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OPT3001 ambient light sensor

(preliminary) driver

September 20, 2017

Introduction

OPT3001 is an ambient light sensor manufactured by TI. Documentation available from the manufacturer (data sheet + specification) covers all the technical details.

The sensor can be used to measure the intensity of ambient light and signal events on thresholds.

Summary of the sensor's functionality

The event signaling capability of the sensor is not implemented in the present driver, but it will be trivial to add, if needed. The reason is that the interrupt pin is NC in the wiring of the sensor on the CC1350 SENSORTAG, and I have no other device to test the driver.

The sensor can operate in two basic modes: *continuous acquisition* and *single shot*. In the first mode, the sensor collects data continuously at either 100 (fast) or 800 ms (slow) intervals. The faster conversion results in slightly lower accuracy. In the single shot mode, the sensor sleeps until a conversion is explicitly started. Once the conversion is over, data becomes available, and the sensor automatically goes back to sleep. Note that the fats/slow timing selection also determines the waiting time for a reading in the single-shot mode. The current drain when the sensor is inactive is between 0.3 and 0.4 µA. In the active state (meaning continuous acquisition or when initiated in the single shot mode) the sensor drains between 1.8 and 3.7 µA (it is never a hog).

The 16-bit value produced by the sensor includes an exponent, which means that the value is scaled exponentially. The exponent is 4 bits, and its range is from 0 to 11 (0xB), inclusively. The value reads as 2^{exp} x m, where m is the 12-bit unsigned mantissa (the remaining portion of the word). With a bit of pragmatic simplification (compared to the datasheet) we can say that the smallest resolution of the result is 0.01 lux. This is what corresponds to the LSB of the mantissa for exp = 0, and the range then is 4095 x 0.01 = 40.96 lux. Every next value of the mantissa doubles the range while halving the resolution.

The sensor can be set to operate in a preset range, whereby the exponent is confined to a singe value pre-selected by the user, or in the auto-range mode, whereby the sensor can adjust the exponent based on the actual lighting conditions. The measurement is slightly faster in the preset-range mode, because in the auto-range mode, the sensor may have to issue dummy measurements to recalibrate the range. The details, described in the datasheet, are probably not interesting. The extra measurement may take ca. 10 ms, i.e., adding max 10% to the official measurement time. One advantage of using a preset range is that the application doesn't have to deal with the exponent. To make it easier, there is one more option (that only makes sense in the preset-range mode): to make the exponent zero in all returned values.

There are two settable limits (lower and upper) for the lighting value that trigger events when *exceeded*. They transform into interrupts, which are not implemented in the present driver, but some related hooks are already available. The status of the limits can be determined by looking at the configuration register, which is returned as part of the sensor value. The format for those limits is exactly the same as for the lighting value returned by the sensor, i.e., exponent + mantissa. To prevent jumpiness, it is possible to set the *fault count* parameter to the number of times that a limit must be exceeded to actually trigger an event.

Driver interface

The sensor must be explicitly turned on, which operation determines its mode and parameters. This is accomplished by invoking:

```
opt3001_on (word options);
```

where **options** is a collection of fields composed by or'ring a few constants defined in opt3001.h and listed below:

Constant name	Meaning
OPT3001_MODE_AUTORANGE	selects the auto-range mode
OPT3001_MODE_RANGE_0 … OPT3001_MODE_RANGE_11	selects a specific range exponent from 0 to 100 (range 0 is the default)
OPT3001_MODE_TIME_100 OPT3001_MODE_TIME_800	selects the measurement time (100 is the default)
OPT3001_MODE_NOEXP	select “no exponent” in the returned lighting value (ignored when auto-range is selected)
OPT3001_MODE_CMODE_SS	selects the single-shot mode (the default)
OPT3001_MODE_CMODE_CN	selects the continuous mode
OPT3001_MODE_FAULT_1 OPT3001_MODE_FAULT_2 OPT3001_MODE_FAULT_4 OPT3001_MODE_FAULT_8	selects the number of consecutive measurements that must exceed a limit before the event is signaled (1 is the default)

For example:

```
opt3001_on (OPT3001_MODE_RANGE_11 |
            OPT3001_MODE_TIME_800 |
            OPT3001_MODE_NOEXP);
```

selects the single-shot mode with 800 ms measurement time and the maximum possible fixed range.

The limits for triggering events can be set with this function:

```
void opt3001_setlimits (word hi, word lo);
```

where the arguments must be properly formed lighting values with the exponents. The default setting of the limits is 0xBFFF and 0x0000, respectively, which effectively means disabled. There is no other way to disable a limit than overwriting it with the respective default value.

```
void opt3001_off ();
```

The operation turns the sensor off. If the sensor is powered from a pin, the operation sets the pin low effectively bringing the current drawn by the sensor down to exactly zero. If the sensor has been set up in the single-shot mode, and it is not powered dynamically (from a pin), turning it off does not reduce the current drain.

Reading values

The sensor value can be read in the standard way:

```
read_sensor (word st, address val);
```

The second argument should point to a structure consisting of two words, e.g., like this one declared in opt3001.h:

```
typedef struct {
      union {
            word result;
            struct {
                  word man:12;
                  word exp:4;
            };
      };
      union {
            word status;
            struct {
                  word unused3:5;
                  word lo:1;
                  word hi:1;
                  word unused2:1;
                  word ovf:1;
                  word unused1:7;
            };
      };
} opt3001_data_t;
```

The returned value consists of two parts: the lighting (the first word) and the configuration/status register. Of the latter, we may be interested in three flags: the **`ovf`** bit indicating that the fixed lighting range has been exceeded, and the **`lo`** and **`hi`** bits indicating that the corresponding limit has been exceeded.

The state argument is relevant when the sensor operates in the single-shot mode, because then the operation has to wait for the result of the measurement that it has started. If **`st`** is **`WNONE`**, the operation busy-waits for the result (note that it may be over 800 ms). In the continuous mode, results are always available, so the **`st`** argument is ignored.