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## Sensor comparison – ambient light, proximity, motion

POSTED ON NOVEMBER 15, 2020 (HTTPS://WOLLES-ELEKTRONIKKISTE.DE/EN/SENSOR-COMPARISON-AMBIENT-LIGHT-PROXIMITY-MOTION) BY WOLFGANG EWALD (HTTPS://WOLLES-ELEKTRONIKKISTE.DE/EN/AUTHOR/WOELLELLE\_EWOOD).



## About the post

This sensor comparison is the conclusion of my series on ambient light, gesture, motion and distance and proximity sensors. Surely, there are many more sensors that fall into these categories and that I haven't tested. Accordingly, of course, my series cannot be complete. But I think I've covered the most common representatives.

In the last posts I have systematically gone through sensor by sensor (except the UV sensors (<https://wolles-elektronikkiste.de/en/uv-sensors-and-sensor-modules>), which I have covered in a single post). In this sensor comparison, on the other hand, the functions are the ordering principle. Many of the sensors have several functions and therefore appear more frequently in this post. It is about the following sensors:

Category	Sensor / Module					
	APDS-9960	TSL2561	VL6180X	VL53L0X	VL53L1X	SI1145
Measuring principle	IR_LED, Photodiodes	Photodiodes	TOF / IR Laser Photodiode	TOF / IR Laser Photodiode	TOF / IR Laser Photodiode	IR-LED Photodiode
Motion sensor	no	no	no	no	no	no
Proximity sensor	yes	no	yes	yes	yes	yes
- absolute (m/mm)	no	n.a.	yes	yes	yes	no
Range	30 cm	n.a.	< 20 cm	up to 200 cm	up to 400 cm	< 60 cm
Ambient light sensor	yes	yes	yes	no	no	yes
- IR	no	yes	no	no	no	no
- UV	no	no	no	no	no	extrapol.
- absolute (Lux)	no	yes	yes	no	no	yes
Gesture	yes	no	no	no	no	no
Color	yes	no	no	no	no	no

Category	Sensor / Module					
	HC-SR04	JSN-SR04T	BH1750	AP3216	HC-SR501	RCWL-0516
Measuring principle	Ultrasound	Ultrasound	Photodiode	Photodiodes / IR-LED	IR-Photodiodes	Mikrowave / Doppler effect
Motion sensor	no	no	no	no	yes	yes
Proximity sensor	yes	yes	no	yes	no	no
- absolute (m/mm)	yes	yes	no	no	no	no
Range	ca. 400	ca. 400 cm	n.a.	30 cm	up to 7 m	up to 5-7 m
Ambient light sensor	no	no	yes	yes	no	no
- IR	no	no	no	yes	no	no
- UV	no	no	no	no	no	no
- absolute (Lux)	no	no	yes	yes	no	no
Gesture	no	no	no	no	no	no
Color	no	no	no	no	no	no

([https://wolles-elektronikkiste.de/wp-content/uploads/2020/11/big\\_table.png](https://wolles-elektronikkiste.de/wp-content/uploads/2020/11/big_table.png))

The large sensor comparison



And here are the links to the posts:

- APDS-9960 (<https://wolles-elektronikkiste.de/en/apds-9960-the-all-rounder>)
- TSL2561 (<https://wolles-elektronikkiste.de/en/tsl2561-light-sensor-module>)
- VL6180X (<https://wolles-elektronikkiste.de/en/vl6180x-tof-proximity-and-ambient-light-sensor>)
- VL53L0X, VL53L1X (<https://wolles-elektronikkiste.de/en/vl53l0x-and-vl53l1x-tof-distance-sensors>)
- SI1145 (<https://wolles-elektronikkiste.de/en/si1145-als-ir-uv-und-ps-sensor>)
- HC-SR04, JSN-SR04T (<https://wolles-elektronikkiste.de/en/hc-sr04-and-jsn-sr04t-2-0-distance-sensors>)
- BH1750 (FVI) (<https://wolles-elektronikkiste.de/en/bh1750fvi-gy-30-302-ambient-light-sensor>)
- AP3216 (<https://wolles-elektronikkiste.de/en/ap3216-cjmcu-3216-ambient-light-and-proximity-sensor>)
- HC-SR501 (<https://wolles-elektronikkiste.de/en/hc-sr501-pir-bewegungsmelder-2>)
- RCWL-0516 (<https://wolles-elektronikkiste.de/en/rcwl-0516-microwave-radar-motion-detector>)

A little hint before we start. There is another addendum to this series. It's about how to build an IR proximity sensor yourself. You can find the article here (<https://wolles-elektronikkiste.de/en/ir-proximity-sensor-how-to-build-it-yourself>).

## Sensor comparison – (visible) ambient light



([https://wolles-elektronikkiste.de/wp-content/uploads/2020/11/light\\_sensors.png](https://wolles-elektronikkiste.de/wp-content/uploads/2020/11/light_sensors.png))

Sensor comparison visible light: APDS-9960, BH1750, TSL2561, AP3216, VL6180X, SI1145

## The problem of lux measurements

The sensor modules shown above use photodiodes to measure the luminous intensity. To achieve this, the sensors measure the photo voltage or the photo current, digitize the measured value and save it to a data register, where you can read by I2C. The size of the measured value depends, among other things, on the amplification factors, the sensitivity of the photodiode and the measurement time (usually referred to as integration time). Except for the APDS-9960, the sensors there are formulas to calculate an absolute value in lux from the bare reading.

However, the following factors complicate the lux calculation:

1. Common light sources have a more or less large, invisible infrared (IR) content. To some extent, the photodiodes are sensitive to this radiation, which results in too high readings.
2. The photodiodes do not have a constant sensitivity over the entire visible light spectrum. However, different light sources have different spectra. This results in



different measured values for the same luminous intensity depending on the sensor.

Most sensors have a separate IR photodiode with which the measured value of the visible light can be corrected. However, the IR spectra of different light sources are also different. This results in the same problem as with visible light (point 2).

## An experiment with commercial luxmeters

I would like to come back to the example from my last post, (<https://wolles-elektronikkiste.de/en/sil145-als-ir-uv-und-ps-sensor>) which illustrates how different lux measurements can be with different light sources (excuse all those who are reading this for the second time!).

Many commercially available luxmeters are calibrated for incandescent light, which is hardly to be found anymore. With the two luxmeters shown below, I have determined good matching results for incandescent light. What happens in natural outdoor light with overcast sky, you can see here:



(<https://wolles-elektronikkiste.de/wp-content/uploads/2019/11/Luxmeter.jpg>)

Measurement with luxmeters with overcast sky: 5200 vs. 7255 Lux

## Sensor comparison – series of experiments with light sensors

I used the two luxmeters and the light sensors to take measurements of incandescent light, halogen lamp light and LED light. I did not include the APDS-9960 because it does not provide values in Lux. I tried to align the sensors at the same distance and angle to the respective light source. My experimental setup certainly does not meet any scientific requirements. But I repeated some values and the variation was less than five percent – good enough for me. Here's the result:

Light source	Results in Lux (upper row) / percent (bottom row)						
	Voltcraft Luxmeter	Urceri Luxmeter	SI1145	BH1750	TSL2561	VL6180X	AP3216
Halogen	345	300	360	370	230	240	230
	100	87	104	107	67	70	67
Light bulb (incandescent)	1380	1350	1350	1300	750	770	880
	100	98	98	94	54	56	64
LED	480	610	600	480	500	390	430
	100	127	125	100	104	81	90

([https://wolles-elektronikkiste.de/wp-content/uploads/2020/11/light\\_sensor\\_test.png](https://wolles-elektronikkiste.de/wp-content/uploads/2020/11/light_sensor_test.png))

Sensor comparison: Lux values for different light sources

I was very surprised by the results. On the one hand, the variation is very high, on the other hand, due to the special spectrum of LED light, I would have expected a higher deviation from sensor to sensor than with the incandescent light. It is difficult to say

what are right or wrong values. The only reliable value is the one from the Voltcraft luxmeter at incandescent light, as it has been calibrated accordingly. At least under these conditions, the SI1145 and BH1750 deliver very good results.

Overall a bit sobering, isn't it? I must therefore conclude that exact lux measurements represent a certain challenge. If you require exact results, you can't help but adjust the calculation parameters to the light sources using calibrated measuring devices or light sources.

## Sensor Comparison – Distance (Proximity)

This sensor family can be divided into two groups:

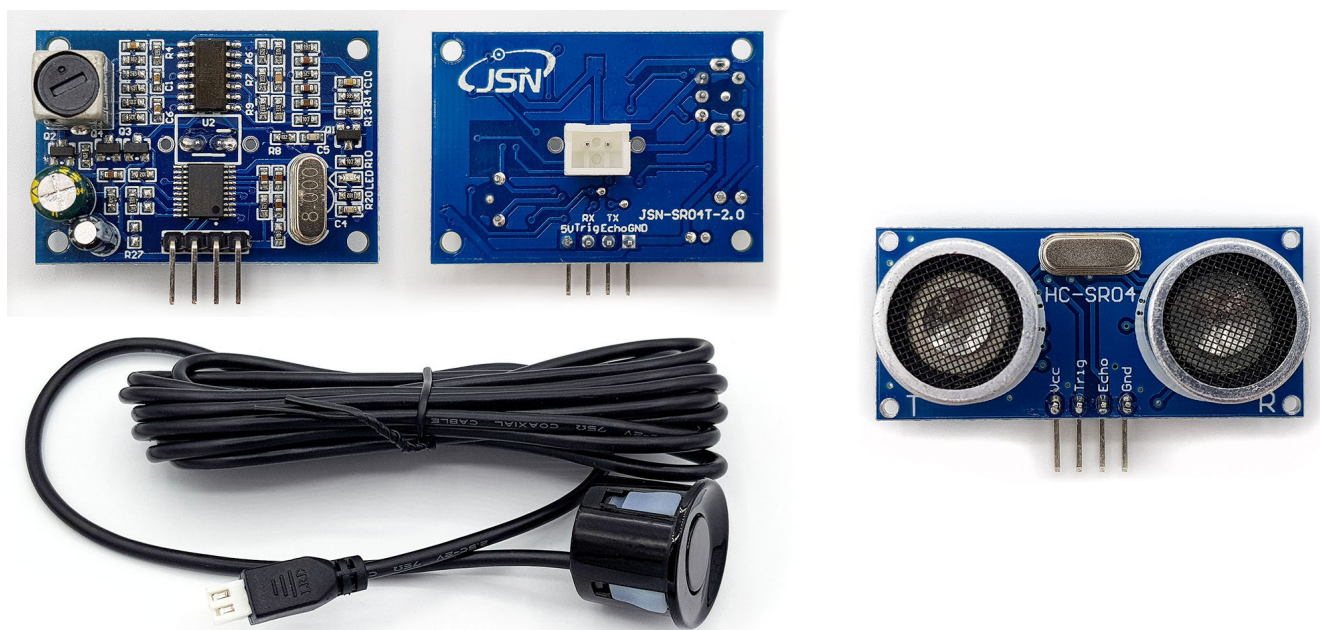
- Group 1 provides distances in absolute values, e.g. centimeters
  - these are real distance sensors
- Group 2 returns dimensionless values
  - are often referred to as proximity sensors

Of course, any distance sensor can also be used as a motion sensor, but not the other way around. That's why I treat the motion sensors separately.

### “Real” distance sensors

Distance sensors emit ultrasonic or infrared light signals. If objects are in the detection range, the signals they reflect are detected by the sensor. The distance is calculated over the time and the speed of sound or light. With the light-based sensors, I am still very impressed that a component which costs few euros can detect such extremely short times.

#### Ultrasonic distance sensors



(<https://wolles-elektronikkiste.de/wp-content/uploads/2019/11/Ultraschallsensoren.jpg>)

JSN-SR04T (left) and HC-SR04 (right)

The classic distance sensor is the HC-SR04. There is hardly an introductory book about Arduino & Co. in which this sensor is not mentioned. An interesting variant is the JSN-SR04T, as the actual sensor is waterproof and can be flexibly installed due to its small size.

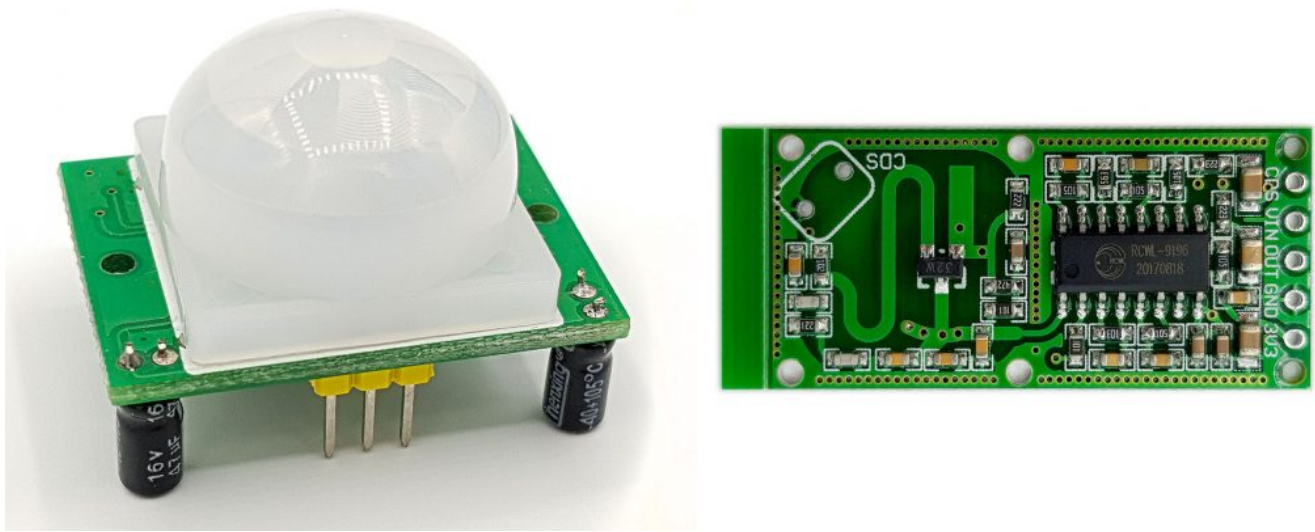
The ultrasonic distance sensors provide surprisingly accurate values. However, I find it difficult to specify an exact error because the accuracy of a measurement depends on the size and geometry of the object to be captured. In addition, the results depend on whether influences on the speed of sound such as temperature and humidity are considered in the calculation.

#### Time of Flight Distance Sensors





# Sensor Comparison – Motion



(<https://wolles-elektronikkiste.de/wp-content/uploads/2019/11/Bewegungsmelder.jpg>)

Sensor comparison: HC-SR501 and RCWL0516

Pure motion sensors indicate when motion occurs within their detection range. On the other hand, they cannot measure the distance to the object.

The classic among motion sensors is the HC-SR501. Its measuring principle is based on the pyroelectric effect. This causes the electric potential of a pyroelectric crystal to change with temperature. The temperature change is generated by the infrared radiation of warm bodies (people or animals) in the detection area. I described this in more detail in my post (<https://wolles-elektronikkiste.de/en/hc-sr501-pir-bewegungsmelder-2>) about this component.

The measurement principle of the RCWL0516 could not be more different. The module emits microwaves that are reflected by all objects in the detection area. If the object moves in the direction of or away from the sensor, there is a very low frequency shift (Doppler effect) that the RCWL0516 detects. Everyone knows the phenomenon from sound effects. The siren of an approaching ambulance or police car sounds higher than when the car is moving away.

Despite the different measuring principle, both motion detectors have many similarities:

- The range is up to about 7 meters, whereby the RCWL0516 from 5 meters becomes a little less reliable.
- both can be regulated in terms of their range
- both have an output pin that turns HIGH when a signal is detected
- in both, the length of the HIGH phase can be adjusted
- in both, you can set whether another motion during the HIGH phase extends the signal or it is ignored

A big difference is that you can make the settings on the HC-SR501 comfortably with jumpers and potentiometers. With the RCWL0516, on the other hand, you have to solder. A nice feature of the RCWL0516 is that you can attach a photo resistor (LDR) to deactivate the motion alert in daylight.

## Sensor Comparison – Gestures and Color

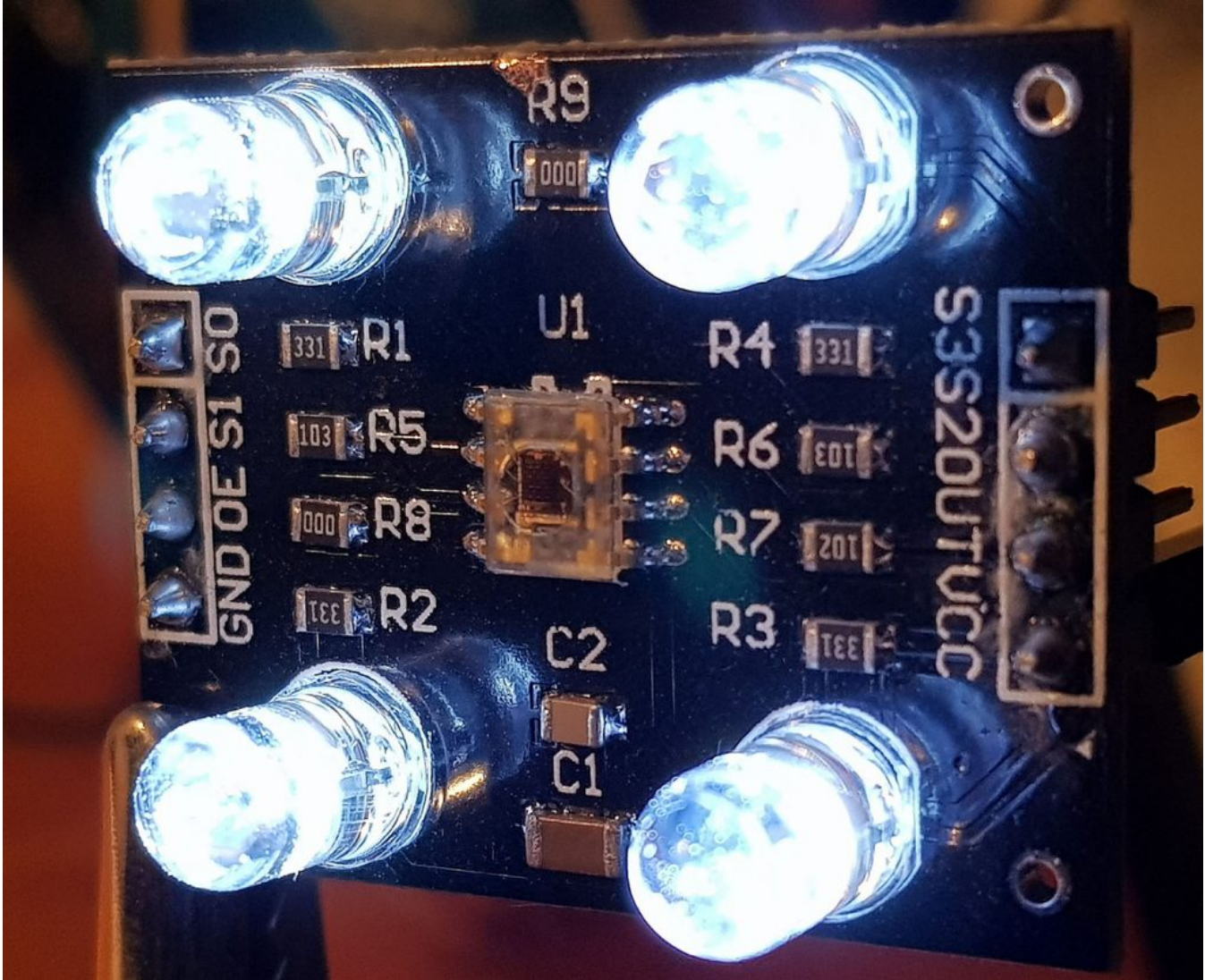
Gestures, of course, don't have much to do with color. I only summarize the two because among the sensors discussed, only the APDS-9960 has these two features.

For those who take it exactly: all proximity and distance sensors can detect one-dimensional gestures, namely “approaching” and “moving away”. But I leave this simple form of gesture detection aside. The APDS-9960, however, has four directed photodiodes and can therefore also detect left-right and up-down movements. This makes it possible to realize very nice things, such as switching on and off lamps by moving your hands.

Color recognition works via photodiodes with appropriate color filters. As a measurement result, you get an RGB value. One should not expect too much of it, but a pure red, green or blue are clearly distinguished from each other.

If you only need the color detection function, the TCS230/TCS3200, which I did not discuss in my series, might be eligible for you:





(<https://wolles-elektronikkiste.de/wp-content/uploads/2019/11/Farbsensor.jpg>)

TCS230 / TCS 3200 Color Sensor

## Acknowledgement

Once again I used a drawn male by Peggy and Marco Lachmann-Anke ([https://pixabay.com/de/users/3D\\_Maennchen-1553824/?utm\\_source=link-attribution&utm\\_medium=referral&utm\\_campaign=image&utm\\_content=1026424](https://pixabay.com/de/users/3D_Maennchen-1553824/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=1026424)) from Pixabay ([https://pixabay.com/de/?utm\\_source=link-attribution&utm\\_medium=referral&utm\\_campaign=image&utm\\_content=1026424](https://pixabay.com/de/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=1026424)) for the post picture.

Posted in [Distance, light, movement](https://wolles-elektronikkiste.de/en/category/sensors/distance-light-movement) (<https://wolles-elektronikkiste.de/en/category/sensors/distance-light-movement>), [Sensors](https://wolles-elektronikkiste.de/en/category/sensors) (<https://wolles-elektronikkiste.de/en/category/sensors>). Tagged [color detection](https://wolles-elektronikkiste.de/en/tag/color-detection) (<https://wolles-elektronikkiste.de/en/tag/color-detection>), [gesture detection](https://wolles-elektronikkiste.de/en/tag/gesture-detection-en) (<https://wolles-elektronikkiste.de/en/tag/gesture-detection-en>), [Lux measurement](https://wolles-elektronikkiste.de/en/tag/lux-measurement) (<https://wolles-elektronikkiste.de/en/tag/lux-measurement>), [luxmeter](https://wolles-elektronikkiste.de/en/tag/luxmeter-en) (<https://wolles-elektronikkiste.de/en/tag/luxmeter-en>), [motion sensors](https://wolles-elektronikkiste.de/en/tag/motion-sensors) (<https://wolles-elektronikkiste.de/en/tag/motion-sensors>), [proximity sensors](https://wolles-elektronikkiste.de/en/tag/proximity-sensors) (<https://wolles-elektronikkiste.de/en/tag/proximity-sensors>), [sensor comparison](https://wolles-elektronikkiste.de/en/tag/sensor-comparison) (<https://wolles-elektronikkiste.de/en/tag/sensor-comparison>), [Time of Flight](https://wolles-elektronikkiste.de/en/tag/time-of-flight-en) (<https://wolles-elektronikkiste.de/en/tag/time-of-flight-en>), [ultrasound](https://wolles-elektronikkiste.de/en/tag/ultrasound) (<https://wolles-elektronikkiste.de/en/tag/ultrasound>).

← [Sil145 ALS, IR, UV and PS sensor](https://wolles-elektronikkiste.de/en/sil145-als-ir-uv-und-ps-sensor) (<https://wolles-elektronikkiste.de/en/sil145-als-ir-uv-und-ps-sensor>) [IR proximity sensor – how to build it yourself](https://wolles-elektronikkiste.de/en/ir-proximity-sensor-how-to-build-it-yourself) → (<https://wolles-elektronikkiste.de/en/ir-proximity-sensor-how-to-build-it-yourself>)

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