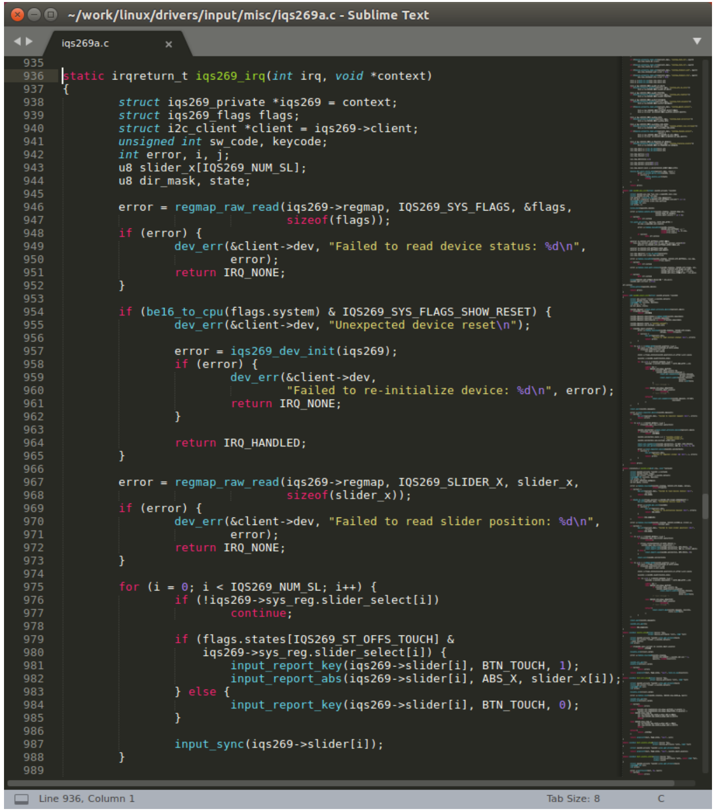
Azoteq IQS269A Linux Kernel Driver

- Enables the IQS269A in Android and other embedded Linux applications
- Interfaces to the Linux input core for direct communication with the Android EventHub
- Efficient use of existing Linux frameworks simplifies integration and system bring-up

- Handles all low-level communication (I^2C transactions and RDY/interrupt handling)
- Registers up to 3 input devices with the Linux kernel
  - Keypad for individual sensing channel events
  - Slider 0 and 1 UIs
- All events can be assigned a Linux input event “key code” (KEY_MUTE, etc.)
  - Proximity, touch and deep touch events
  - Positive or negative delta
- Controls power mode based on system state



- Compile-time control of nearly every register
  - All parameters exposed as device tree properties
  - Device tree is a ubiquitous data structure that describes hardware
- All 8 channels represented as fully configurable device tree child nodes
- Run-time control of ATI-specific registers
  - Mirrored to user space through sysfs attributes (i.e. R/O or R/W “files”)
  - Facilitates production-line calibration of Hall sensor

~/work/linux/arch/arm/boot/dts/overlays/iqs269a-overlay.dts - Sublime Text

iqs269a-overlay.dts

```
iqs269a@44 {
        #address-cells = <1>;
        #size-cells = <0>;

        compatible = "azoteq,iqs269a";
        reg = <0x44>;
        interrupt-parent = <&gpio>;
        interrupts = <17 IRQ_TYPE_LEVEL_LOW>;

        azoteq,gpio3-select = <5>;
        azoteq,hall-enable;

        channel@0 {
                reg = <0x0>;
                azoteq,slider0-select;
        };

        channel@1 {
                reg = <0x1>;
                azoteq,slider0-select;
        };

        channel@2 {
                reg = <0x2>;
                azoteq,slider0-select;
        };

        channel@3 {
                reg = <0x3>;
                azoteq,slider0-select;
        };

        channel@4 {
                reg = <0x4>;
                azoteq,slider0-select;
        };

        channel@5 {
                reg = <0x5>;

                event-touch {
                        linux,code = <KEY_MUTE>;
                };
        };

        channel@6 {
                reg = <0x6>;
                azoteq,invert-enable;
                azoteq,static-enable;
                azoteq,reseed-disable;
                azoteq,rx-enable = <0>;
                azoteq,sense-freq = <0x0>;
                azoteq,sense-mode = <0xE>;
                azoteq,ati-mode = <0x0>;
                azoteq,ati-base = <200>;
```

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Demonstration Platform

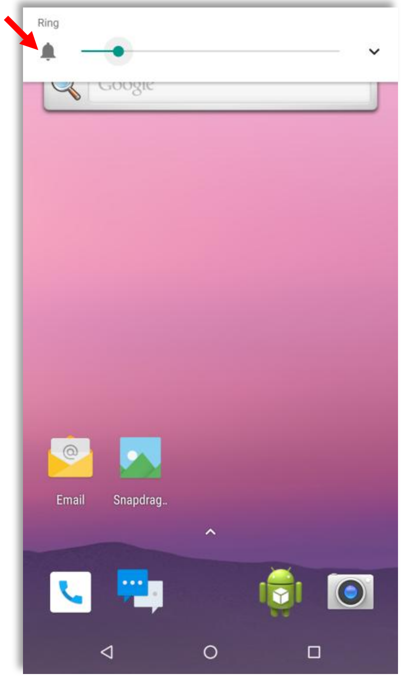
IQS269A Stamp Module

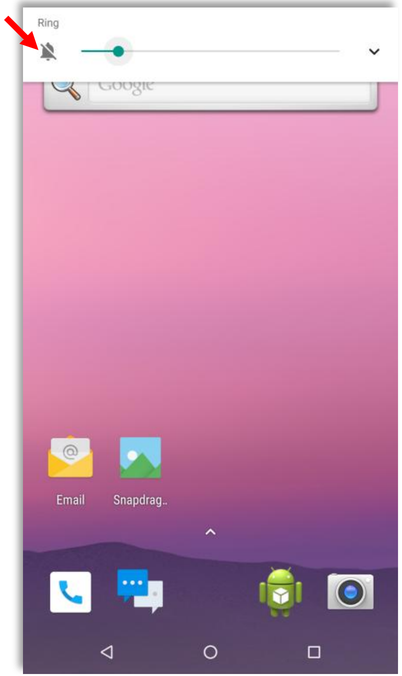
8-Channel Capacitive Keypad/Slider

Power/I²C/GPIO Header

Android Development Kit

Ring/Vibrate Touch Key



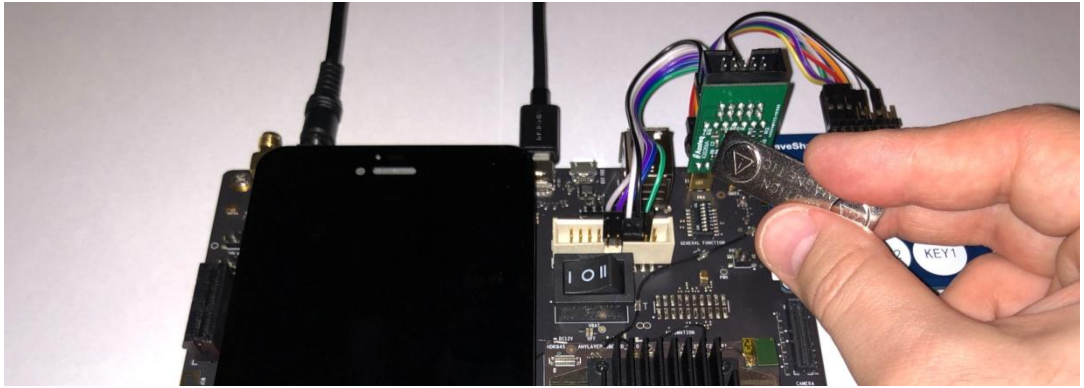


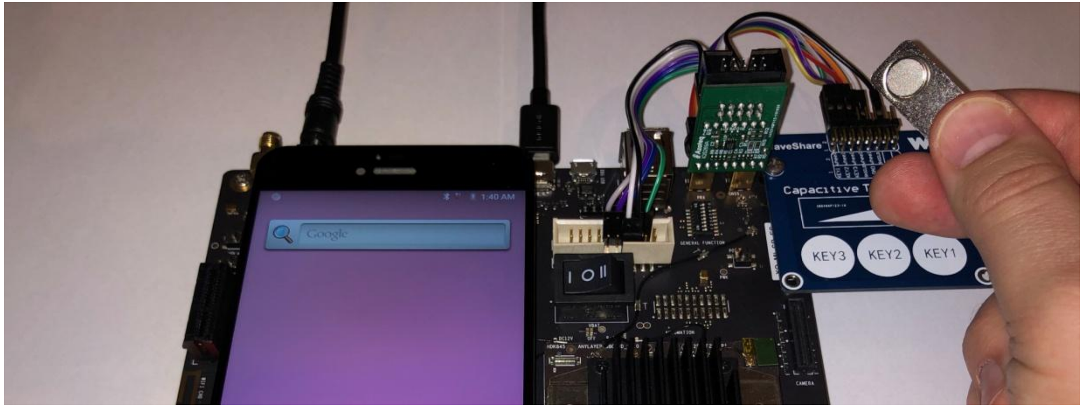
Generic Touch Slider

- Slider activity reported using input event codes commonly used for axial sliders

jlabundy@nixie71: ~

```
0001 014a 00000001   ⟵ EV_KEY: touch start (BTN_TOUCH = 0x014A = 1)
0003 0000 0000002a
0000 0000 00000000
0003 0000 00000032
0000 0000 00000000
0003 0000 00000045
0000 0000 00000000   ⟵ EV_ABS: absolute coordinate change (0–255)
0003 0000 0000004d
0000 0000 00000000
0003 0000 00000055
0000 0000 00000000
0003 0000 0000005c
0000 0000 00000000
0003 0000 00000063
0000 0000 00000000
0003 0000 00000069
0000 0000 00000000
0003 0000 0000006d
0000 0000 00000000
0001 014a 00000000   ⟵ EV_KEY: touch stop (BTN_TOUCH = 0x014A = 0)
0000 0000 00000000
```



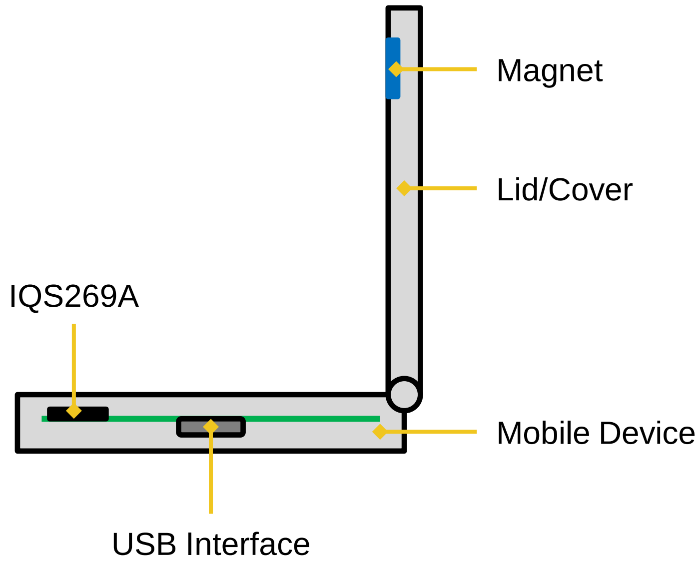


Magnetic Lid Switch

- Channel 7 events reported as change in switch state (EV_SW) instead of key press/release (EV_KEY) if Hall UI is enabled
- Some Linux switch codes (e.g. SW_LID, SW_DOCK) invoke preset behaviors in Android (e.g. screen on/off)

Production-Line Calibration Overview

- Driver provides means to derive unit-specific ATI target (N_T) for Hall channel pair during production
- Calibration is performed using shell scripts executed on host via Android Debug Bridge over USB
- N_T is written to target's nonvolatile memory during production and passed to driver each time target is booted



1. Set compile-time properties in device tree (see iqs269a.yaml)

```
iqs269a@44 {
    [...]
    azoteq,hall-enable;

    channel@6 {
        reg = <0x6>;
        azoteq,invert-enable;
        azoteq,static-enable;
        azoteq,reseed-disable;
        azoteq,rx-enable = <0>;
        azoteq,sense-freq = <0x0>;
        azoteq,sense-mode = <0xE>;
        azoteq,ati-mode = <0x0>;
        azoteq,ati-base = <200>;
        azoteq,ati-target = <320>;
    };

    channel@7 {
        reg = <0x7>;
        azoteq,invert-enable;
        azoteq,static-enable;
        azoteq,reseed-disable;
        azoteq,rx-enable = <0>, <6>;
        azoteq,sense-freq = <0x0>;
        azoteq,sense-mode = <0xE>;
        azoteq,ati-mode = <0x3>;
        azoteq,ati-base = <200>;
        azoteq,ati-target = <320>;

        event-touch {
            linux,code = <SW_LID>;
        };
    };
};
```

2. Override relevant properties in user space

```
echo 0 > /sys/bus/i2c/devices/1-0044/hall_enable
echo 6 > /sys/bus/i2c/devices/1-0044/ch_number
echo 3 > /sys/bus/i2c/devices/1-0044/ati_mode
echo 7 > /sys/bus/i2c/devices/1-0044/ch_number
echo 3 > /sys/bus/i2c/devices/1-0044/ati_mode
```

3. Open lid (i.e. remove magnet)
4. Update registers and trigger ATI

```
echo 1 > /sys/bus/i2c/devices/1-0044/ati_trigger
```

5. Close lid (i.e. apply magnet)
6. Read counts, ATI base/target and Hall pad bin number

```
echo 6 > /sys/bus/i2c/devices/1-0044/ch_number
cat /sys/bus/i2c/devices/1-0044/counts
302
echo 7 > /sys/bus/i2c/devices/1-0044/ch_number
cat /sys/bus/i2c/devices/1-0044/counts
342
cat /sys/bus/i2c/devices/1-0044/ati_base
200
cat /sys/bus/i2c/devices/1-0044/ati_target
320
cat /sys/bus/i2c/devices/1-0044/hall_bin
8
```

7. Ensure neither inverting nor non-inverting counts reach 8192

8. Calculate i_a

$$i_a = IN_B\left|\frac{1}{N_T} - \frac{1}{n}\right| = 6.25 \times 200 \times \left|\frac{1}{320} - \frac{1}{342}\right| = 0.25\ \mu A$$

9. Calculate N_T based on desired counts (e.g. n_z = 500)

$$N_T = \frac{1}{\frac{1}{n_z} + \frac{i_a}{IN_B}} = \frac{1}{\frac{1}{500} + \frac{0.25}{6.25 \times 200}} = 454$$

10. Write N_T to channels 6 and 7

```
echo 6 > /sys/bus/i2c/devices/1-0044/ch_number
echo 454 > /sys/bus/i2c/devices/1-0044/ati_target
echo 7 > /sys/bus/i2c/devices/1-0044/ch_number
echo 454 > /sys/bus/i2c/devices/1-0044/ati_target
```

11. Open lid (i.e. remove magnet)
12. Update registers and trigger ATI

```
echo 1 > /sys/bus/i2c/devices/1-0044/ati_trigger
```

13. Close lid (i.e. apply magnet)

14. Read updated counts

```
echo 6 > /sys/bus/i2c/devices/1-0044/ch_number
cat /sys/bus/i2c/devices/1-0044/counts
414
echo 7 > /sys/bus/i2c/devices/1-0044/ch_number
cat /sys/bus/i2c/devices/1-0044/counts
490
```

15. Ensure channel 7 (EV_SW reporting) counts are reasonably close to n_z
16. Write N_T to nonvolatile memory (e.g. persist partition)
17. Restore compile-time properties

```
echo 1 > /sys/bus/i2c/devices/1-0044/hall_enable
echo 6 > /sys/bus/i2c/devices/1-0044/ch_number
echo 0 > /sys/bus/i2c/devices/1-0044/ati_mode
echo 7 > /sys/bus/i2c/devices/1-0044/ch_number
echo 3 > /sys/bus/i2c/devices/1-0044/ati_mode
```

18. Open lid (i.e. remove magnet)
19. Update registers and trigger ATI

```
echo 1 > /sys/bus/i2c/devices/1-0044/ati_trigger
```

Post-Calibration Boot Sequence

1. Read N_T from nonvolatile memory (e.g. persist partition)
2. Write N_T to channels 6 and 7 via init.rc

```
echo 6 > /sys/bus/i2c/devices/1-0044/ch_number
echo $NT > /sys/bus/i2c/devices/1-0044/ati_target
echo 7 > /sys/bus/i2c/devices/1-0044/ch_number
echo $NT > /sys/bus/i2c/devices/1-0044/ati_target
```

3. Update registers and trigger ATI via init.rc

```
echo 1 > /sys/bus/i2c/devices/1-0044/ati_trigger
```

User-Space Control Summary

Name	Access	Description
ch_number	R/W	Channel number selection (0–7)
rx_enable	R/W*	Sensing pin enable/disable for the selected channel (CRX[7:0])
counts	R/O	Filtered counts for the selected channel
hall_bin	R/O	Bin number for the Hall pad selected by rx_enable[6] and rx_enable[7] (both must agree)
hall_enable	R/W*	Hall UI enable/disable
ati_mode	R/W*	ATI mode for the selected channel (0 = disabled, 1 = semi-partial, 2 = partial, 3 = full)
ati_base	R/W*	ATI base for the selected channel (75, 100, 150 or 200)
ati_target	R/W*	ATI target for the selected channel (0–2016)
ati_trigger	R/W	R: non-zero value indicates all registers are up-to-date W: non-zero value updates all registers and triggers ATI

* Registers are not updated until ati_trigger is written with a non-zero value

Jeff LaBundy

LABUNDY.COM