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Circuit Playground: Q is for Quartz

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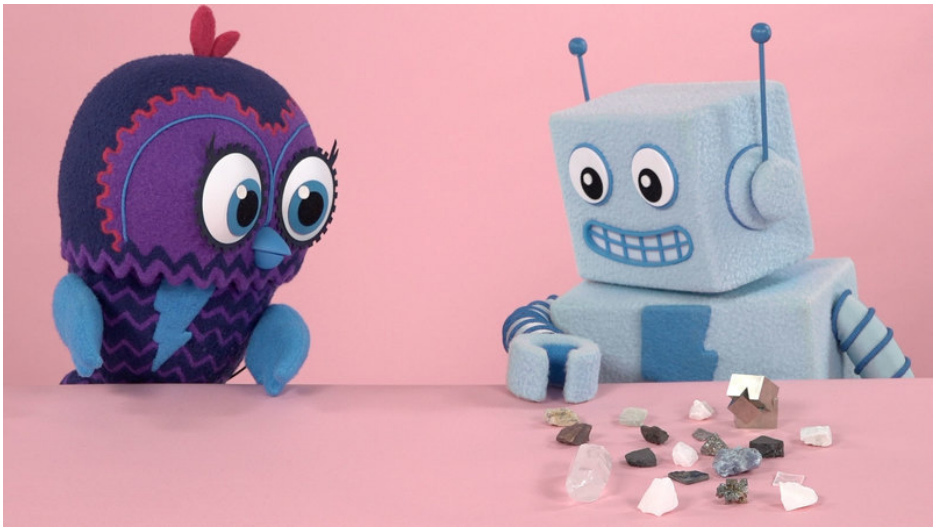
Last updated on 2019-03-19 04:40:06 PM UTC

Video

Adabot finds treasure in his rock collection – Quartz! Have a look inside a quartz watch and learn why quartz is so important for electronics.

Transcript

Adabot: Sandstone, obsidian, pyrite ...



Minerva: Hey Adabot - what you up to?

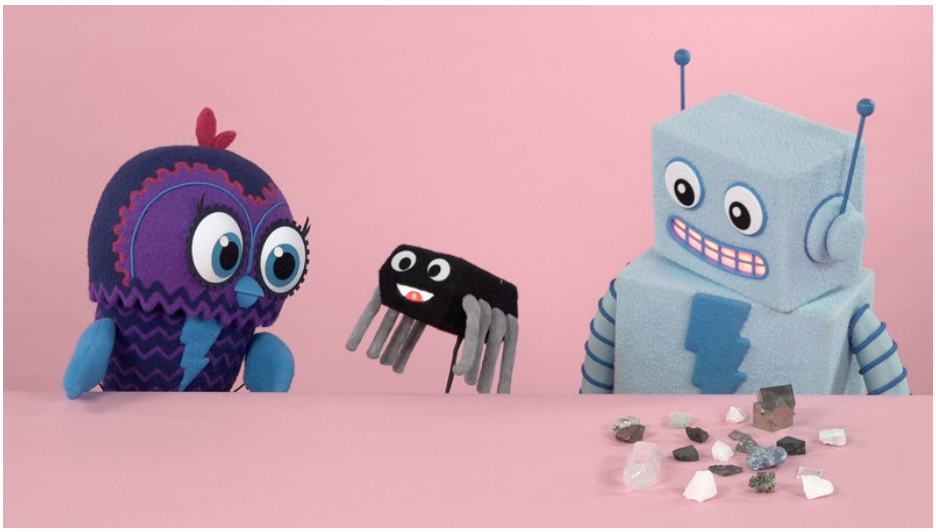
Adabot: Oh - I was just going through my rock collection. I forgot I had so many!

Minerva: Hmm - find anything good?

Adabot: Sure - some precious stones. This one's my favorite - it's quartz!

Minerva: That quartz does look special. Where did you get it?

Adabot: There was a rock show at the museum. I thought there would be more guitar solos, but it turned out to be a bunch of people trading minerals. So, I got this quartz because it looks really neat.



Minerva: It looks neat because it is neat. We use quartz in electronics all the time.

Hans: Did someone say time?!

Minerva: Why, yes! I was just explaining to Adabot how quartz is used in electronics.

Hans: Adabot - do yo know why I am the world's greatest integrated circuit?

Adabot: No, Hans - why are you the world's greatest int –

Hans: Timing! It's what I take care of in a circuit. And do you know why my timing is so impeccable?

Adabot: No - why is your timing so imp–

Hans: Quartz! And why does quartz create perfect timing?

Adabot: Umm - are you gonna keep interrupting me?

Minerva: Oh - settle down, Hans. I can explain why quartz is so important for timing.

Adabot: Why, thank you.

Minerva: You see - certain materials, such as quartz crystals, are Piezoelectric. Simply put - this means if you apply a small amount of mechanical force to a piece of quartz, it will generate a small electrical voltage.

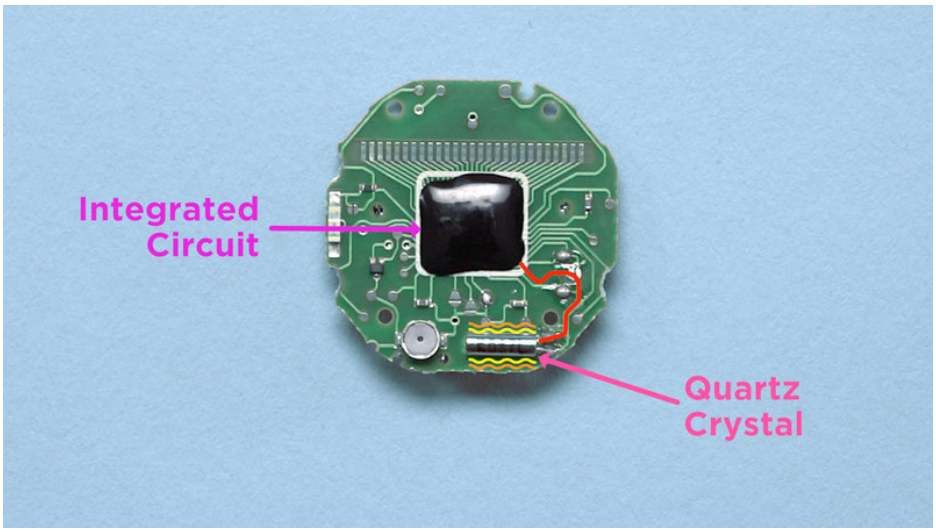
Adabot: Wow - that sounds pretty unusual! So if i crushed it, it would shock me?

Minerva: Well, you have to squeeze it very lightly, and just right and the electrical voltage is very, very small. But...yes I suppose you're right!

Hans: And the opposite is also true! If you apply voltage to a piece of quartz - it will respond with a precise mechanical vibration.

Adabot: Quartz sounds like magic!

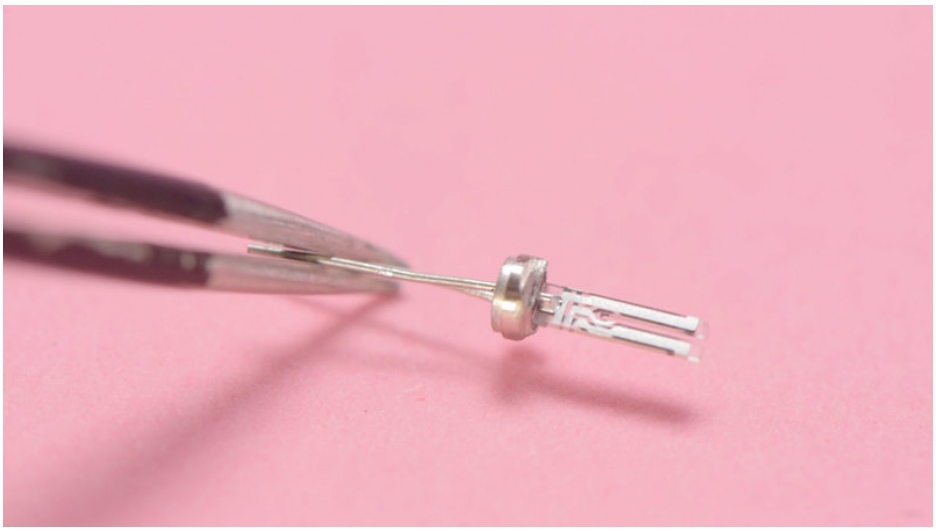
Minerva: It's not magic, Adabot - it's science! Take a look inside this quartz watch for instance.



Hans: this little integrated circuit here passes electrical current to the quartz crystal. Then the quartz vibrates at precisely 32768 times per second.

Minerva: After that, the IC detects the vibrations, counts them one by one, and when it gets all 32,768 it knows one second has passed!

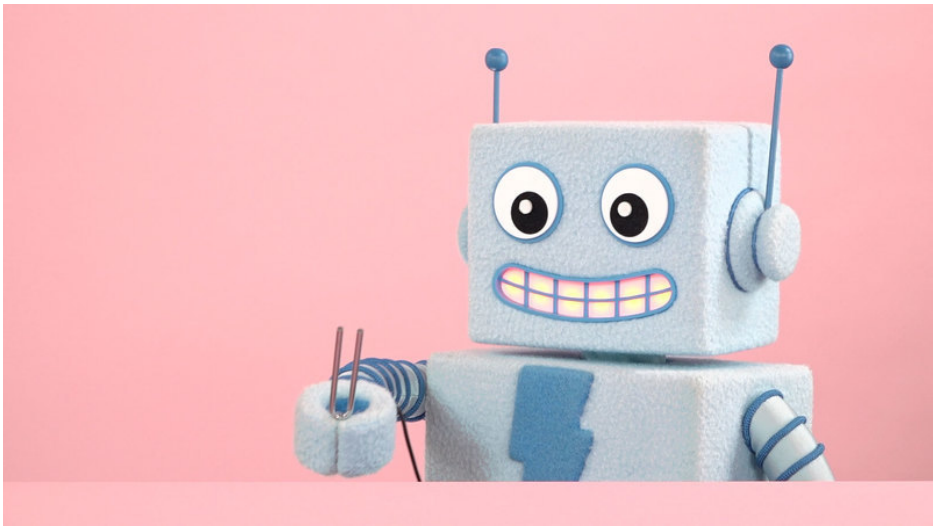
Adabot: So there's a quartz crystal inside of that little metal container?



Hans: Yes - and it looks something like this ...

Adabot: That looks like a tuning fork!

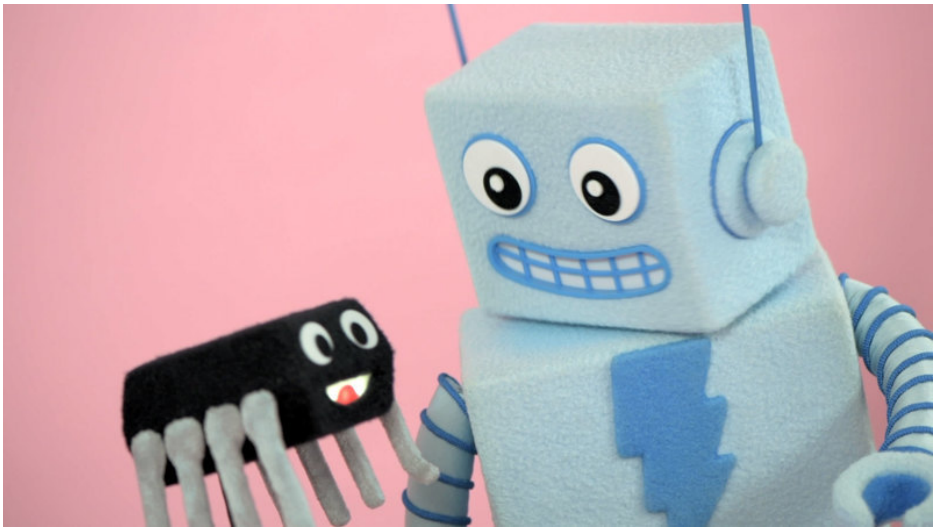
Minerva: That's true - it does look like a tuning fork!



Adabot: Musicians use the vibrations of a tuning fork to tune their instrument - and circuits use quartz to tune their timing!

Hans: You're right!

Minerva: Very true, Adabot. Quartz is an important reference for the timing of so many circuits - microcontrollers, computers, and more.



Adabot: I always wondered what was inside those little metal cans - now I finally know!

Minerva: Well - it's about time!

Hans: ... Adabot, I believe Minerva just made a *time* joke

Adabot: Is that what that was?

Hans: Haaayyooo!

Minerva: Thank you, thank you ...

Learn More

To understand why **quartz** is so useful for **electronics**, we need to understand **piezoelectricity**. Wikipedia defines **piezoelectricity** as such:

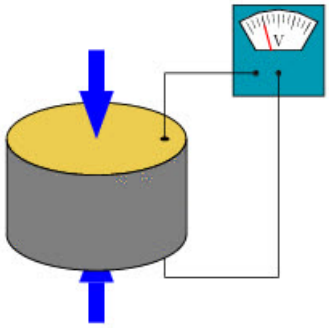


image: CC BY-SA Tizeff (https://adafru.it/Ejy)

> Piezoelectricity is the electric charge (https://adafru.it/Ejz) that accumulates in certain solid materials (such as crystals (https://adafru.it/EjA), certain ceramics (https://adafru.it/EjB), and biological matter such as bone, DNA (https://adafru.it/rRA) and various proteins (https://adafru.it/EjC)) in response to applied mechanical stress (https://adafru.it/EjD). The word *piezoelectricity* means electricity resulting from pressure and latent heat. It is derived from the Greek (https://adafru.it/EjE) word *piezein*, which means to squeeze or press, and ***ēlektron***, which means amber (https://adafru.it/EjF), an ancient source of electric charge. French physicists Jacques (https://adafru.it/EjG) and Pierre Curie (https://adafru.it/EjH) discovered piezoelectricity in 1880.
>
> The piezoelectric effect results from the linear electromechanical interaction between the mechanical and electrical states in crystalline materials with no inversion symmetry (https://adafru.it/EjI). The piezoelectric effect is a reversible process (https://adafru.it/EjJ): materials exhibiting the piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force (https://adafru.it/EjK)) also exhibit the reverse piezoelectric effect, the internal generation of a mechanical strain resulting from an applied electrical field.

Crystal Oscillator

In electronics, the piezoelectric properties of quartz are used in the form of a **crystal oscillator** to provide a stable and reliable timing reference. Quartz's **reference frequency** is used like a **drumbeat** for **digital processors** to follow along with. It keeps software instructions moving along at a **consistent rhythm**!

> A **crystal oscillator** is an electronic oscillator (https://adafru.it/EjL) circuit that uses the mechanical resonance (https://adafru.it/EjM) of a vibrating crystal (https://adafru.it/EjA) of piezoelectric material (https://adafru.it/Ejy) to create an electrical signal with a precise frequency (https://adafru.it/EjN). This frequency is often used to keep track of time, as in quartz wristwatches (https://adafru.it/EjO), to provide a stable clock signal (https://adafru.it/EjP) for digital (https://adafru.it/EjQ) integrated circuits (https://adafru.it/EjR), and to stabilize frequencies for radio transmitters (https://adafru.it/EjS) and receivers (https://adafru.it/EjT). The most common type of piezoelectric resonator used is the quartz (https://adafru.it/EjU) crystal, so oscillator circuits incorporating them became known as crystal oscillators, but other piezoelectric materials including polycrystalline ceramics are used in similar circuits.

Read more on Wikipedia (https://adafru.it/EjV)

Links

- ExplainThatStuff - Quartz Clocks & Watches (https://adafru.it/EjW)
- EngineerGuy - How a quartz watch works (https://adafru.it/EjX)
- Autodesk - How Piezoelectricity works (https://adafru.it/EjY)
- Piezoelectric Effect Explained (https://adafru.it/EjZ)
- Science with Kids - Facts about Quartz (https://adafru.it/Ej-)