

MLT1021

Data Sheet

LIN Transceiver for Automotive

Preliminary
Version: V0.04

Features

- **Supported Protocols:** Compatible with LIN 2.0, 2.1, 2.2, and 2.2A.
- **Voltage Tolerance:** -27V to +40V absolute maximum rating on the LIN pin.
- **Data Rate:** Up to 20 kbps.
- **EMC Performance:** Low EME and high EMI immunity.
- **Power-Off Behavior:** High impedance on the bus pin when unpowered.
- **Logic Compatibility:** 3.3V/5.0V compatible RXD/TXD interface.
- **Integration:** Internal termination resistor for LIN slave nodes.
- **Low Power:** Ultra-low current in sleep mode.
- **Timeout Protection:** TXD dominant time-out function included.
- **Fault Protection:** Short-circuit protected (LIN to BAT/GND).
- **Thermal Protection:** Integrated Thermal Shutdown (TSD) (Note 1: Grade 1).

Applications

- LIN bus systems for automotive applications.

Key Specifications

Supply Voltage:	9V to 27V
Supply Current (sleep mode):	7μA to 13μA
Supply Current:	400μA to 1000μA (Standby mode; Recessive)
Supply Current:	400μA to 1000μA (Normal mode; Recessive)
Supply Current:	500μA to 2000μA (Normal mode; Dominant)

List of Contents

Features	3
Applications	3
Key Specifications	3
List of Contents.....	4
List of Figures	5
1. General Description	7
2. Block Diagram	7
3. Pin Configuration(s).....	8
3.1. Package Instruction	8
3.2. Pin Description(s).....	8
4. Description of Block(s)	9
4.1. Sleep mode	9
4.2. Standby mode	9
4.3. Normal mode.....	9
4.4. TXD dominant time-out counters Fail-safe function.....	10
4.5. Fail-safe function	10
5. Electrical Characteristics	11
5.1. Absolute Maximum Rating(Ta = 25°C)	11
5.2. Recommended Operating Conditions	11
5.3. DC Characteristics	12
5.4. AC Characteristics.....	14
5.4.1. Timing Chart.....	15
5.5. Application Example(s).....	17
6. Package Dimension	18
6.1. SOP-8 Dimension.....	18
7. Revision History	19
8. Disclaimers	20

List of Figures

Figure 2–1. MLT1021 Block Diagram	7
Figure 3.1–1. MLT1021 SOP8 Top View	8
Figure 4–1. State Transition Chart	9
Figure 5–1. AC characteristic timing chart	15
Figure 5–2. Bus timing chart	15
Figure 5–3. Remote wake-up (Sleep → Standby → Normal)	15
Figure 5–4. Local wake-up (Sleep → Standby → Normal)	16
Figure 5–5. Wake-up/Sleep-in with NSLP (Sleep → Standby → Normal)	16
Figure 5–6. Application Example	17
Figure 6-1. SOP-8 (150 mil) Package Dimension	18

List of Tables

Table 4–1. The state of the pin in each mode..... 10

Table 5–1. Absolute Maximum Ratings 11

Table 5–2.Recommended Operating Conditions..... 11

Table 5–3. Static Characteristics 12

Table 5–4. Static Characteristics ...continued..... 13

Table 5–5. Dynamic Characteristics 14

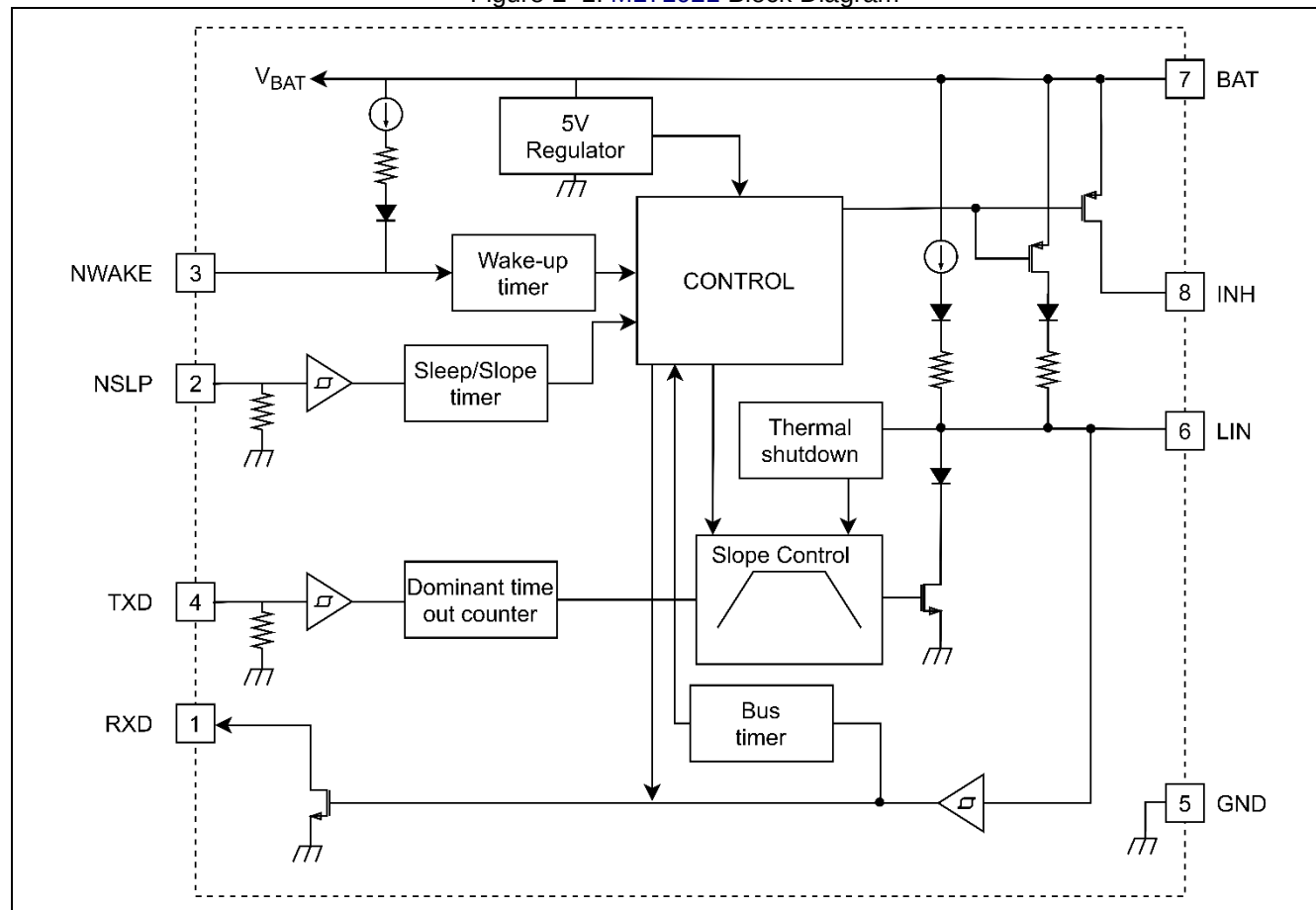
Table 7–1. Revision History 19

1. General Description

The **MLT1021** is a dedicated physical layer transceiver designed for Local Interconnect Network (LIN) bus systems. It provides a robust interface between the LIN protocol controller and the physical bus, supporting both master and slave node applications. Additionally, the device features a sleep mode with ultra-low current consumption to meet stringent system power requirements.

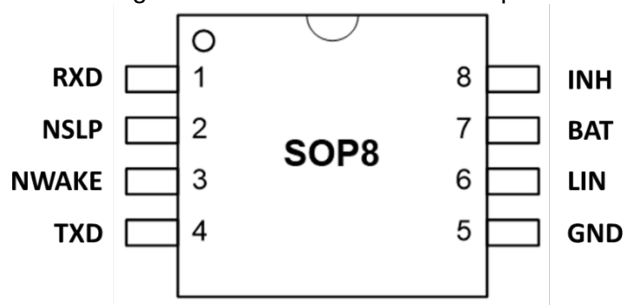
2. Block Diagram

Figure 2–1. **MLT1021** Block Diagram



3. Pin Configuration(s)

3.1. Package Instruction

Figure 3.1–1. **MLT1021** SOP8 Top View

3.2. Pin Description(s)

MNEMONIC	PIN NUMBER	I/O TYPE	DESCRIPTION
	8-Pin SOP		
RXD	1	O	* Received data output pin (Open Drain). "L" is output at standby mode.
NSLP	2	I	* Sleep control input pin ("L" Active mode). Shift to sleep mode by "L" input in normal mode.
NWAKE	3	I	* Local wake-up input pin ("L" Active mode). Active at leading edge.
TXD	4	I	* Transmission data input pin
GND	5	G	* Ground
LIN	6	I/O	* LIN bus input and output pin.
BAT	7	P	* Power supply pin.
INH	8	O	* Sleep status indicator. "Hi-z" at sleep mode and "H" in the other modes.

4. Description of Block(s)

4.1. Sleep mode

Sleep mode is the lowest power consumption state of the **MLT1021**, during which all transmit and receive functions are disabled. The device enters this mode either at initial power-up (when VBAT is applied) if the NSLP pin is held "L", or by driving the NSLP pin "L" while operating in normal mode.

To exit sleep mode, one of the following wake-up events must occur:

- A high-to-low transition on the NWAKE pin ("H" → "L") (Transitions to Standby mode)
- A dominant-to-recessive pulse on the LIN pin ("H" → "L" → "H") (Transitions to Standby mode)
- A low-to-high transition on the NSLP pin ("L" → "H") (Transitions directly to Normal mode)

A wake-up event is only recognized as valid if the signal state is maintained for its specified filter time (t_{NWAKE} , t_{BUS} , or $t_{gotonorm}$). Throughout this document, a wake-up triggered by the NWAKE pin is referred to as a **Local wake-up**, while a wake-up initiated via the LIN bus is termed a **Remote wake-up**.

4.2. Standby mode

The **MLT1021** transitions from sleep mode to standby mode upon detecting a valid Local or Remote wake-up event (via the NWAKE or LIN pin, respectively).

Upon entering standby mode, the device configures the following pin states:

- **INH pin:** Pulled "H" (Driven to the VBAT voltage level)
- **RXD pin:** Pulled "L" (Serves as an interrupt flag to notify the host microcontroller that a wake-up has occurred)
- **LIN pin:** The internal slave termination resistor is activated (ON)

To transition the MLT1021 from standby mode into normal mode, the host microcontroller must drive the NSLP pin "H".

4.3. Normal mode

The **MLT1021** enters normal mode when the NSLP pin is driven high ("H") from either sleep or standby mode. In this active state, full bidirectional communication over the LIN bus is enabled.

Data Reception: Incoming signals from the LIN bus are translated into logic-level outputs and routed to the host microcontroller via the RXD pin.

Data Transmission: The transceiver takes the digital logic input from the TXD pin and converts it into a slew-rate-controlled signal, which is then driven onto the LIN bus.

The maximum operating frequency supported in this mode is 10 kHz.

To transition the device from normal mode back to sleep mode, the host microcontroller must pull the NSLP pin low ("L") and maintain this state for the specified transition duration ($t_{gotosleep}$).

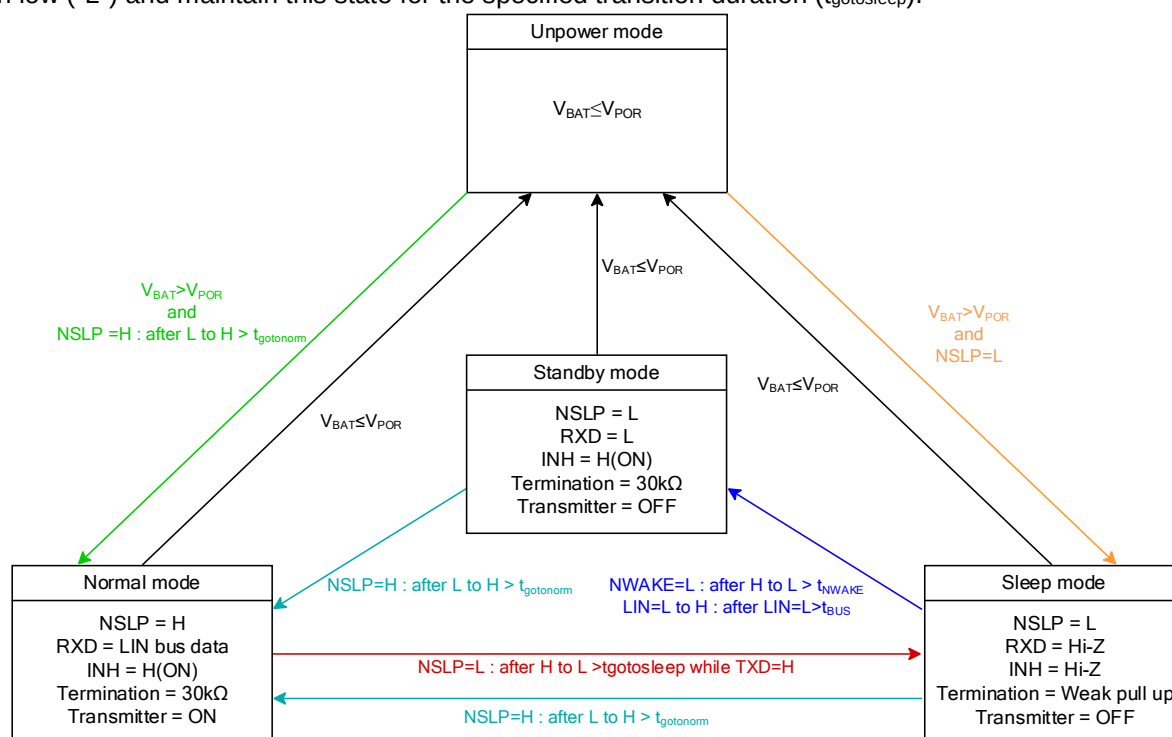


Figure 4–1. State Transition Chart

Table 4–1. The state of the pin in each mode

MODE	NSLP	TXD	RXD	INH	TRANSMITTER
Sleep mode	L	Pull-down	Hi-Z	Hi-Z	OFF
Standby mode	L	Pull-down	L	H	OFF
Normal mode	H	Pull-down	H : recessive state L : dominant state	H	ON

4.4. TXD dominant time-out counters Fail-safe function

To prevent a hardware or software failure from locking up the entire LIN network, the device is equipped with a TXD dominant time-out timer. If the TXD pin is forced low (dominant) continuously, a timer is initiated upon the falling edge of the TXD signal. Should this state persist longer than the internal timeout threshold (t_{dom}), the LIN transmitter is automatically disabled, releasing the bus line back to a recessive state. The timer is reset, and normal transmission can resume, upon detecting a rising edge (positive edge) on the TXD pin.

4.5. Fail-safe function

The device incorporates several fail-safe mechanisms to ensure system stability under fault conditions:

- **TXD Pin:** Integrates an internal pull-down resistor to GND. This ensures the input defaults to a safe, predefined logic level if the pin is left floating or disconnected.
- **NSLP Pin:** Equipped with an internal pull-down resistor to GND. This guarantees the transceiver defaults to the low-power sleep mode in the event of a lost connection.
- **RXD Pin:** Transitions to a high-impedance state (Hi-Z) upon loss of the VBAT power supply, preventing unwanted reverse currents.
- **Thermal Shutdown (TSD):** If the junction temperature exceeds the thermal shutdown threshold (T_J), the LIN output driver is immediately disabled to prevent damage, overriding any active signal on the TXD pin. To prevent thermal oscillation, the protection circuit features a hysteresis band. The LIN output driver will only be re-enabled after the junction temperature drops by approximately 15°C (Typ) below the initial shutdown threshold.

5. Electrical Characteristics

5.1. Absolute Maximum Rating(Ta = 25°C)

Table 5–1. Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply voltage on pin BAT ^(Note 1)	V _{BAT}	-0.3 to +40.0	V
DC voltage on pin TXD, RXD, NSLP	V _{TXD}	-0.3 to +7.0	V
	V _{RXD}		
	V _{NSLP}		
DC voltage on pin LIN	V _{LIN}	-27 to +40	V
DC voltage on pin NWAKE	V _{NWAKE}	-1 to V _{BAT} + 0.3	V
Current on pin NWAKE ^(Note 2)	I _{NWAKE}	-15	mA
DC voltage on pin INH	V _{INH}	-0.3 to V _{BAT} + 0.3	V
Output current at pin INH	I _{INH}	-50 to +15	mA
Power dissipation ^(Note 3)	P _d	674	mW
Storage temperature range	T _{stg}	-55 to +150	°C
Junction Max temperature	T _{jmax}	+150	°C
Electro static discharge (HBM) ^(Note 4)	V _{ESD}	TBD	V

(Note 1) P_d, ASO should not be exceeded.

(Note 2) Available only when V_{NWAKE} < V_{GND}-0.3V. Current flow to pin GND.

(Note 3) Regarding above Ta=25°C, P_d decreased at 5.40mW/°C for temperatures when mounted on 70x70x1.6mm Glass-epoxy PCB.

(Note 4) JEDEC qualified.

*Note: stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the devices at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

5.2. Recommended Operating Conditions

Table 5–2.Recommended Operating Conditions

Parameter	Symbol	Range	Unit
Supply voltage	V _{BAT}	9.0 to 27.0	V
Operating temperature range	T _{opr}	-40 to +125	°C

5.3. DC Characteristics

Table 5–3. Static Characteristics

Electrical Characteristics (Ta= -40 to +125°C; V_{BAT} =9 to 27V; R_{L(LIN-BAT)} =500Ω; typical values are given at Ta=25°C; V_{BAT} =12V; unless otherwise specified)

Symbol	Parameter	Test Condition	Limits			Unit
			min	typ	max	
BAT						
I _{BAT1}	Supply current 1 on pin BAT (Sleep mode)	Sleep mode. V _{LIN} = V _{BAT} V _{NWAKE} = V _{BAT} V _{TXD} = 0V V _{NSLP} = 0V	7	3	13	uA
I _{BAT2}	Supply current 2 on pin BAT (Standby mode, Recessive)	Standby mode. V _{LIN} = V _{BAT} (bus: Recessive) V _{INH} = V _{BAT} V _{NWAKE} = V _{BAT} V _{TXD} = 0V V _{NSLP} = 0V	100	400	1000	uA
I _{BAT3}	Supply current 3 on pin BAT ^(Note 1) (Standby mode, Dominant)	Standby mode. V _{BAT} = 12V V _{LIN} = 0V (bus: Dominant) V _{INH} = V _{BAT} V _{NWAKE} = V _{BAT} V _{TXD} = 0V V _{NSLP} = 0V	300	900	2000	uA
I _{BAT4}	Supply current 4 on pin BAT (Normal mode, Recessive)	Normal mode. V _{LIN} = V _{BAT} (bus: Recessive) V _{INH} = V _{BAT} V _{NWAKE} = V _{BAT} V _{TXD} = 5V V _{NSLP} = 5V	100	400	1000	uA
I _{BAT5}	Supply current 5 on pin BAT ^(Note 1) (Normal mode, Dominant)	Normal mode. V _{BAT} = 12V (bus: Dominant) V _{INH} = V _{BAT} V _{NWAKE} = V _{BAT} V _{TXD} = 0V V _{NSLP} = 5V	200	1000	2000	uA
V _{UVLO}	UVLO threshold voltage		-	-	4.9	V
V _{POR}	POR threshold voltage		-	-	4.3	V
TXD						
V _{IH}	High level input voltage		2.0	-	7.0	V
V _{IL}	Low level input voltage		-0.3	-	+0.8	V
R _{TXD}	Pull-down resistor	V _{TXD} = 5V	125	350	800	Kohm
I _{IL}	Low level input current	V _{TXD} = 0V	-5.0	0.0	+5.0	uA
NSLP						
V _{IH}	High level input voltage		2.0	-	7.0	V
V _{IL}	Low level input voltage		-0.3	-	+0.8	V
V _{hys}	Hysteresis voltage		0.03	-	0.50	V
R _{TXD}	Pull-down resistor	V _{NSLP} = 5V	125	350	800	Kohm
I _{IL}	Low level input current	V _{NSLP} = 0V	-5.0	0.0	+5.0	uA

(Note 1) When V_{BAT} is 12V or more, add to the circuit current the value calculated by the following expression because I_{BAT} depends on pull-up resistor inside LIN terminal.

$$I_{BAT(increase)} = \frac{V_{BAT}-12V}{20k\Omega} \quad (20k\Omega \text{ is the minimum value of pull-up resistor inside LIN terminal})$$

Table 5–4. Static Characteristics ...continued

Electrical Characteristics (Ta= -40 to +125°C; V_{BAT} =9 to 27V; R_{L(LIN-BAT)} =500Ω; typical values are given at Ta=25°C; V_{BAT} =12V; unless otherwise specified)

Symbol	Parameter	Test Condition	Limits			Unit
			min	typ	max	
RXD(open-drain)						
I _{OL}	Low level output current	Normal mode. V _{LIN} = 0V V _{RXD} = 0.4V	1.3	3.5	-	mA
I _{OZH}	High level leakage current	Normal mode. V _{LIN} = V _{BAT} V _{RXD} = 5V	-5.0	0.0	+5.0	uA
NWAKE						
V _{IH}	High level input voltage		V _{BAT} -1.0	-	V _{BAT} +0.3	V
V _{IL}	Low level input voltage		-0.3	-	V _{BAT} -3.3	V
I _{IH}	High level leakage current	V _{NWAKE} = 27V V _{BAT} = 27V	-5.0	0.0	+5.0	uA
I _{IL}	Pull-up current	V _{NWAKE} = 0V	-30	-10	-3	uA
INH						
R _{INH}	Switch-on resistance between pins BAT and INH	Standby mode, Normal mode. I _{INH} = -15mA, V _{BAT} = 12V	-	30	50	ohm
I _{OZH}	High level leakage current	Sleep mode. V _{INH} = V _{BAT} =27V	-5.0	0.0	+5.0	uA
LIN						
V _{O_rec}	LIN recessive output voltage	V _{TXD} = 5V, I _{LIN} = 0mA	V _{BAT} x 0.9		V _{BAT}	V
V _{O_dom1}	LIN dominant output voltage	V _{TXD} = 0V, V _{BAT} = 7.3V	-	-	1.2	V
V _{O_dom2}		V _{TXD} = 0V, V _{BAT} = 7.3V R _{L(LIN-BAT)} = 1kΩ	0.6	-	-	V
V _{O_dom3}		V _{TXD} = 0V, V _{BAT} = 18V	-	-	2.0	V
V _{O_dom4}		V _{TXD} = 0V, V _{BAT} = 18V R _{L(LIN-BAT)} = 1kΩ	0.8	-	-	V
I _{IH}	High level leakage current	V _{LIN} = V _{BAT}	-5.0	0.0	+5.0	uA
I _{IL}	LIN pull-up current	Sleep mode. V _{LIN} = V _{NSLP} = 0V	-10.0	-5.0	-2.0	uA
R _{SLAVE}	Pull-up resistance (Slave termination resistance to pin BAT)	Standby mode, Normal mode. V _{LIN} = 0V, V _{BAT} = 12V	20	30	47	Kohm
C _{LIN}	Capacitance of pin LIN (Note 2)		-	-	30	pF
I _{O_SCO}	Short-circuit output current	V _{LIN} = V _{BAT} = 18V, V _{TXD} = 0V t < t _{dom}	40	-	200	mA
I _{BUS_PAS_dom}	Input leakage current at the receiver operating (included pull-up resistor)	V _{LIN} = 0V V _{BAT} = 12V V _{TXD} = 5V	-1	-	-	mA
I _{BUS_PAS_rec}	Input leakage current at the receiver operating	V _{LIN} = 18V V _{BAT} = 8V V _{TXD} = 5V	-	-	20	uA
I _{BUS_NO_GND}	Loss of ground leakage current	V _{BAT} = V _{GND} = 12V V _{LIN} = 0V to 18V	TBD	-	1	mA
I _{BUS_NO_BAT}	Loss of battery leakage current	V _{BAT} = 0V V _{LIN} = 18V	-	-	100	uA
V _{th_rx}	Receiver threshold voltage	V _{BAT} = 7.3V to 27.0V	V _{BAT} X 0.4	-	V _{BAT} X 0.6	V
V _{cn_rx}	Receiver center voltage (Note 3)	V _{BAT} = 7.3V to 27.0V V _{cn_rx} = (V _{th_dom} + V _{th_rec})/2	V _{BAT} X 0.475	V _{BAT} X 0.500	V _{BAT} X 0.525	V
V _{th_hys}	Receiver threshold voltage (Note 3)	V _{BAT} = 7.3V to 27.0V V _{th_hys} = V _{th_rec} - V _{th_dom}	V _{BAT} X 0.100	V _{BAT} X 0.140	V _{BAT} X 0.175	V

(Note 2) It is a design guarantee parameter, and is not production tested.

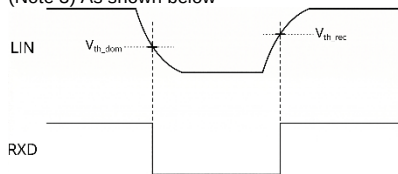
5.4. AC Characteristics

Table 5–5. Dynamic Characteristics

Electrical Characteristics (Ta= -40 to +125°C; V_{BAT} =9 to 27V; R_{L(LIN-BAT)} =500Ω; typical values are given at Ta=25°C; V_{BAT} =12V; unless otherwise specified)

Symbol	Parameter	Test Condition	Limits			Unit
			min	typ	max	
AC characteristics ^(Note 7)						
t _{PropRxDom}	RXD propagation delay	Normal mode C _L (LIN-GND) = 0nF R _L (LIN-BAT) = ∞ Voltage on LIN externally forced. LIN t _f , t _r < 20nsC _{RXD} = 20pF R _{RXD} = 2.4kΩ Δt _d _(BUS-RXD)=t _{PropRxDom} -t _{PropRxRec}	-	-	6.0	us
t _{PropRxRec}			-	-	6.0	us
Δt _d _(BUS-RXD)	RXD propagation delay failure		-2.0	0.0	+2.0	us
D1	Duty cycle 1 ^(Note 4, Note 5)	Normal mode TH _{Rec(max)} = 0.744 x V _{BAT} TH _{Dom(max)} = 0.581 x V _{BAT} V _{BAT} =7.0 to 18.0V t _{Bit} =50μs	0.396	-	-	
D2	Duty cycle 2 ^(Note 4, Note 6)	Normal mode TH _{Rec(min)} = 0.422 x V _{BAT} TH _{Dom(min)} = 0.284 x V _{BAT} V _{BAT} =7.6 to 18.0V t _{Bit} =50μs	-	-	0.581	
D3	Duty cycle 3 ^(Note 4, Note 5)	Normal mode TH _{Rec(max)} = 0.778 x V _{BAT} TH _{Dom(max)} = 0.616 x V _{BAT} V _{BAT} =7.0 to 18.0V t _{Bit} =96μs	0.417	-	-	
D4	Duty cycle 4 ^(Note 4, Note 6)	Normal mode TH _{Rec(min)} = 0.389 x V _{BAT} TH _{Dom(min)} = 0.251 x V _{BAT} V _{BAT} =7.6 to 18.0V t _{Bit} =96μs	-	-	0.590	
t _{BUS}	Dominant time for wake-up via bus	Sleep mode (Remote wake-up)	30	70	150	us
t _{NWAKE}	Dominant time for wake-up via pin NWAKE	Sleep mode (Local wake-up)	7	20	50	us
t _{gotonorm}	Time period for mode change from sleep or standby mode into normal mode	Shift from Sleep/Standby mode to Normal mode	TBD	5	10	us
t _{gotosleep}	Time period for mode change from normal mode into sleep mode	Shift from Normal mode to Sleep mode	2	5	10	us
t _{dom}	TXD dominant time out	V _{TXD} = 0V	6	12	20	ms

(Note 3) As shown below

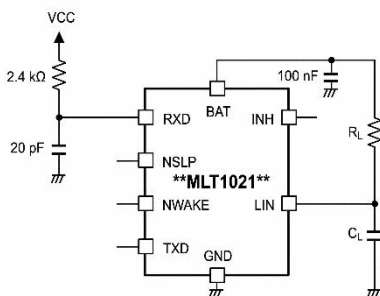


(Note 4) Load condition at bus (C_{L(LIN-GND)};R_{L(LIN-BAT)}) : 1nF;1kΩ / 6.8nF;660Ω / 10nF;500Ω

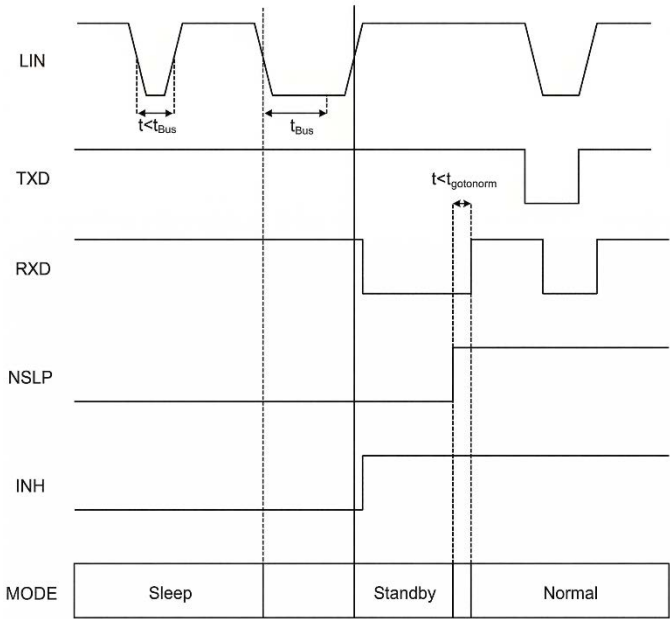
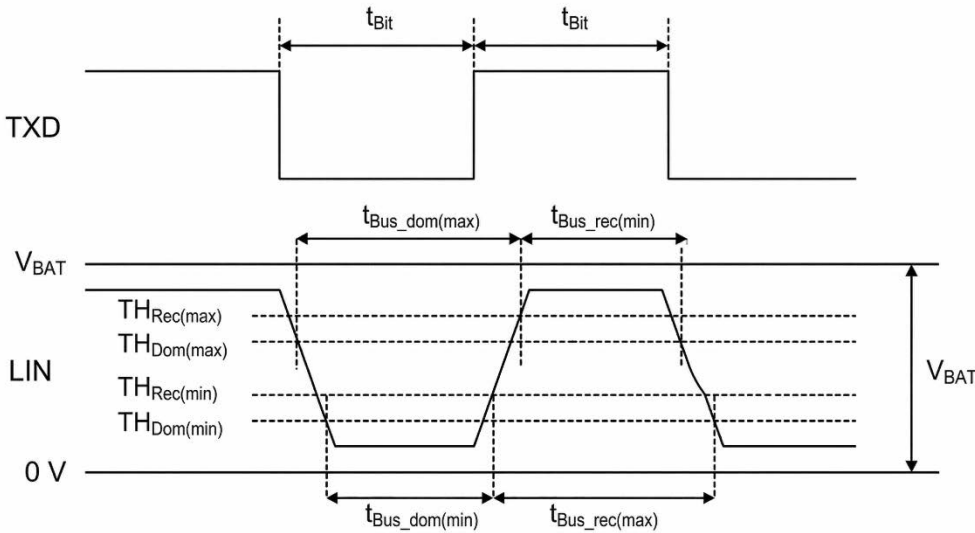
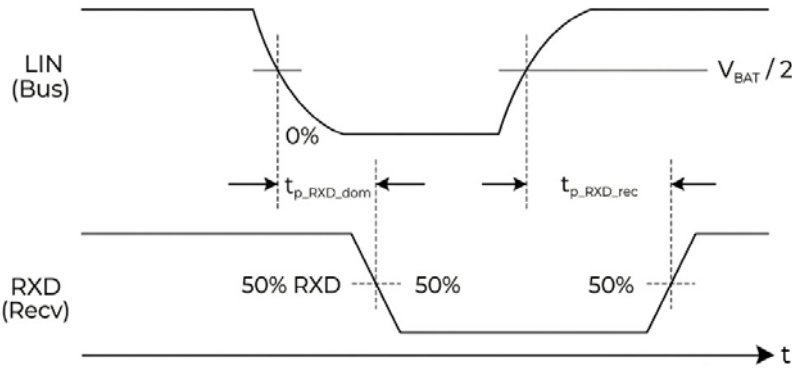
(Note 5) $D1, D3 = \frac{t_{Bus_rec(min)}}{2 \times t_{Bit}}$

(Note 6) $D2, D4 = \frac{t_{Bus_rec(max)}}{2 \times t_{Bit}}$

(Note 7) AC characteristic evaluation circuit diagram



5.4.1. Timing Chart



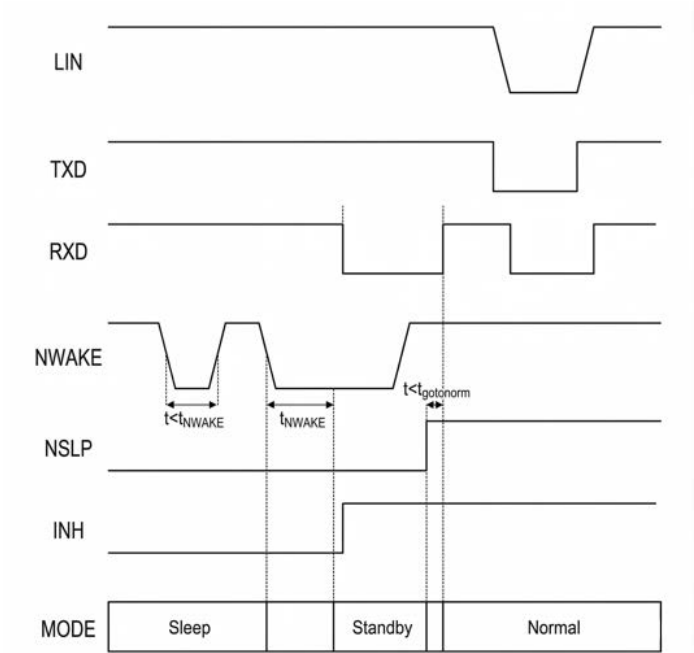


Figure 5–4. Local wake-up (Sleep → Standby → Normal)

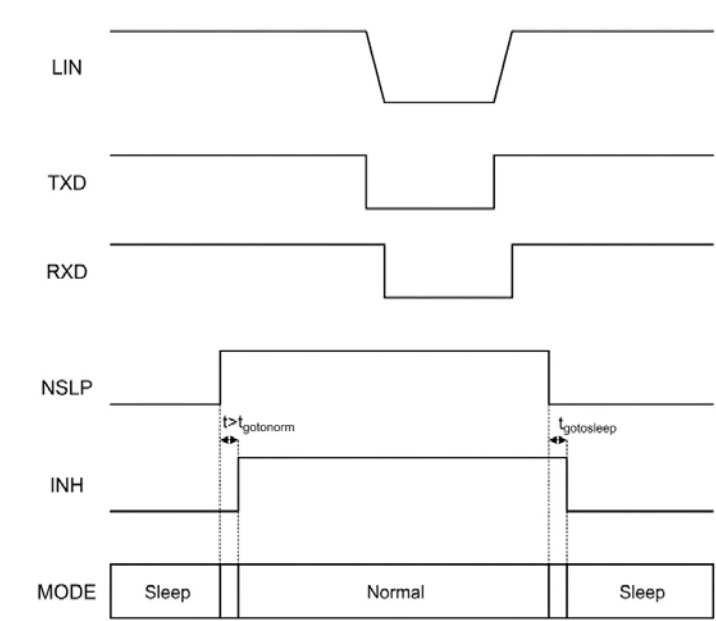


Figure 5–5. Wake-up/Sleep-in with NSLP (Sleep → Standby → Normal)

5.5. Application Example(s)

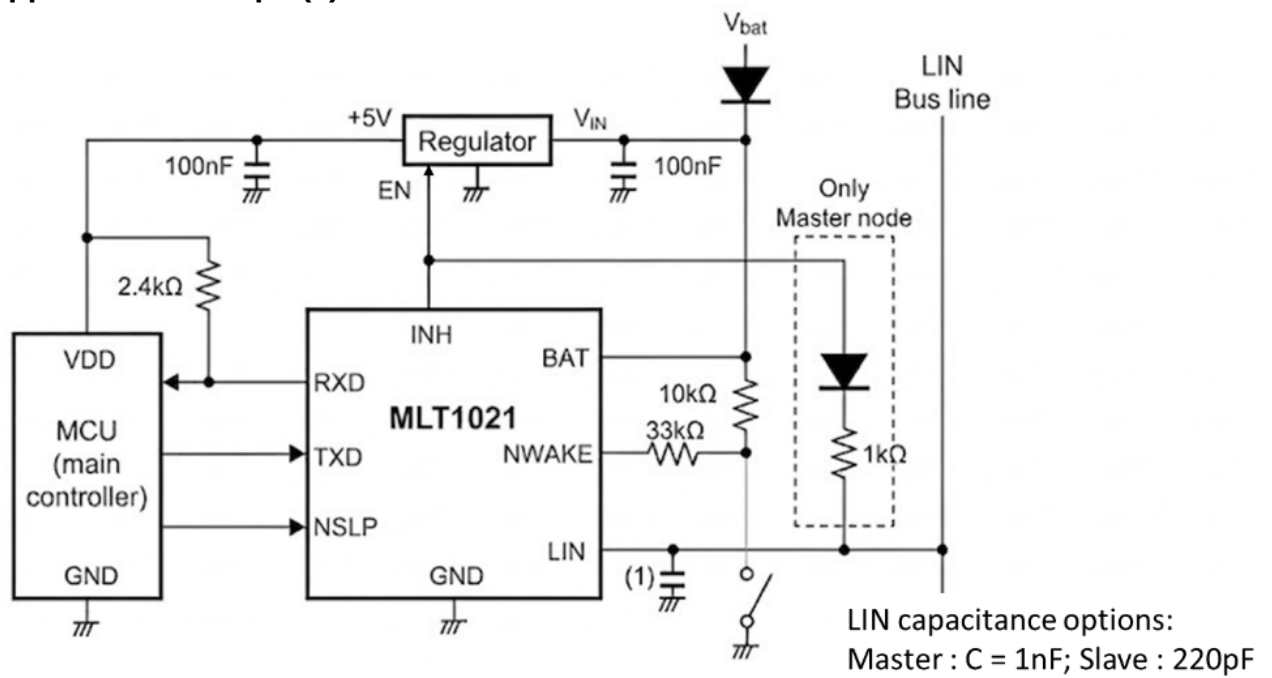
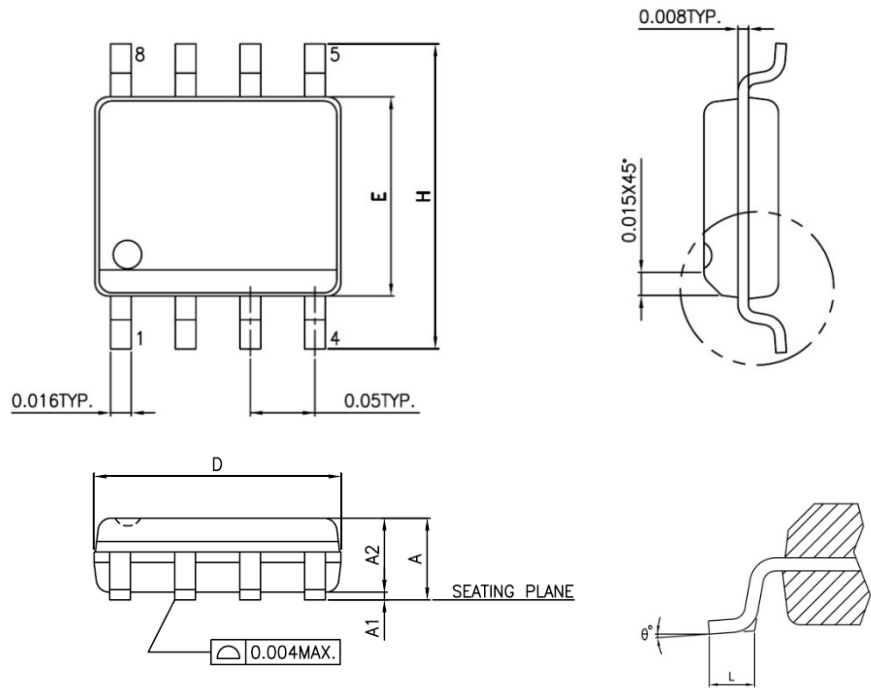


Figure 5–6. Application Example

6. Package Dimension

6.1. SOP-8 Dimension

Figure 6-1. SOP-8 (150 mil) Package Dimension



Unit	mm		inch	
Symbols	Min.	Max.	Min.	Max.
A	1.346	1.752	0.052	0.068
A1	0.101	0.254	0.003	0.010
A2	1.346	1.498	0.052	0.058
D	4.800	4.978	0.188	0.195
E	3.810	3.987	0.150	0.156
H	5.791	6.197	0.227	0.243
L	0.406	1.270	0.015	0.050
θ	0°	8°	0	8

7. Revision History

Table 7–1. Revision History

Rev	Descriptions	Date
V0.01	Preliminary version released	2026/03/24
V0.02	Modify Figure 4-1 format	2026/03/25
V0.03	Modify V_{BAT} Range	2026/06/17
V0.04	Corrected typographical errors in Section 3.2.	2026/09/21

8. Disclaimers

Herein, Megawin stands for “***Megawin Technology Co., Ltd.***”

Life Support — This product is not designed for use in medical, life-saving or life-sustaining applications, or systems where malfunction of this product can reasonably be expected to result in personal injury. Customers using or selling this product for use in such applications do so at their own risk and agree to fully indemnify Megawin for any damages resulting from such improper use or sale.

Right to Make Changes — Megawin reserves the right to make changes in the products - including circuits, standard cells, and/or software - described or contained herein in order to improve design and/or performance. When the product is in mass production, relevant changes will be communicated via an Engineering Change Notification (ECN).