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WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

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Fundamentals Radio Communication

The History of Radio Technology

Radio technology is a wireless method of transmitting signals by means of modulated electromagnetic waves. In 1884 James Clerk Maxwell predicted the existence of radio waves, which was experimentally confirmed by Heinrich Hertz on November 11th, 1886.

There are five main key facts, which have to be considered:

1. Transmission of the Signal
2. Link Budget
3. Duty Cycle
4. Access
5. Integration of Radio Technology

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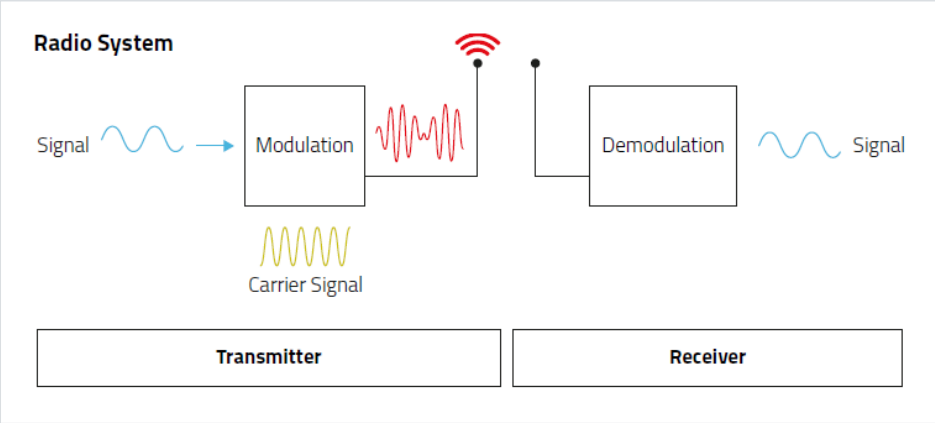
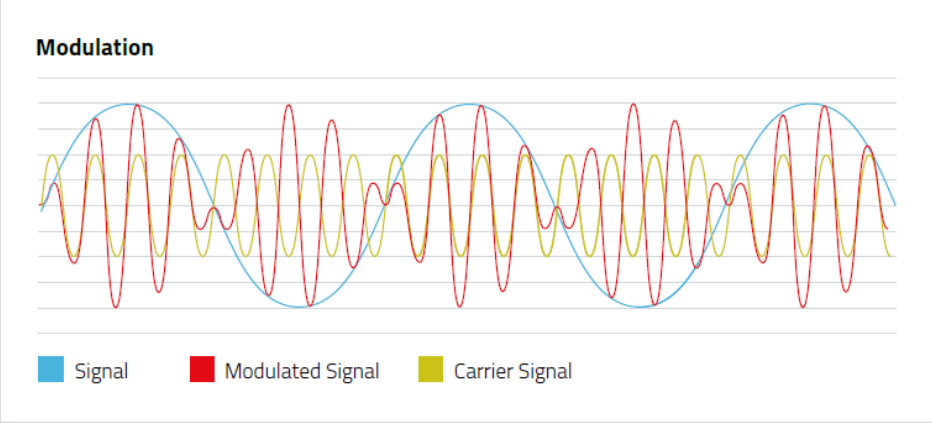
1. Transmission of the Signal

For the Transmission the signal will be modulated on a carrier signal, mostly sinus with constant amplitude. Thereby the amplitude or frequency will be adopted in the rhythm of the transmitted signal. The modulated wave is radiated by an antenna and received on the otherside with an antenna too. Due to demodulation at the receiver the transmitted signal can be used.





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Range Estimation

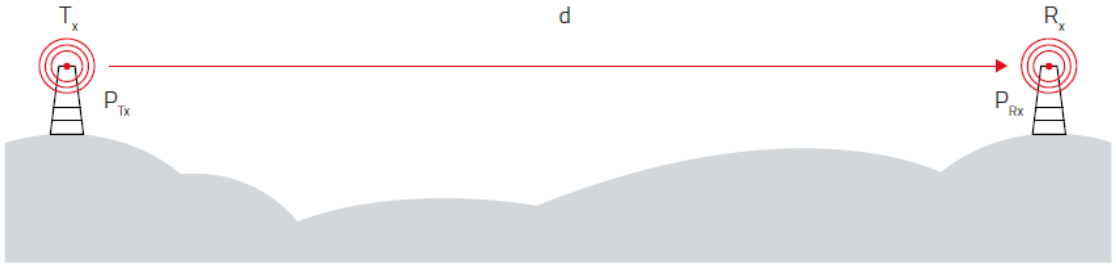
When a radio connection is planned, the given circumstances define largely the requirements for radio range, operating temperature and available space.

- ANR010 Range Estimation www.we-online.com/ANR010

Model 1: Friis Transmission for Free Space

Friis transmission for Free Space is a model to calculates the path loss, to estimate the range of a radio link in a free space environment. Free field condition: The first Fresnel zone is free of objects.

This model makes the assumption, that the emitted power is radiated equally in every direction (isotropic) and calculates the power loss only taking into account the decreasing power density of the wavefront with increasing distance to the origin, without any reflection, absorption or attenuation.

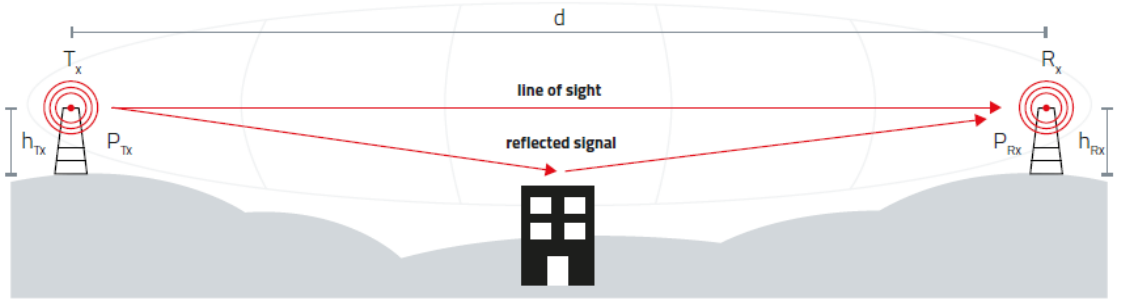


It should be known, that the lower the frequency is, the higher is the possible range of the transmission path.

f ↓ ~ d ↑ ↓ ~ Antenna size ↑

Model 2: Two-ray Ground Reflection

The two-ray ground reflection model is applied, when transmitter and receiver are in line of sight but the first Fresnel zone is not free of objects. So the calculation considers the received power of the direct line of sight path and in addition the power of the reflection path with slight phase difference.



As long as the free space requirements are not met, it should be known, that the higher the antenna is mounted above ground, the higher is the possible range of the transmission path.

h_{Tx} ↑ ~ d ↑ h_{Rx} ↑ ~ d ↑

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Conclusion

In a lot of cases there is the need of long distances with regard to the antenna height, so usually the two ray ground model is a good fitting estimation. Only for some special cases with the free space condition fulfilled the Friis model is useful. Having a closer look to the models there are several interesting points to mention.

The Dependency of the Frequency

Often it is mentioned in general, that the lower the frequency is, the greater the range is. We have learned, that this is only the case when free field conditions are met. But there are other effects of the frequency, as the fact, that for higher frequencies smaller objects will cause reflections, or that for low frequencies it might be hard to find an antenna with acceptable size and efficiency.

The Influence of the Antenna Height on the Range

The higher the antennas can be placed, the longer is the range that can be reached. Placing an antenna directly above ground reduces the range so radical, a layman could hardly imagine.

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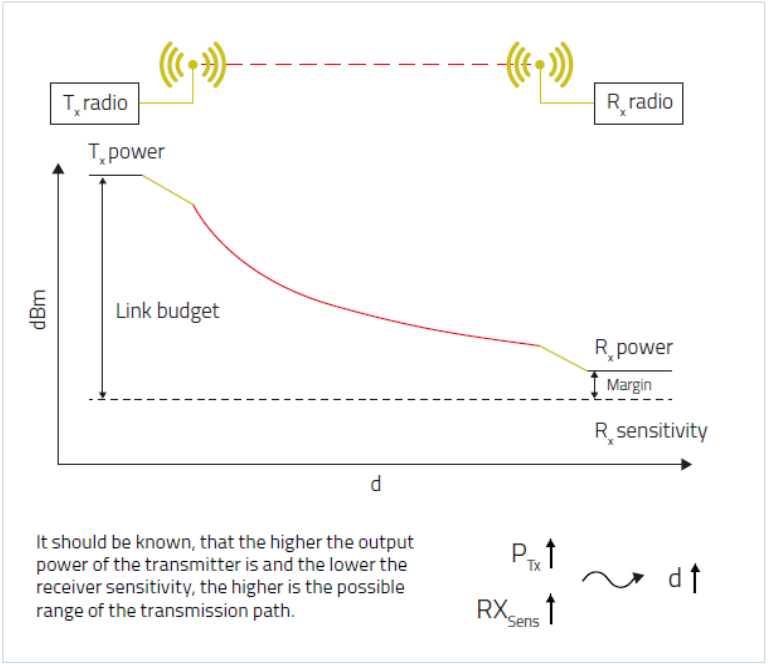
2. Link Budget (power of the carrier)

A link budget is an accounting of all of the power gains and losses that a communication signal experiences in a telecommunication system; from a transmitter, through a medium (free space, cable, waveguide, fiber, etc.) to the receiver. It is an equation giving the received power from the transmitter power, after the attenuation of the transmitted signal due to propagation, as well as the antenna gains and feedline and other losses, and amplifications of the signal in the receiver or any repeaters it passes through.



Power [dBm]	Power [watt]
- 120 dBm	1 fW
- 110 dBm	0.01 pW
- 100 dBm	0.1 pW
- 90 dBm	1 pW
- 80 dBm	10 pW
- 70 dBm	100 pW
- 60 dBm	1 nW
- 50 dBm	10 nW
- 40 dBm	100 nW
- 30 dBm	1 µW
- 20 dBm	10 µW
- 10 dBm	100 µW
- 1 dBm	794 µW
0 dBm	1 mW
1 dBm	1.26 mW
10 dBm	10 mW
20 dBm	100 mW
30 dBm	1 W
40 dBm	10 W

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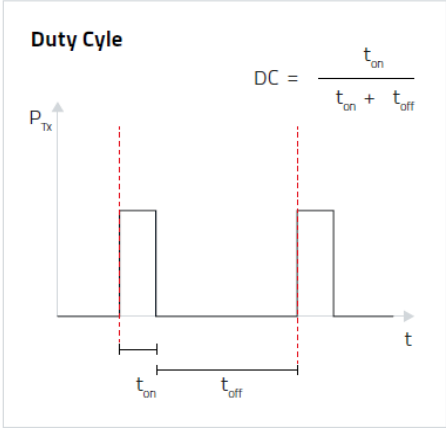
3. Duty Cycle

A duty cycle or power cycle is the fraction of one period in which a signal or system is active. Duty cycle is commonly expressed as a percentage or a ratio. A period is the time it takes for a signal to complete an on-and-off cycle. E.g. using a duty cycle of 10 %, means that the used transmitter is allowed to send 6 minutes in between one hour.



4. Polite Spectrum Access – listen before talk

When an application uses polite spectrum access, the duty cycle restrictions are loosened. Polite spectrum access encompasses two aspects: Listen Before Talk (LBT) and Adaptive Frequency Agility (AFA). LBT defines that the device must listen if the medium is already in use by a Clear Channel Assessment (CCA) check. When the medium is in use, the device must wait a random backoff interval or change the frequency before checking again. The latter is called AFA.

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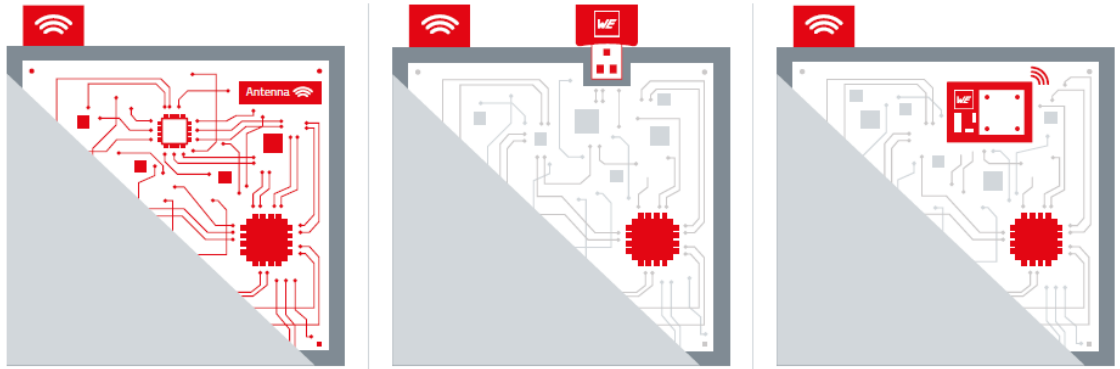
5. Integration of Radio Technology

One of the last steps before a product with integrated wireless technology can be launched on the market is the certification. Manufacturers of products with integrated RF-technology may only market these with the necessary certification. The following graphics display the three options which are available for integrating wireless technology.



1

Device without certified radio chip and antenna

- ⊕ Flexible
- ⊖ High effort
- ⊖ High costs

2

Device with external radio dongle

- ⊕ Plugable
- ⊕ Easy integration
- ⊖ Not that flexible

3

Device with certified radio module and antenna

- ⊕ Low design effort
- ⊕ Fully integrated
- ⊕ Low Certification effort
- ⊖ Not that flexible

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Challenges within Telecommunication

Complexity

LTE technology is very complex

Certification

- Regulatory
- Industry specific
- Operator specific

Connectivity

IoT SIM cards

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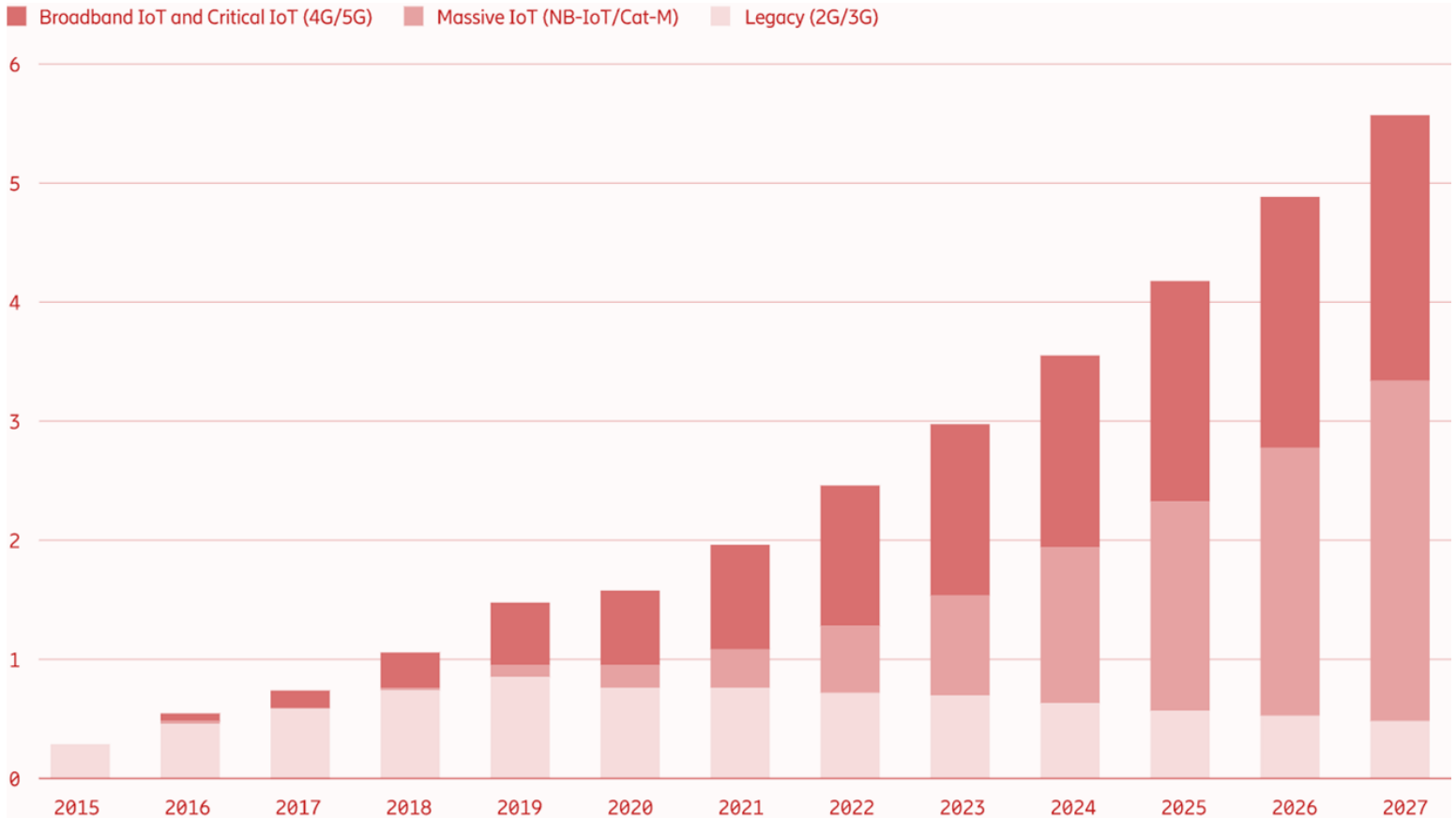
Market Situation

IoT is growing more and more the next years



https://www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/iot-connections-outlook

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Applications

- **Smart Factory / Industrial 4.0:** Predictive Maintenance | Supply Chain Management | Mobile Construction Machines | Vending and Kiosk | Condition Monitoring
- **Smart City / Smart home:** Waste and Water Management | Security and Surveillance | smart metering | Traffic and Parking Lighting | Facilities Management
- **Automotive & Transport:** Fleet Management | Asset Tracking | Usage-Based Insurance
- **Agriculture and Healthcare:** Crop & Livestock Monitoring | Irrigation Management | Health Monitoring | Wearables

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Telecommunication and Würth Elektronik

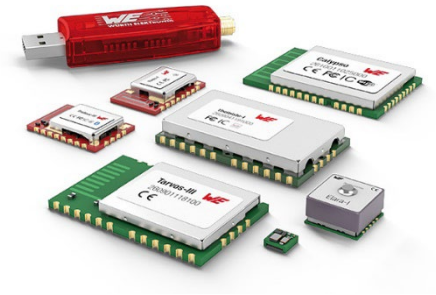
Würth Elektronik is helping small and medium size customers by enabling complext LTE technology to them. WE offers support hot line, webinars, trainings, product guide. Moreover, WE has a Partnership with DTAG for IoT Sim cards.

Technologies for IoT and Wireless Connectivity - Discover the Possibilities of Our Radio Technologies

WE has a wide range of different radio modules from

- Bluetooth,
- Wi-Fi,
- Cellular Module,
- Mesh,
- GNSS,
- Wirepas
- Propriarity

to cover everything you may need.



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Further Information

- Product Guide
- Overview Radio Technologies
- WE-DTAG (Deutsche telekom) portal for IoT SIM card ordering
- Application Note to send and receive data to DT cloud using UDP
- Taking into operation Video: Adrastea-I - High performance, ultra-low power consumption, multi-band LTE-M and NB-IoT module
- Webinar: Sunset of 2G/3G: Accelerate Migration of Your Cellular IoT Products Into 5G