Texas Instruments Electronics Challenge

Texas Instruments TI-36X Solar Calculator Deconstruction

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The calculator: a basic invention, but with complex algorithms and components not apparent. In 1972, Jack Kilby and colleagues at Texas Instruments filed a patent for a calculator and, two years later, were granted. For this Texas Instrument challenge, I disassembled a scientific calculator —TI-36X Solar designed by Texas Instruments. It consists of numeral keys and functional keys, the latter to execute several mathematical functions including log (logarithm to the base 10), natural log, and trigonometric functions (sine, cosine, and many others). I chose this device because it is one of the most essential devices I use throughout the day.

The calculator has a plastic casing on the backside as its support and to hold the calculator with six screws. I used a Phillips screwdriver to remove them. Inside, I found the components that enable the calculator to function. The input sources are the 41 plastic keys located on the front of the calculator, with different symbols imprinted on each of them. These are used to solve equations. Underneath each key, there is a rubber membrane and a touch-sensitive circuit below it. There is also a processor that does all the computation, and the result it arrives at is displayed on a liquid crystal display -- a combination of solid and liquid used to produce a visible image. The calculator is powered by a solar panel, located at the top of the calculator, which absorbs solar and light (photonic) energy and transforms it into electrical energy, and stores it for consumption. Since the TI created this calculator, I assume that the TI engineers created its processor, codes, algorithms, and other parts inside the calculator also.

Every component of the calculator has a critical role in enabling the machine to perform smoothly. As a key is pressed, the following sequence of events happen in microseconds:

- 1. As the key is pressed, the rubber membrane underneath is pressed.
- 2. As the rubber button on the membrane gets pushed down, an electric current gets detected by the keyboard circuit.
- 3. As the signal arrives at the processor chip, it executes the algorithm linked to the key pressed.
- 4. The result is displayed on the LCD
- 5. As the numbers are keyed in, the processor chip shows them on the display.
- 6. When an operation key such as + or × is pressed, the calculator stores the number in a small memory called a register. As the second number is entered, the processor displays the result and then stores the new numbers.
- 7. The calculator converts the numbers into **binary numbers**, which allows the processor to compare them using the **logic gates**.
- 8. Finally, when we prompt the "=" key, the calculator uses the contents in the registers, performs the operation, and displays the result.

In conclusion, this project made me realize that even the basic electronic devices such as calculators require many different components to operate, the algorithms and the codes need to be written, and the electric circuits and chips need to be designed so that the desired mathematical operations are performed.

Part List of TI-36X Solar

- 1. 41 plastic keys labeled with symbols (input source)
- 2. LCD (liquid crystal display) which had 10 different 7-Segment Displays
- 3. Solar Panel (used for power)
- 4. TI Processor
- 5. Circuit Board
- 6. Rubber Membrane (used to detect key pushes)
- 7. Keyboard sensors (picks up the signal from rubber membrane)
- 8. 6 screws (hold plastic casing in place)
- 9. Front and back cover (holds the components together)

Pictures



 \leftarrow Left: Front view of Texas Instruments TI-36X calculator. There are different function keys, and a key can have more than 1 function or job.



Above: A zoomed-in view of the processor. It uses complex code and algorithms to execute the instructions it receives.



Above: All parts of the TI-36X Solar. The keyboard sensors are not visible, but they are located on the reverse side of the circuit board.

Right: The back of the keyboard membrane. The black dots create a signal (with keyboard sensors), which transmits to the processor.





Right: A closer look at the LCD display and the solar panel. The LCD displays information (from the processor), and the Solar Panel provides power.

Left: The keyboard sensors are vital in enabling the calculator to perform. There 41 total, matching the number on the keyboard membrane and plastic keys.





Left: A labeled photograph of components that are overlooked. Wires send and receive all the information, and the capacitors (conductor) and resistors, which fix voltage.