



# Nest Learning Thermostat 2nd Generation Teardown

Nest Learning Thermostat 2nd Generation teardown on April 17, 2013.

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## INTRODUCTION

The future of thermostats has a name, and that name is Nest. The 2nd Generation Nest Learning Thermostat is the thermostat that never stops learning. With hardware this smart, it's important for us to keep a watchful eye on it, so we naturally had to open it up!

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### TOOLS:

- [Phillips #0 Screwdriver](#) (1)
  - [iFixit Opening Tools](#) (1)
  - [Spudger](#) (1)
  - [Tweezers](#) (1)
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## Step 1 — Nest Learning Thermostat 2nd Generation Teardown



- Some impressive tech specs are [nested](#) in this learning thermostat, or learn-o-stat, as we lovingly call it:
  - 24 bit color LCD Screen with 320 x 320 pixel resolution
  - Built-in rechargeable lithium-ion battery
  - Various sensors (temperature, humidity, far-field activity, near-field activity, ambient light)
  - 802.11b/g/n and [802.15.4](#) Wi-Fi support (both at 2.4 Ghz)
  - Compatible with 95% of 24V heating and cooling systems, including gas, electric, forced air, heat pump, radiant, oil, hot water, solar, and geothermal

## Step 2



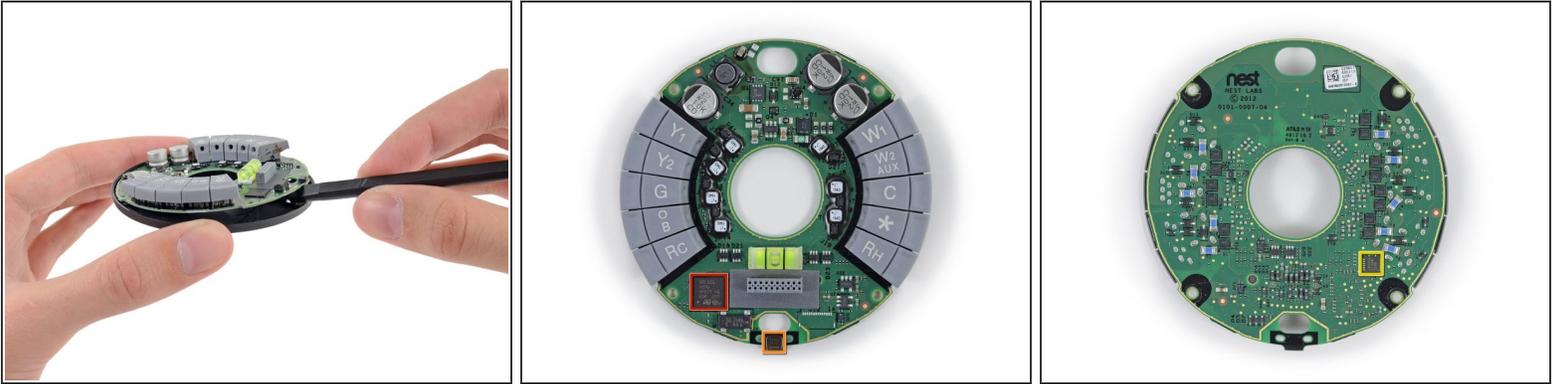
- As we open up the box, we find a Nest thermostat, an installation guide, a welcome guide, a concierge card, a screwdriver, screws, and trim kit.
- The Nest is made up of two primary components: a wall-mounted base that connects to the signal lines from your [HVAC](#) system(s), and the snap-on display unit that houses the LCD and controls.
- Nest advertises ease of installation for its thermostat. According to Nest, "three out of four customers install Nest in 30 minutes or less."
- ⓘ If you happen to be the one out of four experiencing difficulties during the install, don't despair. Simply purchase [Nest Concierge Service](#).

### Step 3



- The base unit is home to ten spring-loaded connectors that let you easily route signal lines from all of your heating and cooling systems into the Nest:
  - ⓘ Rc, Rh, W1, W2/AUX, Y1, Y2, G, O/B, Common “C”, Nest star
- Responsible for both the wiring and the mounting of the Nest, this component is fitted with two oblong screw holes and a built-in [bubble](#) level to aid in a neat and tidy installation.
- A few screws stand between us and the base motherboard—a quick turn of the screwdriver, and we see the green.

## Step 4



- With only light adhesive holding the base motherboard to its case, it doesn't take us long to pull it out for a closer look.
- We [rarely](#) see circular circuit boards. It's quite refreshing and alliterates nicely.
- The base motherboard is equipped with a surprising amount of hardware for an auxiliary board:
  - ST Microelectronics [STM32L151VB](#) ultra-low-power 32 MHz ARM Cortex-M3 MCU
  - Sensirion [SHT20](#) humidity and temperature sensor
  - Texas Instruments [LW051A](#) 8-channel CMOS analog multiplexer/demultiplexer

## Step 5



- The back of the Nest display has two ports: a micro USB port that [can be used for charging](#) (and possibly hacking the Nest's software), and a proprietary 20-pin connector that fits onto the base unit's matching plug.
- Removing a few screws allows us to separate the Nest display's rear panel from the rest of the unit and continue our exploration.
- ⓘ We'd like to point out that these screws can in fact be removed with the included driver. Way to make your product's internals accessible, Nest!

## Step 6



**i** Nothing makes us happier than a device with an [easily replaceable battery](#). We feel the engineers at Nest Labs must have been thinking of us when they added these numbered flags showing three easy steps for battery removal.

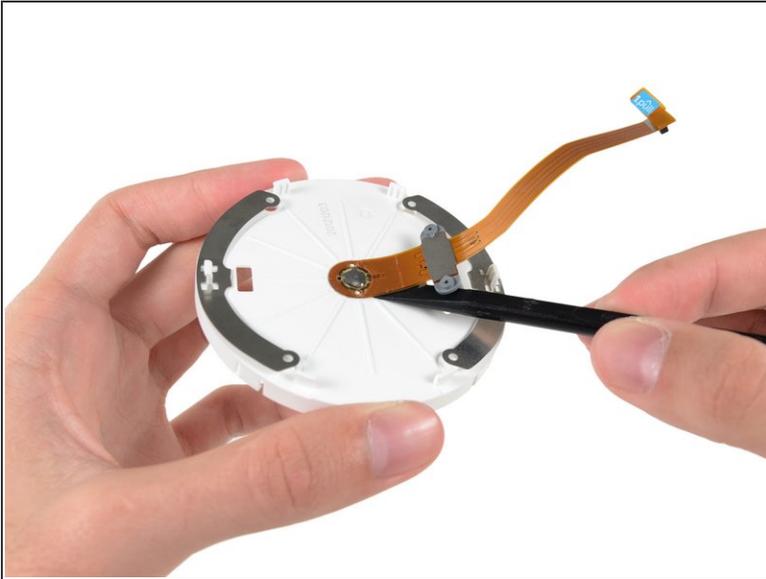
- We dutifully follow the steps to remove the battery:
  - Step 1: Disconnect the base connection ribbon cable.
  - Step 2: Pull the battery.
  - Step 3: Unplug the battery connector.
  - Step 3.5: Profit???

## Step 7



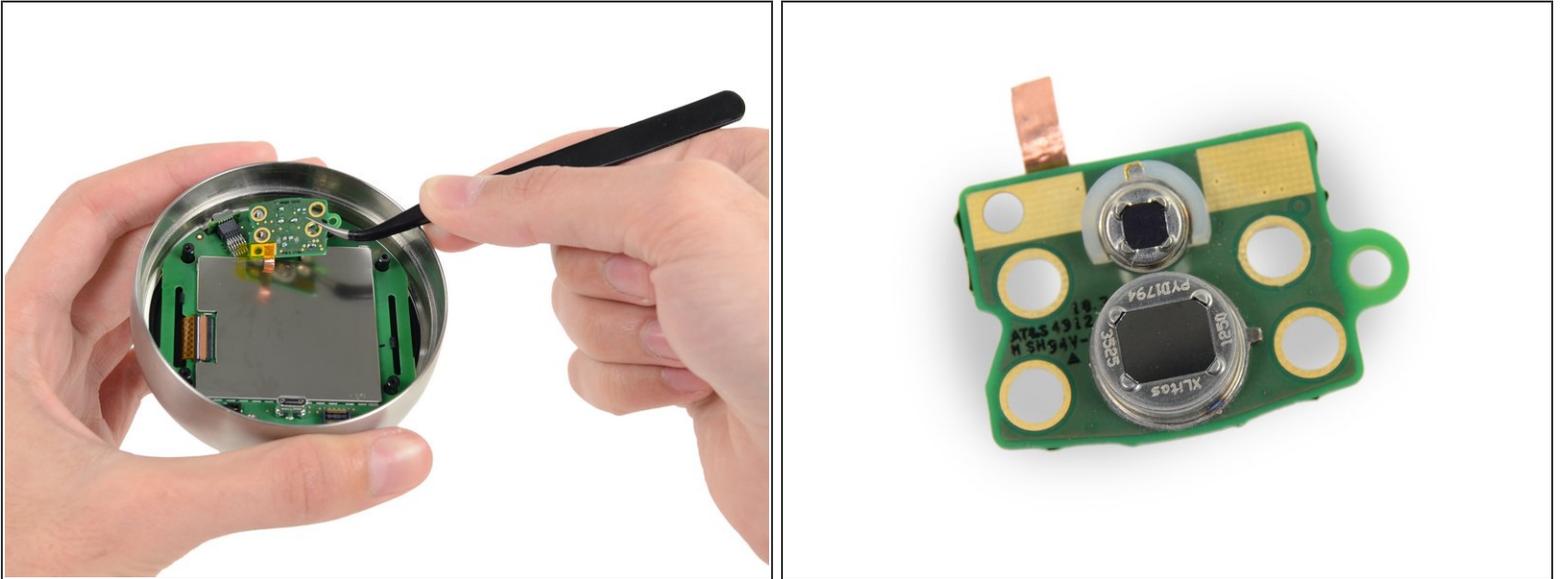
- The lithium-ion rechargeable battery in the Nest is rated at 3.7 volts, 2.1 Wh (568 mAh).
- ⓘ The Nest receives a constant source of power from your home's thermostat lines, a low-power connection that can't provide enough juice for big operations like Wi-Fi broadcasts and powering the LCD. Keeping this battery topped off means the Nest always has [reserve power](#) to spare.

## Step 8



- At the other end of the rear panel's 'Pull' tab, we have a push option.
- This ribbon cable-mounted button turns the whole display assembly into the menu navigator, allowing users to [scroll with the exterior ring and select with a press of the display](#).
- The cable is very securely adhered to the rear panel, but can be safely peeled off with a little patience and a lot of spudger.

## Step 9



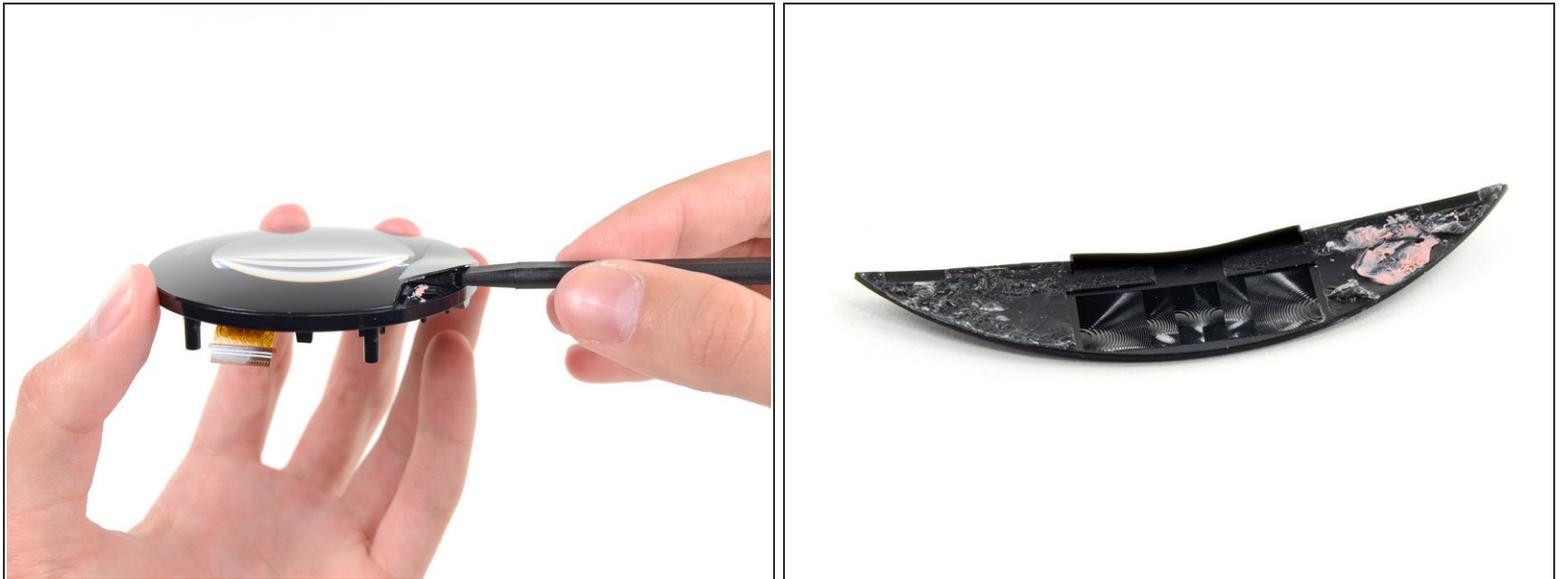
- i** The Nest features an auto-away function that can detect when you've left your home and automatically switch to an "away temperature" to avoid heating or cooling an empty house.
- This small board houses the two motion sensors (long and short range) responsible for this feature. These sensors are capable of [detecting movement within a 150° field of vision](#).
  - Through a rather clever design, the sensor board has no cable connecting it to the motherboard. Instead, it rests on four screw posts that make up its contacts.

## Step 10



- We took a break from our headlong rush into the Nest's innards to sneak a peek under the large EMI shield that was covering the back of the motherboard. [Unfortunately, there wasn't much to be seen.](#)
- After expelling a few more screws, we disconnect the LCD ribbon cable to free the front panel from the device.

## Step 11



- Our first foray into the front panel involves peeling off the small plastic plate adhered below the screen. Mild adhesive holds it securely in place, but is easily dispatched with a little patient spudgering.
- The plastic plate turns out to actually be a window for infrared light, and is fitted with an array of [Fresnel lenses](#) that are used to widen the motion sensors' field of view and increase their range.

## Step 12



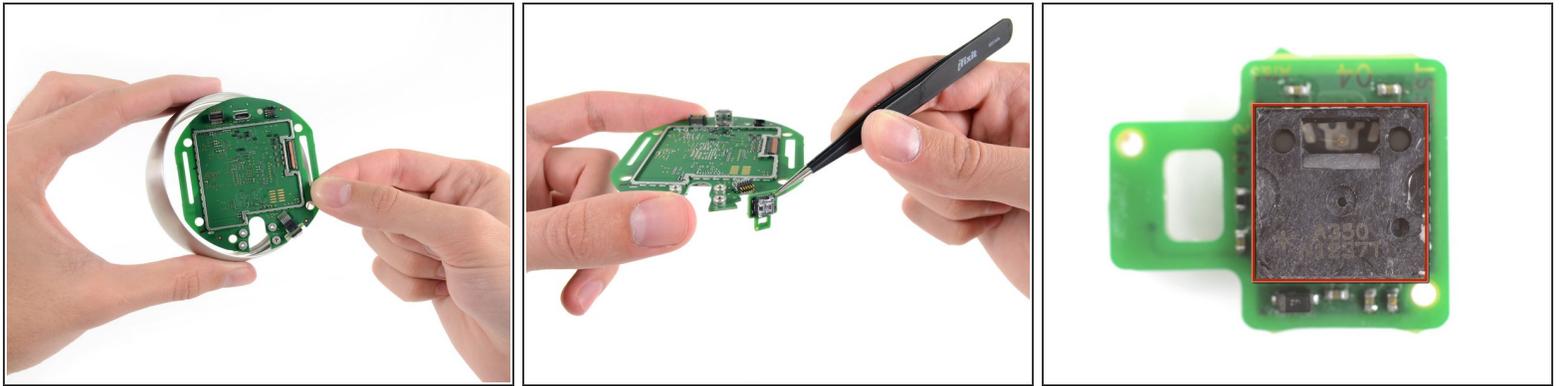
- The LCD is sandwiched between the front glass and a plastic frame. Adhesive secures the glass to the frame and the LCD to the glass.
- It may look like the folks at Nest cut a couple of corners on the LCD, but in fact it's a rather remarkable round display, with only the visible portion [populated with pixels](#).

## Step 13



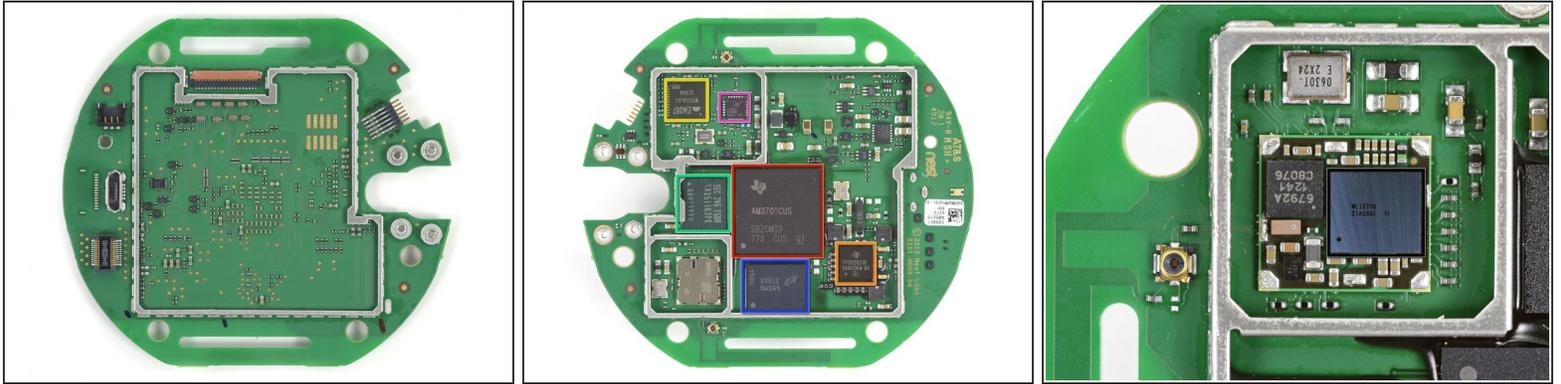
- By virtue of being a curved piece of glass, the front panel is a lens, capable of magnifying and focusing all of your [important documents](#).
- From the looks of things, we'd venture to guess that this is a [plano-convex](#) lens, designed to wrangle the light of the LCD into a focal point.

## Step 14



- With everything else out of the ring, we're able to pull out the motherboard for its closeup.
  - A quick look at the last component hanging off the side of the motherboard reveals an Avago [ADBM-A350](#) optical finger navigation module, responsible for detecting the position of the outer steel ring.
- i** This component works similarly to an optical mouse's sensor, by snapping images of the inside of the ring and comparing sequential pictures to determine position as it spins.

## Step 15



- With all of the I/O connections on the back, the main motherboard houses all of its important ICs on the front:
  - Texas Instruments [AM3703CUS](#) Sitara ARM Cortex A8 microprocessor
  - Texas Instruments [TPS65921B](#) power management and USB single chip
  - Samsung [K4X51163PK](#) 512 Mb mobile DRAM
  - Ember [EM357](#) integrated ZigBee/802.15.4 system-on-chip
  - Micron [MT29F2G16ABBEAH4](#) 2 Gb NAND flash memory
  - Skyworks [2436L](#) high power 2.4 GHz 802.15.4 front-end module
- And under that last EMI shield: Texas Instruments [WL1270B](#) 802.11 b/g/n Wi-Fi solution, just like the one we found in the [Kindle Fire](#)

## Step 16



- Nest Learning Thermostat 2nd Generation Repairability Score: **9 out of 10** (10 is easiest to repair)
  - Battery is clearly intended to be user-replaceable (with built-in directions) and can be removed with the included Phillips screwdriver.
  - Solid construction surrounded by a hefty steel ring makes for great durability.
  - Separation of components onto two motherboards increases modularity.
  - Light adhesive holds the front panel assembly together, slightly increasing difficulty of replacing the LCD or glass.

To reassemble your device, follow these instructions in reverse order.