Exploring the URC-9960 (Kameleon) Motion Sensor

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1. BACKGROUND. The Kameleon electro-luminescent display is a battery hog that can draw 50 milliamps when lighted. At that rate, AAA alkaline batteries (with a rated capacity of 1150 milliampere-hours) would last about one day, so the display must be turned off when inactive. The designers thought it would be elegant if the display turned on automatically when needed. To make that happen as if by "magic" they opted for a very sensitive motion sensor. The down side, as some of you have found out, is occasional nuisance triggering of the display. There's been a lot of discussion about the motion sensor in the Forum. This article explains all about this controversial little gadget, how it is used in the remote, and several ways to modify its performance. Although the details apply primarily to the URC-9960 model, the information is applicable to other remotes in the Kameleon family as well.

2. LOOKING UNDER THE HOOD. Opening up a 9960 is not for the faint-hearted, but these instructions should make it a little easier. For tools you'll need a **thin** knife blade (preferably not too sharp), an old credit card cut into a half-dozen strips, and a small Phillips screwdriver. Start by taking out the batteries and removing two screws from inside the battery compartment.

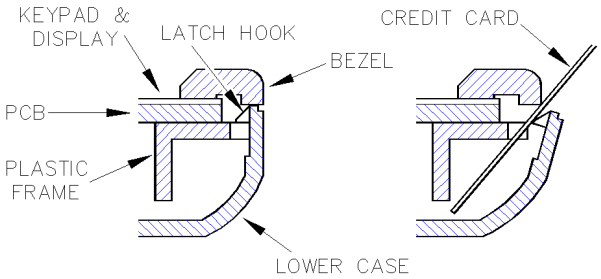

Figure 1. Cross-Section Showing Typical Latch Detail

Figure 1 shows an enlarged cross-section through one of the 11 latches around the perimeter that hold the case together. The latch hooks are molded along the inside edge of the lower case, and they engage with a molded plastic frame that's fastened to the metal bezel with 13 screws, sandwiching the circuit board, keypad, and display together. Figure 2 shows the exact location of the side latches, which are the ones you should unhook first. It helps to mark the locations of the latches on the bezel with a pencil so you have some idea exactly where to work.

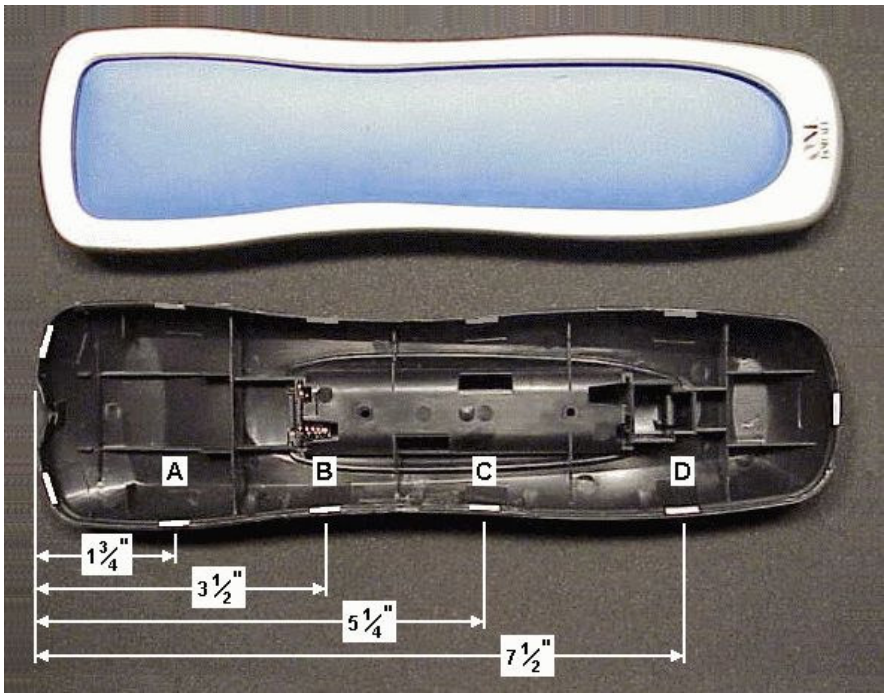

Figure 2. Location of Side Latches

With the remote resting on a flat surface, keyboard facing up, insert the knife blade horizontally, just to the right of latch B (looking at Figure 2). When the blade encounters resistance, rotate it almost vertically so it can be pushed down into the lower case. Gently pry the case open while inserting a credit card strip at location B to keep that latch unhooked. Next, insert the knife blade horizontally about midway between latches C and D, rotate it vertically, and insert a credit card strip at location C. Once you get latches B and C blocked open you're half way home.

Use the knife blade to pop loose latches A and D, adding additional credit card strips if necessary. Then work around the corner to pop loose the rear latch. Continue up the other side until you have unhooked all but the two front latches. Now lift the rear end of the upper assembly away from the lower case about an inch, and wiggle it from side to side until the front end pops free.

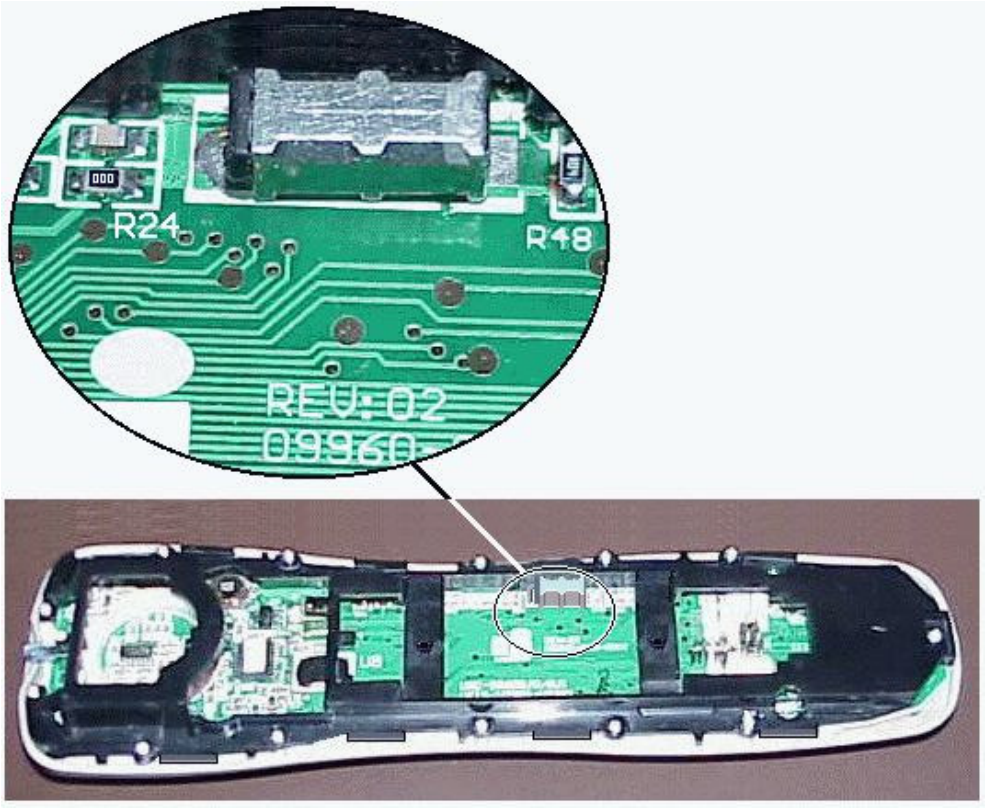

Figure 3. Motion Sensor Switch on Main Circuit Board

Figure 3 shows the underside of the upper assembly, with the motion sensor soldered to the circuit board. All the stuff we're interested in is accessible without any further mechanical disassembly. If you're curious about what's inside the sensor, take a look at Figure 4. The sensor consists of a tin-plated cylinder containing two 1/8 inch diameter gold-plated balls. The open end of the cylinder is sealed with a plastic plug that contains a gold-plated cup-shaped contact on the inside, connected to a bent wire lead. The metal cylinder is one contact of the switch, and the cup is the other.

Figure 4. Disassembled Motion Sensor Switch

If there were only one ball inside it would be what's generally called a "ball switch", which is a type of switch that's intended primarily to detect tilt in the direction that causes a ball to roll against a contact. But there seems to be more to this device than that. Figure 5 shows that when assembled, there's barely enough room for the two balls.

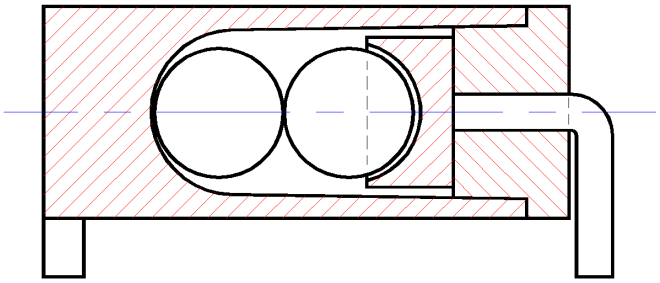

Figure 5. Cross-section of Motion Sensor Switch

Notice that regardless of the orientation of the switch, horizontal, vertical up, or vertical down, the balls will always be resting against each other and the cup, yet susceptible to contact jiggling by vibration in any plane. With a single ball there's always an orientation where the ball is drawn away from one contact by gravity, and vibration in a direction perpendicular to that is least effective. Apparently the designers of the Kameleon wanted the motion sensor to remain sensitive regardless of which direction the remote was being held. All of this is pure speculation on my part, but it is the only explanation I can give you as to why the switch manufacturer went to the trouble of using two balls instead of one, and making both ends hemispherical cavities instead of simply flat. You may not care about that, but it does have a bearing on what can be done about excessive sensitivity.

The ball switch is assembled at the factory under very clean conditions because contact pressure is so slight that even a fingerprint can cause poor or intermittent contact. (Remember that if you're tempted to open up the switch.) To help ensure that the switch does its job, the circuit that turns on the display has been designed to tolerate very high contact resistance. During tests I was able to trigger the display on consistently while simulating contact resistance as high as 10K ohms or more.

When turned on, the display is kept on by a delay timer that operates a little differently depending on whether it is triggered by the motion sensor switch or a key switch. The display will remain on as long as any key is pressed, and for seven seconds after the last key is released. But the motion sensor switch can only turn the display on if it is off to begin with, and then only for seven seconds. That may not seem important, but it's the reason the display doesn't stay on when the motion sensor switch remains closed.

3. WHAT YOU CAN AND CAN'T DO ABOUT MOTION SENSITIVITY. The previous discussion of the omnidirectional sensitivity characteristics of the motion sensor explains why it often does no good to park your remote in a certain orientation, such as upside down, in an effort to avoid activation by loud noises or heavy footsteps. For the same reason, loosening the solder and tilting the switch inside the remote is ineffective.

If you're about to disable the feature, you have nothing to lose by first trying to convert the switch to a single ball sensor, then re-install it at a slight angle so that when the remote is resting on a horizontal surface the ball is biased toward the rear end, away from contact with the cup. That will eliminate vibration sensitivity, but the ball will still roll forward to contact the cup and turn on the display when you pick up the remote. Don't try this if you have no experience removing components from circuit boards.

To remove the sensor, first pick up all the solder you can from the joints at both ends, using solder-wick. Then gently pry up the rear end slightly with a sharp blade or jeweler's screwdriver as you hold your iron against the solder joint to melt it. Now pry up at the lead end slightly while you soften that joint. Repeat until both ends are free of the board. Use solder-wick again to make sure the holes in the board are clear of solder.

To open the sensor, insert a sharp blade between the metal cylinder and the black plastic end cap. Hold the sensor vertically so the balls won't spill out. Carefully remove one ball without touching the other ball, the inside of the cylinder, or the cup-shaped end contact, then press the end cap back into the cylinder. When you replace the sensor, prop the rear end up with a toothpick before soldering so that the sensor is angled about 1/32 inch higher at the rear end than at the lead end. Since you are working with the board upside down, the end you have raised will

actually be the low end when the remote is reassembled, and the switch will be normally open when resting on a table.

If you like the idea of desensitizing the motion detection but are reluctant to try modifying the existing switch, an alternative approach is to install your own tilt switch. Mouser Electronics sells a variety of miniature tilt switches for less than a dollar. Switches that use a conductive liquid electrolyte or mercury may not be entirely satisfactory because the liquid surface tension gives them a noticeable amount of hysteresis (the angle through which they must be rotated between making and breaking contact). My recommendation among the Mouser selection would be one of the ball types, 107-1006 or 107-1007.

First remove R24, following the instructions in Section 4 below. Solder a couple of insulated wires about two inches long to the terminals of the new switch. Connect one of these wires to the rear end of the existing motion sensor, and the other to the pad of R24 toward the front of the remote, as shown in Figure 6. Locate the new switch directly across the board from the old sensor, where it will clear the battery compartment. Temporarily stick the switch to the wall of the black plastic frame so that the wire end is about 1/32 inch closer to the board than the free end. That will cause the switch to be normally open when resting on a table with the keyboard facing up. When you pick up the remote to use it you will instinctively tilt it slightly upward, causing the ball to roll forward and close the switch. You can adjust the sensitivity by how steep an angle you mount the switch.

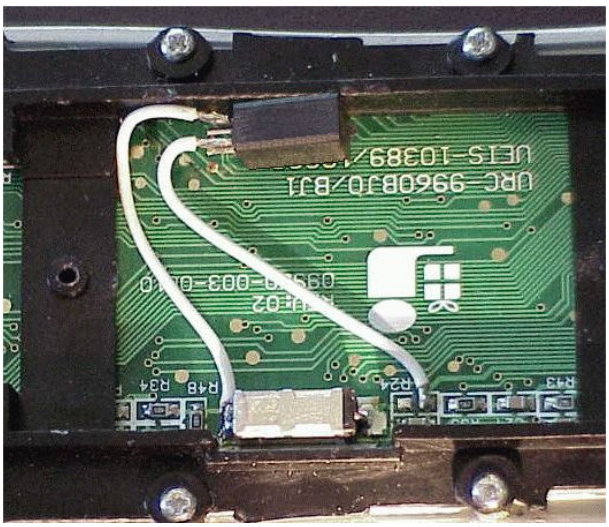

Figure 6. Tilt Switch Installation

Because it's such a hassle to open the case, I suggest you test the unit thoroughly to make sure you like the way it works before reassembling. Place the lower case onto the upper assembly as far as it will go without engaging the latches. (This will also give you some practice at guiding the battery contact springs into the slots in the plastic frame.) There will be a gap of about 1/8 inch between the two case halves, but the rear battery springs should extend far enough into the battery compartment to contact the batteries. The battery compartment door will keep them from popping out. Use a couple of pieces of masking tape to hold the whole thing together if you want, so that you can lay it down and pick it up several times to see how easily the display turns on. With the remote resting on a table, try banging on the table to see how sensitive it is. Adjust the angle of the switch until you are satisfied with its performance, then make the mounting permanent with epoxy or hot-melt cement, to keep it from being jarred out of adjustment if you drop the remote.

4. THE BEST WAY TO DEACTIVATE THE MOTION SENSOR. If you've had it with motion sensing and your goal is to completely deactivate the sensor switch, cutting its wire lead will do the trick, but that's a somewhat crude and irreversible method. Cutting a gap in the clad at either end with an Exacto knife is a bit more elegant. But I prefer another method that is even less destructive and easier to undo in case you ever change your mind. See that little chip resistor labeled R24 in Figure 3. The chip is marked with its resistance, "000", which means it is zero ohms, or really just a jumper in series with the sensor switch. Remove that jumper by placing the tip of your soldering iron on one end for a couple of seconds, then move quickly to heat the other end and sort of flick the chip off its solder pads. Very often the chip will just stick to the soldering iron. Don't worry about damaging the resistor, since you won't need it again. You'll be left with a couple of little solder bumps on the resistor's mounting pads. If you ever decide to reactivate the motion sensor you can either replace the zero ohms chip resistor, or just jumper those bumps together with a blob of solder or a short wire.