



ROHM GROUP
LAPIS
SEMICONDUCTOR

ROHM-Lapis Sub-GHz RF Products for Smart Metering Applications



October, 2014

- **ML7406 (868MHz wM-BUS), ML7345 (169MHz/433MHz wM-BUS) and ML7396E are optimized for smart meters and applications that reliability is the most important.**
- **Highest RF performance in the industry, up to 20 years aging simulation, low power consumption, hardware baseband processor to reduce MCU task.**
- **Test procedure of ML7406, ML7345 and ML7396E are very strict. Worst case parameters are specified in the data sheets, while most of our competitors guarantee typical case only. In the end, our solutions will reduce testing cost of the meter manufacturers.**

1. ROHM/LAPIS Communication technology overview

2. ML7396E - IEEE802.15.4g

- Best RF performance in the industry

3. ML7406 - 868MHz wM-BUS

- Best RF performance in the industry
- Best average stand-by power consumption in the industry

4. ML7345 - 169MHz/433MHz wM-BUS

- Best RF performance in the industry
- Best RX-TX power & average stand-by power consumption in the industry

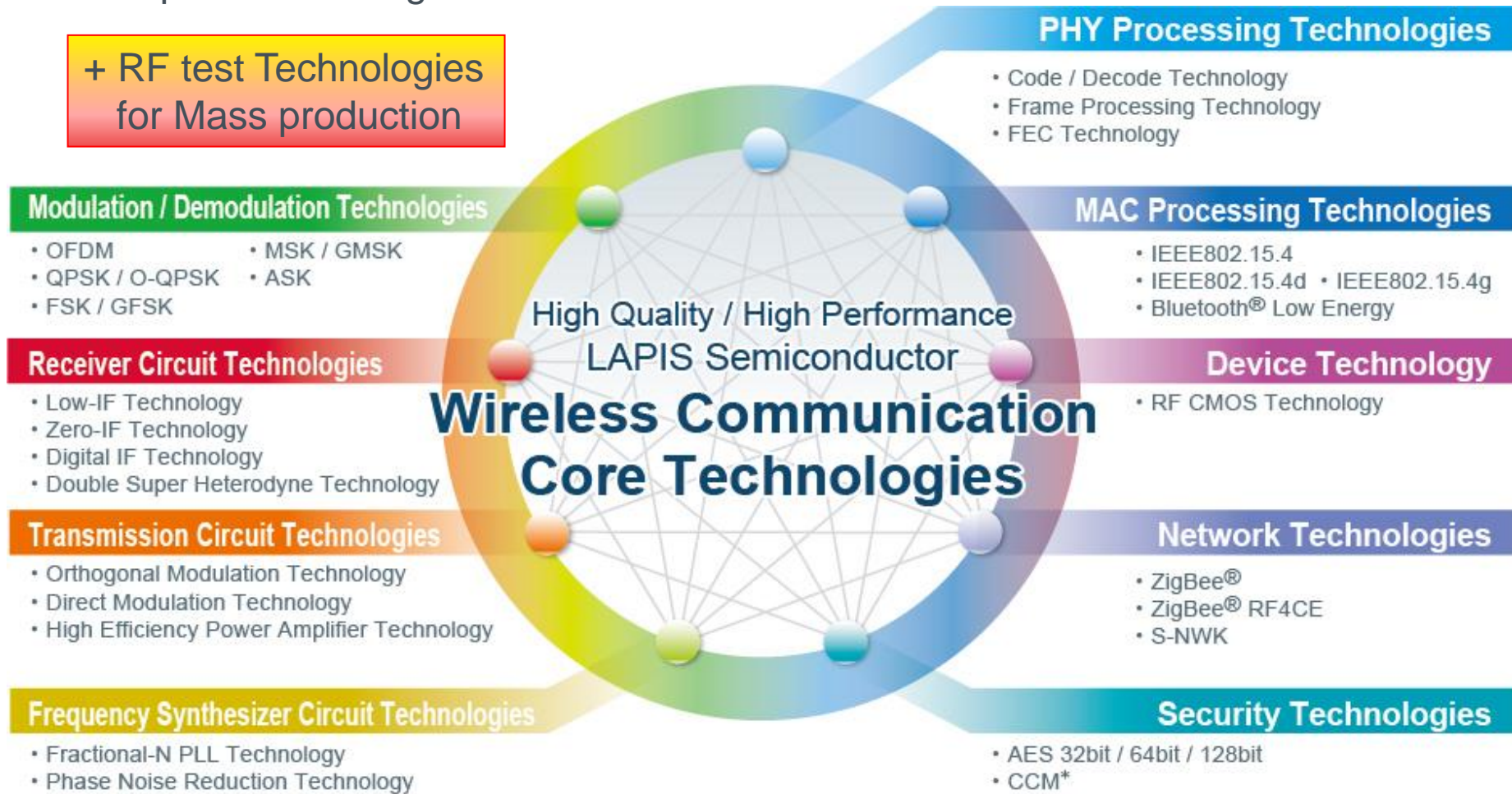
5. Evaluation tools and software

Low Power Wireless Communication Technologies

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LAPIS semiconductor provides RF products based on various low power consumption technologies.

+ RF test Technologies
for Mass production



Next Generation PLC Technologies

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- ✓ ROHM is an active member of HD-PLC alliance, in order to develop next generation technology in smart meters, smart grid.....
- ✓ HD-PLC employs Wavelet OFDM technology, which overcome drawback of the conventional FFT OFDM technology. (IEEE P1901)

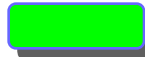


HD-PLC
Power Line Communication

Sub GHz Products Lineup

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| Product | Compliance | Frequency Range | Tx Power | Data Rate [NRZ] | Power Supply (V) | PKG | Features |
|---------|--|-----------------|-----------------------|---|------------------|--------|---|
| ML7386 | RCR STD-30 | 200MHz - 972MHz | 10mW | 1.2kbps - 100kbps | 1.8 to 3.6 | WQFN28 | •426MHz low power transmitter LSI. •1.8V operation suitable for battery operated fire alarm, security equipment, etc. •Built-in regulator makes the TX output stable independently of the supply voltage fluctuation |
| ML7386B | ARIB STD-T67/ RCR STD-30 | | 1mW 10mW | | | | |
| ML7396B | ARIB STD-T108 | 750MHz - 960MHz | 1mW 10mW 20mW | 50kbps 100kbps 200kbps 400kbps | 1.8 to 3.6 | WQFN40 | •900MHz transceiver LSI. •ML7396 Family LSI covers regional requirement. •Reliable communication via superior RF performance. •Receiver sensitivity can be improved via FEC. |
| ML7396A | FCC part15. 247/249 | | | | | | |
| ML7396E | EN300-220 | | | | | | |
| ML7406 | EN300-220 EN13757-4:2013 | 750MHz - 960MHz | 1mW 10mW 20mW | 1.2kbps - 500kbps | 1.8 to 3.6 | WQFN32 | •868MHz transceiver LSI for Europe wireless smart meters. •Built-in Wireless M-Bus packet handler •Suitable for the Wireless M-Bus S, T and C mode system. |
| ML7344C | Q_GDW374.3 | 168MHz - 510MHz | 10mW 20mW 100mW | 1.2kbps - 15kbps | 1.8 to 3.6 | WQFN32 | •ML7344C can output 100mW (+20dBm) and suitable for China wireless smart meters. •ML7344E is suitable for the proprietary systems in Europe •Receiver current consumption of 6.2mA, well suited to battery operation. •Built-in RC oscillation and wake-up function implemented. |
| ML7344E | EN300-220 EN13757-4 | | 1mW 10mW 20mW | | | | |
| ML7344J | ARIB STD-T67/ RCR STD-30 | | | | | | |
| ML7345 | EN300-220 EN13757-4:2013 | 160MHz - 510MHz | 1mW 10mW 20mW | 1.2kbps - 150kbps | 1.8 To 3.6 | WGFN32 | •For 169MHz Wireless M-bus(2013) meter. •Receiver current consumption of 8.5mA, •Support 4FSK modulation. |
| ML7416 | RF characteristic is same as ML7396 family | | | | 1.8 To 3.6 | BGA81 | •Cortex-M0+ RISC core (Up to 40MHz) •FLASH: 256kBx2, SRAM: 64kB •AES etc. |



:Maas production



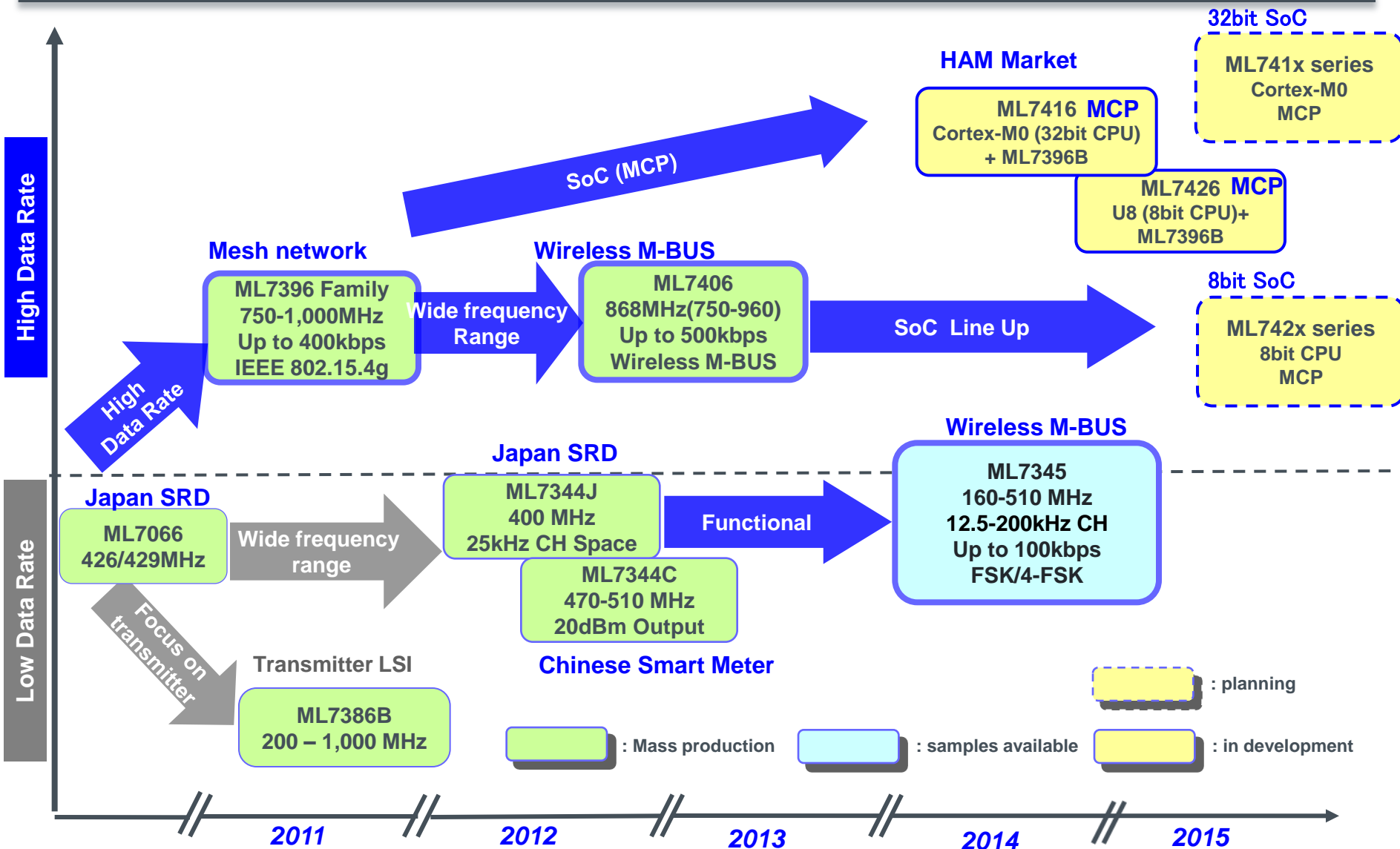
:Engineering sample available



:in development

Sub GHz Products Road Map

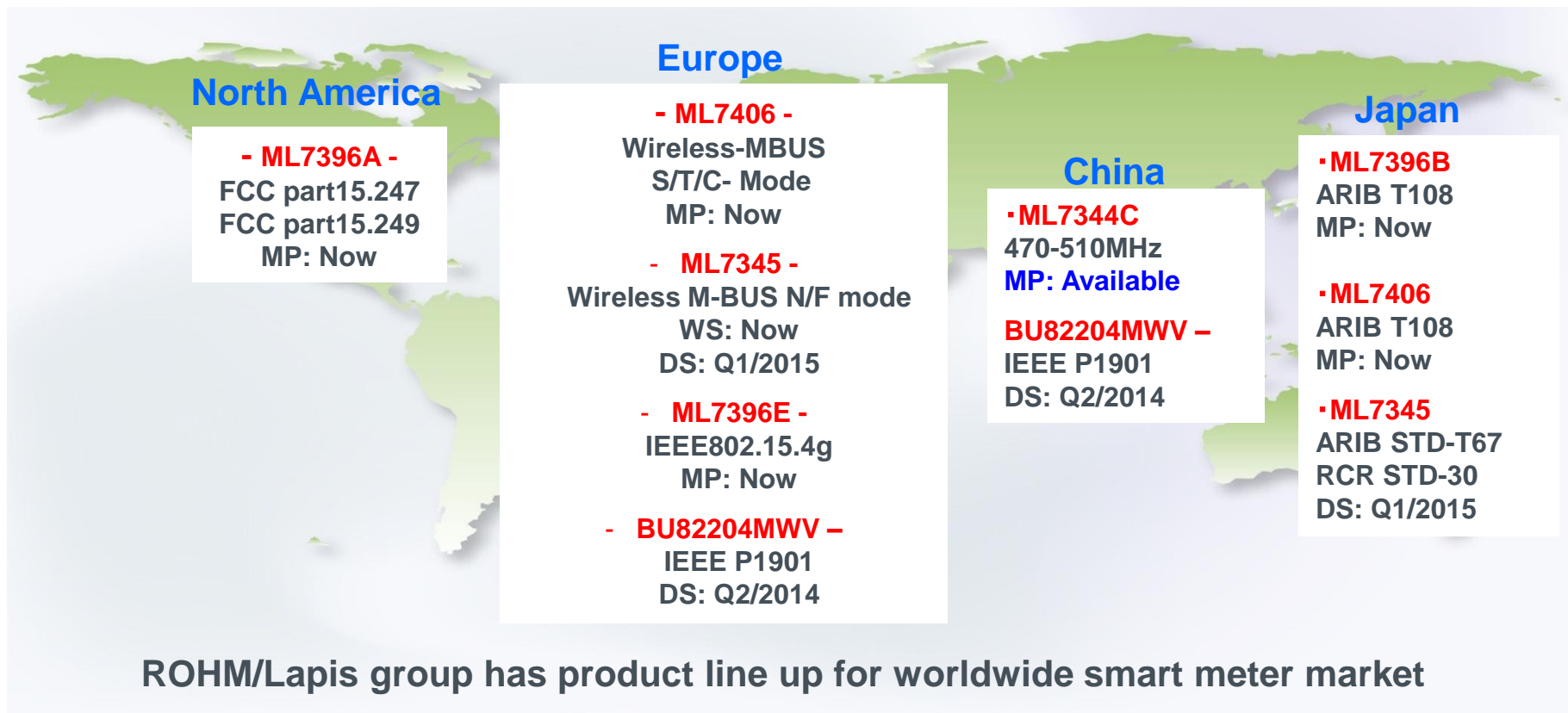
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Communication Products Regional Product Status

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- ❑ ML7396/ML7406/ML7345 Family LSI
 - Have been selected for field trials of several Electric Power Company in Japan
 - Under evaluation by tier1 European meter customers
- ❑ PLC Modem: BU82204MWV for Smart Grid in Europe and China



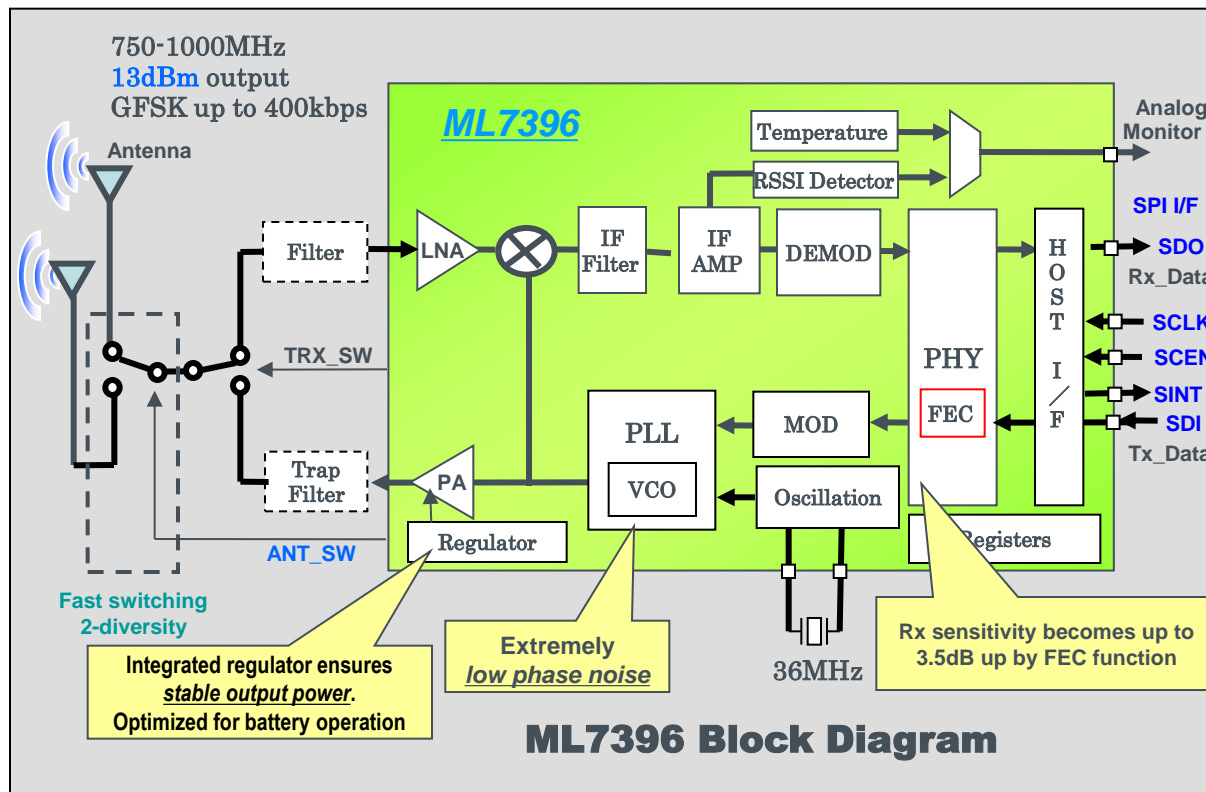
IEEE 802.15.4g Transceiver -- ML7396 family

ML7396 Family Overview

ML7396

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- ❑ ML7396 family supports IEEE 802.15.4g PHY layer and part of MAC layer
- ❑ Achieve high quality and reliable communication
- ❑ Available to extend communication range by FEC function



Features

- ❑ Operating Frequency Range
750MHz to 1GHz
- ❑ Power Supply
1.8V to 3.6V
- ❑ Operating Temperature
-40°C to 85°C
- ❑ Consumption Current
TX (13dBm): 32 mA
RX : 15 mA
Sleep: 0.9µA
- ❑ Modulation Scheme
GFSK, FSK
- ❑ Rx Sensitivity (BER=0.1%)
-106 dBm @ 100 kbps
- ❑ Data Rate
up to 400 kbps
- ❑ CH Spacing
200 kHz x n (n= 1 to 4)
- ❑ Package
40pin WQFN (6x6x0.8mm)
- ❑ RoHS compliant

Product Status: ML7396A, ML7396B and ML7396E are in mass-production

- ❑ Compliance: FCC Part 15, EN 300-220
- ❑ IEEE 802.15.4g support Hardware packet processor (including FEC)
- ❑ Data rates: up to 400kbps (GFSK Option)
- ❑ Channel Spacing: 200 kHz x n (n=1,2,3 and 4)
- ❑ Auto Frequency Control (AFC)
- ❑ Built-in Test Pattern Generator
- ❑ Wide RSSI dynamic range of 70dB
- ❑ Integrated PA: 20mW / 10mW / 1mW
Single-end interface to external PA
- ❑ Low phase noise -119 dBc/Hz @ 700 kHz
- ❑ Rx Sensitivity: -106 dBm typ. @100 kbps and BER = 0.1%
-108 dBm typ. @ 50 kbps and BER = 0.1%
- ❑ Adjacent Channel Rejection 35 dB @ +/- 200 kHz; 45 dB at +/- 400 kHz (50 kbps)
- ❑ Blocking performance 40 dB @ 1 MHz; 55 dB @ 10 MHz
- ❑ Operating Temperature: - 45 to 85°C
- ❑ Power Consumption
Transmitting (20mW/10mW/1mW) 32mA/ 24 mA / 13 mA typ.
Receiving 15 mA typ.
Sleep 0.9 uA typ. (RAM retention)
- ❑ Package: WQFN (6mm x 6mm), RoHS, Halogen Free

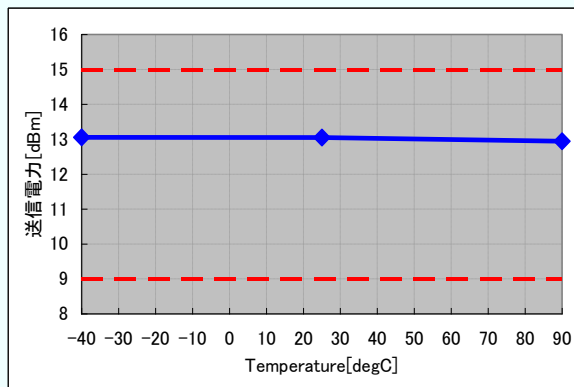
Tx power, Rx sensitivity voltage, and temperature dependence is minimized, ensuring a high reliable Communication range

- Temperature correction of PA current is implemented.
- PA is operating at the saturation point. And it contributes the absorption of the temperature variation of the output power.

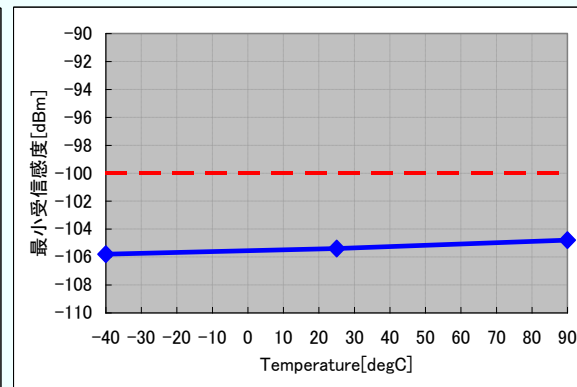
FEC function improves receiver sensitivity

- When in use more than 250 byte packet, the PER will be improved up to 3.5dB
- Available to extend the communication range via FEC function.

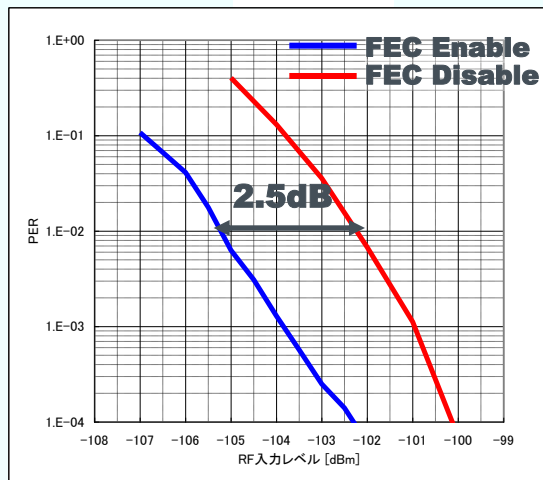
Tx Power



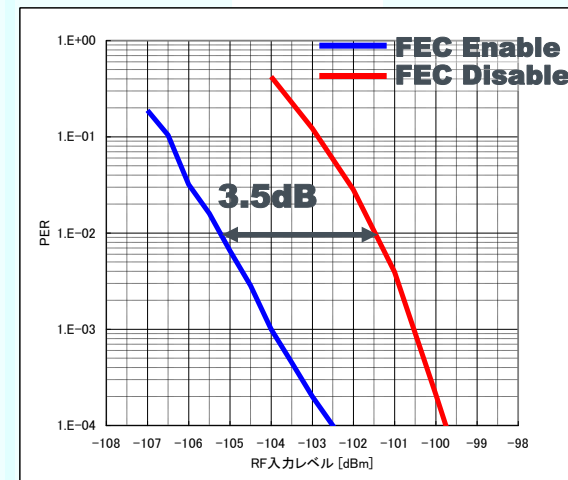
Rx Sensitivity



FEC PER (18Byte)



FEC PER (250Byte)



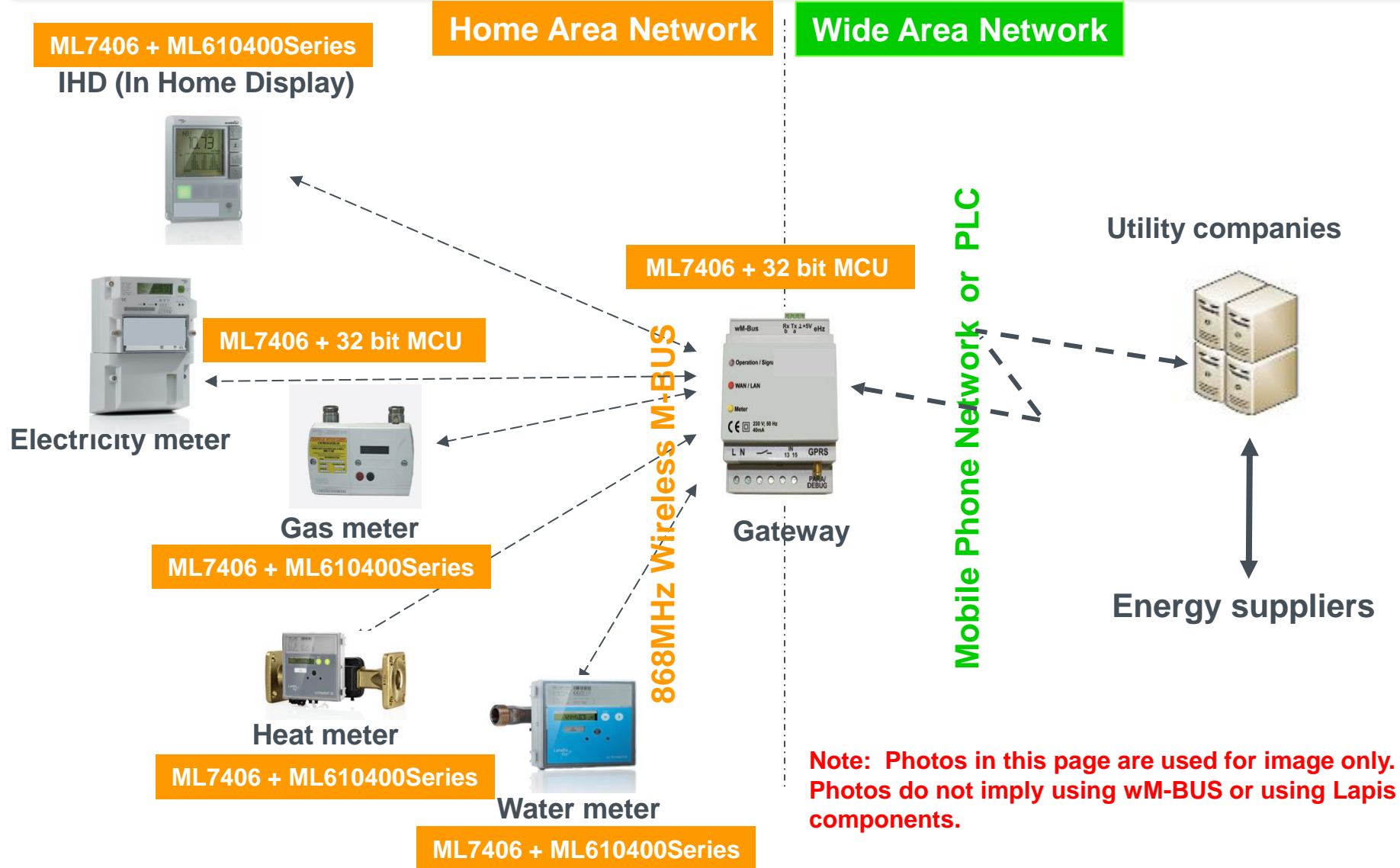
Wireless M-BUS Transceiver

-- ML7406 and ML7345 family

wM-BUS Systems Architecture Example

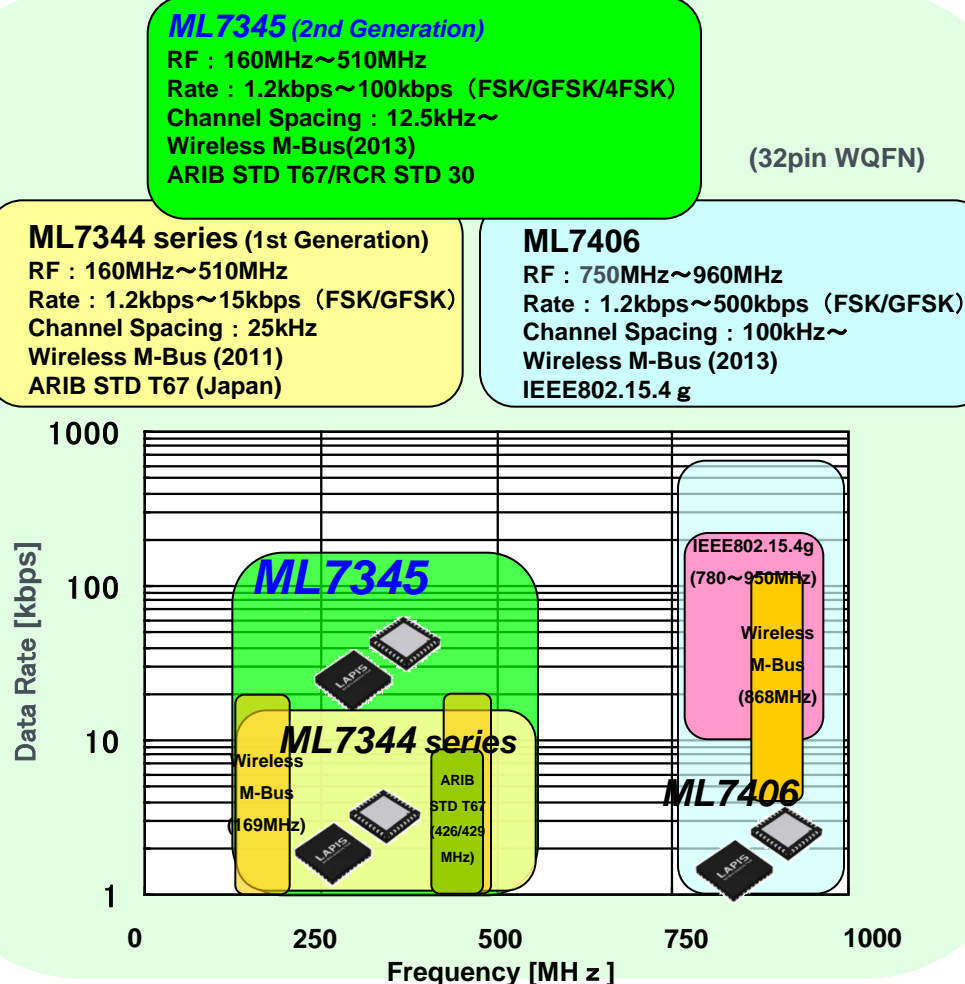
ML7406

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Design Compatibility

- ML7344 , ML7406 and ML7345 have the same package, pins assignment and major registers.
(Dedicated registers exist in each LSI)



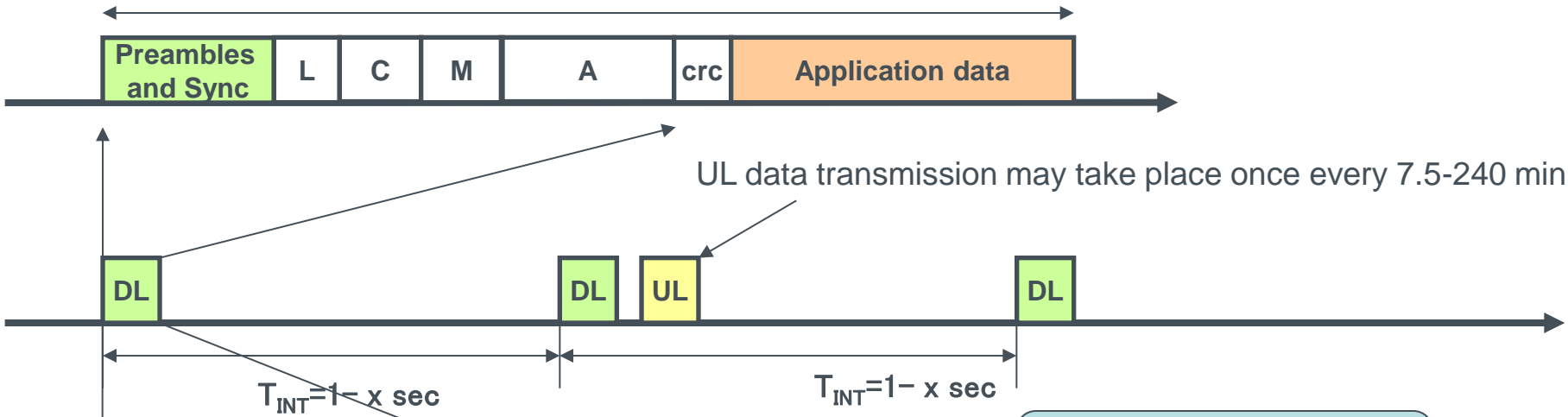
ML7345/ML7406 Common Features

- Automatic Wake UP and Sleep function
 - ✓ Built-in RC oscillator or external 32kHz input selectable
- RSSI indicator and threshold judgment function
 - ✓ High-speed RSSI check mode enable to achieve RSSI judgment in minimum 1 m sec (ML7345).
- Transmission power fine tuning function ($\pm 0.2\text{dB}$)
- General purpose timer (2CH)
- PN9 and other test pattern generator
- Packet handling function
 - ✓ Wireless M-bus packet format and general packet format
 - ✓ Packet length of Max. 255 byte (Wireless M-bus), 2047 byte (general)
 - ✓ Tx FIFO(64Byte) and Rx FIFO (64Byte)
 - ✓ Automatic Tx preamble generator (Max. 16383Byte)
 - ✓ Rx preamble pattern detection (Max. 4Byte)
 - ✓ SyncWord setting and detection (Max. 4Byte)
 - ✓ Programmable CRC function
 - 8/16/32bit selectable, fully programmable polynomial)
 - ✓ Address check function
 - Wireless M-bus C-Field、M-Field and A-Field can be detected automatically)

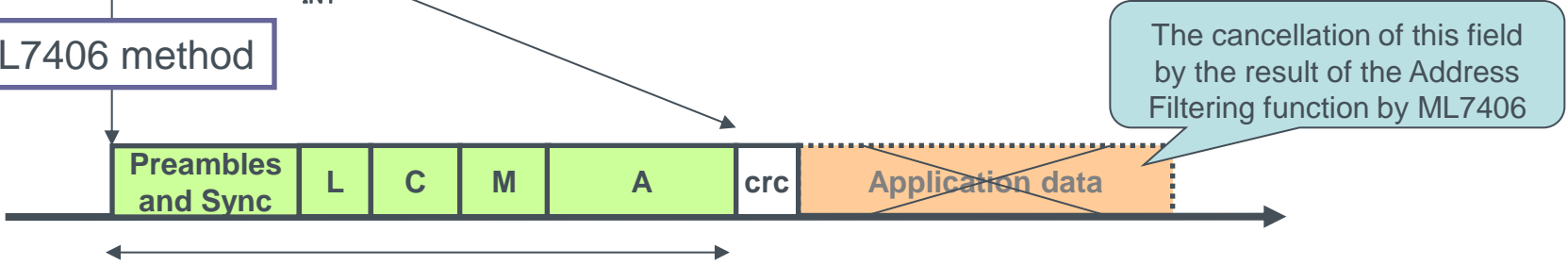
Hardware co-processor for WMBUS

Conventional method

RF and MCU has to be wake up every few seconds in order to check the receiving packet is designated to the device (meter).



ML7406 method

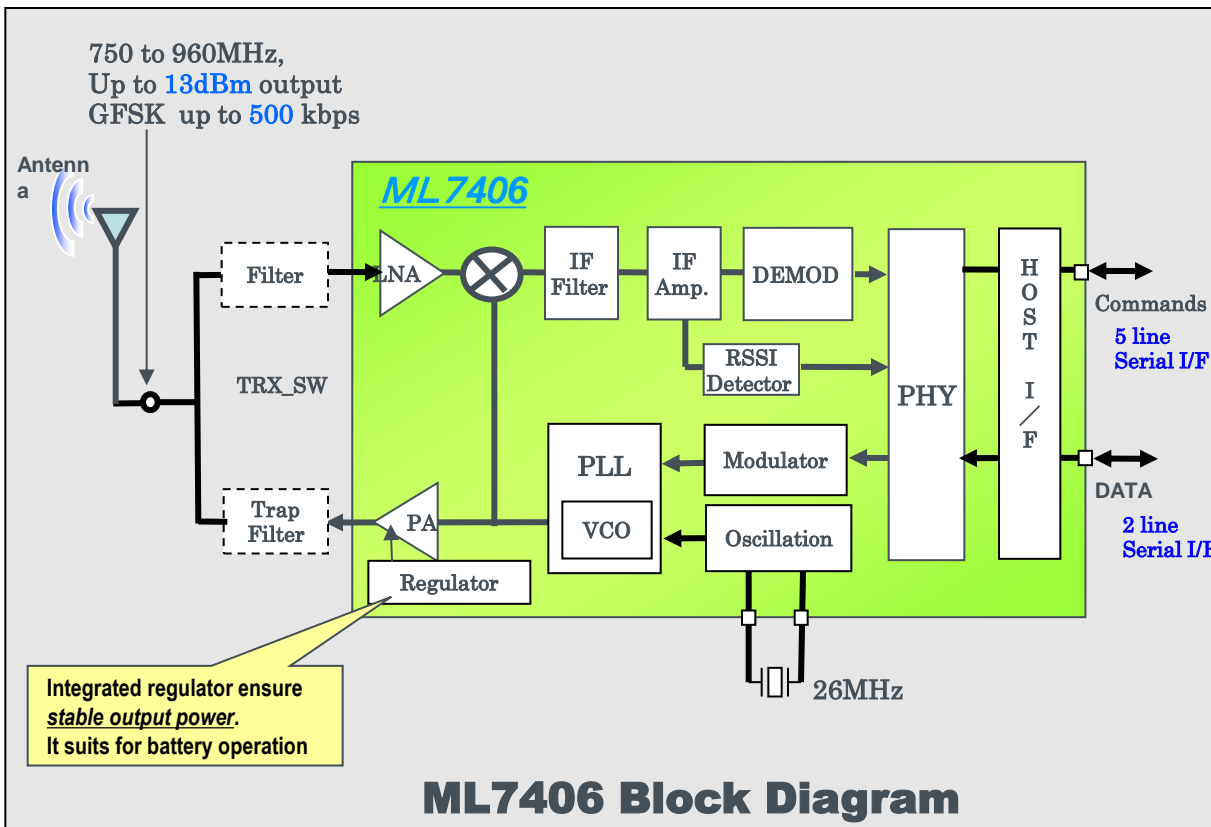


Address Filtering function solely performed in ML7406 will check the receiving packet is designated to the device, MCU can be "halt" mode while it is analyzing packet.

Average current saving 16-18% *1

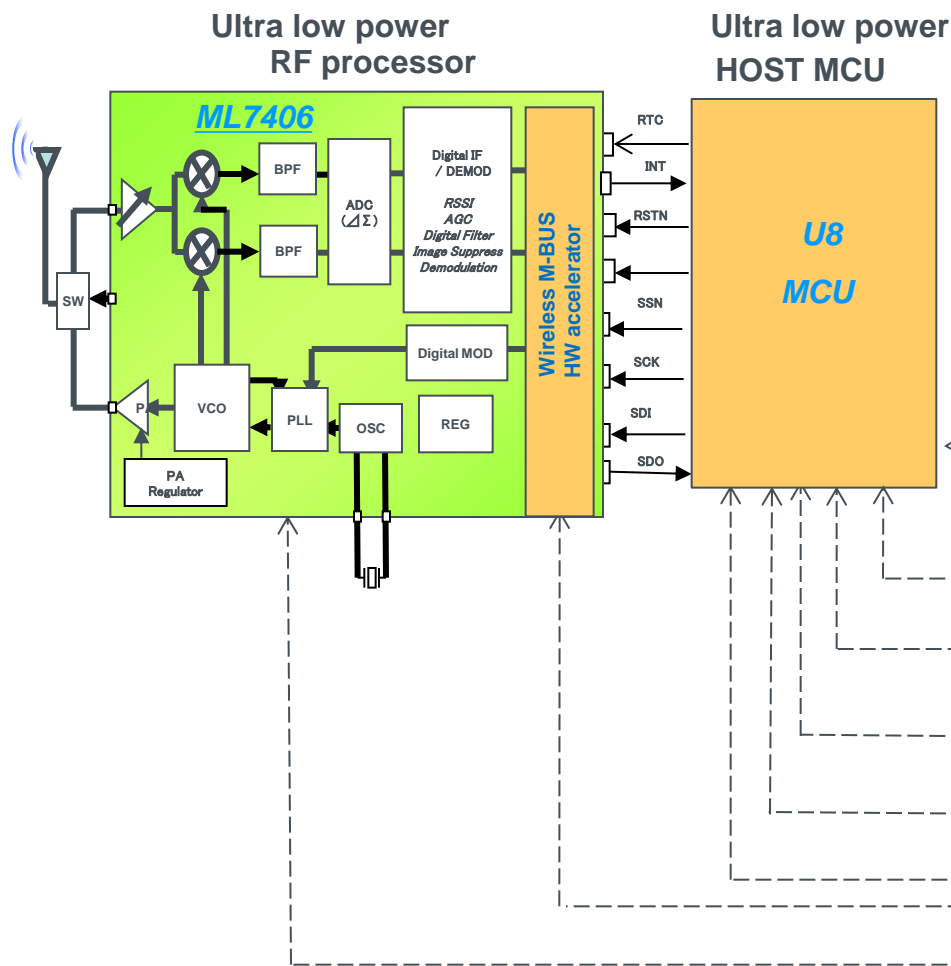
*1 assumption by LAPIS

- The ML7406 compliant with EN300-220 and EN13757-4:2013, supporting Wireless M-bus S-mode, T-mode and C-mode.
- Field filter function, CRC generate function and Wake-up function are implemented to save control MCU operation.
- Automatic wake-up and sleep function are integrated.



[Features]

- Operating Frequency Range
750MHz to 960MHz
- Power Supply
1.8V to 3.6V
- Operating Temperature
-40°C to 85°C
- Excellent Low Consumption Current
TX (13dBm): 34 mA
(10dBm): 24 mA
(0dBm): 13 mA
RX : 15 mA
Sleep: 0.56 μ A
Deep Sleep: 0.1 μ A
- Rx Sensitivity: **-106dBm @100kbps**
- Modulation Scheme
(G)FSK / (G)MSK
- Data Rate
up to 500kbps
- CH spacing
Programmable from 60KHz
- Package
32pin WQFN (5x5x0.8mm)
- RoHS compliant



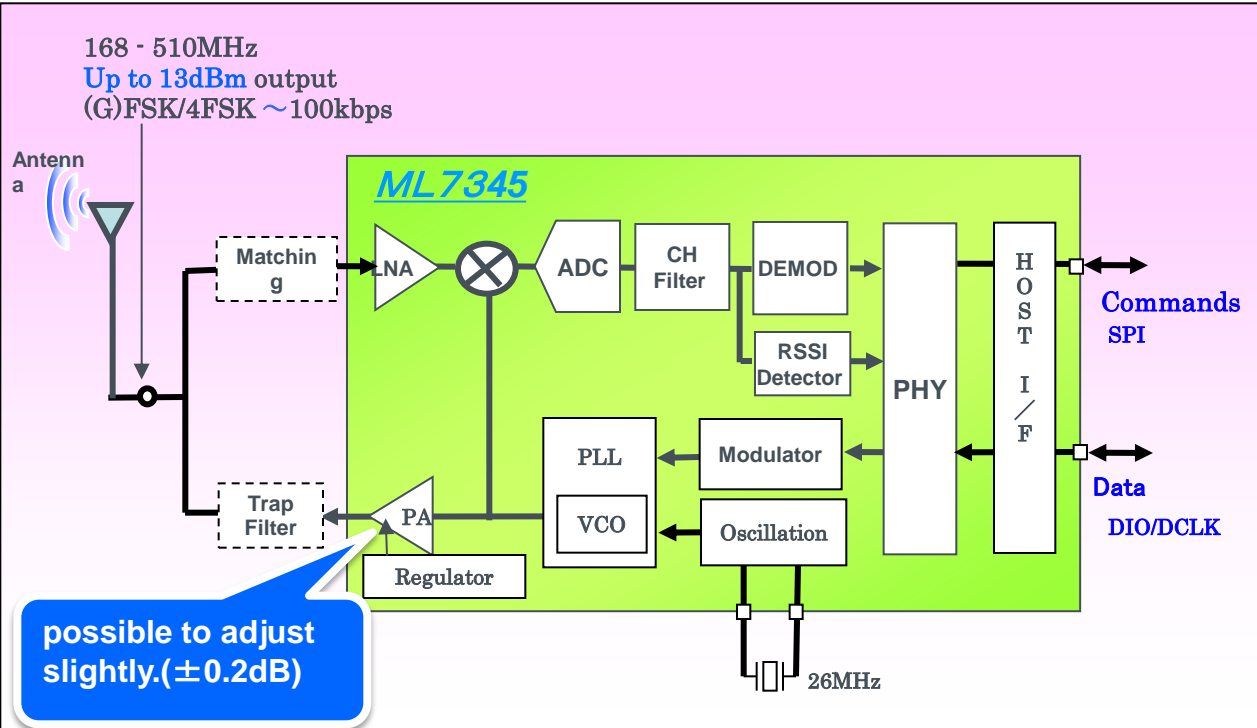
By combining LAPIS’s wireless M-BUS RF processor and ultra low power MCU, power consumption can be reduced significantly.

Wireless M-BUS layer

| ISO/OSI Layer | Layer name | Standard |
|---------------|--|---------------------|
| Layer 7 | Data exchange for meter reading, tariff and load control | DLSM/COSEM, SML.... |
| Layer 7 | Country/Regional specific meter application | OMS, DSMR.... |
| Layer 7 | Application Layer | EN 13757-3 |
| Layer 7 | Application Layer | Security (AES128) |
| Layer 2 | Data Link Layer | EN 13757-4 |
| Layer 1 | Physical Layer | EN 13757-4 |

- ✓ **ML7406 supports wireless M-BUS T mode, C mode and S mode in both data collectors and meters. Meeting all requirement of the EN13757-4:2013.**
- ✓ **ML7406 Evaluation board + Steinbeis OMS/Wireless M-BUS stack. (Basic reference package is using Renesas RX62N platform)**
- ✓ **MCU can be changed to STM STM32F4 series, TI MSP430 series, Renesas RL78 series upon request. (5 days lead time necessary)**
- ✓ **OMS can be changed to DSMR upon request. Approximately, 2 month lead time.**
- ✓ **ML7406 Evaluation board + PC based ML7406 Data Link Layer API GUI is available.**

- The ML7345 compliant with EN300-220 and EN13757-4:2013.
It covers Wireless M-bus N-mode and F-mode.
- Supports wireless communication in the range of 160MHz to 510MHz.
 - Selectable Channel spacing (12.5kHz -)
 - (G)FSK / 4FSK (Max 100kbps)
- The high speed carrier checking function enables reception signal monitoring in less than 1mS. And Automatic wake-up and sleep function are integrated.



ML7345 Block Diagram

- [Features]
- Operating Frequency Range
160MHz to 510MHz
 - Power Supply
1.8V to 3.6V
 - Operating Temperature
-40°C to 85°C
 - Excellent Low Consumption Current
 - TX (13dBm): 26 mA
 - (10dBm): 20 mA
 - (0dBm): 6.8 mA
 - RX : 8.5 mA
 - Idle mode (RTC on): 0.6mA
 - Deep Sleep mode: 0.1 µA
 - Rx Sensitivity: -120dBm@4.8kbps
 - Modulation Scheme
(G)FSK/(G)MSK/4FSK
 - Data Rate: 1200bps to 100kbps
 - CH spacing: 12.5-
 - Package
32pin WQFN (5x5x0.8mm)

Excellent PLL-AFC feature

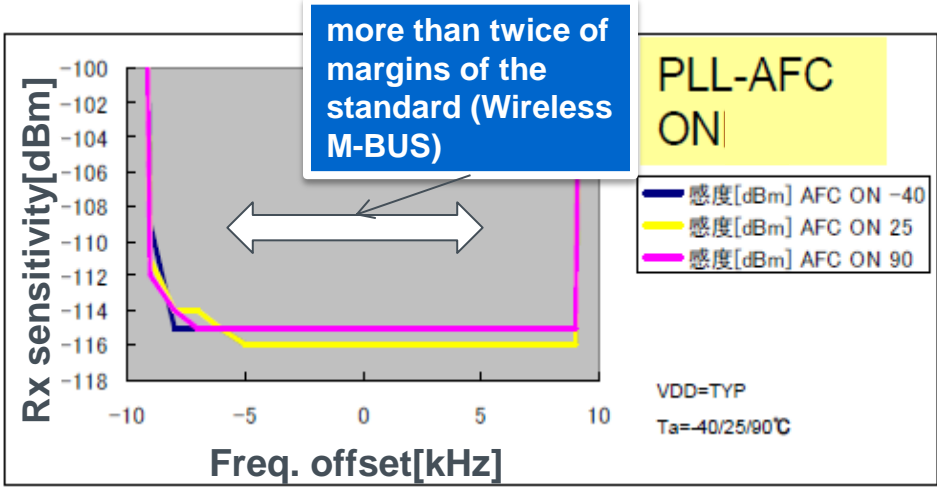
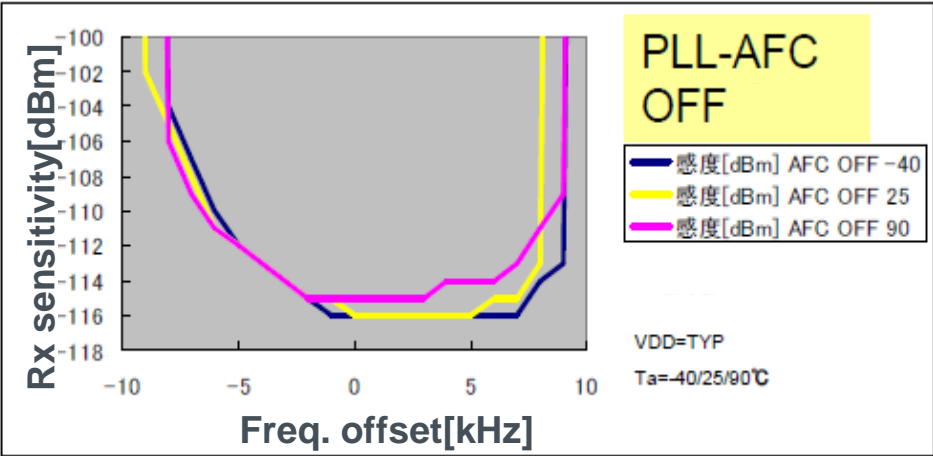
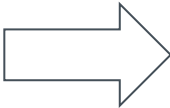


Table 18 – Mode N, Frequencies Frequency for N-mode

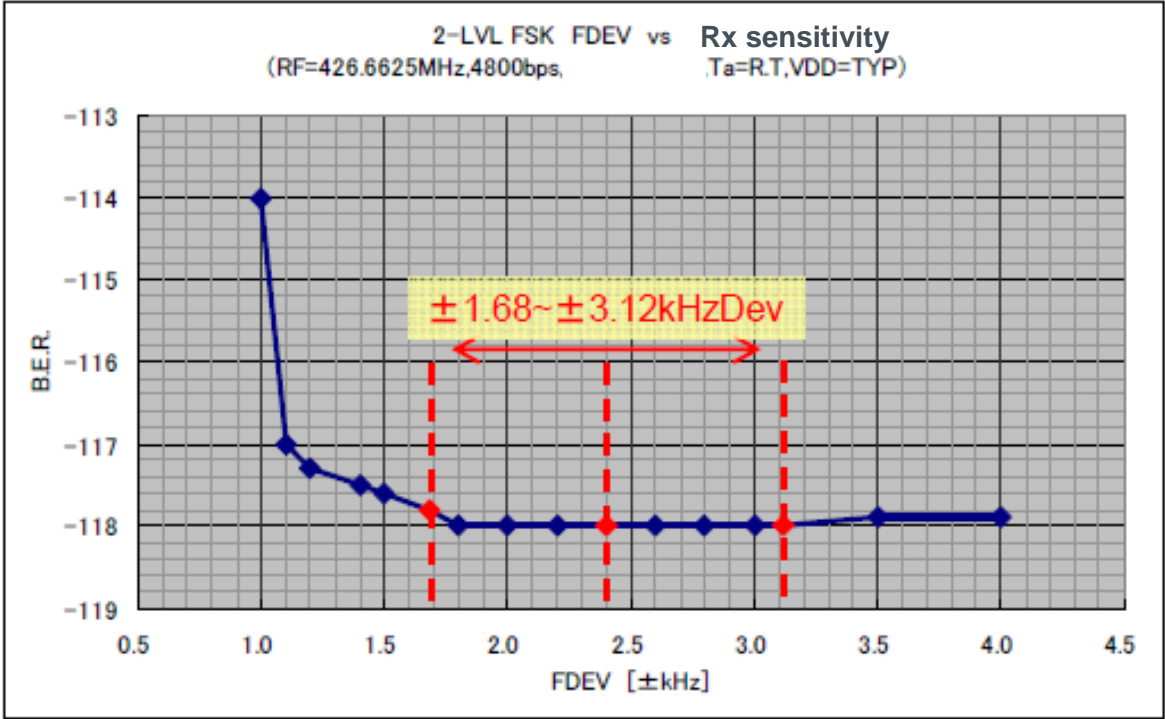
| Submode | Channel ^b | Condition | Condition | Condition | | | Condition |
|---------|----------------------|------------------------|-----------------------|-------------|-------------|--------------|----------------------------|
| | | Centre frequency [MHz] | Channel spacing [kHz] | GFSK [kbps] | GMSK [kbps] | 4GFSK [kbps] | Frequency tolerance [±kHz] |
| N1a,N2a | 1a ^c | 169.406250 | 12.5 | | 4.8 | | 1.5 |
| N1b,N2b | 1b | 169.418750 | 12.5 | | 4.8 | | 1.5 |
| N1c,N2c | 2a | 169.431250 | 12.5 | 2.4 | | | 2 |
| N1d,N2d | 2b | 169.443750 | 12.5 | 2.4 | | | 2 |
| N1e,N2e | 3a | 169.456250 | 12.5 | | 4.8 | | 1.5 |
| N1f,N2f | 3b ^c | 169.468750 | 12.5 | | 4.8 | | 1.5 |
| N2g | 0 ^d | 169.437500 | 50 | | | 19.2 | 2.5 |



ML7345 has more than twice of margins of the standard (Wireless M-BUS) by the excellent PLL-AFC feature.

ML7345 covers Wireless M-BUS standard. (The characteristic doesn't degrade)

| Freq. deviation condition | | | | | |
|---------------------------|----------|-------|-------------------------------|-------|------|
| Characteristic | Class | Min | Typ | Max | Unit |
| GFSK mod. Index 1.0 | 4.8kbps | ±1.68 | ±2.40 | ±3.12 | kHz |
| GFSK mod. Index 2.0 | 2.4kbps | | | | kHz |
| GFSK mod. Index 1.0 | 4.8kbps | | | | kHz |
| GFSK mod. Index 1.0 | 4.8kbps | | | | kHz |
| 4GFSK mod. Index 0.5 | 19.2kbps | | -7.2, - 2.4, +2.4, +7.2 | | kHz |
| 4GFSK peak mod. | 19.2kbps | ±5.04 | | ±9.36 | kHz |



Evaluation tools and software

| Tools/software | source | HW requirement | Comments | license | status |
|-----------------------------------|--------------|---|---|--------------|--|
| PC GUI evaluation | ROHM EUDC | - ML7406 EVB - USB-SPI interface - PC | PHY/DATA LINK layers: EN13757-4:2013 C mode/T mode/S mode. Customers are able to extract ML7406 register parameters. | Free | available |
| Wireless M-BUS Software Library | ROHM EUDC | - ML7406 EVB -Freescale Cortex M0 or U16 EVB - PC | PHY/DATA LINK layers: EN13757-4:2013 C mode/T mode/S mode. C source code library. Customers are able to build wireless M-BUS stack based on this package. | Free | In development -Cortex M0 version available beginning /Dec -U16 version planning |
| Steinbeis OMS software | Steinbeis | - ML7406 EVB -Renesas RX62N EVB (other major MCUs can be supported upon request) - PC | PHY/DATA LINK layers. EN13757-4:2013 C mode/T mode/S mode. Application layer: OMS specification volume 2 version 3.0.1 Frame format : EN 60870 5 2. OMS test suit included. Steinbeis OMS stack is industry standard and ready to use for the final products. | Steinbeis | available |
| TeraTerm based evaluation tool | Lapis | -ML7406 EVB -U8 daughter board -Serial interface -PC | PHY/DATA LINK layers: EN13757-4:2013 C mode/T mode/S mode. IEEE802.15.4g PHY/MAC layer (subset) | Free | available |
| SimpleMAC software | Lapis | -ML7406 EVB -U8 daughter board -Serial interface -PC | PHY/DATA LINK layers: EN13757-4:2013 C mode/T mode/S mode. IEEE802.15.4g PHY/MAC layer (subset) Source code available | Free | available |
| IEEE802.15.4g/e full MAC software | OKI Electric | -ML7406 EVB -ARM7 board -PC | IEEE802.15.4g/e PHY/MAC layer | OKI Electric | available |

EVB: Evaluation Board

| Tools/software | source | HW requirement | Comments | license | status |
|---------------------------------------|--------------|--|---|--------------|-----------|
| TeraTerm based evaluation tool | Lapis | -ML7396E EVB -U8 daughter board -Serial interface -PC | PHY/DATA LINK layers: EN13757-4:2013 C mode/T mode/S mode. IEEE802.15.4g PHY/MAC layer (subset) | Free | available |
| Simple MAC software | Lapis | -ML7396E EVB -U8 daughter board -Serial interface -PC | PHY/DATA LINK layers: EN13757-4:2013 C mode/T mode/S mode. IEEE802.15.4g PHY/MAC layer (subset) Source code available | Free | available |
| IEEE802.15.4g/e full PHY/MAC software | OKI Electric | -ML7396E EVB -ARM7 board -PC | IEEE802.15.4g/e PHY/MAC layer | OKI Electric | available |

EVB: Evaluation Board

| Tools/software | source | HW requirement | Comments | license | status |
|---------------------------------|-----------|---|---|---------|----------------|
| PC GUI evaluation | ROHM/EUDC | - ML7345 EVB - USB-SPI interface - PC | PHY/DATA LINK layers: EN13757-4:2013 N mode/ F mode | Free | In development |
| Wireless M-BUS Software Library | ROHM/EUDC | - ML7345 EVB - Freescale Cortex M0 or U16 EVB - PC | PHY/DATA LINK layers: EN13757-4:2013 N mode/ F mode C Source code library. | Free | In development |
| TeraTerm based evaluation tool | Lapis | -ML7345 EVB -U8 daughter board -Serial interface -PC | PHY/DATA LINK layers: EN13757-4:2013 N mode/ F mode IEEE802.15.4g PHY/MAC layer (subset) | Free | In development |
| SimpleMAC software | Lapis | -ML7345 EVB -U8 daughter board -Serial interface -PC | PHY/DATA LINK layers: EN13757-4:2013 N mode/ F mode Source code available | Free | In development |

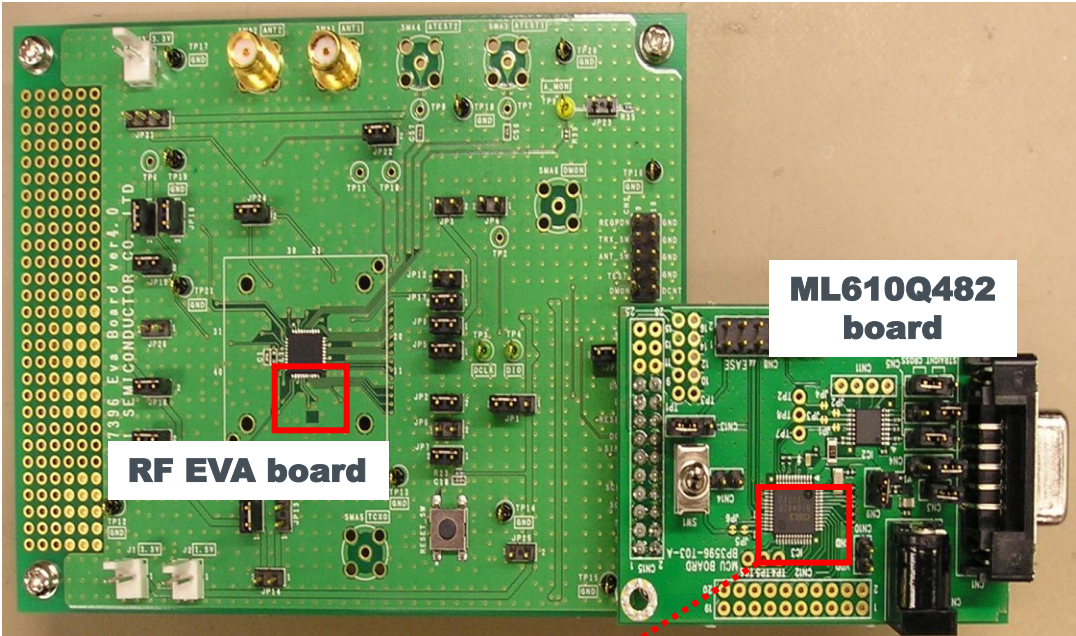
EVB: Evaluation Board

SimpleMAC –TeraTerm Evaluation tool

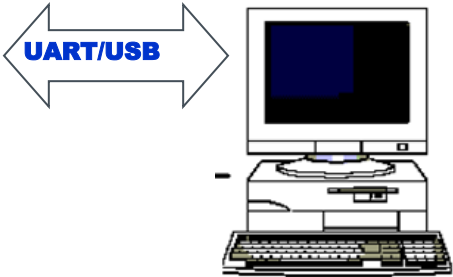
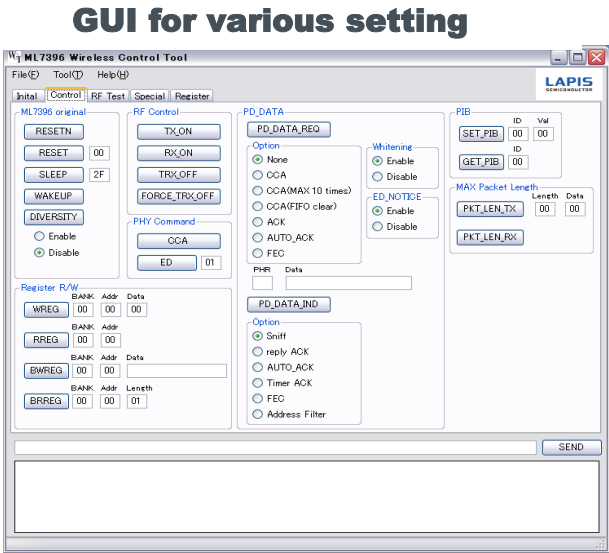
ML7406

ML7345

ML7396

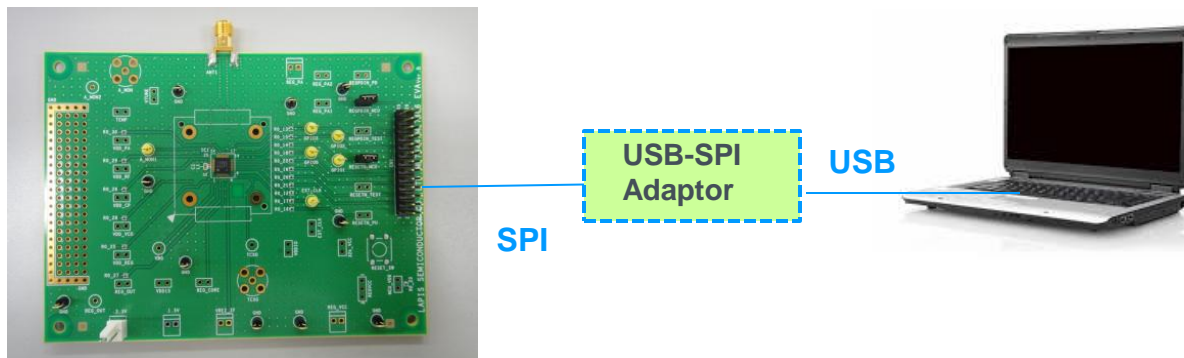


SimpleMAC firmware to run macro command.



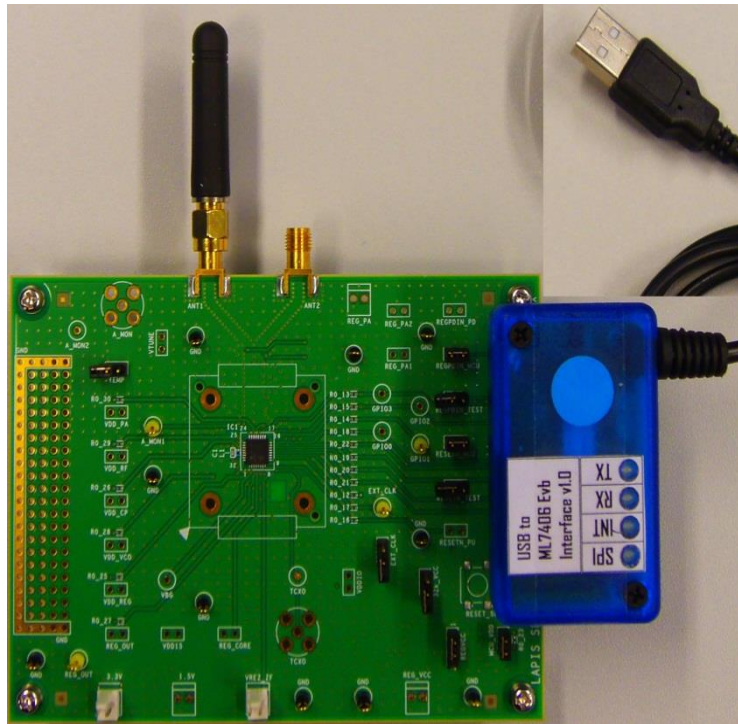
Lapis’s basic tools to test RF and support test mode for regional certifications. (ETSI, FCC, ARIB standard)

ML7406 evaluation board

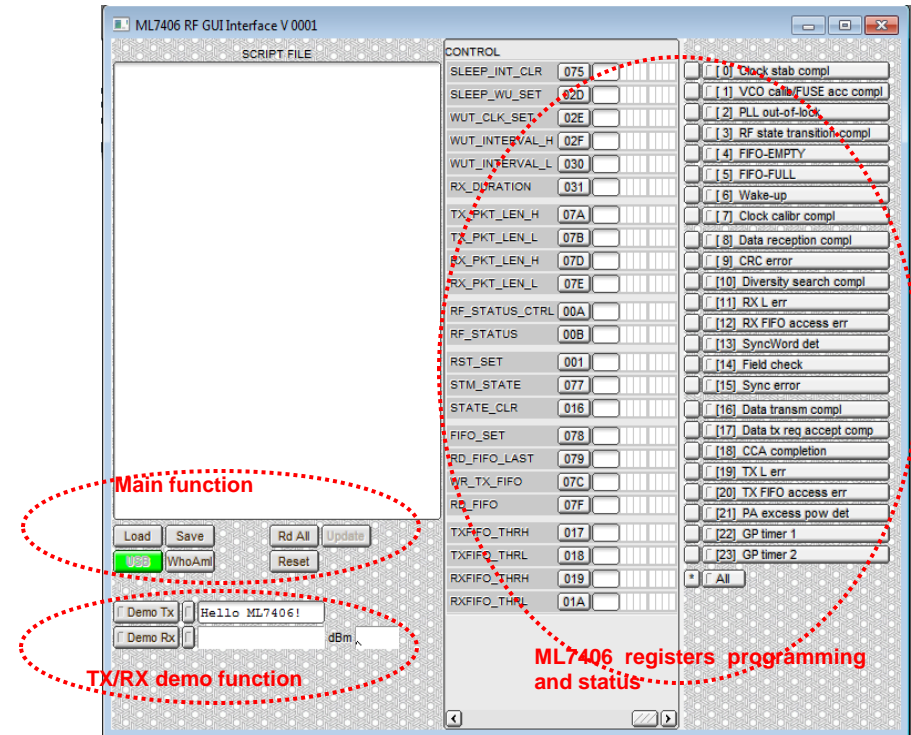


Powerful tool for ML7406/ML7345 hardware evaluation , RF performance test and PHY/ Data Link layer evaluation

- ☐ **PC based GUI** that users are able to build up sequence of the operations
- ☐ **Wireless M-BUS** T mode, C mode, S mode, N mode and F mode are fully supported
- ☐ **Wireless M-BUS** data collector mode and meter mode are fully supported
- ☐ **Customers are able to extract ML7406/ML7345 register parameters.**

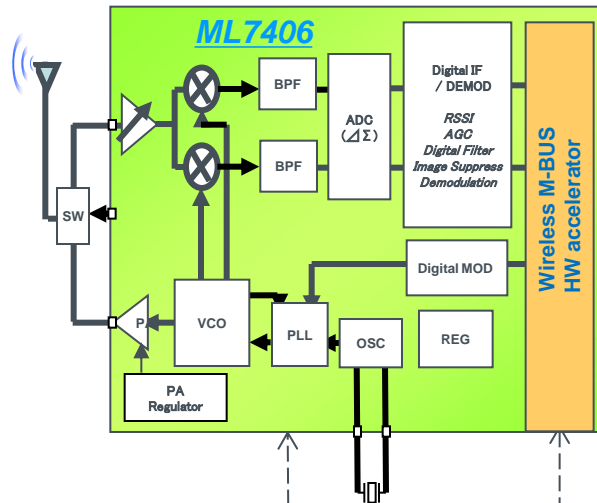


Evaluation board with USB-SPI interface.

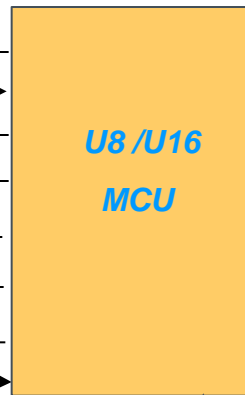


- ✓ GUI based Performance evaluation tool.
RF chip control script generation.
- ✓ TX/RX Demo mode supports Wireless M-BUS T mode, C mode, S mode, N mode, F mode

Ultra low power RF processor



Ultra low power HOST MCU



✓ PHY/Data Link Layer & AES128 library (option) are available.

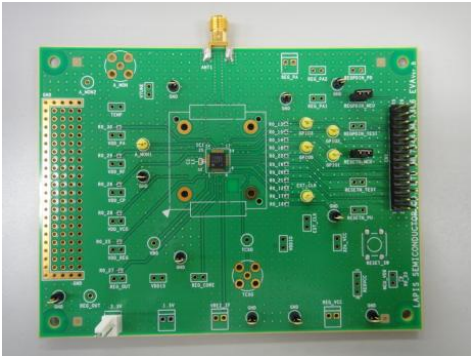
✓ EN13757-4:2013 C mode/T mode/S mode .
Data collector mode and meter mode are fully supported.

| ISO/OSI Layer | Layer name | Standard |
|---------------|--|---------------------|
| Layer 7 | Data exchange for meter reading, tariff and load control | DLSM/COSEM, SML.... |
| Layer 7 | Country/Regional specific meter application | OMS, DSMR.... |
| Layer 7 | Application Layer | EN 13757-3 |
| Layer 7 | Application Layer | Security (AES128) |
| Layer 2 | Data Link Layer | EN 13757-4 |
| Layer 1 | Physical Layer | EN 13757-4 |

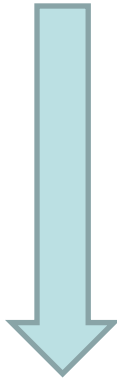
Wireless M-BUS layer

ML7406 + Steinbeis OSM/wM-BUS stack are MCU platform independent solution

ML7406 evaluation board



RS232



Ready to use OMS solution

SPI

Supported Host MCUs

| | | | | |
|------------------------------------|--|--|--|-----------------------------------|
| Cortex M0/M3/M4 from other venders | RENESAS RL78 (16bit) Evaluation board | TI MSP430 (16 bit) Evaluation board | ST Micro STM32F4 (Cortex M4) Evaluation board | RENESAS RX62N Evaluation board |
|------------------------------------|--|--|--|-----------------------------------|

possible Estimation necessary

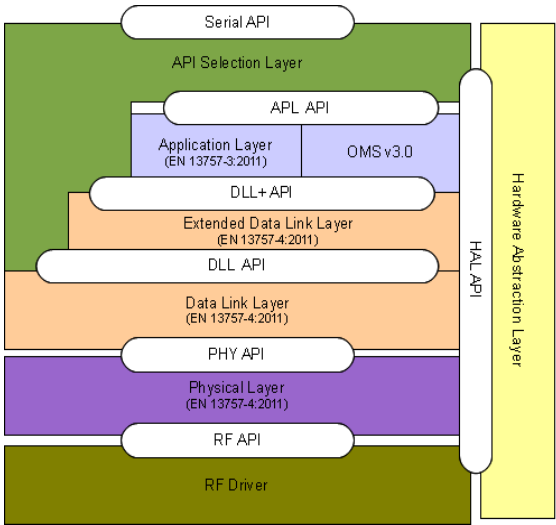
Upon request 5 days lead time necessary

Upon request 5 days lead time necessary

Upon request 5 days lead time necessary

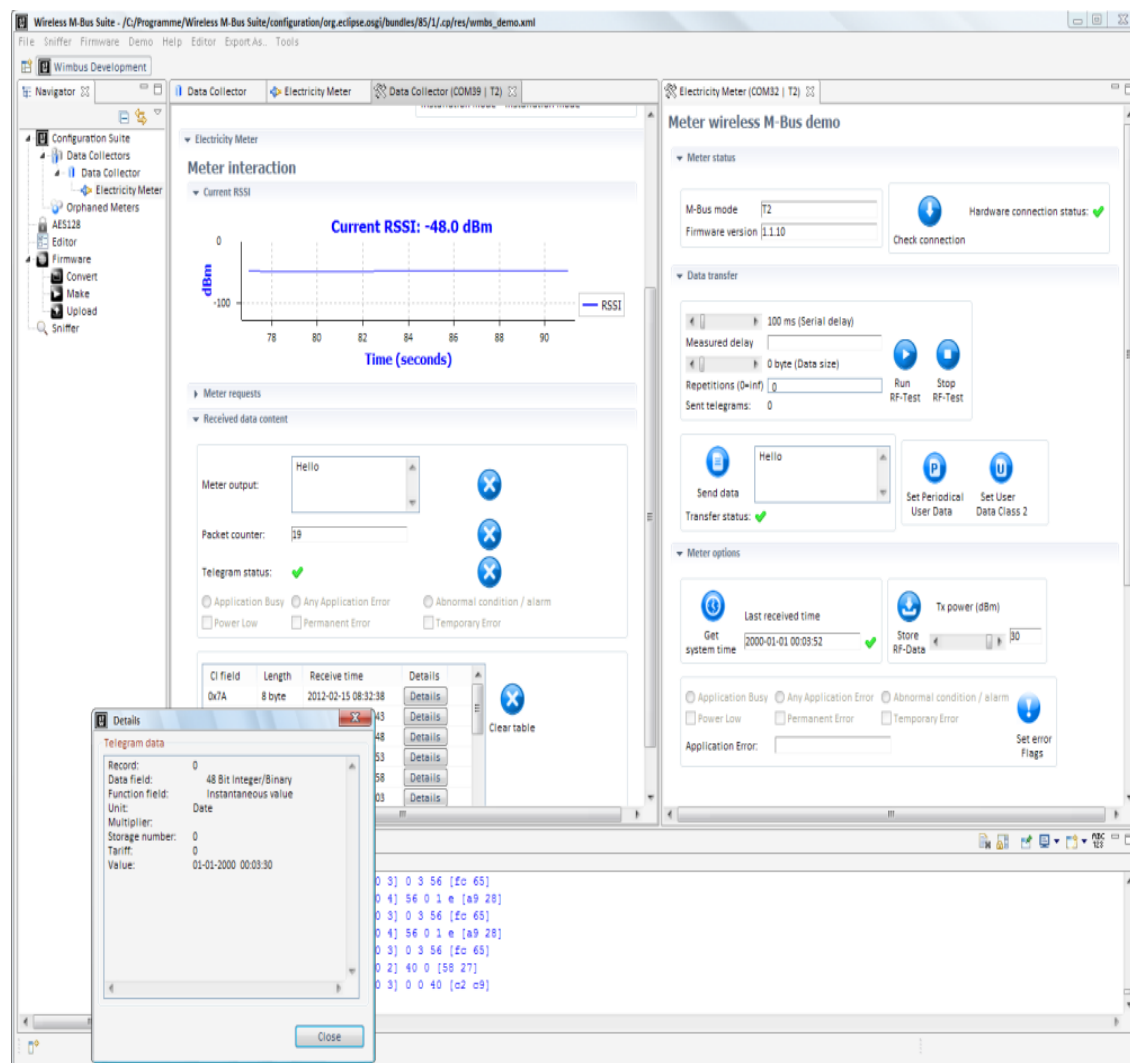
reference platform Available now

Steinbeis OMS stack



For evaluation and network deployment, a Java-based PC suite is provided with these features:

- ☐ Firmware download
- ☐ Radio performance tests
- ☐ M-Bus packet generation and evaluation plus record handling
- ☐ Network configuration
- ☐ AES128 Encryption support including key provisioning
- ☐ Utilization of the serial command set to ease the host communication.



Proposal of Radio Module

RF module for “868/169MHz w/ wireless M-BUS” 34

Micro
RL78



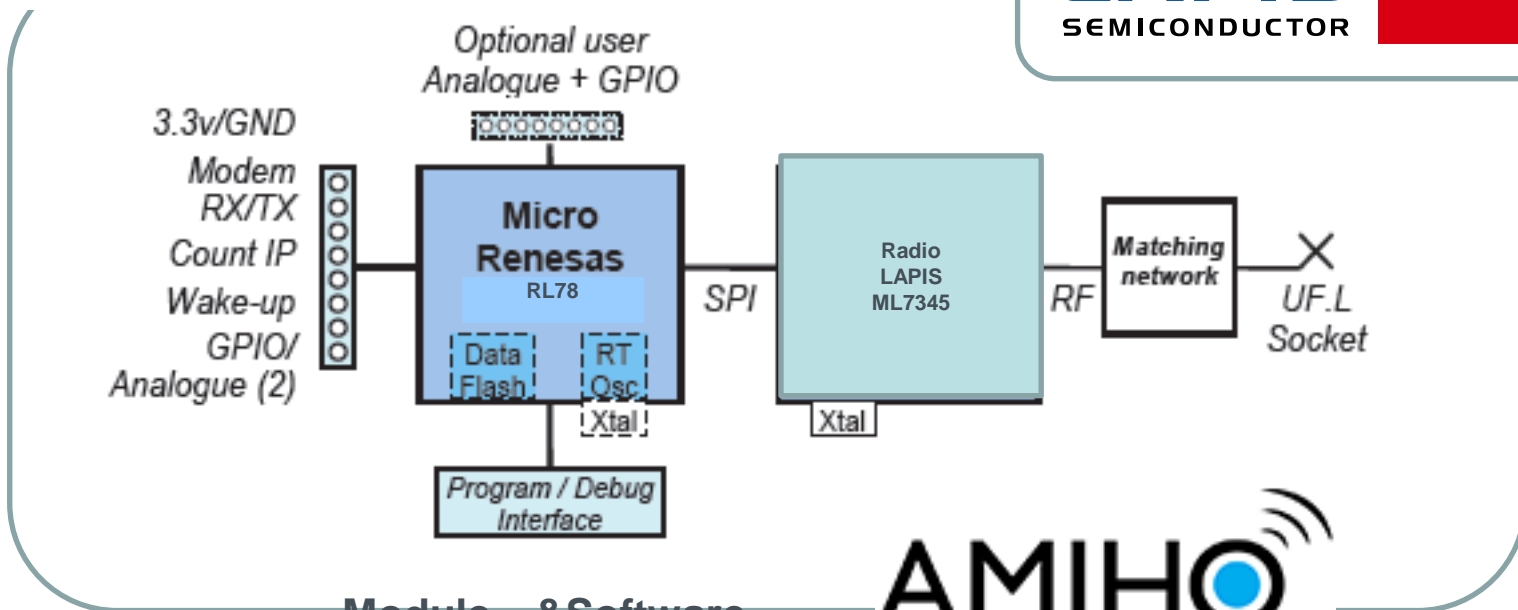
Radio

ML7406 (868MHz)

ML7345 (169MHz/433MHz)

ROHM GROUP

LAPIS
SEMICONDUCTOR



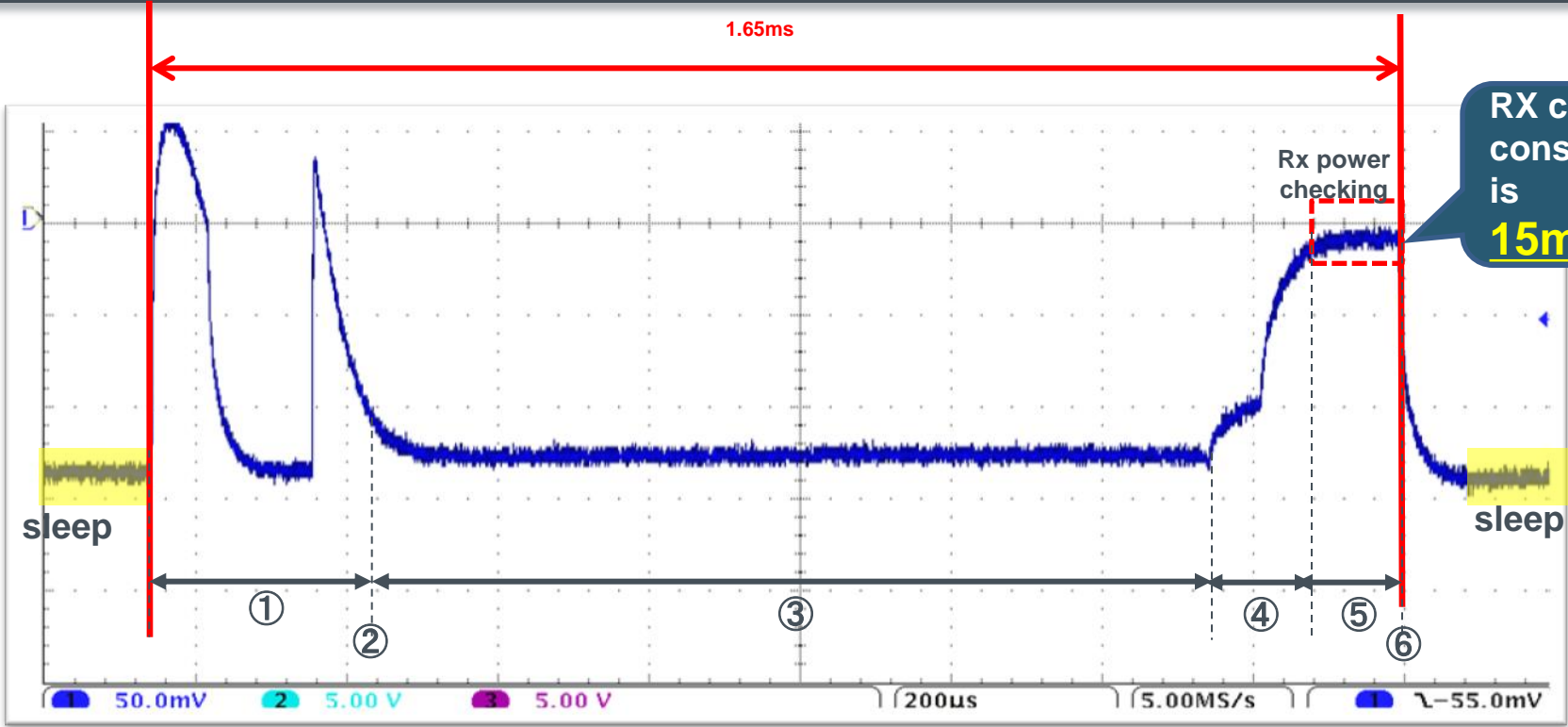
Module & Software
wireless-M-BUS
OMS



Additional Information

Power consumption profile (sleep/RX)

ML7406



- ① pre charge: 266µs
- ② Wake-Up timer time up
- ③ clock、 reg. wakeup : 1,125µs (TCXO)
1,255 µs (Crystal)
- ④ RF wakeup : 126µs
- ⑤ RX power check : 128µs
- ⑥ sleep

➡ Total :
1,645µs (TCXO)
1,775µs (Crystal)

Ave. current consumption(1sec interval) : 9.9µA (TCXO) 10.1µA (Crystal)

Field Test Report (extraction)

Test product: ML7396

Test Geography: Line of sight , 3.5Km straight road parallel to the coast.

Bit rate: 100kbps

FEC (Forward Error Correction): OFF

TX power level: 20mW (on-chip PA)

Antenna diversity: not used

| distance | RSSI | | | | PER |
|----------|---------|-------|-------|-----------------|-----------------------|
| | Average | Max. | Min. | Deviation range | |
| 50m | -50.7 | -50 | -50 | 2.0 | 0 |
| 200m | -69.7 | -69 | -71 | 2.0 | 0 |
| 500m | -84.0 | -84 | -85 | 1.0 | 0 |
| 1000m | -95.8 | -94 | -97 | 3.0 | 0 |
| 1500m | -100.9 | -100 | -104 | 4.0 | 0 |
| 1600m | -105.8 | -103 | -107 | 4.0 | 80.6 |
| 2000m | ----- | ----- | ----- | ----- | Unable to communicate |

Problem of deep-submicron CMOS:

NBTI (Negative Bias Temperature Instability) and HC (Hot Carrier) have become big reliability issues in the deep-submicron CMOS devices. They cause the aged degradation of transistor characteristics, such as Gm degradation, Vt change.

Question:

How much does the output signal degrade after 20 years?



It can be predicted by the aging simulation.

Simulation results :

The PA output port characteristic (drain) **after 20 years** condition

- Gm degradation of **HC** is less than 1%.
- The degree of deterioration of the Vt of the **NBTI** is 30 ~ 40mV.

Simulation condition :

- PA output (first) : 13.1dBm @50Ω
- Temp. : 25°C
- Voltage : 1.5V (Core) / 3.3V (IO)
- Duty : 50% (active period)

Performance Comparison

ML7406

ML7396

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■ ML7396 /ML7406 have good receiver sensitivity and well balanced performance.

| Item | | LAPIS semiconductors ML7396 | Company A | Company B | Company C |
|--|---------|--------------------------------------|---------------------------------|--------------------------------|---|
| RF frequency | | 900MHz band (750 to 960MHz) | 900MHz band (900 to 960 MHz) | 900MHz band (40 to 960 MHz) | 862 MHz to 928 MHz |
| LO phase noise (in TX mode) | | -119dBc/Hz worst @700kHz. | -115dBc/Hz typ. @ 1MHz | -123dBc/Hz typ. @1MHz | -117.2dBc/Hz typ.@800kHz -126dBc/Hz @1MHz |
| Data Rate | | 50kbps to 400kbps | 0.123 to 1,000 kbps | 1.2kbps to 200kbps | 1 kbps to 300 kbps, |
| TX Power | | 0,10,13dBm. *1 | -40 to +16dBm | -11 to +15dBm | -20 to +13.5 dBm |
| RX Sensitivity @XXMHz | 100kbps | -106dBm @0.1% | -106dBm @0.1% | Not defined | -105 dBm@0.1% |
| | 50kbps | -108dBm @0.1% | Not defined | -110 (-99) dBm @ 1% | -106.5 dBm@0.1% |
| Power supply | | 1.8 to 3.6V | 1.8 to 3.6 V | 2.0 to 3.6V | 1.8 to 3.6V |
| Current consumption in RX mode | | 15mA | 13.7(10.7) mA | 21 (16) mA | 12.8mA |
| Current consumption in TX mode (0/10/13dBm) | | 13mA/24mA/32mA *1 | -/18/29 mA | -/34/45 mA | 13.3/24.1/32.1 mA |
| Package | | 40 QFN (6x6mm) | 20 QFN (4x4mm) | 32 QFN (5x5mm) | 32 LFCSP (5x5mm) |

*1 Given value is results at antenna end, which is including loss caused by antenna SW and filter.
Assuming 21mA@10dBm at LSI itself.