Higher

LOGARITHMS AND EXPONENTIALS

ROB HEATON

Retired

SUBJECTS STUDIED AT SCHOOL

O Levels in:

French • German • English Language
English Literature • Maths

A Levels in:

French • German • Maths • Physics

FURTHER EDUCATION: BSc Electrical Engineering & Electronics, MSc Digital Systems & Instrumentation

CAREER JOURNEY SO FAR

- Engineer working on military manpack radios (Racal BCC)
- Design engineer working on microwave radio links for outside broadcasting (BBC)
- Technical manager responsible for microwave radio communications (CML)
- Communications projects manager responsible for research projects (Mitsubishi Electric ITE)
- Now retired

FUTURE ASPIRATIONS

To assist the IET (Institute of Engineering & Technology) and others to encourage young people to take an interest in a career in Science & Engineering.

Q&A WITH ROB

What does your company/organisation do?

Mitsubishi Electric VIL carried out research work dedicated to digital video broadcasting, also to improvements to GPS (global positioning system) receivers and to improvements to collision avoidance radar for cars. Other work involved the latest techniques in video processing.

What types of activities do you do in your job?

Research typically involves looking for ideas by any means possible then making a model using computer software initially. The idea can then be tested and compared with other known ideas to see if the new idea has promise. Later a hardware model can be constructed and measurements can be taken to check the efficacy of the software simulation. Finally a patent can be applied for or a paper published.

What does a typical day at work look like for you?

A typical day could involve reading research papers, attending meetings, reading and writing reports and interacting with other members of the team. The aim is to work together in order to find new ways of dealing with communication problems related to digital signal processing, such as synchronisation, channel estimation and dealing with errors occurring during digital transmission, in order to produce patents or make discoveries.

What are your favourite things about your job?

One of the favourite aspects about working in research and development was the opportunity to travel and meet other experts and academics working in similar areas of activity.

HOW ROB USES LOGARITHMS AND EXPONENTIALS AT WORK

Science uses very small and very large numbers. For example the power output of a transmitter might be 100 kW (100,000 Watts) and a received signal level may be 0.001 uW (1/1000th of a micro Watt). Using logarithms and exponentials makes large and small numbers easier to visualise and handle in calculations.

ACTIVITIES

As an electromagnetic wave, such as a radio wave, passes from the transmitting aerial to a receiver it spreads out in space so that the field strength becomes weaker as seen by the receiver. The power density P falls as the square of the distance R from the transmitter. This can be shown in the equation $P = P_0\left(\frac{R_0}{R}\right)^2$, where F_0 is the field strength measured at a distance R_0 from the transmitter.

This reduction in power density as the wave travels through space is called path loss, and is normally shown by the equation $L = 10\left(\frac{P_R}{P_T}\right)$, where P_R is the power density at the receiver and P_T is the power density at the transmitter.

For a new radio system, the path loss has been measured at -40 dB with the transmitter and receiver 1km apart. If the transmitter and receiver are moved to be 2km apart, what will the path loss be?

Solutions

Approach 1:

We aren't given values for P_R or P_T, so assume that $P_R = 1\frac{W}{m^2}$. Substitute this into the path loss equation and solve:

$$L(1km) = 10\left(\frac{P_R}{P_T}\right)$$

$$-40 = 10\left(\frac{1}{P_T}\right)$$

$$\frac{1}{P_T} = 10^{-4}$$

$$P_T = 10^4 = 10{,}000\frac{W}{m^2}$$

Using the power density equation, we can then find the value of P_R at 2km:

$$P = 1\left(\tfrac{1}{2}\right)^2 = 0.25\frac{W}{m^2}$$

Substituting back into the path loss equation,

$$L(2km) = 10\left(\frac{0.25}{10000}\right) = -46dB$$

Approach 2:

Using the laws of logarithms, we can simplify the problem to:

$$L(2km) = L(1km) + L(1km\ to\ 2km)$$

We can rearrange the equation for power density to give:

$$\frac{P}{P_0} = \left(\frac{R_0}{R}\right)^2 = \left(\frac{1km}{2km}\right)^2 = 0.25$$

Although we don't know the values on the left-hand side, we can still substitute this into the path loss equation, to give

$$L(1km\ to\ 2km) = 10\,(0.25) = -6dB$$

The overall path loss at 2km is then

$$L(2km) = -40dB - 6dB = -46dB$$

The problem is much simpler to solve and easier to visualise using logarithms.