

# AN11231

## KNX evaluation board using LPC1227 and NCN5120

Rev. 2 — 8 May 2013

Application note

### Document information

Info	Content
<b>Keywords</b>	KNX, LPC1227, ON Semiconductor NCN5120, Weinzierl Engineering GmbH, Building Automation, Sensors, HVAC, Lighting, ARM Cortex-M0, Twisted pair TP1.
<b>Abstract</b>	This application note describes the OM13042 KNX evaluation board that uses the LPC1227 Cortex-M0 microcontroller and the NCN5120 KNX TP1 physical layer transceiver from ON Semiconductor.



**Revision history**

Rev	Date	Description
2	20130508	Modifications: <ul style="list-style-type: none"><li>• Chapters 2, 3, 4 and 5 restructured and updated.</li><li>• Added Chapter 6.</li><li>• Updated Fig 6.</li><li>• Added references.</li></ul>
1	20120701	Initial version

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## 1. Document purpose

The purpose of this document is to describe the OM13042 KNX evaluation board design.

This document is intended for technical persons such as system architects, hardware and software engineers interested in designing and developing a KNX device using an NXP microcontroller.

For readers new to KNX we advise to read the KNX Basic Course Documentation [\[1\]](#) available from the KNX association.

## 2. Introduction

The KNX evaluation board is an example implementation for KNX devices using an NXP Cortex-M0 microcontroller LPC1227, the KNX twisted pair transceiver NCN1520 from ON Semiconductor and a KNX System B software stack from Weinzierl Engineering GmbH.

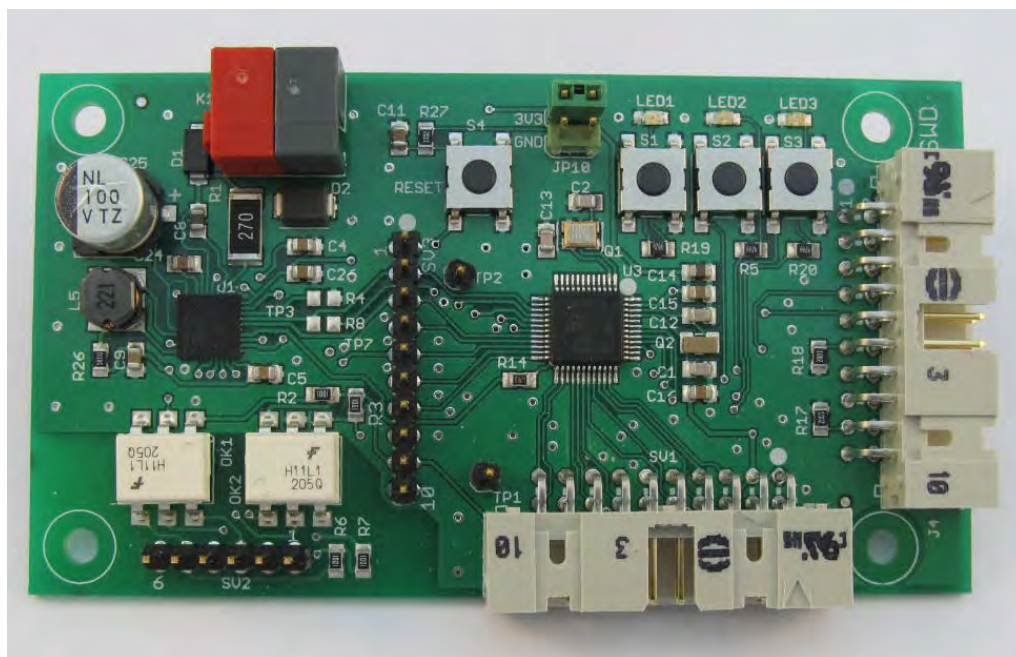


Fig 1. OM 13042 KNX TP1 NCN5120 LPC1227 evaluation board

The board supports the connection of actuators, sensors, switches or other applications in a building automation network. The evaluation board is available under the full name OM13042,598 and order code 935298293598. Apart from the documentation in this application note, refer to the KNX project pages at NXP MCU community site [LPCware.com](http://LPCware.com) [\[6\]](#).

### 3. Hardware

This chapter provides an overview of the board, its partitioning and all other hardware related information of the evaluation board.

#### 3.1 Overview

An overview of the main components of the evaluation board is given in [Fig 2](#). The KNX transceiver IC NCN5120 connects via UART to the LPC1227 microcontroller. The transceiver creates a regulated 3.3 V power supply for the microcontroller from the unregulated KNX bus supply. The LPC1227 creates a clock signal for the digital control part of the transceiver. Several button and LEDs are available as sensor and actuator inputs to the system.

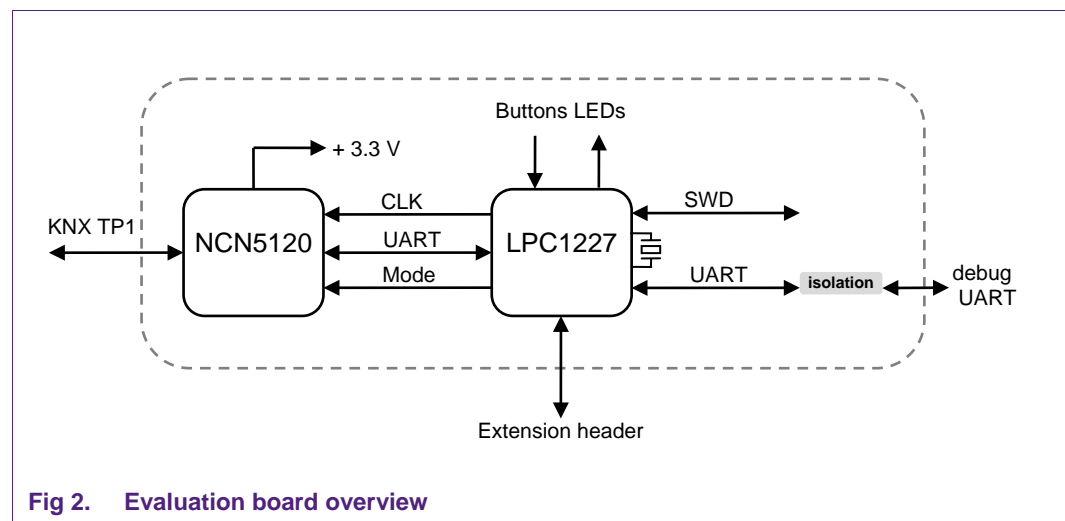
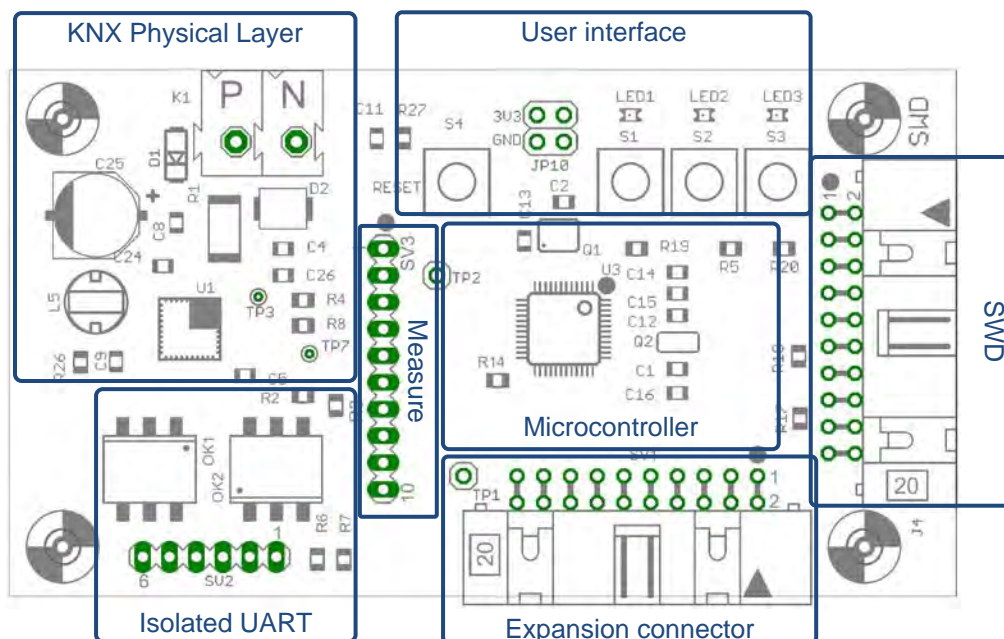


Fig 2. Evaluation board overview

#### 3.2 PCB overview

The evaluation board is a two layer board with all components on the top side of the board. The partitioning of the design is given in [Fig 3](#).



**Fig 3. Partitioning of the design**

The upper left part of the board contains the KNX TP1 header K1 to connect the KNX bus. Below the KNX connector the board contains the physical transceiver part of the design. On the left bottom side the isolated UART interface is available on header SV2.

In the middle of the board a header is available to measure the various signals between the microcontroller and the transceiver. The top part contains the user interaction: LEDs and buttons. The header on the right hand side provides a debug probe connection that complies with the Serial Wire Debug (SWD) interface standard. To interface with other boards an extension connector is present on the lower part of the board.

All components are placed on the top side of the board as depicted in [Fig 4](#).

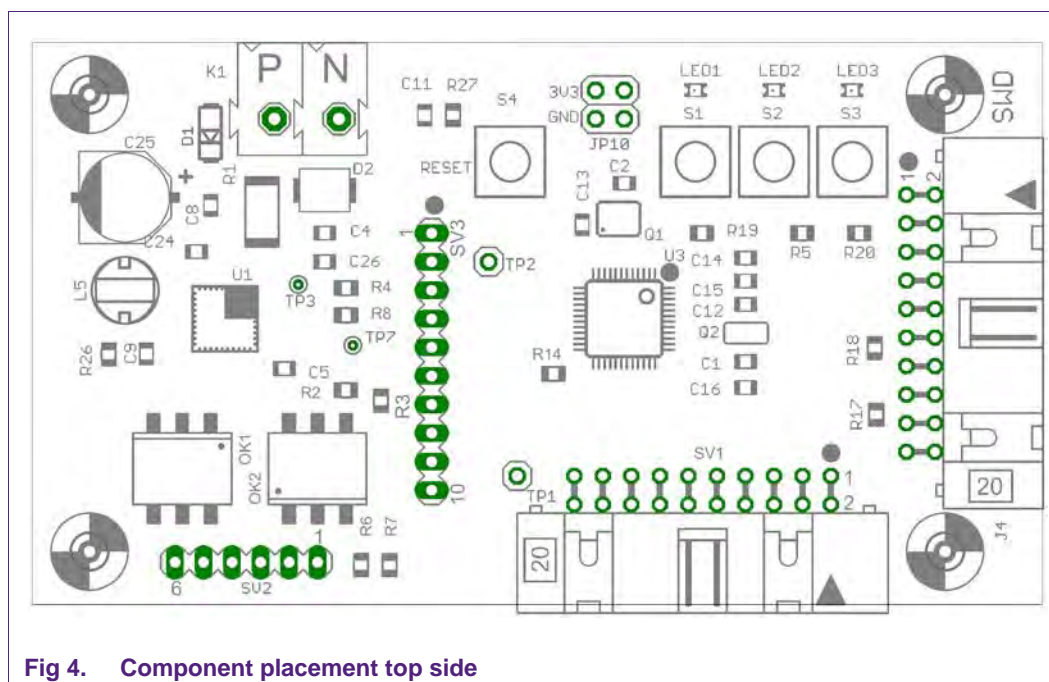


Fig 4. Component placement top side

### 3.3 Microcontroller

To allow easy KNX application development, the development board is equipped with an LPC1227 Cortex-M0 microcontroller with a flash memory size of 128 kB and 8 kB of RAM. This allows for downgrading to other LPC122x microcontrollers with smaller memory sizes while maintaining software and hardware compatibility. More information on the LPC122x microcontroller series is available in the LPC122x datasheet [\[2\]](#).

The microcontroller uses UART1 to connect to the transceiver. Furthermore, some GPIO's are used to connect to the KNX Phy. The second UART (UART0) on the design can be used to connect an external terminal program for debugging messages. The debug UART is electrically isolated from the design and the KNX bus.

Software can be downloaded via the SWD interface and debugged to the microcontroller on header J4. The LPC1227 user manual [\[3\]](#) contains a full description of the processing core and all the on board peripherals of the microcontroller. [Fig 5](#) gives the schematic of the microcontroller section of the board.

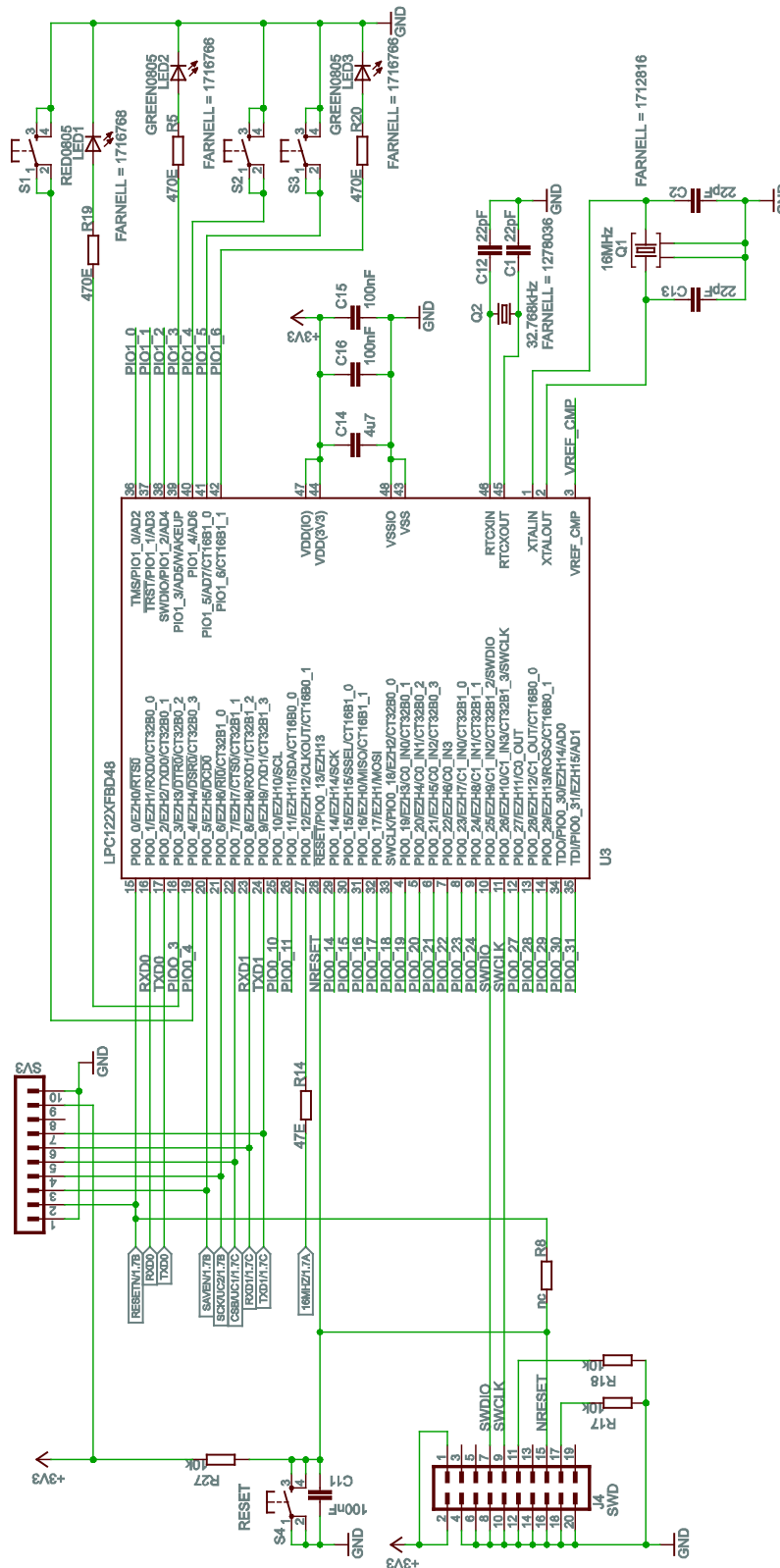
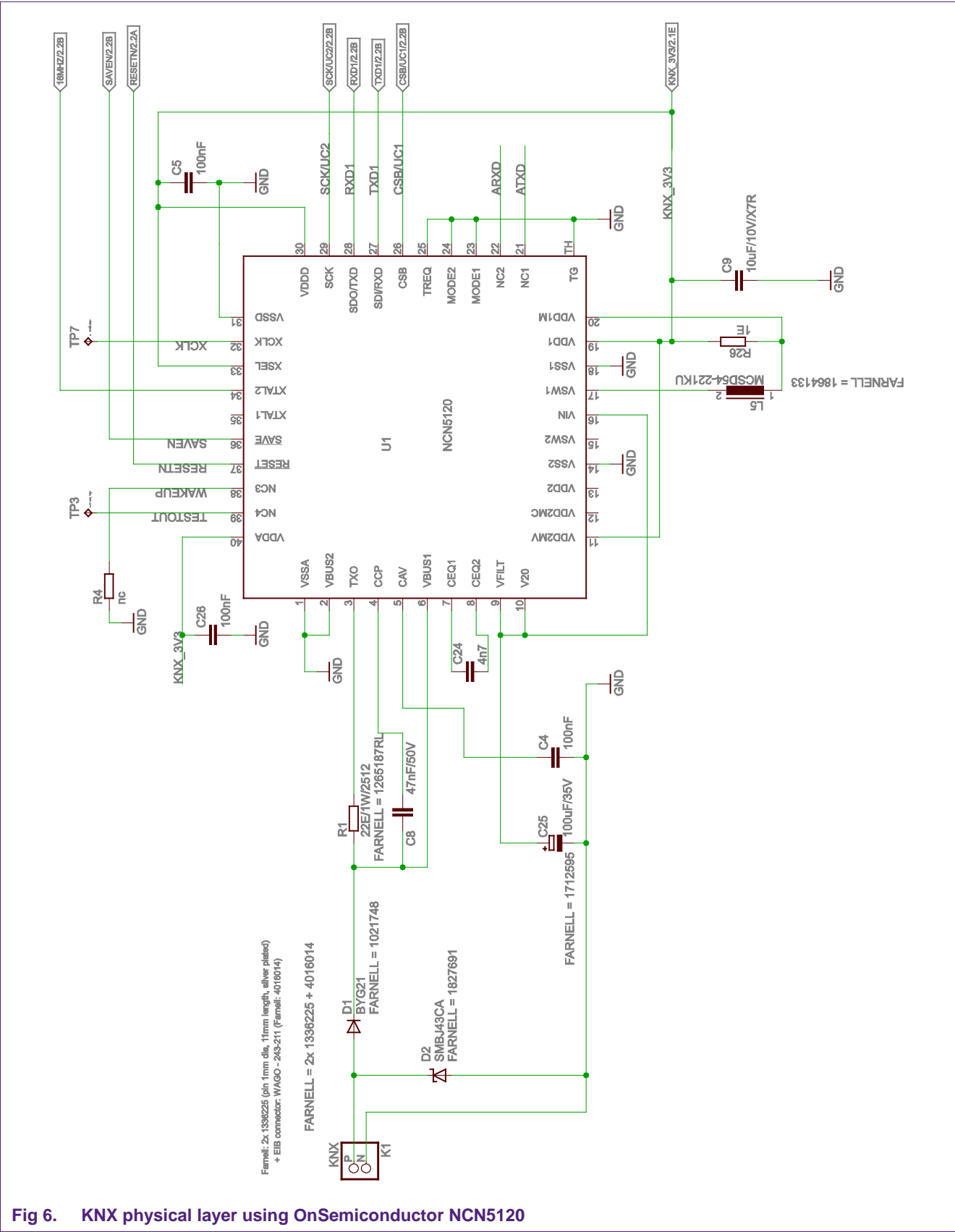


Fig 5. LPC1227 Microcontroller section of the schematic

### 3.4 KNX physical layer

The twisted pair 1 (TP1) KNX physical layer standard is used in the design. The design uses an NCN5120 receiver-transmitter IC [\[4\]](#) for TP1 communication. The NCN5120 handles the transmission and reception of data on the bus. It generates from the unregulated KNX bus voltage stabilized voltages for its own power needs as well as power for external devices as the microcontroller in this design. The NCN5120 assures safe coupling to and decoupling from the bus. Bus monitoring warns the external microcontroller for loss of power so that critical data can be stored in time.





### 3.5 Isolated UART interface

The isolated debug UART can be used for showing messages on a terminal. The 6-pin connector is compatible with a TTL-232R-3V3 cable from FTDI (Farnell order code: 1329311). This cable is shown in [Fig 7](#).



Fig 7. FTDI TTL-232R-3V3 cable

[Fig 8](#) gives the schematic diagram of the electrical isolated debug UART. This connection can both be used for input and output to the design and is not necessary for an end product.

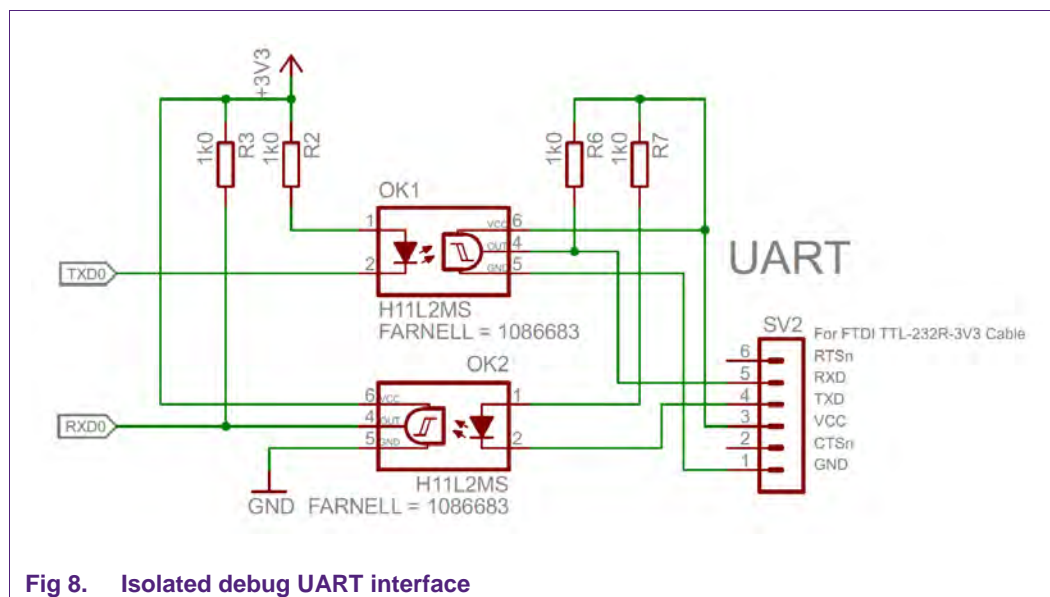


Fig 8. Isolated debug UART interface

### 3.6 Expansion connector

To facilitate the connection of external hardware the expansion connector SV1 is available. The expansion connector can be used to connect external hardware boards for lighting, sensor, HVAC or other control purposes.

The connections of the expansion connector are given in [Fig 9](#). All the connections, except ground and power, are directly connected to the microcontroller. The connections available support the usage of the 16-bit timers CTB16B0 and CTB16B1, and the 32-bit timers CT32B0 and CT32B1 for PWM generation. Furthermore, two analog to digital inputs are available; for communication purposes an SPI/SSP or I2C connection is available.

Not all these I/O connections are available simultaneously as the microcontroller uses pin multiplexing to select the specific function of an I/O pin. For detailed information on the pin multiplexing possibilities of the LPC1227 microcontroller see the LPC1227 user manual [\[3\]](#).

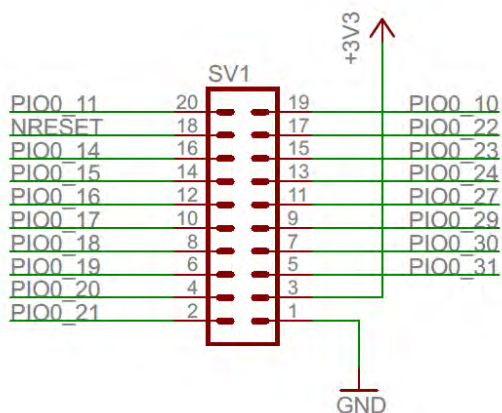


Fig 9. Expansion connector

## 4. Bill of Materials

**Table 1. Component list**

Part	Value	Device	Package	Description	Farnell
C1	22pF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C2	22pF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C4	100nF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C5	100nF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C8	47nF/50V	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C9	10uF/10V/X7R	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C11	100nF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C12	22pF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C13	22pF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C14	4u7	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C15	100nF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C16	100nF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C24	4n7	C-EUC0805K	C0805K	CAPACITOR, European symbol	
C25	100uF/35V	CPOL-EUF	PANASONIC_F	POLARIZED CAPACITOR, European symbol	1712595
C26	100nF	C-EUC0805K	C0805K	CAPACITOR, European symbol	
D1	BYG21	DIODE-DO214AC	DO214AC	DIODE	1021748
D2	SMBJ43CA	SUPPRESSOR-SMBJ	SMBJ	Suppressor diode	1827691
J4	MC9A22-2034	MC9A22-2034		HEADER, RIGHT ANGLE, 20 WAY	8396027
JP10		PINHD-2X2	2X02	PIN HEADER	
K1	KNX	KNX	KNX	TP1 pins and connector	2x 1336225 + 4016014
L5	220uH	NPI54C221KTRF	5.8x5.2	NIC Components, SMD non-shielded	RS online 740-9619
LED1	RED0805	LEDCHIPLED_0805	CHIPLED_0805	LED	1716768
LED2	GREEN0805	LEDCHIPLED_0805	CHIPLED_0805	LED	1716766
LED3	GREEN0805	LEDCHIPLED_0805	CHIPLED_0805	LED	1716766
OK1	H11L2MS	H11L2MS	DIL6-SMD	6-pin DIP Optocoupler	1086683
OK2	H11L2MS	H11L2MS	DIL6-SMD	6-pin DIP Optocoupler	1086683
Q1	16MHz	CRYSTAL4	XTAL4	16MHZ, 50PPM, 12.5PF - CRYSTAL, 3.2 mm x 2.5 mm	1712816
Q2	32.768kHz	RTCCRYSTAL	XTAL2	EPSON TOYOCOM - FC-135 32.768KHZ ±20PPM, 12.5PF	1278036
R1	22E/1W/2512	R-EU_R2512	R2512	RESISTOR, European symbol, +/- 5%	1265187RL
R2	1k0	R-EU_R0805	R0805	RESISTOR, European symbol	
R3	1k0	R-EU_R0805	R0805	RESISTOR, European symbol	
R4	nc	R-EU_R0805	R0805	RESISTOR, European symbol	
R5	470E	R-EU_R0805	R0805	RESISTOR, European symbol	
R6	1k0	R-EU_R0805	R0805	RESISTOR, European symbol	

Part	Value	Device	Package	Description	Farnell
R7	1k0	R-EU_R0805	R0805	RESISTOR, European symbol	
R8	nc	R-EU_R0805	R0805	RESISTOR, European symbol	
R14	47E	R-EU_R0805	R0805	RESISTOR, European symbol	
R17	10k	R-EU_R0805	R0805	RESISTOR, European symbol	
R18	10k	R-EU_R0805	R0805	RESISTOR, European symbol	
R19	470E	R-EU_R0805	R0805	RESISTOR, European symbol	
R20	470E	R-EU_R0805	R0805	RESISTOR, European symbol	
R26	1E	R-EU_R0805	R0805	RESISTOR, European symbol	
R27	10k	R-EU_R0805	R0805	RESISTOR, European symbol	
S1	B3FS-1000	B3FS-1000	SWITCH-TACT_DTSM-6	OMRON ELECTRONIC COMPONENTS - B3FS-1000 - SWITCH, FLAT, SPNO	3121161
S2	B3FS-1000	B3FS-1000	SWITCH-TACT_DTSM-6	OMRON ELECTRONIC COMPONENTS - B3FS-1000 - SWITCH, FLAT, SPNO	3121161
S3	B3FS-1000	B3FS-1000	SWITCH-TACT_DTSM-6	OMRON ELECTRONIC COMPONENTS - B3FS-1000 - SWITCH, FLAT, SPNO	3121161
S4	B3FS-1000	B3FS-1000	SWITCH-TACT_DTSM-6	OMRON ELECTRONIC COMPONENTS - B3FS-1000 - SWITCH, FLAT, SPNO	3121161
SV1	MC9A22-2034	MC9A22-2034		HEADER, RIGHT ANGLE, 20 WAY	8396027
SV2		MA06-1	MA06-1	PIN HEADER	
SV3		MA10-1	MA10-1	PIN HEADER	
TP1		PINHD-1X1	1X01	PIN HEADER	
TP2		PINHD-1X1	1X01	PIN HEADER	
U1	NCN5120	NCN5120	QFN40_6X6_NCN5120	ON Semiconductor KNX TP1 transceiver	Mouser 863-NCN5120MNG
U3	LPC1227FBD48	LPC122XFBD48	SOT313-2	NXP ARM Cortex-M0 32 bit Microcontroller	1862476

## 5. Device configuration

The demo board is programmed with the App\_DemoBoardNXP\_LPC12xx.hex file to create an example KNX device. Together with the example project for the ETS tool (the manufacturer independent configuration tool from the KNX association), the user can setup a KNX network using the OM13042 board.

The example application file for the microcontroller contains a limited version of the KNX stack from Weinzierl Engineering. For more information on the KNX system stack refer to Weinzierl Engineering [5]. Although this example board uses the LPC1227 microcontroller from the LPC122x series the KNX stack is also available for other Cortex-M0 microcontrollers like the LPC11Exx, LPC11Uxx series and for the Cortex-M3 based LPC1700 microcontroller series.

For more details please refer to LPCware.com [6].

**Table 2. Accompanying files AN11231**

File name	Description
App_DemoBoardNXP_LPC12xx.hex	Flash file for the LPC1227 microcontroller
Test_Project_App_Demo_NXP_2012_04_11.pr5	Example project for KNX ETS configuration tool

Although the evaluation board is not included in the device database of ETS, the project file *Test\_Project\_App\_Demo\_NXP\_2012\_04\_11.pr5* contains the device information of the demoboard. This test project should be imported into the ETS tool of the KNX association to work with this board.

The board already has the physical address 1.0.1 assigned. Button S2 sends messages to group object 2/0/0 and button S3 sends messages to group object 4/0/1.

### 5.1 KNX programming mode

KNX programming mode can be activated with button S1. An active programming mode is indicated by LED1.

### 5.2 Channel configuration

The board contains four channels. Channel one and two are coupled to buttons and LEDs on the boards. Channel three and four are not coupled to I/O on the evaluation boards. An overview of the functions is given in [Table 3](#).

**Table 3. Evaluation board functions and their board mapping**

Channel	Description	Board mapping	Group Objects	Parameters
1	Pushbutton	LED2 and S2	GO1 1 bit input GO2 4 bit output GO3 1 bit input	Parameter1: 1 byte "Sensor type"
2	Switch actuator with stopping time	LED3 and S3	GO1 1 bit input GO2 1 bit output	Parameter1: 1 byte "Stopping time" ( 0 to 60 Seconds )
3	Temperature sensor	None	GO1 2 byte input GO2 1 bit output	Parameter1: 2 bytes "Limit value" ( 11 °C to 29 °C)

Channel	Description	Board mapping	Group Objects	Parameters
4	Room controller	None	GO1 2 byte input GO2 1 bit input	Parameter1: 2 byte "Switch value" (10 °C to 60 °C ) Parameter2: 1 byte "Manual delay" ( 0 to 60 Seconds)

### 5.2.1 Channel 1: Pushbutton

The function of channel 1 depends on the parameter "Sensor type". The following four functions are possible:

#### Disabled:

No function.

#### Switch:

After pressing the button, the value on GO1 will be toggled and sent via bus.

After updating GO3, the LED will be set depending on GO3 value:

- GO1 Switch On/Off
- GO3 Switch State

#### Dimmer:

After pressing the button for a short duration, the value on GO1 will be toggled and sent via bus.

After pressing the button for a long duration, the value on GO2 will be toggled and sent via bus.

There is only one toggle state for switching and dimming; if you "switch on" (short) the following dim command (long) will be "dim darker".

After updating GO3, the LED will be set depending on GO3 value:

- GO1 Dimmer Switch
- GO2 Dimmer Relative
- GO3 Dimmer Switch state

#### Shutter:

After pressing the button for a short duration, the value on GO1 will be the same within a delay of 1.5 seconds, and then it will be toggled and sent via bus.

After pressing the button for a long duration, the value on GO2 will be toggled and sent via bus.

For example: Move up -> Stop -> Step down -> wait 1.5 seconds -> Step up -> Move down.

The LED is not used:

- GO1 Shutter Step/Stop
- GO2 Shutter Up/Down (1bit)

### 5.2.2 Channel 2: Switch actuator with stopping time

Channel 2 is a switch actuator which can be controlled via button or group object. The parameter sets the stopping time in seconds. If 0 there will be no automatic switch off, else the value on GO2 (it has to be 1) will be set to 0 and sent via bus after stopping time

After pressing the button, the value on GO2 will be toggled and sent via bus. After updating GO1, the value will be set on GO2 and sent via bus.

There is also a counter (4byte) which counts +1 on every switch on.

The LED is for visualization of GO2:

- GO1 Switch actuator On/Off

### 5.2.3 Channel 3: Temperature sensor

This channel is not mapped to hardware functions (LEDs or switches). The function is illustrated as follows:

Channel 3 is a simple temperature sensor which increments the temperature with a resolution of 2 °C from 10 °C to 30 °C every time you press the button. If 30 °C is reached, the temperature will be decremented with the same resolution every time you press the button.

If the temperature value is higher than the limit value (parameter 11 °C to 29 °C), then the value on GO2 will be set to 0x01. Otherwise if the temperature value is lower, the value on GO2 will be set to 0x00.

The LED is for visualization of GO2:

- GO1 Temperature State
- GO2 Alert On/Off

### 5.2.4 Channel 4: Room controller

This channel is not mapped to hardware functions (LEDs or switches). The function is illustrated as follows:

Channel 4 is a room controller, which receives temperature value via GO1. If the received temperature is underneath the switch value, then the value on GO2 will be set to 0x01. Otherwise if the temperature is above the switch value, the value on GO2 will be set to 0x00.

In addition to the automatic control, you can press the button to toggle the value on GO2 for a defined manual delay (if the delay is not 0s). After this the automatic control will be executed again.

The LED is for visualization of GO2:

- GO1 Temperature State
- GO2 Room controller State



### 5.3 Property overview

**Table 4. User Interface Object 1 – Push Button Sensor**

	Object ID	Write	Type	Max El.	Access	Flags
InterfaceObject-Type (50001d)	1	No	PT_UINT	1		ValueRef
Sensortype (ETS-Parameter)	201	No		1	ANY	ValueRef

**Table 5. User Interface Object 2 – Switch Actuator**

	Object ID	Write	Type	Max El.	Access	Flags
InterfaceObject-Type (50002d)	1	No	PT_UINT	1		ValueRef
Stopping time (ETS-Parameter)	201	Yes	PT_CHAR	1	ANY	ValueRef, Postfnc Wr
Switch count	202	No	PT_ULONG	1	ANY	FncRd

**Table 6. User Interface Object 3 – Temperature Sensor**

	Object ID	Write	Type	Max El.	Access	Flags
InterfaceObject-Type (50003d)	1	No	PT_UINT	1		ValueRef
Temperature value (IEEEFloat)	201	No	PT_FLOAT	1	ANY	FncRd

**Table 7. User Interface Object 4 – Room Controller**

	Object ID	Write	Type	Max El.	Access	Flags
InterfaceObject-Type (50004d)	1	No	PT_UINT	1		ValueRef
State of room controller	201	No	PT_CHAR	1	ANY	FncRd
Manual Control Delay (ETS-Parameter)	202	Yes	PT_CHAR	1	ANY	ValueRef, PostFnc Wr

## 6. Conclusion

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This application note illustrates how to use the OM13042 to create a KNX TP1 node using a LPC1227 Cortex-M0 Microcontroller and an NCN5120 TP1 physical layer transceiver with integrated power supply.

The external interfaces and the device configuration of the example application using the KNX System B software stack from Weinzierl Engineering are detailed.

This total set makes it possible to use the OM13042 as evaluation board together with other KNX TP1 nodes and the ETS software tool from the KNX association.

The stack is also available for other Cortex-M0 microcontrollers like the LPC11Exx or LPC11Uxx and for the Cortex M3 based LPC1700 series. More details can be found on the KNX project pages at NXP's MCU community website [LPCware.com](http://LPCware.com) [6].

## 7. References

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- [1] KNX Basic Course Documentation, February 2011, KNX Association
- [2] Product data sheet LPC122x 32-bit ARM Cortex-M0 microcontroller, Rev. 2 — 26 August 2011 [http://www.nxp.com/documents/data\\_sheet/LPC122X.pdf](http://www.nxp.com/documents/data_sheet/LPC122X.pdf)
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- [4] NCN5120 datasheet, Rev. 2 – April 2013 ON Semiconductor <http://www.onsemi.com/PowerSolutions/product.do?id=NCN5120>
- [5] Weinzierl Engineering GmbH, <http://www.weinzierl.de/>  
KNX project pages at NXP's MCU community website lpcware.com  
<http://lpcware.com/content/project/knx-lpc-microcontrollers>

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