AN10940

FAQs on UCODE G2i

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Application note
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Document information

Info	Content
Keywords	RFID, UHF, UCODE, UCODE G2iL+, UCODE G2iM+
Abstract	Frequently asked questions and answers on the additional functionality of UCODE G2iL+ and UCODE G2iM+.

Revision history

Rev	Date	Description
1.3	20140513	EPC backscatter length update
1.2	20130610	Tamper pulse added
1.1	20120925	UCODE G2iM+ added
1.0	20100602	Initial version

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1. Introduction

All UCODE G2i products contain the basic functionality of the EPC Gen2 standard [1]. In addition UCODE G2iL+ and UCODE G2iM+ have additional features that are described in [2] and [3]. Target of this application note is to answer frequently asked questions on the additional features of the UCODE G2iL+ and UCODE G2iM+ IC, which are available via the two additional pins of the UCODE ICs.

Such as:

- External supply mode
- Tag tamper alarm
- Digital output
- Direct data pipe

Command	G2iL	G2iL+	G2iM	G2iM+
Read Protection (bankwise)	X	X	X	X
PSF (Built-in Product Status Flag)	X	X	X	X
Backscatter strength reduction	X	X	X	X
BlockWrite (32 Bit)	X	X	X	X
BlockPermalock	-	-	X	X
Extended TID (UserTID)	-	-	X	X
Tag Tamper Alarm	-	X	-	X
Digital switch / Digital Input	-	X	-	X
External supply mode	-	X	-	X
Data Transfer	-	X	-	X
Real Read Range Reduction	-	X	-	X
Conditional Read Range Reduction	-	-	-	X
EPC size scalable (max 448 Bit)	-	-	-	X
Segmented User memory	-	-	-	X
Additional User memory PWD for private memory	-	-	-	X

Fig 1. Features of UCODE G2i family

This document answers questions on which hardware requirements need to be fulfilled, in order to use these features efficiently.

General note:

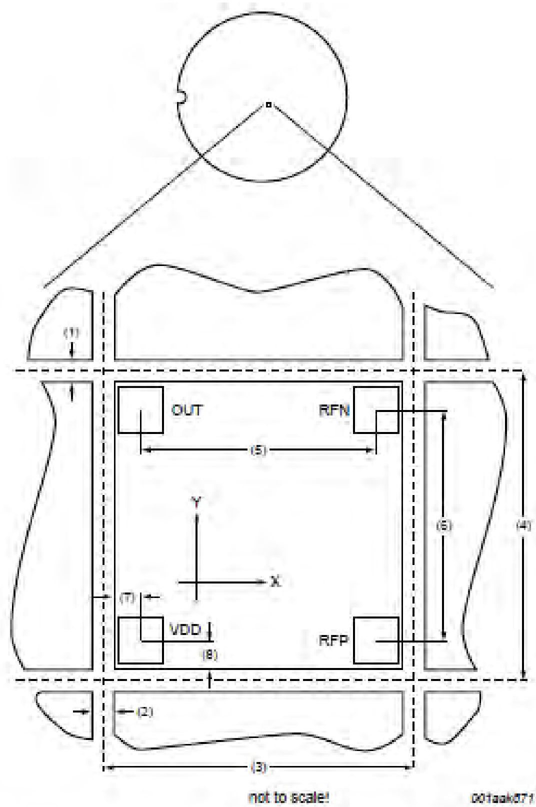
The typical values were measured at 25°C.

2. What is the function of each IC pad?

UCODE G2i has 4 functional pins. Fig 2 below shows the UCODE G2iL+ and Fig 3 the UCODE G2iM+. “RFN” and “RFP” are used for the connection of the label antenna. Via the “VDD” and “OUT” pads, additional functionalities can be used.

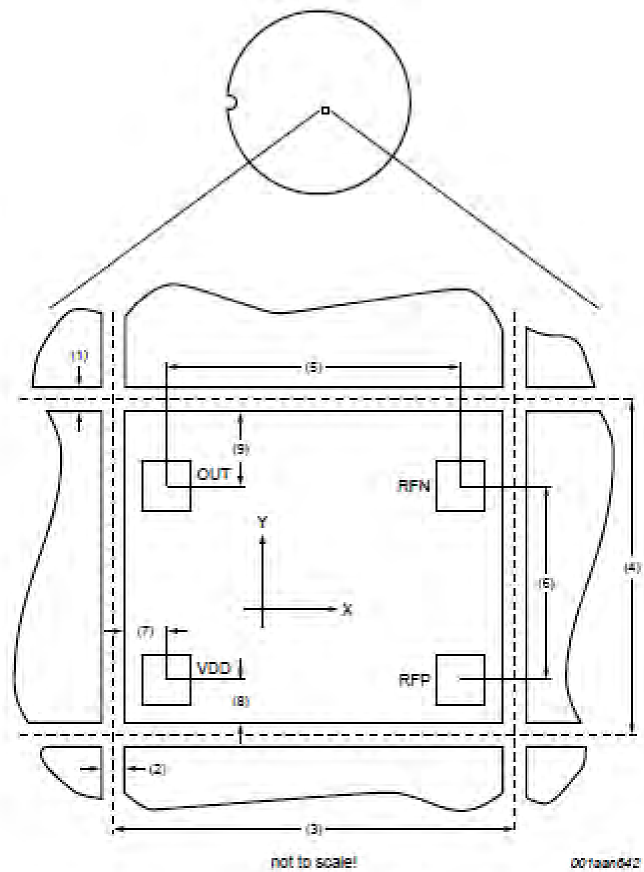
VDD: The IC can be externally supplied via this pin

OUT: If the IC gets externally supplied via VDD, then the OUT pin can be switched between “high” and “low”. In this way either data can be transferred to another device, or a connected device can be switched on or off.



(1) Die to Die distance (metal sealring - metal sealring) 21,4 μm, (X-scribe line width: 15 μm)
(2) Die to Die distance (metal sealring - metal sealring) 21,4 μm, (Y-scribe line width: 15 μm)
(3) Chip step, x-length: 485 μm
(4) Chip step, y-length: 435 μm
(5) Bump to bump distance X (OUT - RFN): 383 μm
(6) Bump to bump distance Y (RFN - RFP): 333 μm
(7) Distance bump to metal sealring X: 40,3 μm (outer edge - top metal)
(8) Distance bump to metal sealring Y: 40,3 μm
Bump size X x Y: 60 μm x 60 μm
Remark: OUT and VDD are used with G2iL+ only

Fig 2. Pad location and dimensions of UCODE G2iL+



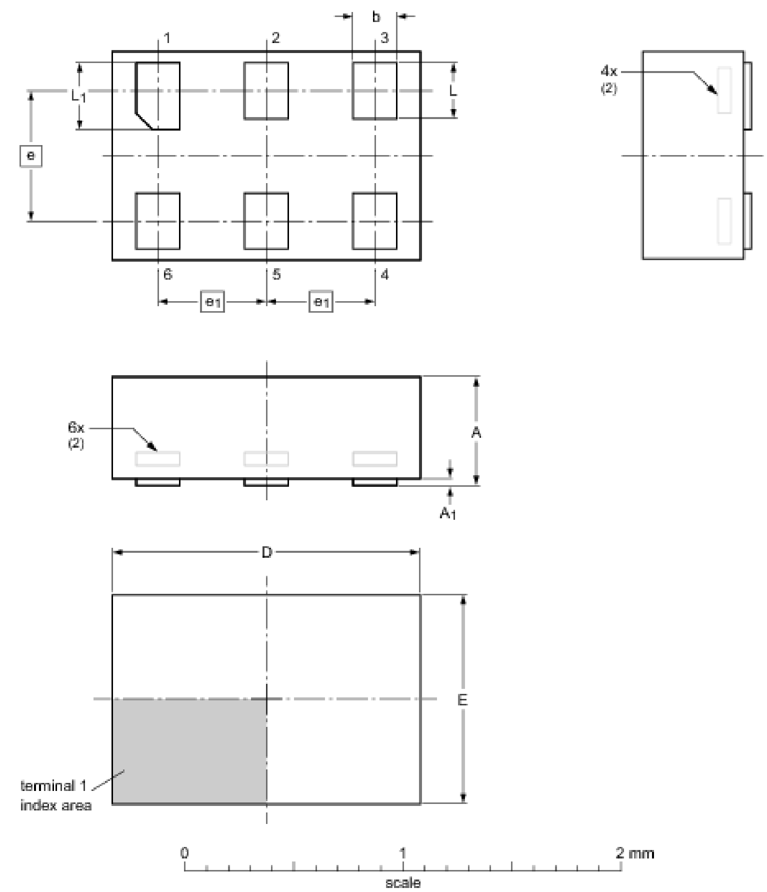
(1) Die to Die distance (metal sealring - metal sealring) 21,4 μm, (X-scribe line width: 15 μm)
(2) Die to Die distance (metal sealring - metal sealring) 21,4 μm, (Y-scribe line width: 15 μm)
(3) Chip step, x-length: 615 μm
(4) Chip step, y-length: 475 μm
(5) Bump to bump distance X (OUT - RFN): 513 μm
(6) Bump to bump distance Y (RFN - RFP): 333 μm
(7) Distance bump to metal sealring X: 43,5 μm (outer edge - top metal)
(8) Distance bump to metal sealring (RFP, VDD) Y: 40,3 μm
(9) Distance bump to metal sealring (RFN, OUT) Y: 80,3 μm

Bump size X × Y: 60 μm × 60 μm

Remark: OUT and VDD are used with G2iM+ only

Fig 3. Pad location and dimensions of UCODE G2iM+

XSON6: plastic extremely thin small outline package; no leads; 6 terminals; body 1 x 1.45 x 0.5 mm — SOT886



Dimensions (mm are the original dimensions)

Unit		A(1)	A_1	b	D	E	e	e_1	L	L_1
mm	max	0.5	0.04	0.25	1.50	1.05			0.35	0.40
	nom			0.20	1.45	1.00	0.6	0.5	0.30	0.35
	min			0.17	1.40	0.95			0.27	0.32

Notes
1. Including plating thickness.
2. Can be visible in some manufacturing processes.

sot886_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT886		MO-252				~~04-07-22~~ 12-01-05

Fig 4. UCODE G2i SOT886

General VDD supply characteristics:

The supply pin VDD of the G2i behaves similar to a Zener diode or voltage clamp, therefore, a small change of the supply voltage or temperature will result in a noticeable variation of current consumption.

In order to use a certain functionality of the chip (boost read or read/write range) both specified values for minimum current and minimum voltage level should be taken into account i.e. the chip is specified to get into a certain mode if either the minimum current or the minimum voltage level is exceeded.

The supply characteristic typically does not change if the externally supplied tag moves into the RF field, however if it is moved into a strong RF field, the internal voltages result in a reduction of the current consumption on VDD.

During RF communication the current consumption remains constant, except for commands which change the memory contents (Write, Lock). For those commands the current consumption is increased, but will stay within specified limits.

It is explicitly *not* recommended to operate the chip below both, the minimum current (7µA) and the minimum voltage (1.8V) limit. This might lead to undefined chip behavior.

To guarantee chip functionality as specified, the RF coupling to the VDD and OUT pin should be less than 500mV peak.

This especially has to be considered if the tamper alarm feature is used, and long metal structures are connected to the VDD and the OUT pin.

3. How can I boost my Read Range with an external supply?

Situation: An increase of the read range is needed. There is no other device connected, which needs to be powered via the OUT pin (Iout = 0). On the VDD pin, an external supply is available.

Important note: Even if the label is not in the RF field, the IC is permanently supplied and therefore consumes current from the supply.

3.1 Condition 1: Voltage source in a range of 1.8V – 2.2V available and current consumption is not critical

Connect the voltage source directly between VDD and RFN.

The typical, permanent current consumption will be ~120µA for 1.8V and ~340µA for 2.2V.

3.2 Condition 2: Voltage source >1.8V available and current consumption shall be a minimum

Connect the voltage source via series resistor between VDD and RFN.

Choose the value of the series resistor according to following formula:

$R_{series,\,max} = (V_{source} - 1.8V) / 7\mu A$

for minimum current (blue curve, Fig 5).

The absolute minimum value for the necessary series resistor is calculated by:

$R_{series,\,min} = (V_{source} - 2.2V) / 280\mu A$ (red curve, Fig 5).

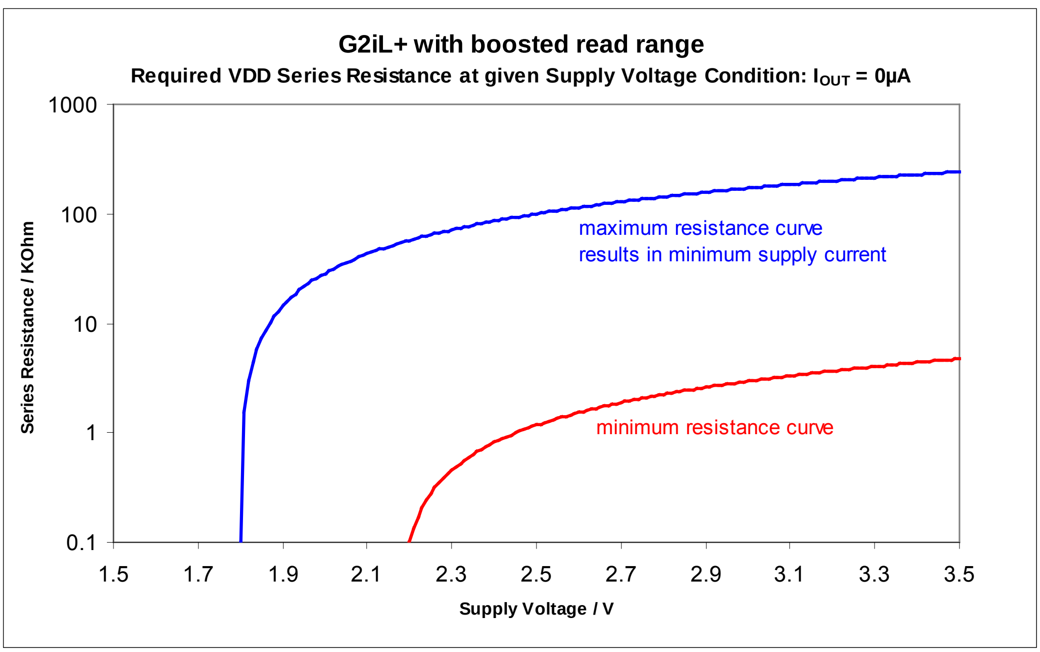


Fig 5. Boost read range: relation between Supply voltage, series resistance and current consumption (blue → minimum current consumption, red → minimum series resistor value

3.3 Examples: What is the DC power consumption if the read range is boosted via en external supply?

- V_{Supply} with 2.5V connected via 100kΩ to VDD will give a typical, permanent supply current of ~ 9.5µA and a VDD voltage of ~1.55V.
- V_{Supply} with 3.3V connected via 200kΩ to VDD will give a typical, permanent supply current of ~8.8µA and a VDD voltage of ~1.55V.

In order to use a certain functionality of the chip (boost read or read/write range) both specified values for minimum current and minimum voltage level should be taken into account i.e. the chip is specified to get into a certain mode if either the minimum current or the minimum voltage level is exceeded.

4. How can I boost my Read and Write Range with an external supply?

Situation: An increase of the read range and the write range is needed. There is no other device connected, which needs to be powered via the OUT pin (I_{out} = 0). On the VDD pin and external supply is available.

Important note: Even if the label is not in the RF field, the IC is permanently supplied and therefore consumes current from the supply.

4.1 Condition 1: Voltage source in a range of 1.85V – 2.2V available + current consumption not critical

Connect the voltage source via series resistor between VDD and RFN.

The typical, permanent current consumption will be ~145µA for 1.85V and ~340µA for 2.2V.

4.2 Condition 2: Voltage source >1.85V available and current consumption shall be a minimum

Connect the voltage source via series resistor between VDD and RFN.

Choose the value of the series resistor according to the formula:

$R_{series,\ max} = (V_{source} - 1.85V) / 125\mu A$

for minimum current (blue curve in Fig 6).

The absolute minimum value for the necessary series resistor is calculated by:

$R_{series,\ min} = (V_{source} - 2.2V) / 280\mu A$ (red curve of Fig 6).

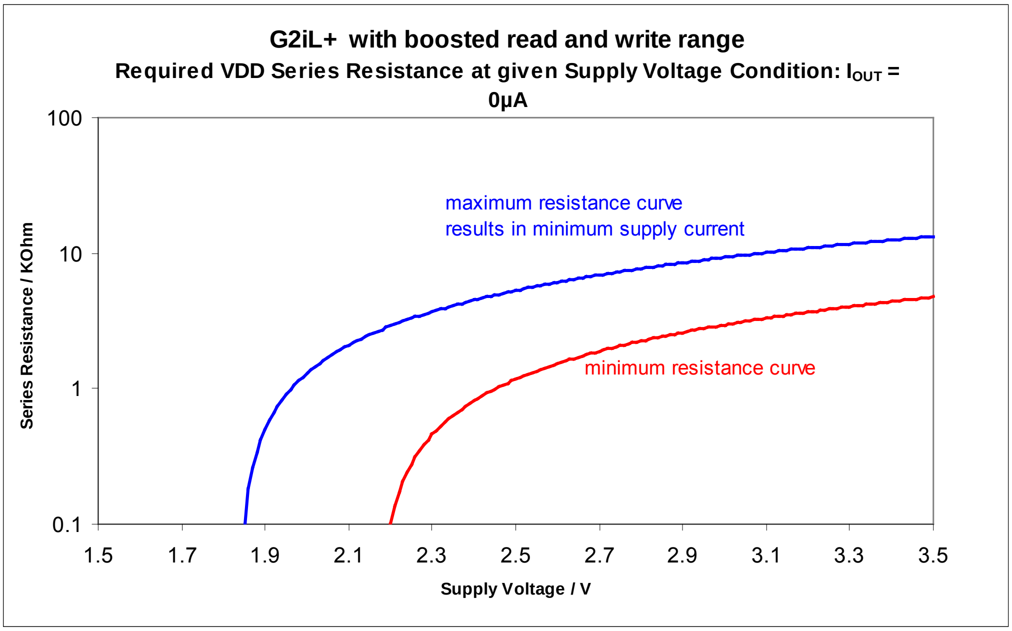


Fig 6. Boost read and write range: Relation between Supply voltage, series resistance and current consumption (blue → minimum current consumption, red → minimum series resistor value

4.3 Examples: What is the DC power consumption if read and write range are boosted via en external supply?

- V_{Supply} with 2.5V connected via 5.1kΩ to VDD will give a typical, permanent supply current of ~132µA and a VDD voltage of ~1.83V.
- V_{Supply} with 3.3V connected via 11kΩ to VDD will give a typical, permanent supply current of ~134µA and a VDD voltage of ~1.83V.

In order to use a certain functionality of the chip (boost read or read/write range) both specified values for minimum current and minimum voltage level should be taken into account i.e. the chip is specified to get into a certain mode if either the minimum current or the minimum voltage level is exceeded.

5. Can I connect multiple devices to the OUT pin?

Situation: Target is to switch another device on or off, or to transfer data from the RF reader device via the UCODE G2iL+ IC into another device.

In order to develop this solution, the VDD pin needs to be externally supplied, and a certain amount of current will flow from the OUT pin into the connected device.

G2iL+ is characterized for a drive current (I_{out}) of max. 100µA.

5.1 Condition 1: Voltage source in a range of 1.95V – 2.2V available + current consumption not critical

Connect the voltage source directly between VDD and RFN.

The typical, permanent current consumption will be ~230µA for 1.95V and ~340µA for 2.2V.

5.2 Condition 2: Voltage source >1.95V available + minimized current consumption

Connect the voltage source via series resistor between VDD and RFN.

Choose the value of the series resistor according to:

$R_{series,\ max}$ = (V_{source} – 1.95V) / 265µA for minimum current (blue curve Fig 7).

The absolute minimum value for the necessary series resistor is calculated by:

$R_{series,\ min}$ = (V_{source} – 2.2V) / 280µA (red curve Fig 7).

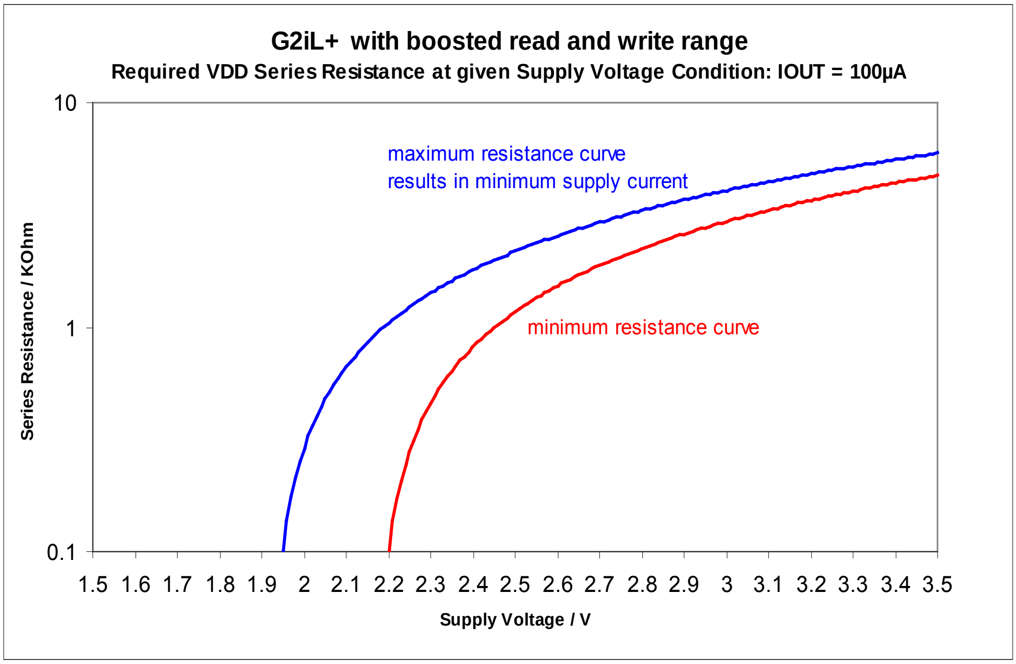


Fig 7. Another device connected to OUT pin: Relation between Supply voltage, series resistance and current consumption (blue → minimum current consumption, red → minimum series resistor value

5.3 Examples – What is the DC power consumption if another device is supplied via OUT?

- V_{Supply} with 2.5V connected via 2kΩ to VDD will give a typical, permanent supply current of ~250µA, a VDD voltage of ~1.99V and an output voltage V_{out} ~1.68V for 100µA load on OUT
  – If no current is pulled from OUT: ~ 240µA supply current and ~ 1.73V on OUT
- V_{Supply} with 3.3V connected via 5.1kΩ to VDD will give a typical, permanent supply current of ~255µA, a VDD voltage of ~2V and an output voltage V_{out} ~1.68V for 100µA load on OUT
  – If no current is pulled from OUT: ~ 245µA supply current and ~ 1.73V on OUT

6. How could an electronic beeper or a LED be activated through triggering the OUT pin?

V_{Supply} with 3.3V connected via 200kΩ to VDD will give a typical, permanent supply current of ~8.8µA and a VDD voltage of ~1.55V.

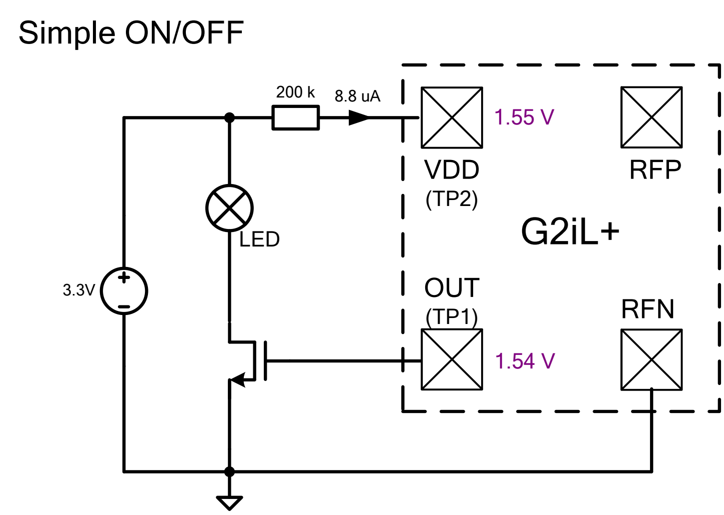


Fig 8. Example with LED

7. How is the special features control mechanism working?

There are three categories of bits:

- **Indicator Bits:** cannot be changed by command.
  (Value is determined by the jumper settings)
- **Temporary Bits:** reset at power up
- **Permanent Bits:** Can be changed by reader commands. Bits are permanently stored in the memory. They maintain their value, also when the tag leaves the RF-field.

The value of the bits can be toggled by sending a WRITE command with the right value for the related bit. In order to address this word, the memory bank 1 (= EPC memory) needs to be chosen, and the word address (32d or 20h).

The factory setting of ConfigWord is 0040_h

Address 200h - 207h

Indicator bits				Temporary bits			
Tamper indicator	External Supply Indicator	0 RFU	0 RFU	Invert Output	Transparent Mode on/off	Data Mode data/rw	0 RFU
0	1	2	3	4	5	6	7

Address 208h - 20Fh

Permanent bits							
0 RFU	Max Backscatter Strength	Digital Output	Read Range Reduction	0 RFU	Read Protect EPC	Read Protect TID	PSF Alarm
8	9	10	11	12	13	14	15

Fig 9. Setup of the "ConfigWord", EPC memory bank, address 200h – 20Fh (G2iL+)

Address 200h - 207h

Indicator bits				Temporary bits			Permanent bits
Tamper indicator	External supply indicator	RFU	RFU	invert Digital Output	Transparent mode on/off	Data mode data/raw	Conditional Read Range Reduction ON/OFF
0	1	2	3	4	5	6	7

Address 208h - 20Fh

Permanent bits							
Conditional Read Range Reduction open/short	max backscatter strength	Digital output	Read Range Reduction	Read Protect USER Memory	Read Protect EPC	Read Protect TID	PSF Alarm Bit
8	9	10	11	12	13	14	15

Fig 10. Setup of the "ConfigWord", EPC memory bank, address 200h – 20Fh (G2iM+)

8. How can the OUT pin be switched with an UHF reader?

The state of the OUT pin is defined by a bit, which is located in the EPC memory bank. It is part of the ConfigWord (Fig 9 and Fig 10).

The "Digital Output" bit determines the state of the OUT pin, and can be set to 0 or 1.

The state can be toggled by performing a WRITE command on this bit:

- First, check the status of the bit by performing a READ command on this memory location. In order to address this word, the memory bank 1 (= EPC memory) needs to be chosen, and the word address. Some reader use the hexadecimal address scheme (in this case 20h), some readers use count the words for addressing a special memory part (in this case word 32d)

- In order to interpret the response (most likely in hex) correctly, find here some examples:
  - 0020: Only the “Digital Output” is set to 1, all other bits of this word are zeros.
  - 8040: Tamper indicator is on 1 (VDD and OUT have a galvanic connection), and the “Max Backscatter Strength” is set to 1, all other bits of this word are zeros.
  - 4020: The “external supply indicator“is set (V_{Supply} is on), and the “Digital Output” bit is set, all other bits of this word are zeros.
- Secondly, toggle the OUT pin –if needed- by performing a WRITE command.
  - Example: Write “0020” on the address 20h (word 32 in EPC memory), and the state of the OUT pin will change

9. Will the state of the OUT pin remain, even if the tag is moved out of the reader field?

Yes, as the digital out bit is located in the category “permanent bits”. It permanently keeps its value, just as the standard memory contents (e.g. EPC number), independent of an RF field.

There are also “temporary” bits defined in the ConfigWord, such as “invert digital output”, (bit 4).

This can be used, if a temporary output, as long as the label is in the reader field, is needed for the application.

For example: “Digital out” would have the value zero. Circuit is set up, power supply is connected as specified. The “invert digital out” can be set as soon as the tag is in the reader field, which is high enough to perform a WRITE operation.

Then the OUT pin will be on “high” as long as the tag is in the field, and would flip back again once it is out of the field.

10. Will the state of the OUT pin remain, even if the IC is killed?

Yes. When the tag/label is in KILLED state, it will stop to respond to any command coming from theReader. However, voltage and current consumption on OUT and VDD will remain the same.

11. What sensitivity / read range can be achieved when the IC is externally supplied?

A minimum operating power level of -27 dBm can be achieved. This corresponds to approximately 30 m read range under European frequency regulations.

Note: Also the matching impedance changes in the external supply mode to 7-j 230 Ω.

This results also in a change of the quality factor of the IC. The Q value increases due to the decreased real part of the impedance. That means, the label will be more sensitive to detuning and there will be higher matching losses.

12. Can the UCODE G2i also be supplied by a battery?

Yes.

But there are certain boundary conditions which should be fulfilled. The battery voltage and the series resistor should be dimensioned as such that it meets the operating points for the respective use case (Chapter3 – Chapter 6).

The IC permanently consumes current when it gets externally supplied; therefore the battery life time is limited.

The battery should have a known characteristic over time. If the voltage level decreases gradually, and falls below the specified values, the IC will only have limited, or no functionality, even if it is in an RF reader field.

12.1 What can happen?

- Writing of the IC does not work
- Reading and writing of the IC does not work
- Current flows back to the battery and could destroy the battery if it is not decoupled

13. What voltage level is available on the OUT Pin?

There is an internal series resistor between VDD and OUT of approximately 1kΩ, therefore the voltage level available on the OUT pin, is defined by the voltage level on VDD reduced by the voltage drop on this resistor.

Following relation holds: $V_{out} \sim I_{vdd}$ * 1KOhm. (I_vdd = I_internal + I_out)

14. What is the correlation between the voltage level on the OUT pin and the supply driven from the RF Field (Vdda via RFN/RFP)

The voltage level on the OUT pin typically does not change if the IC gets powered by the RF field, as long as the external supply is above the specified minimum.

However, at very high RF power levels the internal voltage, and therefore also the OUT level might be slightly increased but stay below 2V.

15. How can a Tag Tamper loop be simulated?

The corrected model takes into account coupling parasitic which take place between OUT-RFN and VDD-RFN IC pins.

In addition to conventional antenna port which models the IC impedance between RFP-RFN pins, the following lumped elements (parallel RC-model) should be added in order to model the IC impedances between VDD-RFN and OUT-RFN IC pins:

OUT-RFN

– R1 = 3136,7Ohm

– C1 = 939fF *

VDD-RFN

– R2 = 971,2Ohm

– C2 = 469fF *

* The shown values of the capacitances are the measurement values at corresponding chip bumps. In order to properly model the effects of antenna-chip parasitic capacitances, additional capacitance C_mount (ca. 100-200fF) should be added to the both values of C1 and C2.

The corresponding HFSS model for the conventional and corrected model is shown in Fig 11.

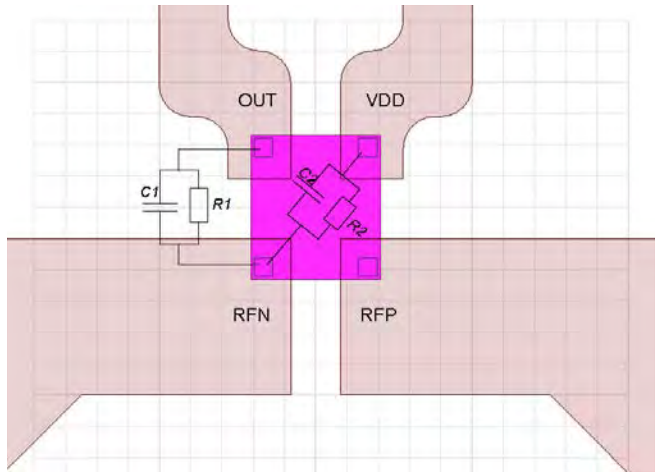


Fig 11. Model for RFID Label Antenna utilizing G2iL+ anti-tamper feature: equivalent circuitry

16. How is the Tag Tamper Alarm used?

If VDD and OUT have a galvanic connection, for example with a little loop, the “tamper indicator” bit will be set to 1. Fig 9 and Fig 10 show the location of this bit (Address 200h).

Remark: The tamper feature and the external supply mode cannot be used at the same time!

Example:

If there is a connection, the value of the ConfigWord could be:

“8040” (Tamper indicator bit is set, max backscatter strength is set)

Opening the connection between VDD and OUT, will change the ConfigWord to: “0040”

Attention: The Connection is only checked during power up of the IC with a current pulse.

The pulse and timing is shown in Fig 12 and Table 1.

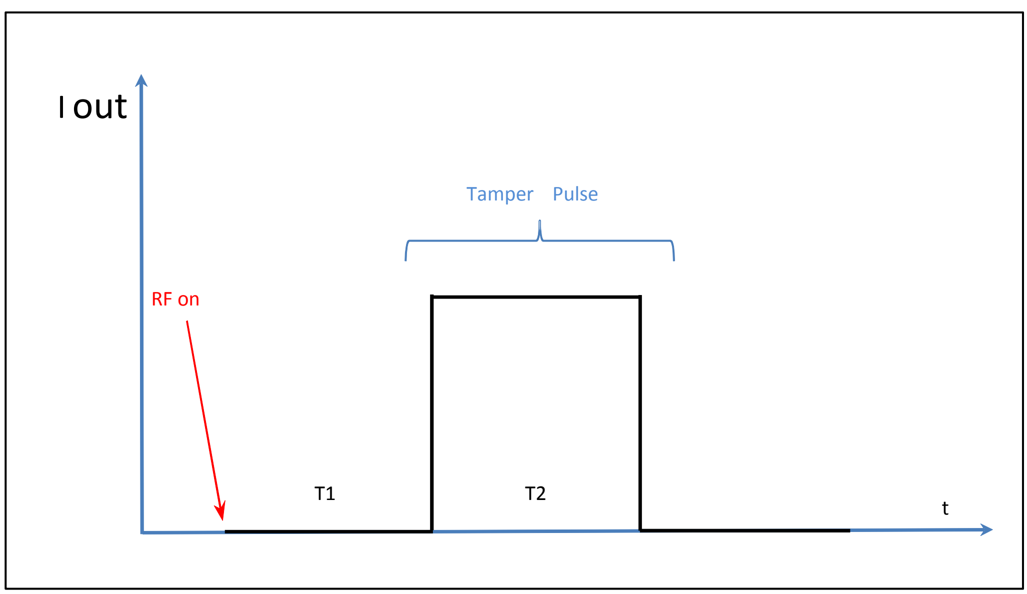


Fig 12. Tamper Pulse timing

Table 1. Tamper Pulse Timing

		G2iL+	G2iM+
T1 [µs]	PC= 3000	380	250
T2 [µs]		300	200
Iout [nA]		300	300

Table 2. Tamper Pulse Output voltage

	min	typ	max
Vout [V]	1	-	1.7

The Vout voltage shape can be seen in Fig 13. This shape depends on the capacitive load.

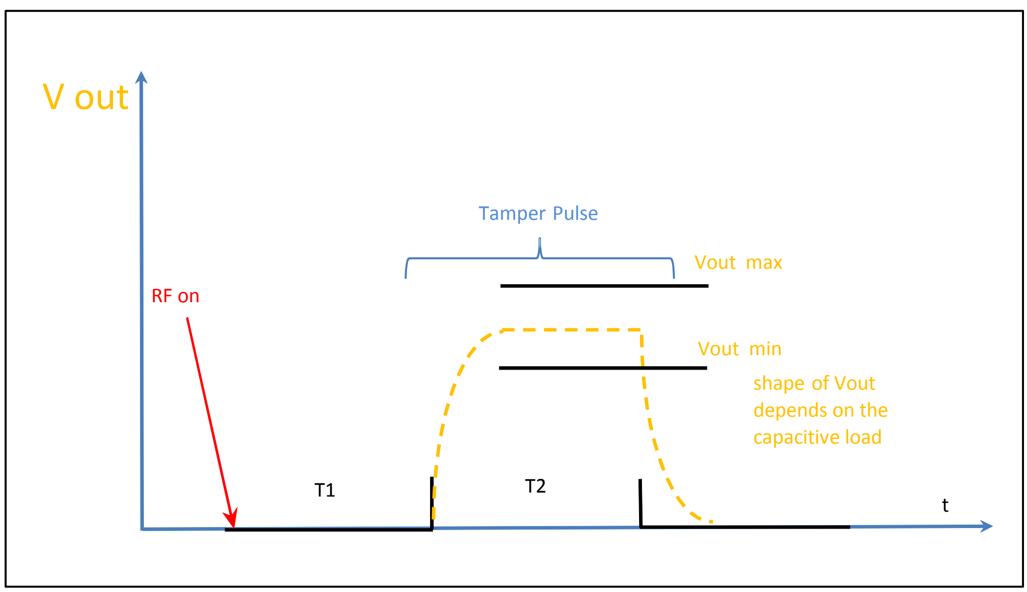


Fig 13. Tamper Pulse: Example Vout

Note:

- The IC detects a connection, “short”, as long as the resistance of the connecting line is below 2 MΩ, and it will detect an “open” above 20 MΩ
- The parasitic capacity of the loop (open or closed) should be below 5pF. If it is above this value, the IC may interpret the remaining voltage level, after the tamper check (due to the capacitance) as an external supply.

Especially for bigger loops RF coupling effects could limit the functionality when the label is in the near field of an electromagnetic reader antenna. The maximum allowed peak voltage to couple into VDD and OUT, without having harmful effects on the functionality, is 500 mV (peak).

17. How can the EPC Backscatter length changed?

The EPC Backscatter length can be changed with the bits in the Protocol word. The Protocol word is the second word in the EPC memory bank. Bit 10h – 14h are responsible for the EPC length that a tag backscatters during an inventory operation.

By default the value of the PC field is 3000 hex / 0011 0000 0000 0000b, which makes the tag backscatter 96 bit EPC number. The bit length of the backscatter is defined by the first 5 bits : 0011 0 from the Protocol word corresponding to the decimal value of 6. This means the backscatter length is 6 words (= 6*16 bits = 96 bits)

For making the tag backscatter 240 bits, write following value in the PC (Protocol Control) field:

Hexadecimal: 7800hex

Binary : 0111 1000 0000 0000b

0111 1 =2^4*0+2^3*1+2^2*1+2^1*1+2^0*1= 15 dec --> 15*16 bits = 240 bit

- 96 Bits mean 6 words EPC- Bits 10h - 14 h -> 00110 -> PC field 3000h
- 128 Bits mean - 8 words EPC - Bits 10h - 14 h -> 01000 -> PC field 4000h
- 240 Bits mean 15 words EPC -Bits 10h - 14 h -> 01111 -> PC field 7800h
- 256 Bits mean 16 words EPC - Bits 10h - 14 h -> 10000 -> PC field 8000h
- 448 Bits mean 28 words EPC - Bits 10h - 14 h -> 11100 -> PC field E000h

Remark: The Maximum EPC length depends on the chosen IC. For G2iL/G2iL+ the maximum EPC length is 128 Bit. The maximum EPC length for G2iM is 256 Bits. The maximum EPC length is for G2iM+ 448 Bits, but depends on the settings in the memory configuration word [3].

18. How can to the EPC Backscatter length changed for the G2iM+?

For the UCODE G2iM+ the memory structure can be changed with the Memory Configuration Word [3].

First step: Memory Configuration Word (EPC memory bank; word 31 or 1Fh) needs to be changed:

Address 1F0h - 1F7h							
RFU				Number of EPC blocks			
0	1	2	3	4	5	6	7
Address 1F8h - 1FFh							
Number of Proteced memory blocks				Number of Private memory blocks			
8	9	10	11	12	13	14	15

Fig 14. UCODE G2iM+ Memory Configuration Word

Table 3. UCODE G2iM+ memory

EPC Memory [Bit]	User Memory [Bit]	Memory Configuration Word [Bit]
128	640	0000h
192	576	0100h
256	512	0200h
320	448	0300h
384	384	0400h
448	320	0500h

For example: Change EPC Memory length to 192 Bit.

64 Bit (4 words) from the User Memory needs to be added to the default EPC Memory size of 128 bit.

So the Memory Configuration Word needs to be changed to 0100 hex.

WRITE 0100hex to EPC memory bank address 31 d.

Remark: It is only ONE TIME Programmable!!!!!

This means for the memory we have now fixed: EPC max size 192 Bit and User memory 576 Bit (Table 3).

As a second step the PC bits need to be changed.

WRITE 4800 hex to EPC memory bank address 01 d.

19. References

[1] EPC™ Radio-Frequency Identity Protocols, Class-1 Generation-2 *UHF RFID, Protocol for Communications at 860 MHz – 960 MHz, Version 1.2.0; EPCglobal™ Inc.*
http://www.nxp.com/redirect/gs1.org/gsmp/kc/epcglobal/uhfc1g2

[2] Data sheet, SL3S1203_1213; UCODE G2iL and G2iL+ (BLID 1788)
http://www.nxp.com/documents/data_sheet/SL3S1203_1213.pdf

[3] Data sheet, SL3S1003_1013; UCODE G2iM and G2iM+ (BLID 2012)
http://www.nxp.com/documents/data_sheet/SL3S1003_1013.pdf

20. Legal information

20.1 Definitions

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