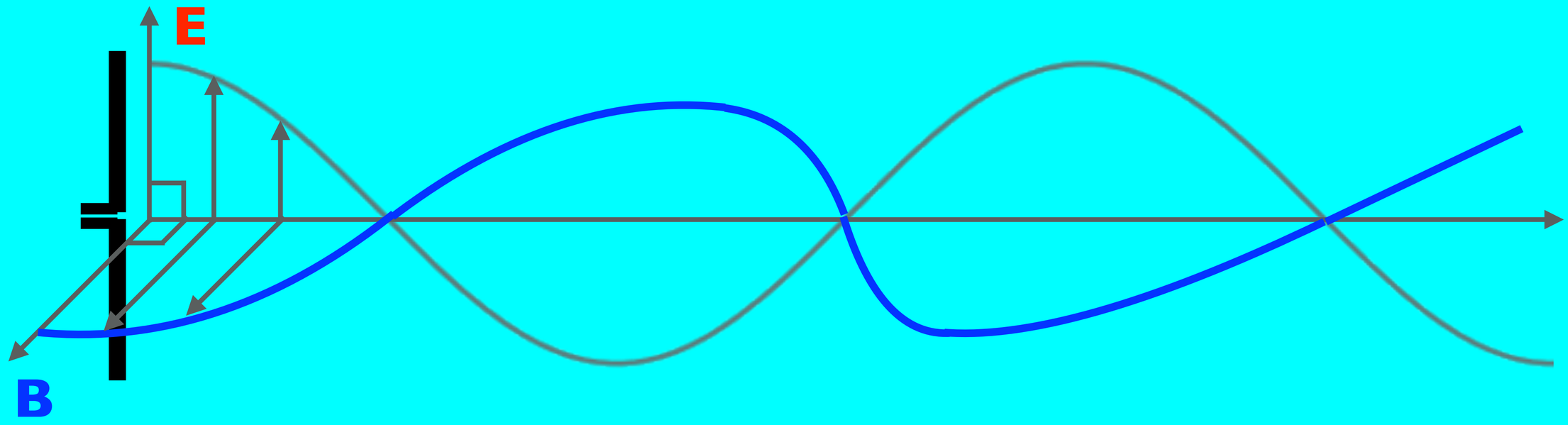
LORA / LORAWAN TUTORIAL 34

Antenna Theory

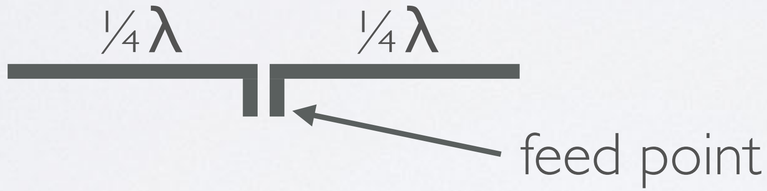


INTRO

- In this tutorial I will explain how an antenna works.

RESONATORS

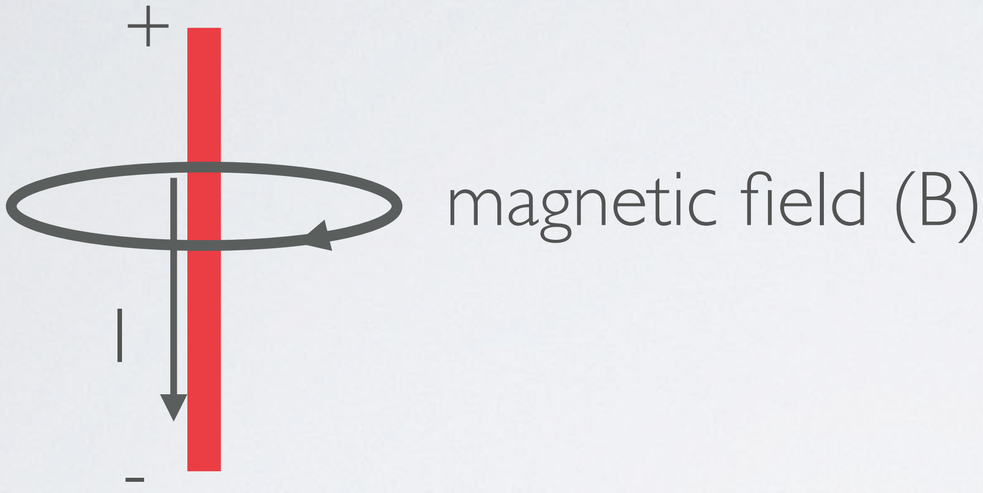
- Most antennas are based on resonance, for example the dipole antenna.
- Dipole antennas are so called resonators and they resonates at a particular frequency.
- When an AC current with frequency f is supplied at a dipole antenna feed point, where each element length is ¼ λ, then this dipole antenna resonates at the same AC frequency.



- The current flows thru the antenna and bounces back at the end of the antenna where the resistance is very high.
  The generated current wave is in fact a standing wave.

MAGNETIC FIELD

- If a current (I) flows thru an electric wire it generates an magnetic field (B).

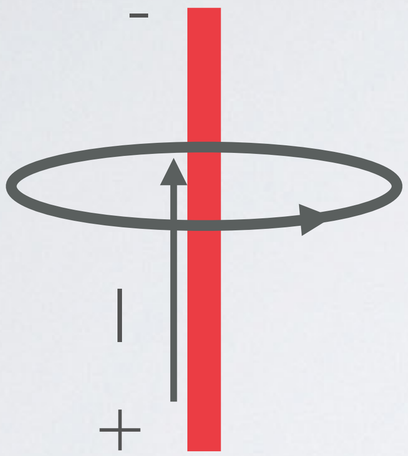


- Use the right hand rule, to find the direction of the magnetic field.
  Thumb points to the same direction of the current, the fingers shows the direction of the magnetic field.

- In the example above the magnetic field direction is clockwise.

MAGNETIC FIELD

- If the current flows in the opposite direction, the magnetic field also changes direction.

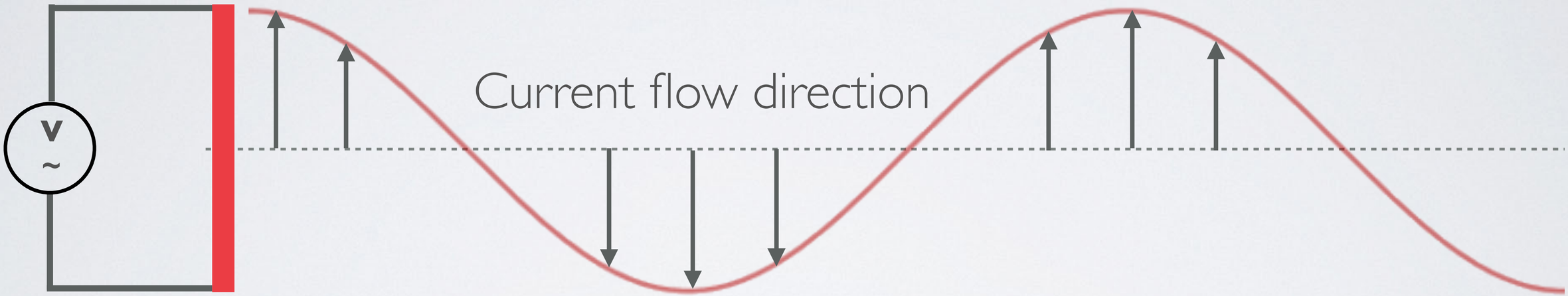


magnetic field (B)

- In the example above the magnetic field direction is counter clockwise.

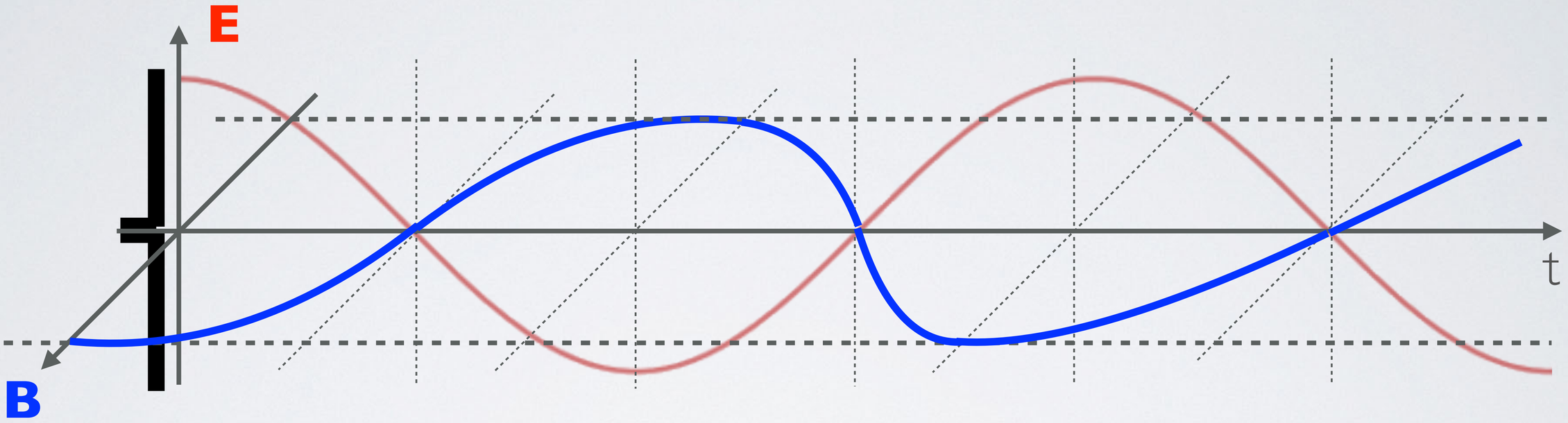
ELECTRIC FIELD

- A voltage generator is connected to this wire and the voltage is changed like a sine wave.



- Corresponding to the voltage change, the current flow (I) oscillates accordingly. An electric field (E) is created in the vertical plane.

MAGNETIC AND ELECTRIC FIELD



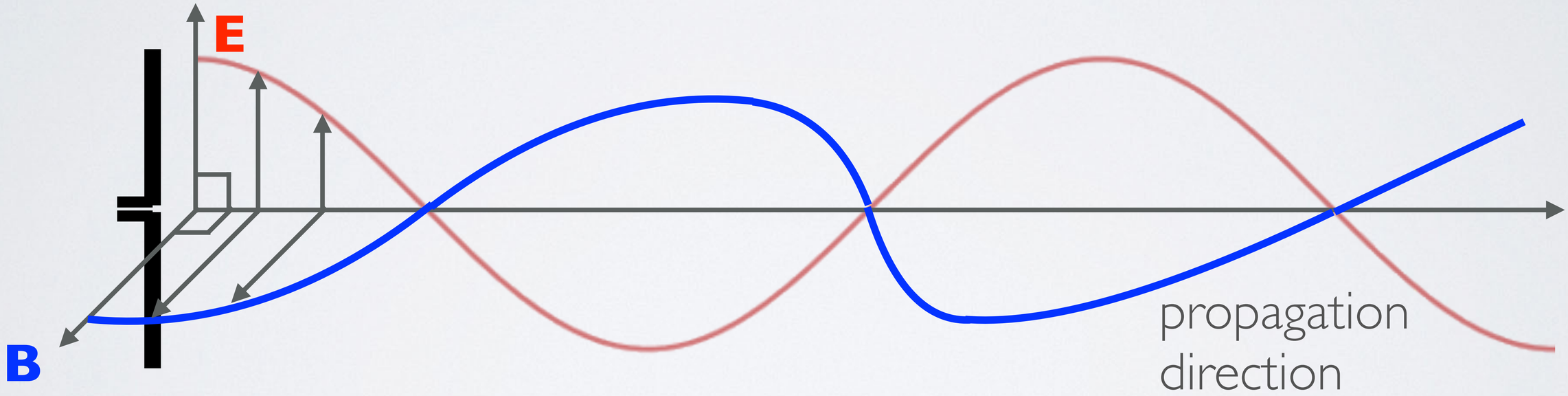
- An oscillating electric field created in the vertical plane, creates an oscillating magnetic field (B) in the horizontal plane.

- The magnetic (B) field is orthogonal, meaning 90° angle, to the electric (E) field.

ELECTRO MAGNETIC WAVE

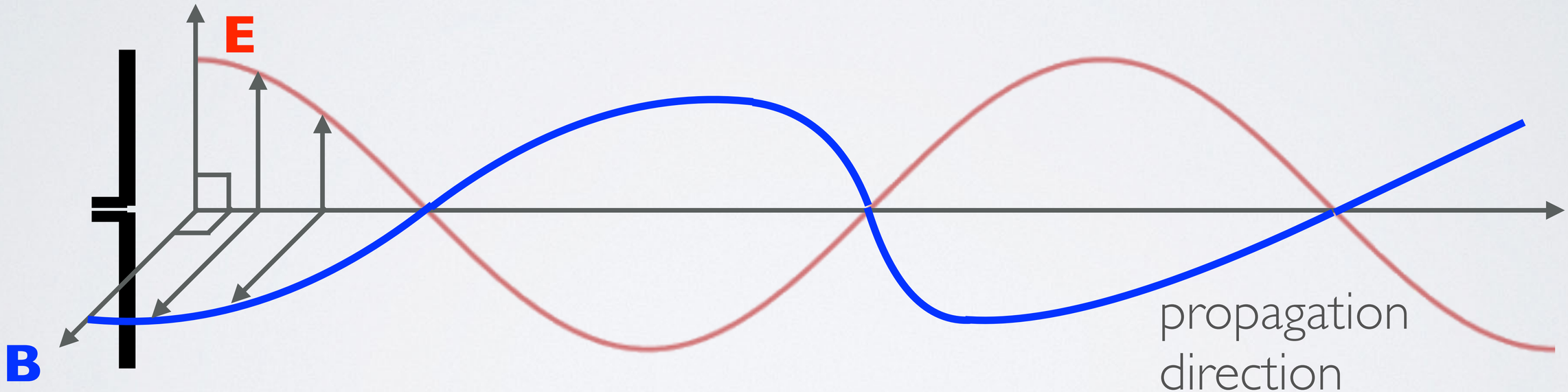
- The electric and magnetic fields creates an Electro Magnetic (EM) wave which "spreads out" (propagates) in a certain direction.

- The EM wave is perpendicular to the propagation direction.



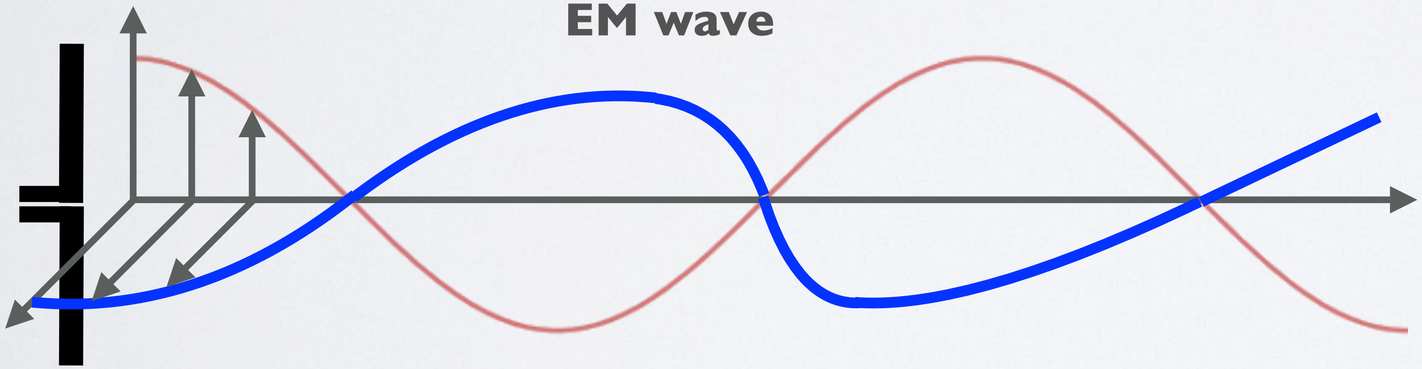
ELECTRO MAGNETIC WAVE

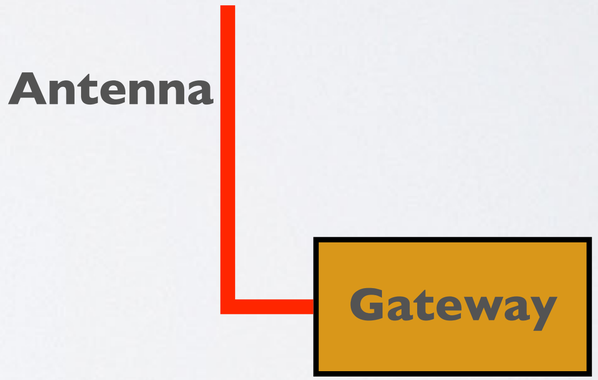
- An EM wave propagates thru free space with a speed of light because light is also an EM wave. The speed of light is c = 299,792,458 m/s



ELECTRO MAGNETIC WAVE

- When an EM wave hits an antenna, this antenna will resonates at a specific frequency depending on the antenna length.
- When the transmission frequency match the antenna frequency the antenna will resonate at an atomic level.
- The electrons in the antenna gets excited and generates an alternating electrical current.

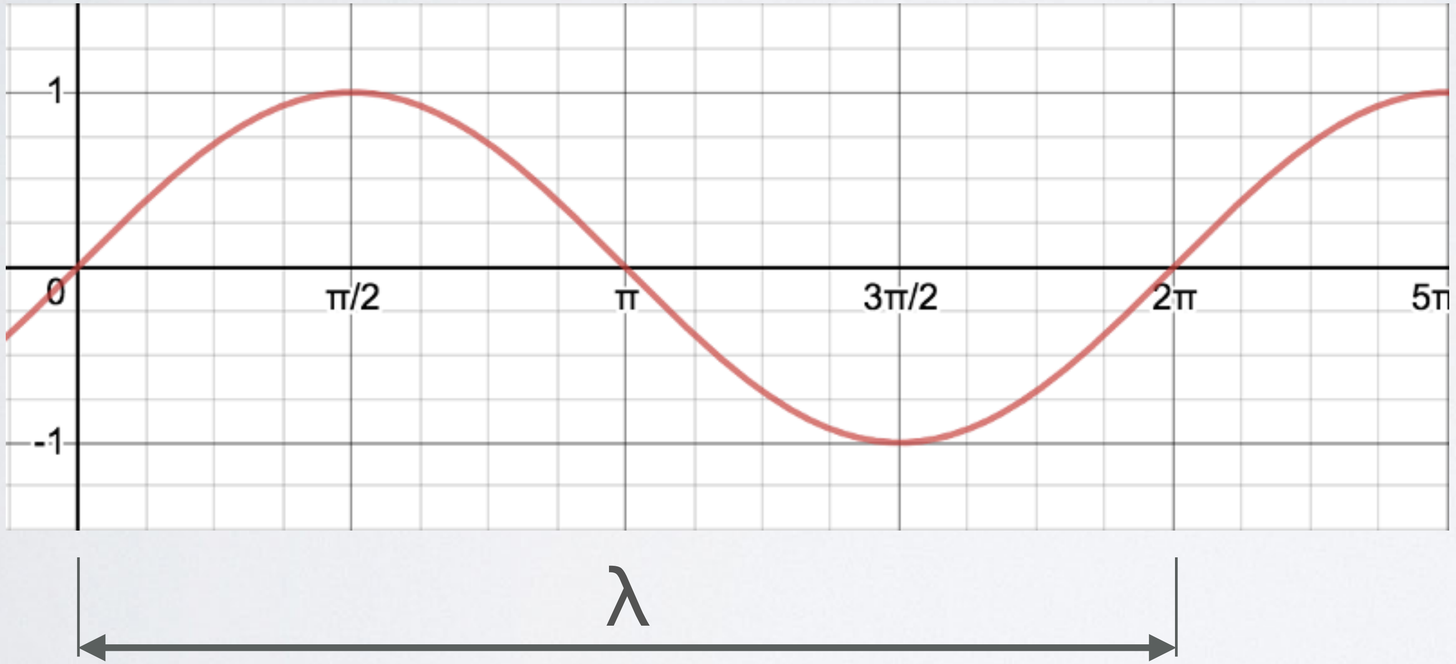




ELECTRO MAGNETIC WAVE

- An antenna can be used to receive and sent electromagnetic waves.

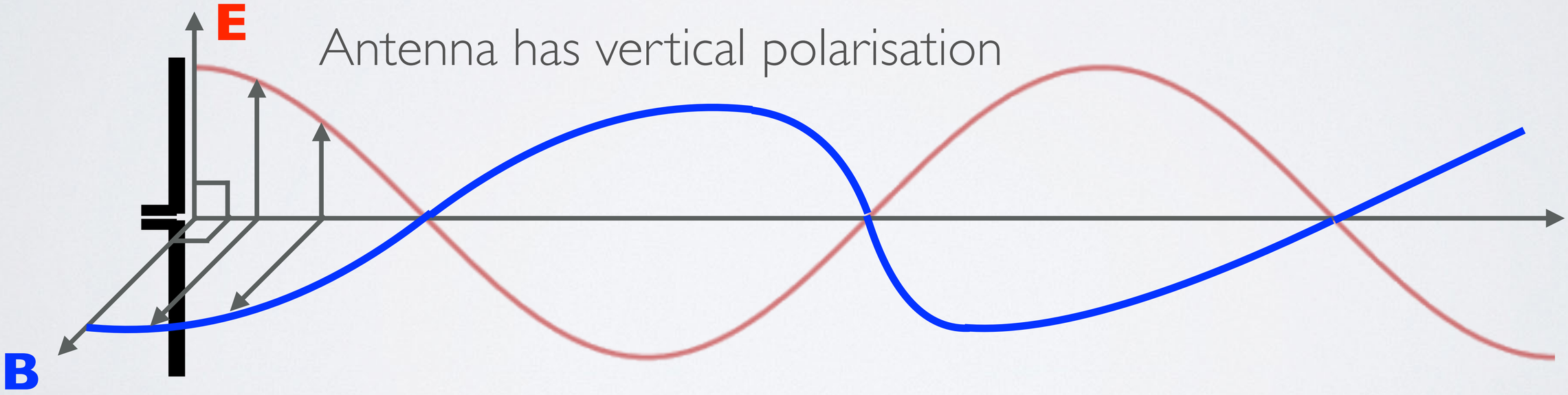
- Electromagnetic waves can be represented by a sine curve.
  One cycle is one wave length represented by the symbol **λ** (lambda).



ANTENNA POLARISATION

- When an antenna is used to transmit a signal, electrons will flow thru this antenna. The electrons change direction depending on the signal frequency, thus creating a fluctuating magnetic field (B).

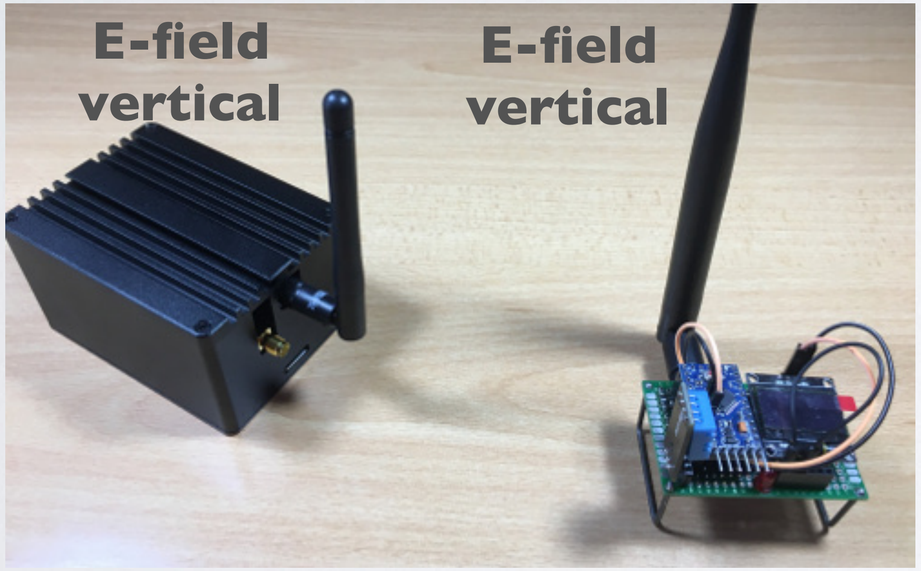
- The Electric (E) and Magnetic (B) fields are 90° out of phase and the polarity of an antenna is determined by the plane of the E field.



ANTENNA POLARISATION

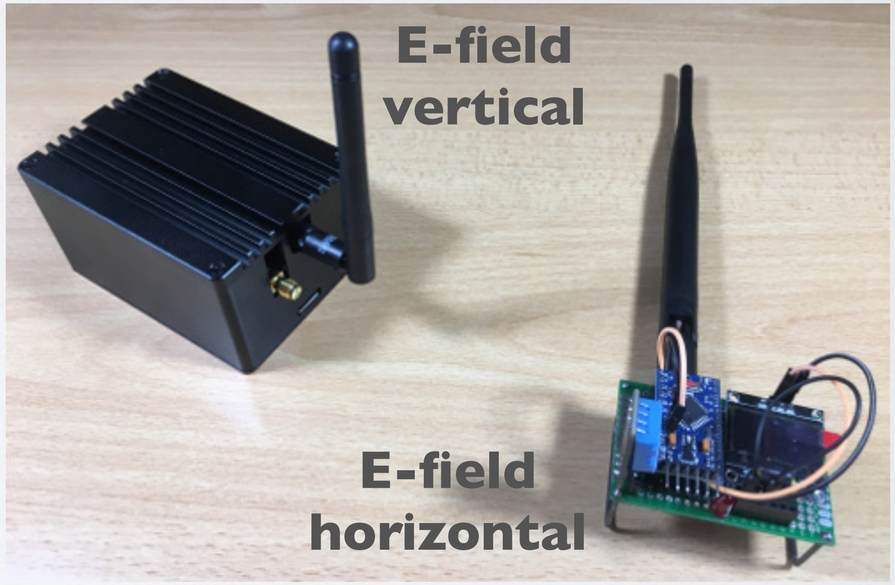
- If the antenna (E-field) is oriented vertically, it has a vertical polarisation.
  If the antenna (E-field) is oriented horizontally, it has a horizontal polarisation.

- For maximum signal transference the antenna polarisation on both transmit and receive side must be the same, otherwise there will be significant signal loss.



Good

Bad



Always place gateway and end device at least 3 meters apart!

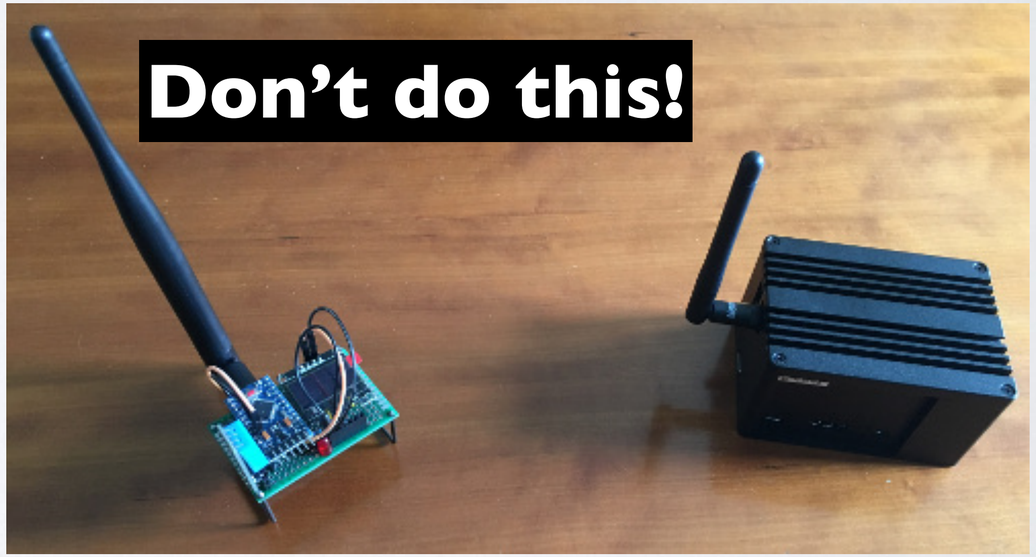
ANTENNA FREQUENCY

- If you use the TTN EU863-870 freq. plan, the LoRaWAN frequencies ranges from 867.1 MHz to 869.525 MHz. The average frequency is (867.1 + 869.525) / 2 = 868.3125 MHz. This means an 868 MHz antenna can be used.
  See: https://www.thethingsnetwork.org/docs/lorawan/frequency-plans.html

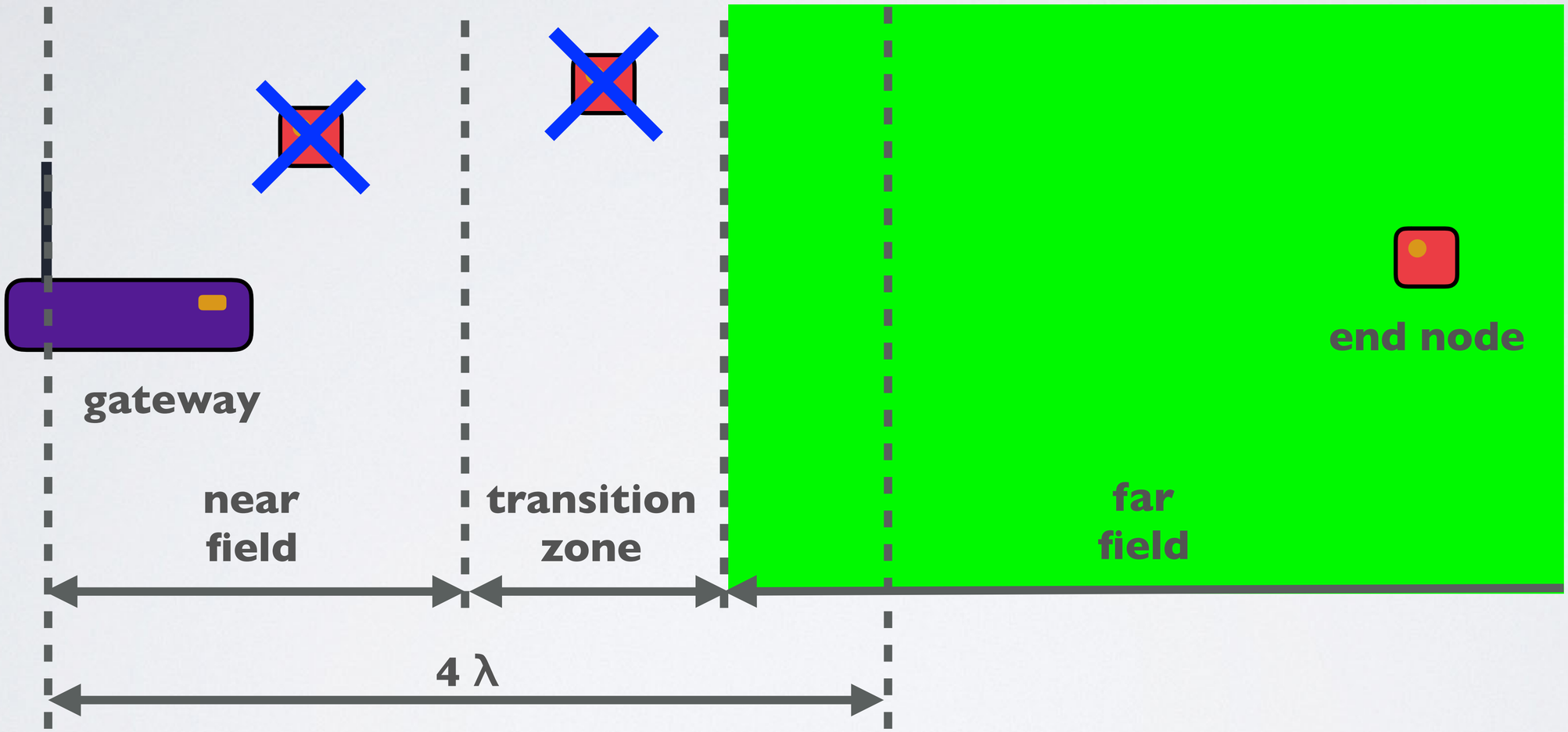
Freq. Plan	Min. Freq. [MHz]	Max. Freq. [MHz]	Average Freq. [MHz]	Antenna Freq. Used [MHz]
EU863-870	867.1	869.525	868.3125	**868**
US902-928	903.9	927.5	915.7	**915**
CN470-510	486.3	508.1	497.2	497
AU915-928	916.8	927.5	922.15	922
AS920-923	921.8*	923.4	922.6	922
AS923-925	923.2	924.8*	924	924
KR920-923	921.9	923.3	922.6	922
IN865-867	865.4025	865.9850	865.69375	865

NEAR FIELD AND FAR FIELD

- An antenna sends out EM waves.
- The near field region is the region right next to the antenna.
- In this region, the EM fields are sort of unpredictable.
- If a LoRa end device is located near a gateway (near field) it may produce strange results.
- **Keep the distance between transmitter and receiver at least 4 wavelengths apart.**



NEAR FIELD AND FAR FIELD



NEAR FIELD AND FAR FIELD

Freq. Plan	Antenna Freq. Used	λ [m]	$4 \times \lambda$ [m]
EU863-870	868	0.345	1.4
US902-928	915	0.327	1.3
CN470-510	497	0.603	2.4
AU915-928	922	0.325	1.3
AS920-923	922	0.325	1.3
AS923-925	924	0.324	1.3
KR920-923	922	0.325	1.3
IN865-867	865	0.346	1.4

As a rule of thumb keep the distance between transmitter and receiver 3 meters apart.