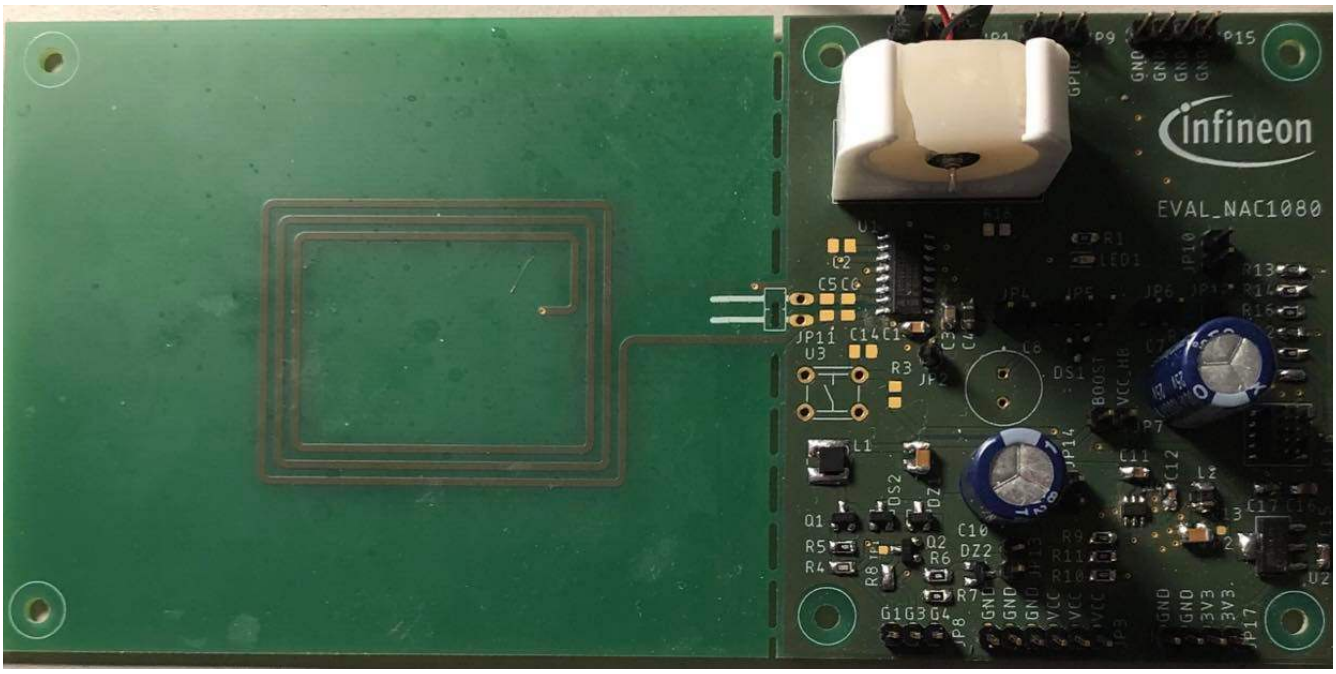

Figure 1 Photo of the evaluation board, top view

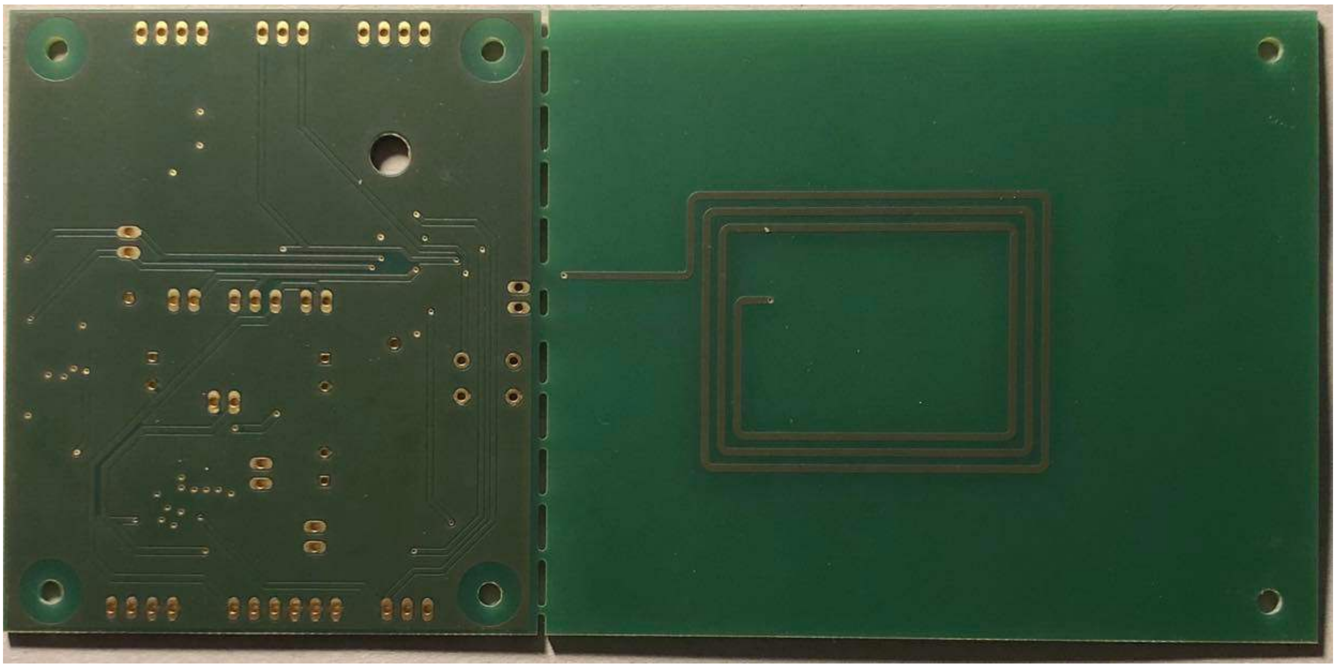

Figure 2 Photo of the evaluation board, bottom view

5 Schematic

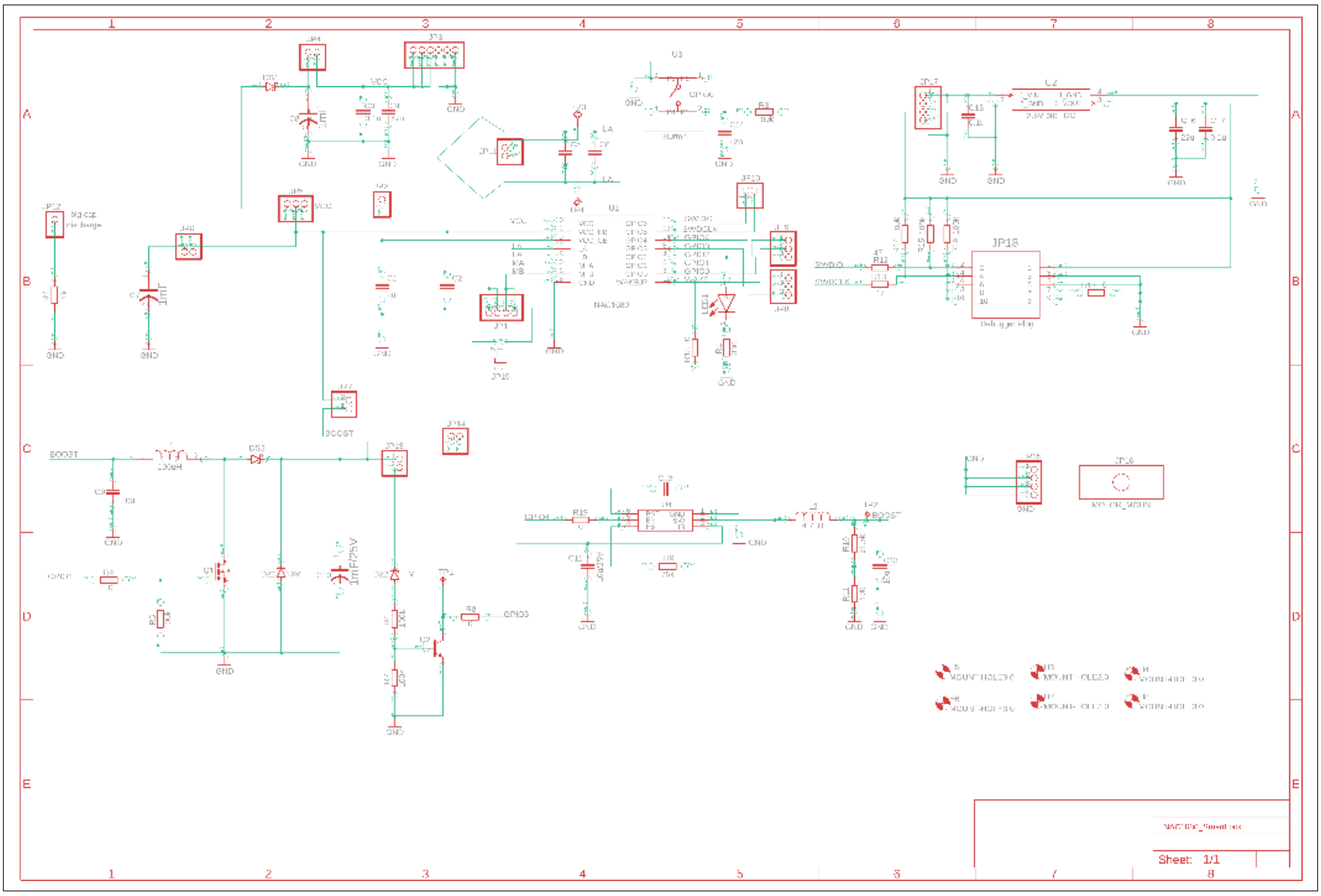

Figure 3 **Schematic**

6 Layout

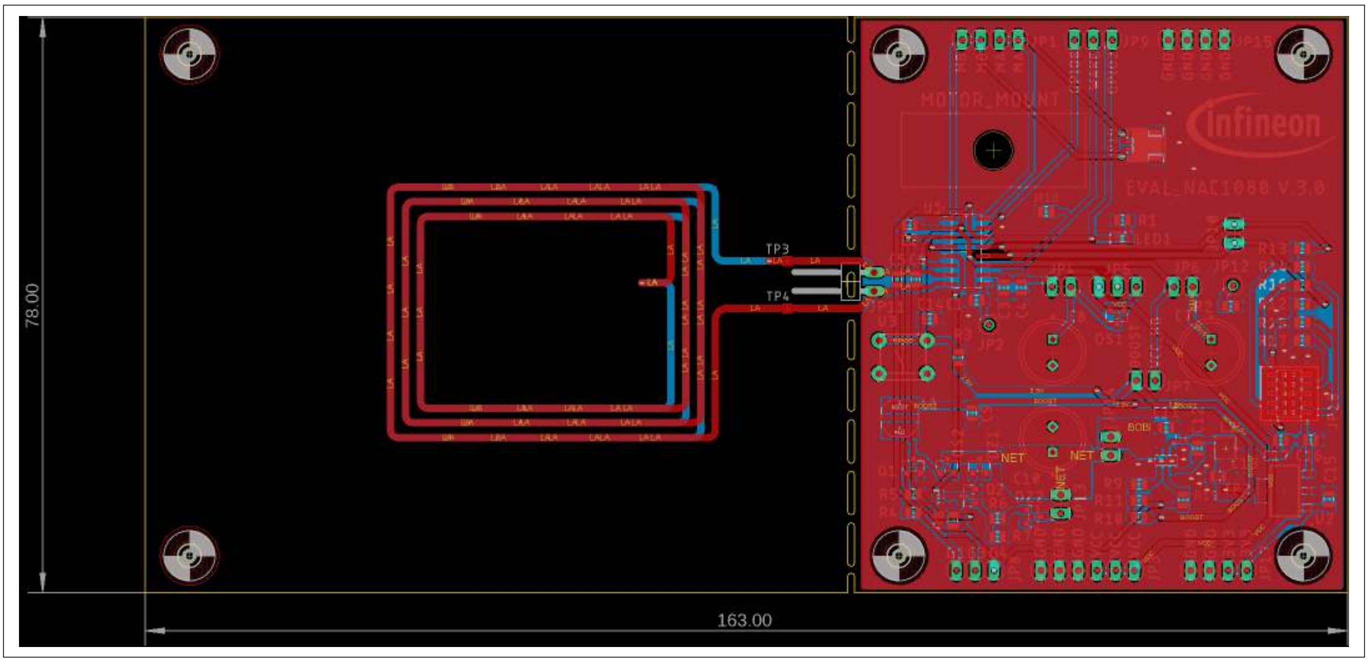

Figure 4 **Layout, top view**

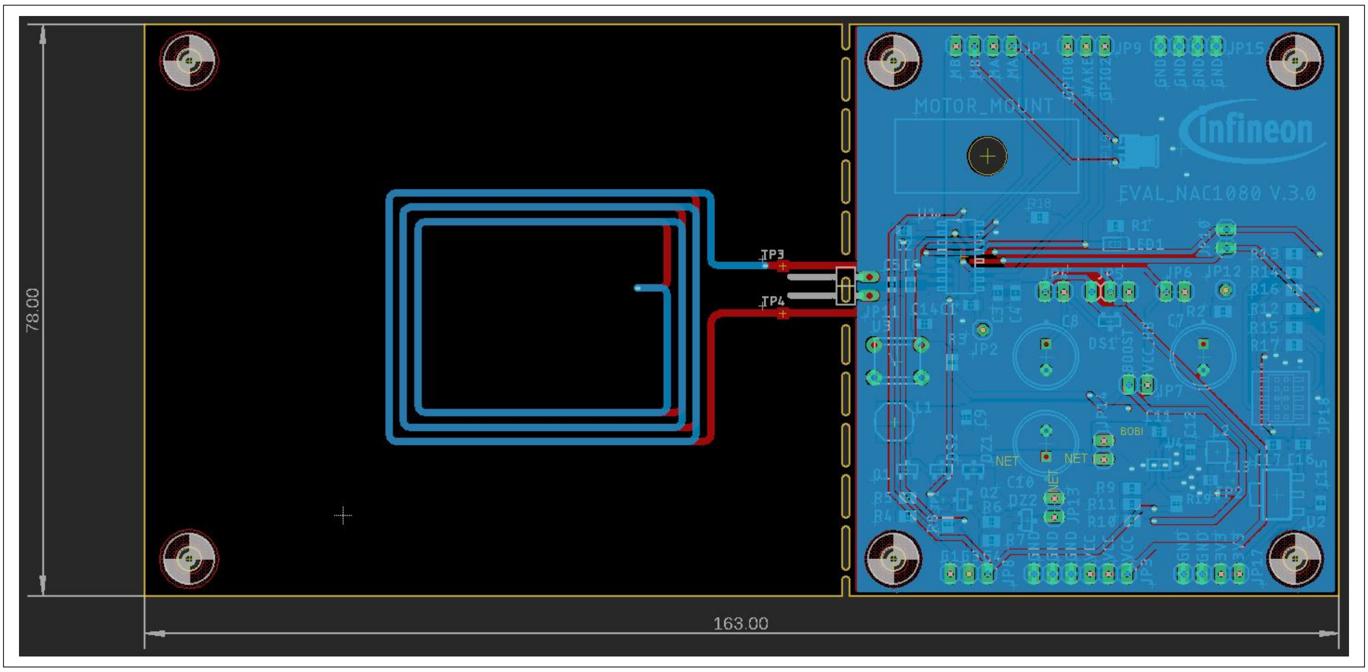

Figure 5 **Layout, bottom view**

7 Operational conditions and parameters

Table 4 Operational conditions and parameters

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Power supply	VCC	2.8	3	3.6[*]	V	
GPIOs as outputs, HIGH Level	GPIO0 to GPIO6	2.2		2.5	V	load 2 mA
GPIOs as outputs, LOW Level	GPIO0 to GPIO6			0.2	V	load 2mA
GPIOs as inputs, HIGH level	GPIO0 to GPIO6	1.75		3.6	V	
GPIOs as inputs, LOW level	GPIO0 to GPIO6	0		0.7	V	
Wake-up threshold HIGH Level	WAKEUP	2.3			V	
Wake-up threshold LOW Level	WAKEUP			0.8	V	
Voltage at VCC_HB	VCC_HB			3.3	V	
Current between MA and MB	I_HB			250	mA	
Boost input voltage	BOOST		3.3	3.6	V	
Buck input voltage	BOBI		15	16	V	
Resonance capacitance between terminals LA and LB	C_chip		23.5		pF	
Debugger target reference voltage	Vtref	2.2		2.5	V	

[*] – the maximum external voltage should not exceed the selected clamping voltage of NAC1080 – see the datasheet for the possible values of the clamping voltage.

8 Jumper descriptions

Table 5 Jumper descriptions

JP1	MA, MB connection
JP2	VCC_CB connector
JP3	VCC connector
JP4	Connection of backup energy storage
JP5	VCC_HB pin connection
JP6	Connection of storage capacitor
JP7	Connection of boost-buck circuit
JP8	GPIOs connection
JP9	GPIOs connection
JP10	SWDIO and SWDCLK connection
JP11	Connection of external antenna
JP12	Energy storage capacitor discharge through 1 kΩ
JP13	Connection of the detection circuit
JP14	Connection of the buck converter
JP15	GNG connection pins
JP16	Motor mount
JP17	LDO input connection
JP18	Debugger plug

9 Bill of materials

Table 6 Bill of materials

Item number	Part reference	Value	Package	Comments
1	U1	NAC1080	DSO16	Infineon tag-side microcontroller
2	U2	MIC5209-2.5YS	SOT223	LDO with 2.5 V output
3	U3	430156070736, Würth Elektronik	Through-hole	General purpose button
4	U4	AP62150WU-7 or MP1470GJ	TSOT26 or TSOT23-6	Buck converter
5	C1	2.2 µF, 10%, 6.3 V	0805	VCC_CB capacitor
6	C2		0805	Not used
7	C3	0.1 µF, 10%, 6.3 V	0805	VCC capacitor
8	C4	10 µF, 10%, 6.3 V	0805	VCC capacitor
9	C5, C6		0805	Antenna tuning capacitors, not populated
10	C7, C8	1 mF, 10%, 6.3 V	Through-hole, radial, can, d = 10 mm, L = 20 mm	Aluminium electrolyte, VCC_HB capacitor
11	C9	10 µF, 10%, 6.3 V	0805	Boost input capacitor
12	C10	1 mF, 10%, 25 V	Through-hole, Radial, Can, d = 10 mm, L = 20 mm	Aluminium electrolyte, boost output capacitor
13	C11	10 µF, 10%, 25 V	0805	Input capacitor of the buck converter
14	C12	0.1 µF for AP62150WU-7 or 1 µF for MP1470GJ; 10%, 25 V	0805	Capacitor to form supply across the high-side switch driver of the buck
15	C13	10 µF, 10%, 6.3 V	0805	Output capacitor of the buck converter
16	C14	22 nF, 10%, 6.3 V	0805	High-frequency filtering capacitor
17	C15, C17	0.1 µF,10%, 6.3 V	0805	LDO capacitors
18	C16	22 µF, 10%, 6.3 V	0805	LDO capacitors
19	R1	330 Ω, 5%	0805	Sets the current through LED1
20	R2	1 kΩ, 5%	0805	Resistor to discharge capacitor C11
21	R3	100 kΩ, 5%	0805	Pull-up resistor
22	R4	10 Ω, 5%	0805	

(table continues...)

Table 6 (continued) Bill of materials

23	R5	100 kΩ, 5%	0805	Pull-down resistor, not used
24	R6, R7	100 kΩ, 5%	0805	Resistors to setup bias current
25	R8	0 Ω	0805	Can be used as an external pull-up resistor for GPIO3. If not used as a pull-up then 0 Ω has to be populated
26	R9	75 kΩ, 1% – for MP1470GJ, 0 Ohm – for AP62150WU-7	0805	Resistor of the feedback network of the buck converter
27	R10	31.6 kΩ, 1% – for AP62150WU-7 or 40.2 kΩ, 1% – for MP1470GJ	0805	Resistor of the feedback network of the buck converter
28	R11	10 kΩ, 1% – for AP62150WU-7 or 13 kΩ, 1% for MP1470GJ	0805	Resistor of the feedback network of the buck converter
29	R12, R13	47 Ω, 5%	0805	Line termination resistors
30	R14, R15, R16	100 kΩ, 5%	0805	Pull-up resistors for SWD debugger interface
31	R17	0 Ω	0805	Debugger resistor
32	R18	100 kΩ, 5%	0805	Pull-down resistor
33	R19	0 Ω	0805	Jumper resistor for buck enable signal
34	L1	100uH; L1007C101MDWIT or LQH3NPN101MMEL	1007	Inductor of the boost converter
35	L2	4.7uH; CBC2518T4R7M	1007	Inductor of the buck converter
36	DZ1	BZX84B16-HE3-08	SOT23-3	Zener diode
37	DZ2	BZX84B11-HE3-08	SOT23-3	Zener diode
38	DS1	BAS40-04T-7-F	SOT23-3	Schottky diode
39	DS2	BAS40-04T-7-F	SOT23-3	Schottky diode
40	Q1	IRLML6244TRPBFor IRLML6246TRPBF	SOT23-3	Boost MOSFET
41	Q2	AS9013	SOT23-3	NPN transistor for the detection circuit
42	LED1	APTD1608LSECK/J4-PF	0603	General purpose orange LED

(table continues...)

Table 6 (continued) Bill of materials

43	JP1-JP10, JP12-JP15, JP17	2.54 mm pitch, TSW-10X-14-G-S; 1-pin - 2 pcs., 2-pin - 6 pcs., 3-pin - 3 pcs., 4-pin - 3 pcs., 6-pin - 1 pc.	Through-hole	Connectors pin headers vertical
44	JP11	2.54 mm pitch, TSW-102-25-G-S-RA, not populated	Through-hole, angled	Connector for antenna
45	JP16	not populated	Through-hole	Motor mount area
46	JP18	FTSH-105-01-L-DV-K-TR	SMD	Connector for the debugger interface
47	JP19	1SH-A-02-TR-SMT	SMD	Connector for the mini-motor
48		2.54 mm pitch; QPC02SXGN-RC		Jumpers for the board configuration

10 NFC antenna

The evaluation kit offers one antenna as part of the evaluation board and two antenna designs (PCB layouts) which can be directly manufactured from the available Gerber files. The description of the antennas as well as the Gerber files can be downloaded after evaluation board registration. The guidelines for the antenna design are given in the application note for NLM0011 here.

NFC readers operate in the 13.56 MHz high-frequency band. The typical value of the internal capacity between terminals LA and LB of NAC1080 is given in the datasheet and it is 23.5 pF. For the antenna tuning (if necessary) capacitors C5 and C6 are laid out on the evaluation board (by default not populated).

11 Debugger connection

NAC1080 IC supportsArm® SWD and TAG debug ports for the firmware programming. Figure 6 shows the connection of the debugger to the device. Two signals of the SWD debug port - SWDCLK and SWDIO - are connected with the pull-up resistors of 100 kΩ. Series termination resistors of 47 Ω on the SWCLK and SWDIO lines are recommended. The system must be supplied from an external power supply of 3.0 V to 3.3 V; that is, it must be in active mode (see Table 3 for jumper configurations). Connect external power supply (3 V to 3.3 V) to LDO input (JP17.3 or JP17.4) and to the VCC pin of the device (JP3.1, JP3.2 or JP3.3). As GPIO outputs of the device have a "HIGH" level (2.2 V to 2.5 V) instead of the 3 V range, a low-dropout (LDO) regulator with the 2.5 V output is used to generate the required level for the VT_{ref} signal of the debugger. 9-pin debugger SWD/JTAG pinout is shown in Figure 7 .

As a debugger tool *micro Trace for Cortex-M* from Lauterbach or *Segger J-LINK* JTAG debuggers can be used (Figure 8). Both debuggers have a 20-pin header, therefore an adapter for 20 pin to 10 pin is required. Please be aware that a debugger is not included in the development kit and must be ordered separately.

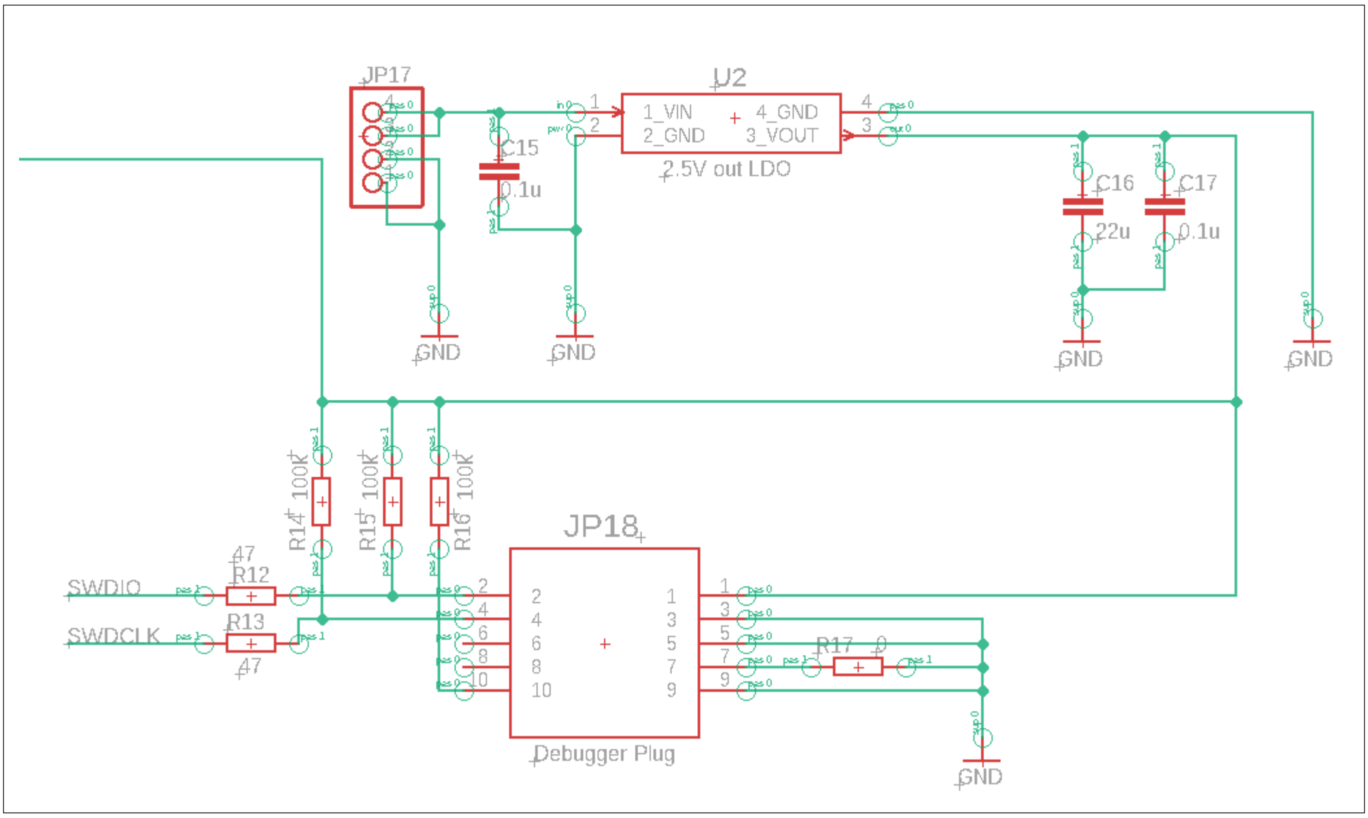

Figure 6 **Part of the circuit showing the debugger connection**

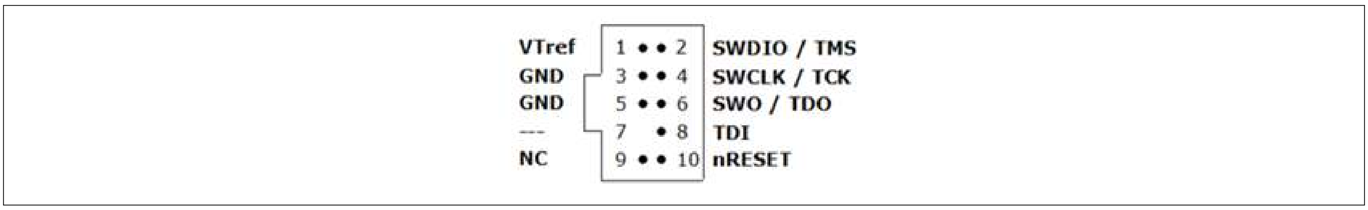

Figure 7 **SWD/JTAG 9-pin connector**

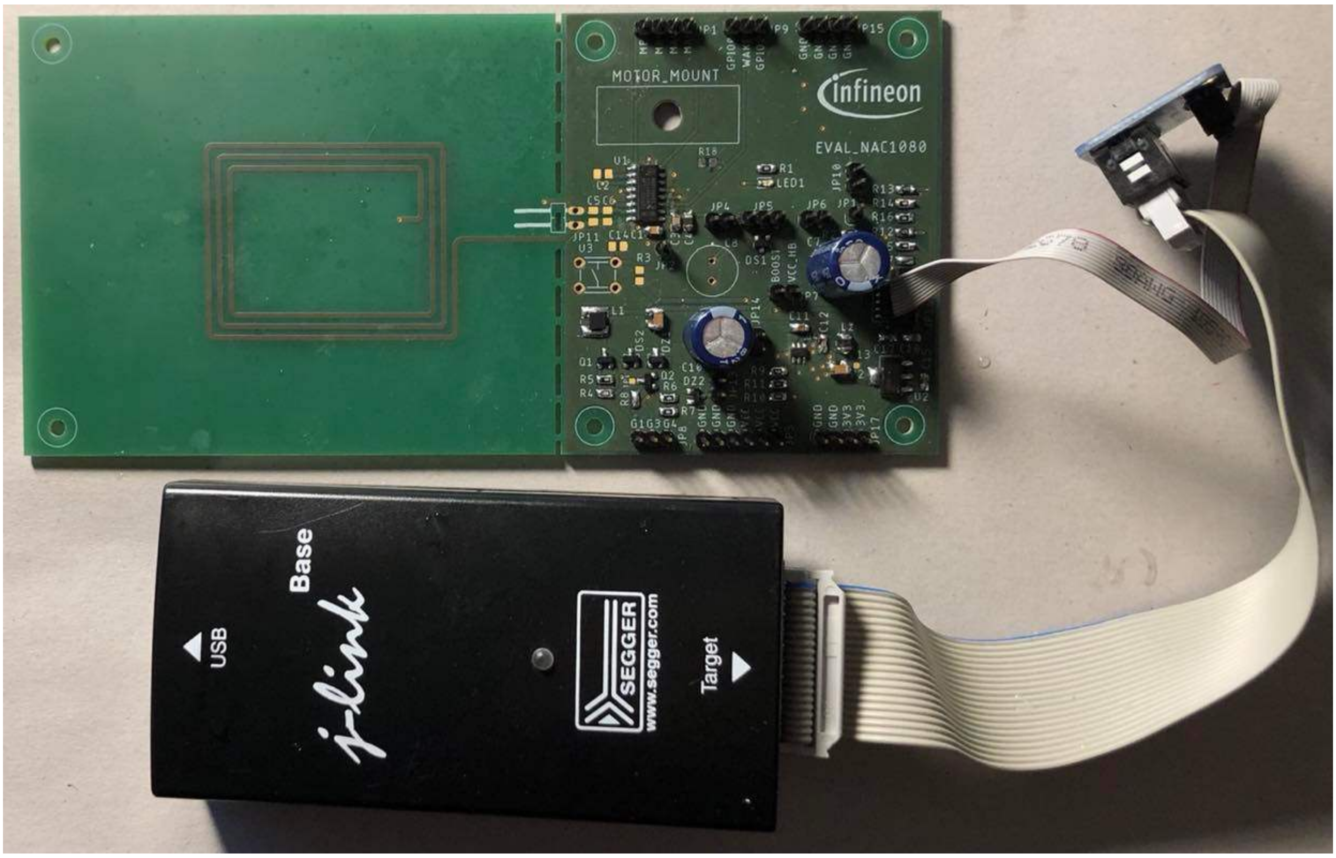

Figure 8 **J-Link debugger connected to the evaluation board**

12 Mobile application software

The mobile application software is designed to support the remote control of the smart lock system under development. The software can work together with the available firmware demo example developed for the three different methods of motor rotation described in Chapter 2.

The mobile application software is available for iOS and Android operating systems.

To install the mobile application on an Android cell phone, copy the file to the *Application* folder of the cell phone, then go to *Installation packages* and install the application. For some Android versions it is necessary to permit the installation – this can be done in the system *Settings --> Applications*. NFC has to be switched on on the cell phone (system *Settings --> device connectivity* or *wireless & networks*).

To install the application on an iPhone an internet connection is necessary. Access to the application can be done either via QR code or via the direct link given in the development kit software package. After the installation of the mobile application is finished the permission has to be set: system *Settings-->General-->Device management-->x-root Software*.

For both Android and iOS, after the installation it is necessary to accept the terms of service.

Figure 9 shows the GUI of the mobile application software. After running the software you will see the *Home* and *Locks* menus at the bottom of the screen. The first time you connect a mobile app with the evaluation board, the mobile app will identify the presence of an unknown lock. It will redirect to "setup new lock" to ask for product registration (Figure 9(a)). The registration can also be started by selecting *Setup* in the top-right corner. During the registration the supervisor key must be entered. For the available firmware demo code the supervisor key is: *0123456789abcdef* . For the real locks in production it is assumed that such a supervisor key is unique and is provided together with every lock in the package, or will be available through the online registration. After the registration is finished the new registered lock will be displayed in the *Locks* (Figure 9(b)) tab. The *Locks* tab shows all the registered keys on the cell phone and allows the user to manage the keys: edit, share or delete. To control the lock from the application software, the *Home* tab (Figure 9(c)) has to be used. In the *Home* tab "Lock" and "Unlock" buttons activate the following flow: initiate the information exchange via NFC between the reader (smartphone) and NAC1080, wait for the energy storage capacitor charge and then send the command to rotate the motor (Lock – forward direction, Unlock – reverse direction). The round diagram shows the current status (Figure 10 and Figure 11). If the communication between the reader and NAC1080 is stable and the sequence is completed the diagram shows the status "Succeeded". If the communication was interrupted then the diagram shows the status "Failed" and the operation has to be repeated by pressing the "Lock" or "Unlock" button on iOS smartphones, or it will be repeated automatically (without pressing any buttons) on Android smartphones.

LED1 on the evaluation board indicates the NFC between the reader and NAC1080. Please note that the indication works differently for iOS and Android. For iOS the NFC can be established only after "Lock" or "Unlock" button is pressed. For Android the NFC communication can be established without pressing any buttons. The following LED1 indications can be distinguished:

- LED1 is permanently on: the NFC between NAC1080 and the mobile application software is established and running.
- LED1 is blinking: H-bridge is active (mini DC motor is rotating if connected) during the established NFC between NAC1080 and the mobile application software.

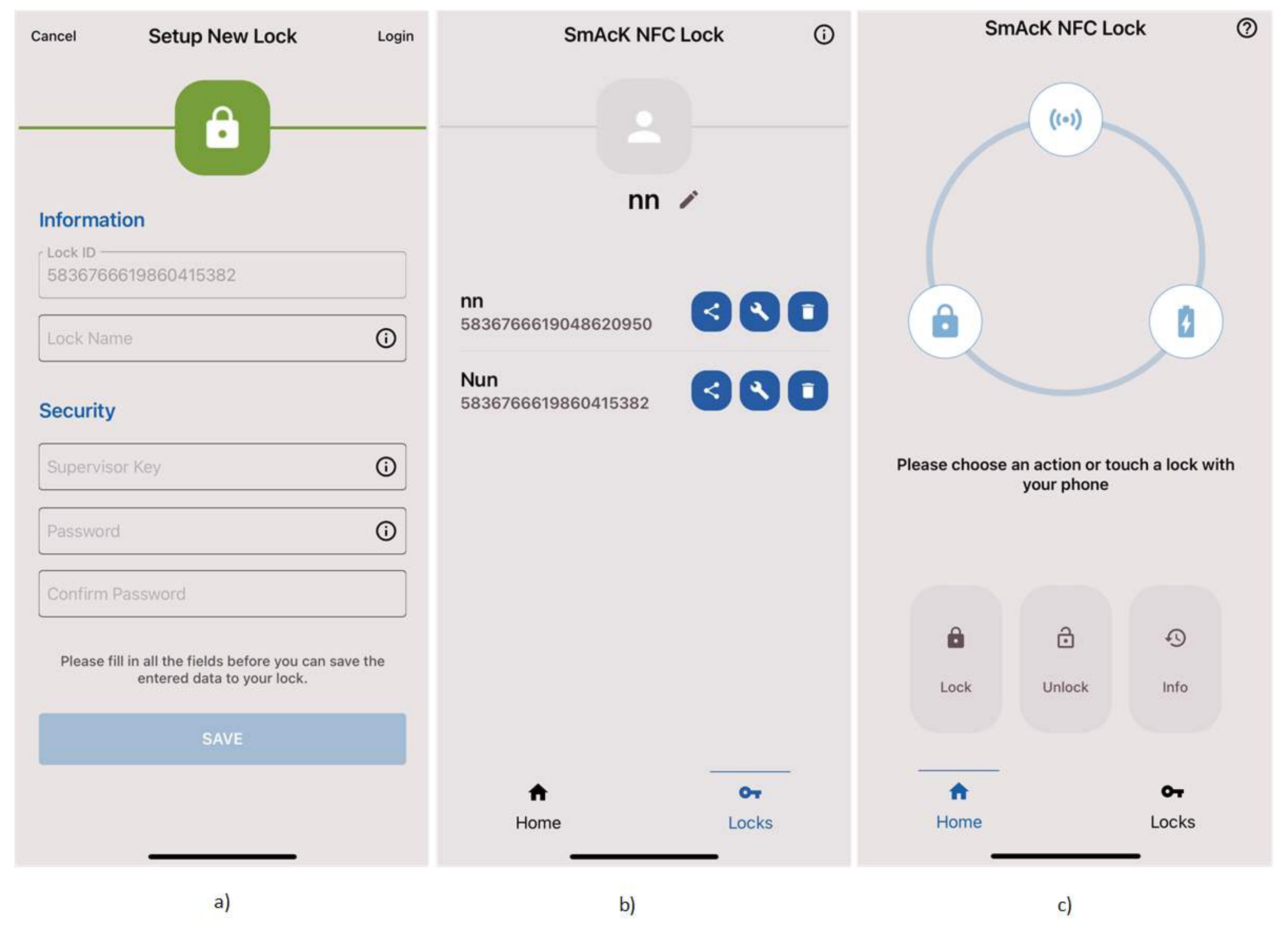

Figure 9 **Graphical user interface of the mobile application software**

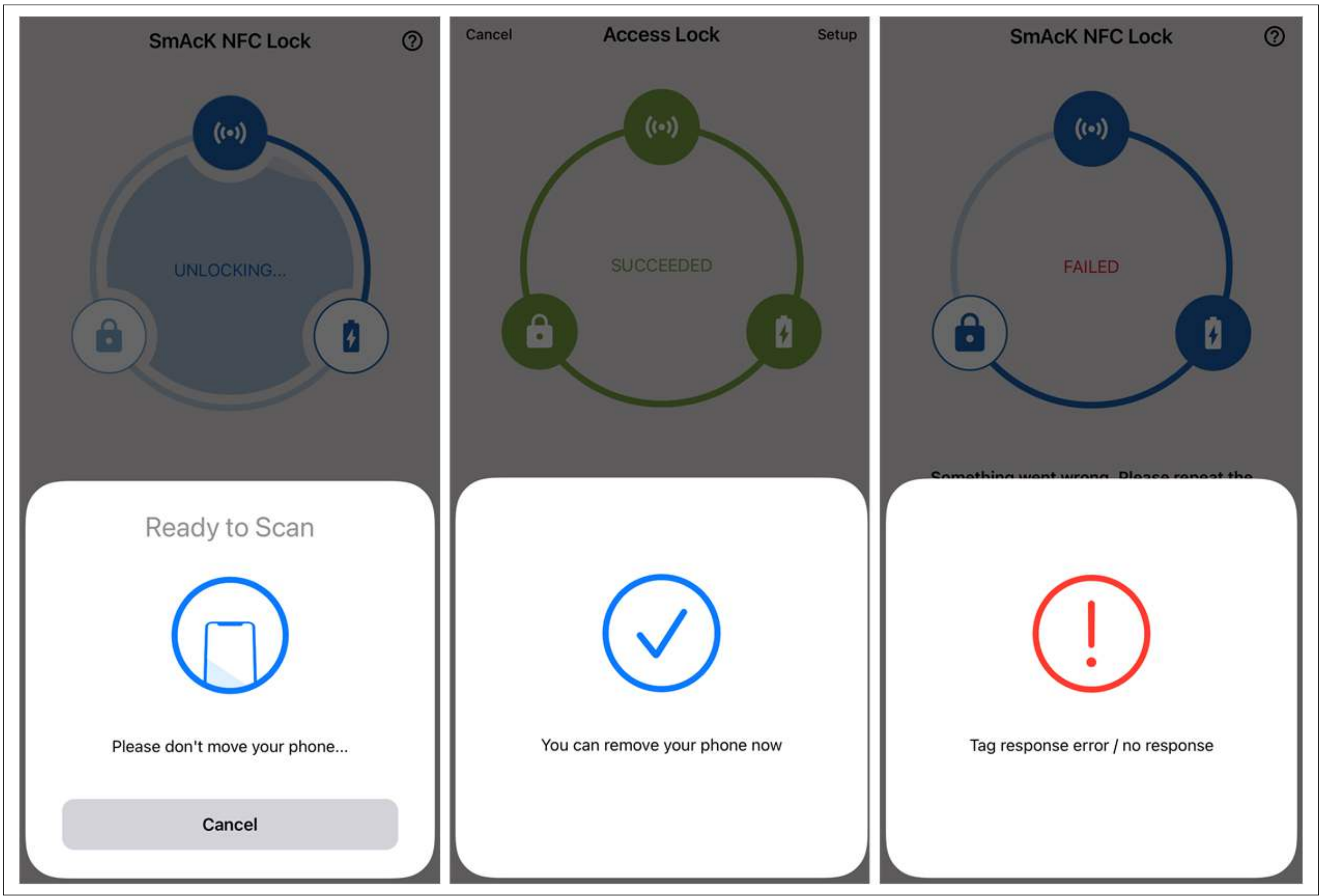

Figure 10 **Different communication statuses between the NAC1080 and the mobile application software (example shown in iOS)**

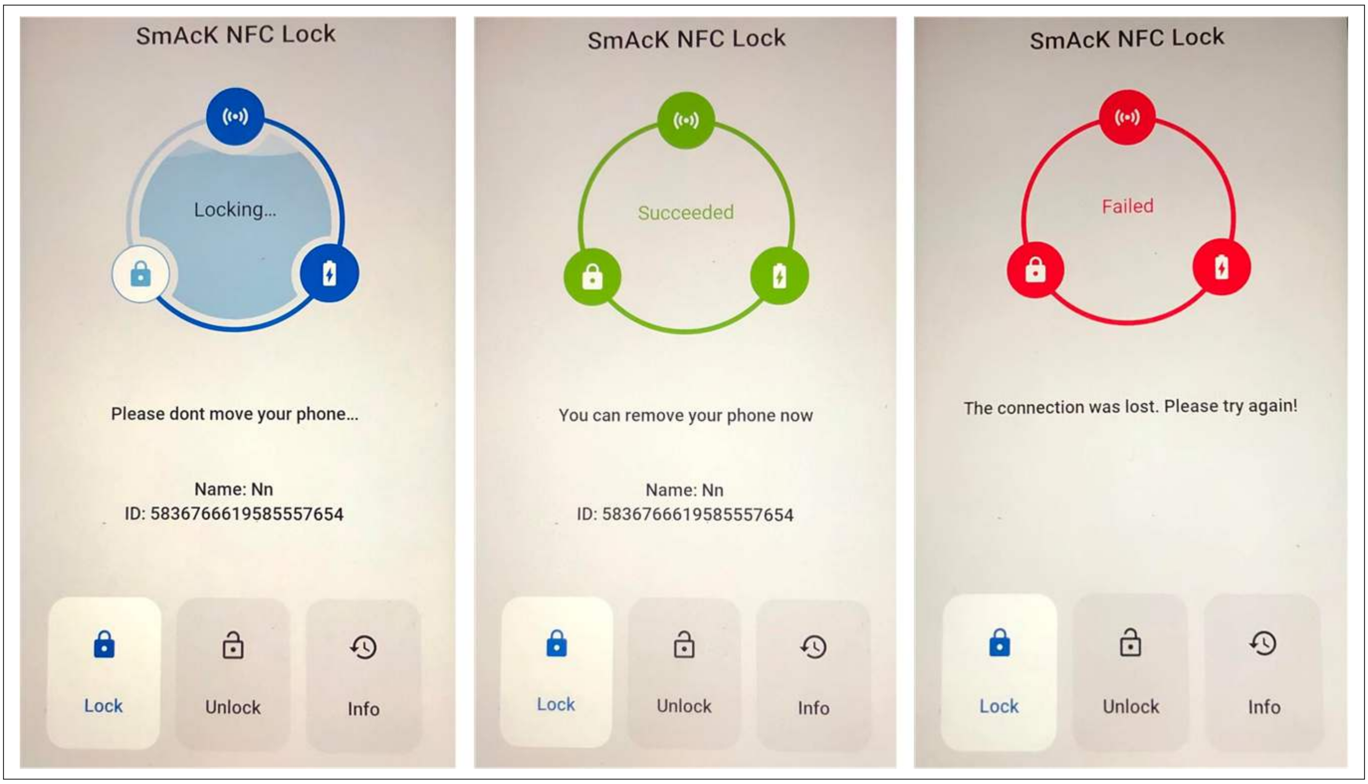

Figure 11 **Different communication statuses between the NAC1080 and the mobile application software (example shown in Android)**

Revision history

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V1.0	2022-06-23	first release

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