INTEGRATED CIRCUITS DIVISION

NCD1015M

HDX RFID Integrated Circuit

PRELIMINARY

Description

The NCD1015M is a module to be used in HDX, no-lead RFID devices for single transponder applications in the area of electronic animal and industrial identification, operating in the low frequency (134.2 kHz) range, and supporting ISO 11784/85 standards. Additionally, it can be used as a read/write HDX module.

The NCD1015M contains an ASIC and 2 internal capacitors: one, a resonant capacitor, and the other a storage capacitor. The ASIC contains 3 memory blocks of 32 bits each, based on field programmable, non-volatile EEPROM.

Each block contains 32 data bits (bit 1 ... bit 32). Blocks 1 and 2 are referred to as the 64-bit identification data page 1, which is secured by an associated 16-bit CRC. Block 0 offers the option to irreversibly lock the RFID device. Once the device is locked, it is fully compatible with ISO 11784/85 standards.

The HDX transponder IC receives Write-Block requests from the reader as a pulse interval encoded, 100% amplitude modulated data signal.

Return data transmission from the transponder to the reader utilizes FSK encoded modulation. This is achieved by a serial data stream controlled Frequency Shift Keying (FSK) of the transponder's resonant circuit oscillation with an additional on-chip modulation capacitor between the two transponder terminals HF and GND. The passive transponder uses the supplied RF signal to obtain the energy needed to send the 64-bit ID code to the reader.

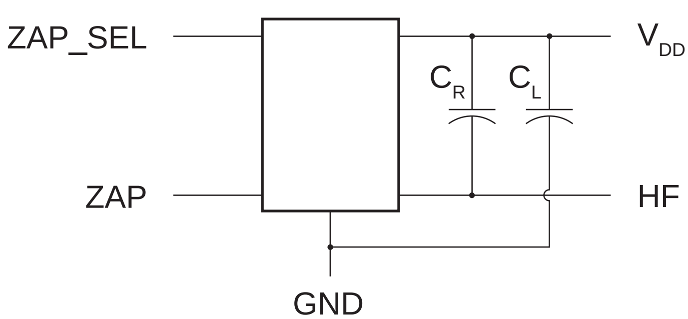
Features

- Air Interface . . . . No-lead, Sequential Power & Data Transmission (HDX)
- Radio Frequency Center Frequency . . . . . . 134.2 kHz Typically
- Reader ➩ Tag Transmission . . . . Pulse Interval Encoding (PIE) ~1 to 2kBits/s
- Tag ➩ Reader Transmission . . . . FSK Modulation, NRZ: “0” ~134.2kHz; “1” ~124.2kHz
- Tag ➩ Reader Data Rate . . . . RF/16 (~8kBits/sec)
- On-Chip 16-Bit CRC Generator . . . . Reverse CRC-CCITT as used in ISO/IEC 11785
- On-Chip Integrated Modulation Cap. C_1 . . . 110pF, ±20% according to silicon process deviation
- Resonance Capacitor, C_R . . . . 470pF, ±2%, 50V External SMD NP0 / C0G Capacitor
- Storage Capacitor, C_L . . . . 220nF, ±5%, 10V Capacitor
- Identification Data Page . . . . 64 Bits Data + Associated 16 Bits CRC

Ordering Information

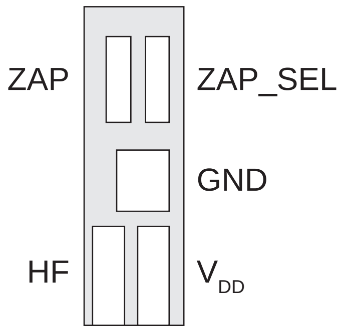
Part #	Package
NCD1015M	No-lead RFID device supporting ISO 11784/85 standards

NCD1015M Block Diagram



1. Specifications

1.1 Package Pinout



Bottom View

1.2 Pin Description

Pin Name	Description
V_{DD}	Voltage Supply
GND	Ground
HF	Oscillating Signal
ZAP_SEL	Clock for the trimming
ZAP	Voltage for the trimming

2. Electrical Data

2.1 Operating Conditions

Parameter	Minimum	Maximum	Unit
Operating Temperature, T_A	-25	+70	°C
Storage temperature, T_{STG}	-40	+100	°C

2.2 Electrical Specifications

Unless otherwise specified, minimum and maximum values are guaranteed by production testing or design. Typical values are characteristic of the device at 25°C, and are the result of engineering evaluations. They are provided for informational purposes only and are not guaranteed by production testing.

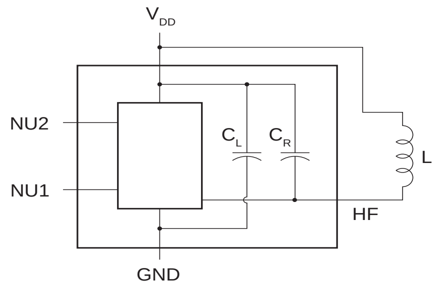
Parameter	Conditions	Minimum	Typical	Maximum	Unit
HF Limiter Current	V_{HF}=5V	-	-	4	µA
HF Maximum Voltage	I_{HF}=10mA	-	-	12	V
Quiescent Current Consumption	V_{DD}=5.5V	-	-	5	µA
Default HF Capacitor	-	-	580	-	pF
Modulation Capacitor	-	-	110	-	pF
Endurance	-	100	-	-	kHz
Data Retention	-	10	-	-	Years

3. Application Information

NCD1015M is designed to be used in a complete RFID HDX. For the RFID front-end to operate, only one inductor is needed, to operate as an antenna.

Figure 1 shows the NCD1015M and the connections with the external component. NU1 and NU2 pins are not used for the final application. Typical value for inductor “L” = 2.41mH. It is important to consider that the inductor has a parasitic capacitance itself, which adds to the HF capacitor modifying the resonant frequency of the tank.

Figure 1: Application Diagram

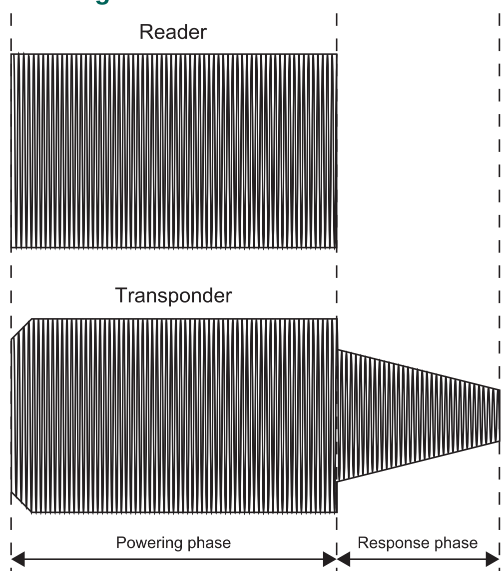


4. Functional Overview and Description

4.1 Power Transfer

Power transfer to the tag is accomplished by radio frequency through coupling antennas in the transponder and the reader. The reader and transponder operate in a sequential mode with time-separated power and data transmission cycles. The RF operating field supplies power at the beginning of the request from the reader to the HDX transponder. During the charge (or powering phase) of between 15 and typically 50 ms the reader generates an electromagnetic field with a frequency of 134.2 kHz. The resonant circuit of the transponder is energized and the induced voltage is rectified by the integrated circuit to charge the capacitor C_L. The transponder detects the end of the charge burst (EOB) and transmits data using Frequency Shift Keying (FSK), utilizing the energy stored in the capacitor C_L. The charge phase is followed directly by the read phase.

Figure 2: Charge and Read Phase - Voltage at the Reader’s Exciter and Transponder Coil



4.2 Communication Signal Interface - Tag to Reader

4.2.1 Frequency

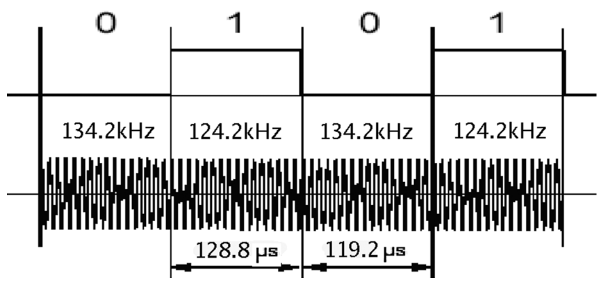
The tag shall be capable of communicating with the reader via an inductive coupling, whereby the power is switched off and the data are FSK modulated using the frequencies:

- f_0 = 134.2kHz for the Data “Low Bit” Encoding . . . . . (ISO 11785 tolerance)
- f_1 = 124.2kHz for the Data “High Bit” Encoding . . . . (ISO 11785 tolerance)

f_1 represents the frequency for a data bit '1' (t_{d1}=16/f_1) and f_0 for the data bit '0' (t_{d0} = 16/f_0).

The low and high bits have different duration, because each bit takes 16 RF cycles to transmit. The high bit has a typical duration of ~130µs, the low bit of ~120µs. Figure 3 shows the FSK encoding principle used.

Figure 3: FSK Transmission Used During the Read Phase



4.2.2 Transponder Data Rate and Data Coding

The data coding is based on the NRZ method, thus achieving an average data rate of ~8kbit/s based on an equal distribution of '0' and '1' data bits.

4.3 Communication Signal Interface - Reader to Tag

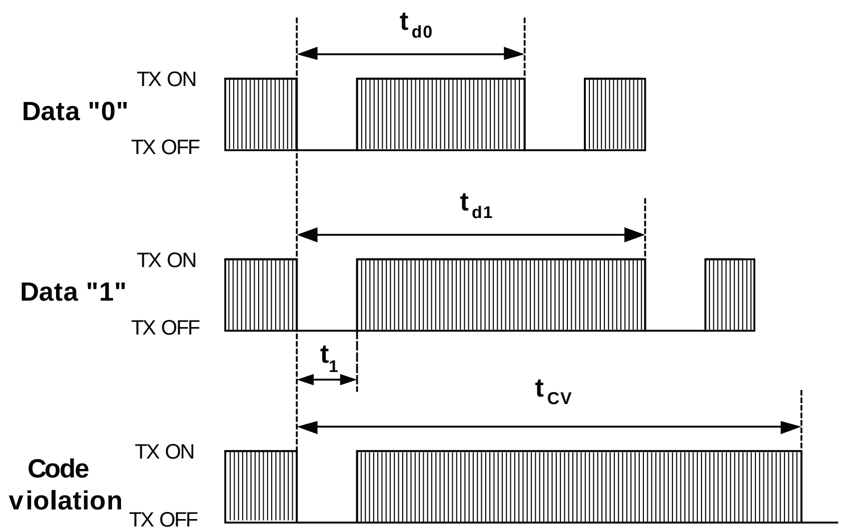
4.3.1 Modulation

Communication between reader and transponder takes place using ASK modulation of the RF field with a modulation index of ~100%. The carrier frequency of the RF operating field is f_C = 134.2 kHz.

4.3.2 Reader Data Rate and Data Coding

The reader to transponder communication uses Pulse Interval Coding (PIC). The reader creates pulses by switching the carrier on and off as described below. The modulation index of this amplitude modulation is 90% to 100%. The time between the falling edges of the pulses determines either the value of the data bit, "0" or "1", a Code violation, or a Stop (EOF) condition. t_1 separates the single intervals. Its duration is $t_1 \leq 40 \cdot t_C$.

Figure 4: Reader to Tag - Pulse Interval Modulation and Encoding



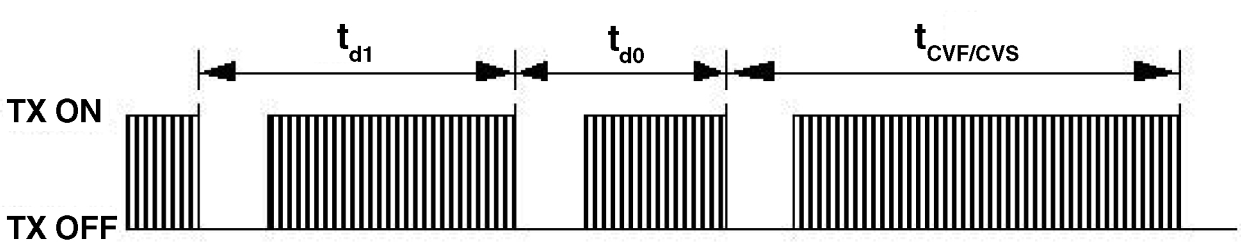
Symbol	Fast Data Rate		
	Minimum	Nominal	Maximum
t_{d0}	42 t_C	47 t_C	52 t_C
t_{d1}	62 t_C	67 t_C	72 t_C
t_{CVF} / t_{CVS}	175 t_C	180 t_C	185 t_C
$t_C = 1/f_C \approx 7.452\mu s$			

The default PIC threshold is configured for a medium data rate of 2.35 kbit/s, realized for example with a low bit period of t_{d0} = 350 µs and a high bit period of t_{d1} = 500 µs. The regenerated clock is available continuously during t_1.

4.3.3 Modulation

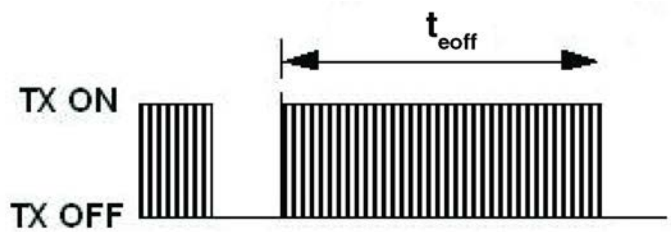
Communication between reader and transponder takes place using ASK modulation of the RF field with a modulation index of ~100%. The carrier frequency of the RF operating field is f_C = 134.2kHz.

Figure 5: Reader to Tag - Encoding of Start of Frame



The End of Frame (EOF) condition of any reader request is defined as the rising edge of the RF field followed by an RF field activation time (T_{eoff}) longer than the maximum T_{d1} value (72 clock cycles).

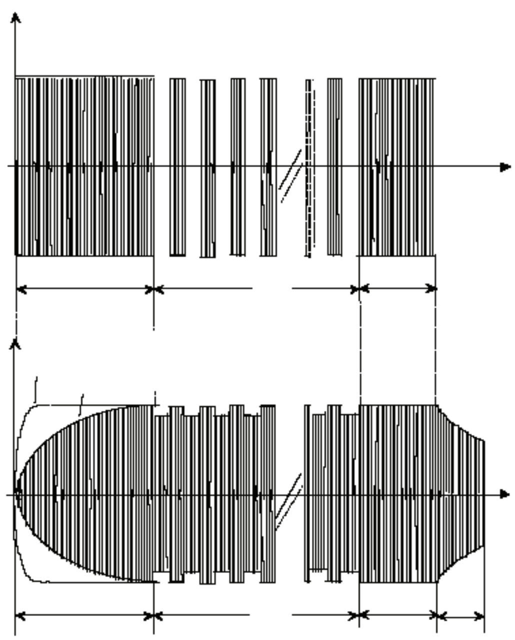
Figure 6: Reader to Tag - Encoding of End of Frame



4.4 Write Phase and the Programming of Data

A new identification number can be programmed into the transponder in the following manner: After the charge phase, the transponder enters the write mode provided that the reader starts to modulate the field by switching the transmitter on and off. Writing means that the transponder shifts the received bits into an internal shift register. After the write phase the reader's transmitter is switched on for the EEPROM programming time in order to energize the process of programming the shift register's data into the EEPROM. Each 32 data bits of a block are programmed simultaneously into the EEPROM.

Figure 7: Charge, Write, and Program - Voltage at the Reader and Transponder Antenna Coil



As illustrated in Figure 7 the EEPROM programming sequence consists of:

- **Charge phase** . . . . .Continuous reader (RF Module) transmitter output signal
- **Write phase** . . . . .Pulse interval encoding of the reader's transmitter output signal
- **Programming phase**. . . . . .Continuous RF transmitter output
- **Read phase** . . . . .FSK modulation of the transponder's resonant circuit oscillation

5. Transmission Protocol

The transmission protocol defines the mechanism to exchange requests and data between the reader and the transponder. The reader always starts the transmission, and the transponder does not start transmitting its response until the reader's RF field is turned off.

The different data exchanges that can happen between reader and transponder are summarized in the lines below:

The requests that can be performed by the transponder built using the NCD1015M are as follows:

Charge-Only Read

The content of page 1 is read without any specific page address by just charging (powering-up) the transponder for typically 50 ms.(ISO 11785 compatibility mode).

Write Block

Following the command and the block address, the lock bit(s) and the 32 data bits to be programmed with the associated 16 CRC bits are sent to the transponder. The 32 data bits are written into the specified block simultaneously. Transponder response starts after the RF field is turned off.

Note: It is possible to write a certain code in the Management Register in order to create a read-only access, and to disable further reprogramming of the transponder.

Note: After writing block 1 and block 2, it is recommended to send a Charge Only Read command to verify successful writing.

5.1 Data Format Definitions

5.1.1 Reader Command - Request Format

A Charge-Read Only request is generated by just charging the transponder: The demodulator starts working once the reader stops generating the electromagnetic field. It counts the number of cycles while the electromagnetic field is low, if that number t_1 is larger than $40 \cdot t_C$, the tag will respond to a Charge-Read Only request.

If the t_1 duration is not larger than $40 \cdot t_C$, the system has to wait for a Reader Request Frame (RRF).

The Reader Request Frame Format as sent by the reader is shown in Figure 8.

Figure 8: Reader Request Frame Format

SOF	COM		ADR		DATA		CRC		EOF
-	0	3	4	7	8-LSB	39	40-LSB	55	-

- **Charge phase** . . . . Continuous reader (RF Module) transmitter output signal
- **Write phase** . . . . Pulse interval encoding of the reader's transmitter output signal
- **Programming phase**. . . . . Continuous RF transmitter output
- **Read phase** . . . . FSK modulation of the transponder's resonant circuit oscillation

The length of the frame varies with the different commands.

The NCD1015M first evaluates the command byte which consists of an address field in the MSN (Most Significant Nibble) and a 4-bit command code of the incoming RRF. All other bit combinations may be considered as illegal. The RRF Normal Mode command details are listed in the following table.

ADDRESS	COMMAND	DESCRIPTION
MSB	LSB	Write
0000	0010	Write Block 0 - Management Register
0001	0010	Write Block 1 - Identification Data / LSB
0010	0010	Write Block 2 - Identification Data / MSB
0111	0010	Write Block 7 - Configuration Register
		Write & Lock
0000	1010	Write & Lock Block 0 - Management Register
0001	1010	Write & Lock Block 1 - Identification Data / LSB
0010	1010	Write & Lock Block 2 - Identification Data / MSB
0111	1010	Write & Lock Block 7 - Configuration Register

5.1.2 Transponder - Response Data Format

Any RFID answer is framed as shown in Figure 9, and it has a fixed length of 112 bits. Depending on the type of answer, the STOP and POST bits change.

Figure 9: Tag Response Frame Format

Start		Data		CRC		Stop		Post	
1	8	9 (LSB)	72	73 (LSB)	88	89	96	97	112

All signals are coded [MSB:LSB].

- START - Start Byte [7:0] . . . . = 7Ehex
- DATA - Data [63:0]. . . . . = Data
- CRC - DCRC [15:0]. . . . . = Data CRC
- STOP - Stop Byte [7:0] . . . . = ADDRESS + STATUS - in all other cases, page status information
- POST - Post Bits [15:0] . . . . = 0000hex

STOP Byte content answering a CRO

The content of page 1 is sent during the response (ISO 11785 compatibility mode). The Stop Byte information will be coded following the table shown below.

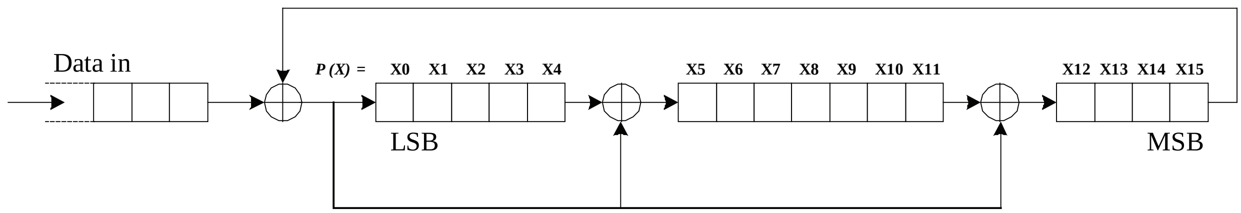
ADDRESS	STATUS	DESCRIPTION
MSB	LSB	
0001	0010	Block 1 (LSB) Unlocked + Block 2 (MSB) Unlocked
0001	1110	Block 1 (LSB) Locked + Block 2 (MSB) Unlocked
0001	1010	Block 1 (LSB) Unlocked + Block 2 (MSB) Locked
0111	1110	Block 1 (LSB) Locked + Block 2 (MSB) Locked + BIT16 ISO11785=0
0001	1110	Block 1 (LSB) Locked + Block 2 (MSB) Locked + BIT16 ISO11785=1

5.2 CRC-CCITT ERROR CHECKING

The CRC error checking circuitry generates a 16-bit CRC to ensure the integrity of transmitted and received data packets. The reader and transponder use the CRC-CCITT (Consultative Committee for International Telegraph and Telephone) for error detection.

The 16-bit Write Frame BCC is generated by the transponder on reception of the complete write data stream to validate the correct data transmission.

Figure 10: Schematic Diagram of the 16-Bit CRC-CCITT Generator



The 16 bits cyclic redundancy code is calculated using the following polynomial with an initial value of 0000hex:

$$P(X) = x^{16} + x^{12} + x^5 + x^0$$

The implemented version of the CRC check has the following characteristics:

- Reverse CRC-CCITT 16 as described in ISO/IEC 13239 and used in ISO/IEC 11784/11785
- The CRC 16-bit shift register is initialized to all zeros at the beginning of a request
- The incoming data bits are XOR-ed with the MSB of the CRC register, and are shifted into the register's LSB
- After all data bits have been processed, the CRC register contains the CRC-16 code
- Reversibility - The original data together with associated CRC, when fed back into the same CRC generator will regenerate the initial value (all zero's)

6. Memory

6.1 Memory Block

The memory is structured into 3 Blocks of 32 bits each. The following table shows the memory organization.

Block Address	Description
0	Management Register
1	Identification Data / LSB
2	Identification Data / MSB

6.1.1 Blocks 1 and 2: Identification Data

Blocks 1 and 2 are used for the Identification Data as specified in ISO/ IEC 11784. These blocks are locked if the RFID is locked by the Management Register. If the RFID is locked, then the stored value can not be overwritten.

6.1.2 Block 0: Management Register

Block 0, which is the Management Register, locks the RFID’s code, if the Management Key inside the Management Register is “0110.”

Management Register

The management register (MREG) contains information about the current state of the system.

Figure 11: Management Register (MREG) Layout

xx							MGM Key	
32							4	1

XX: Undefined

MGM Key: Management key [3:0]

The contents of the Management key are explained in the following table.

Key Value		Description
MSB	LSB	
0000		Normal Mode - by Default
0110		All Blocks Locked

Normal mode

In Normal mode all the commands explained before are valid.

All blocks locked

Writing the “0110” value in the "Management key" ("All Blocks Locked") inside MREG leads to the "All Blocks Locked” state. In this state the memory is protected against writing; **this state is irreversible**.

7 Manufacturing Information

7.1 Moisture Sensitivity

All plastic encapsulated semiconductor packages are susceptible to moisture ingression. IXYS Integrated Circuits Division classified all of its plastic encapsulated devices for moisture sensitivity according to the latest version of the joint industry standard, **IPC/JEDEC J-STD-020**, in force at the time of product evaluation. We test all of our products to the maximum conditions set forth in the standard, and guarantee proper operation of our devices when handled according to the limitations and information in that standard as well as to any limitations set forth in the information or standards referenced below.

Failure to adhere to the warnings or limitations as established by the listed specifications could result in reduced product performance, reduction of operable life, and/or reduction of overall reliability.

This product carries a **Moisture Sensitivity Level (MSL) rating** as shown below, and should be handled according to the requirements of the latest version of the joint industry standard **IPC/JEDEC J-STD-033**.

Device	Moisture Sensitivity Level (MSL) Rating
NCD1015M	MSL TBD

7.2 ESD Sensitivity

This product is **ESD Sensitive**, and should be handled according to the industry standard **JESD-625**.

7.3 Reflow Profile

This product has a maximum body temperature and time rating as shown below. All other guidelines of **J-STD-020** must be observed.

Device	Maximum Temperature x Time
NCD1015M	TBD

7.4 Board Wash

IXYS Integrated Circuits Division recommends the use of no-clean flux formulations. However, board washing to remove flux residue is acceptable, and the use of a short drying bake may be necessary. Chlorine-based or Fluorine-based solvents or fluxes should not be used. Cleaning methods that employ ultrasonic energy should not be used.

Pb RoHS e3

8. Mechanical Data

8.1 Dimensions

Parameter	Limits			Unit
	Min	Typ	Max	
Width	-	2.3	-	mm
Length	-	6.9	-	mm
Height	1.1	-	1.3	mm

Specifications: DS-NCD1015M-R00A

5/13/2016