Comparison

SMT50 vs. VH400

Overview:

The SMT50 (www.truebner.de) and the VH400 (www.vegetronix.com) both are low cost soil moisture sensors which are widely used in consumer applications such as irrigation control.

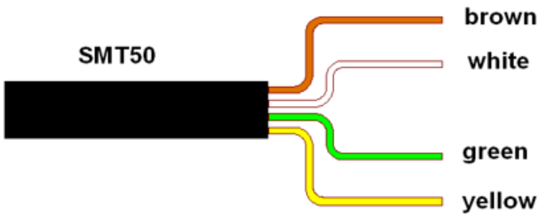
Both sensors are FDR (Frequency Domain Response) sensors and are based on a capacitive measurement principle. The sensors generate an alternating electric field around their electrodes which penetrates the surrounding soil. The higher the volumetric water content of the soil, the higher is the permittivity (dielectric constant) of the soil and thus the resulting total capacitance of the probe.

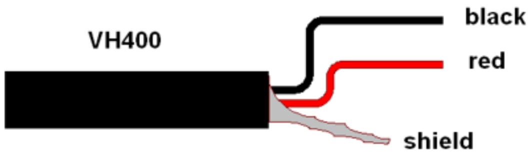
However, there are many differences between the sensors. This paper compares both sensors and explains the technical differences in detail.

Comparison of Technical Data:

	SMT50	VH400
		
supply voltage range	3.3 to 30 VDC	3.5 to 20 VDC
power consumption (measured at 12 VDC)	2,7 mA	13 mA
power on to output stable	300 ms	400 ms
standard cable length	10 m	2 m
cable material	polyurethane (PUR)	polyvinylchloride (PVC)
electrode length	95 mm	95 mm
electrode width	21.5 mm	7 mm
suited for 24V systems	✓	✗
compatible to 3.3 V systems such as ARDUINO	✓	✗
unshielded cable can be used	✓	✗
internal temperature drift compensation	✓	✗
integrated soil temperature sensor	✓	✗
symmetric measurement field around sensor	✓	✗
linear output signal for vol. water content	✓	✗

Wiring:

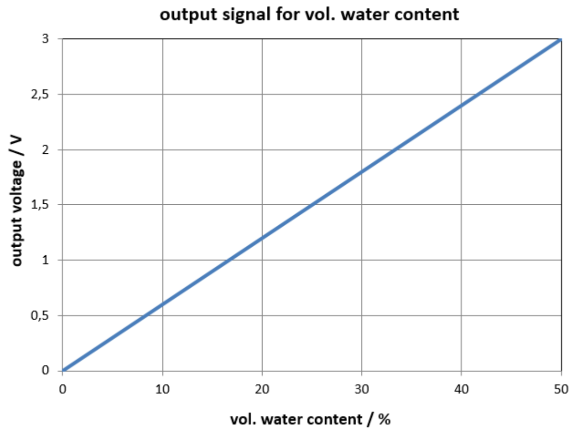
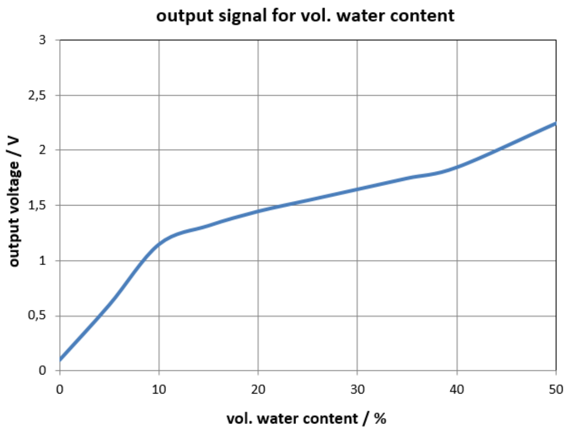
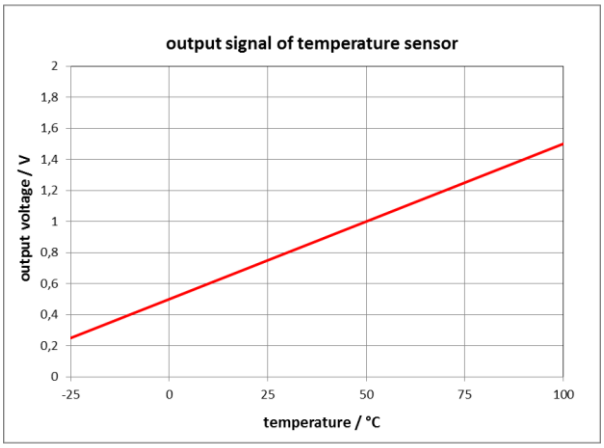




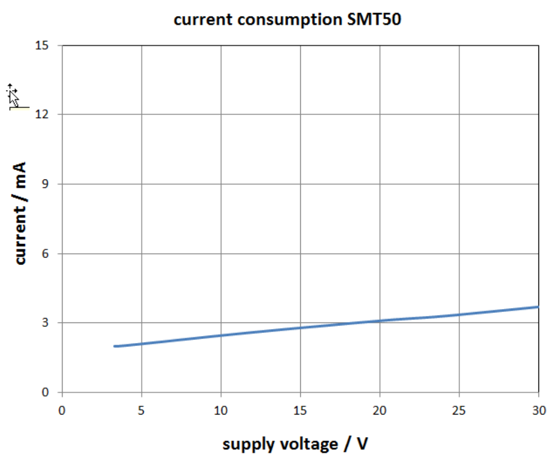
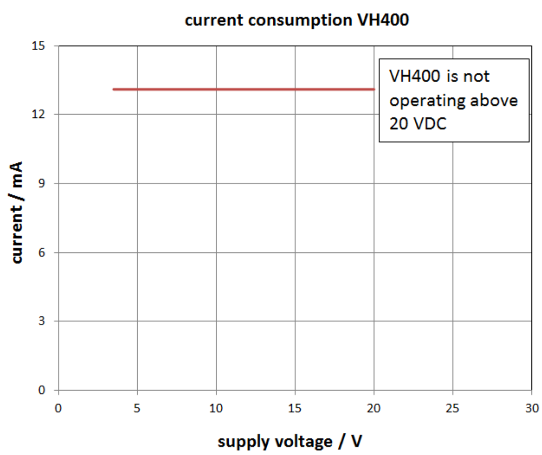
brown	**+ Vcc (3.3 to 30 VDC)**
white	**Ground**
green	**temperature output 0 – 3 V linear**
yellow	**vol. water content output 0 – 3 V linear**

red	**+ Vcc (3.5 to 20 VDC)**
shield*	**Ground**
black	**vol. water content output 0 – 3 V nonlinear**
*** cable must be shielded for VH400**	

Output characteristics:

SMT50	VH400
	
	
	**no temperature measurement**

Power consumption:

SMT50	VH400
	

Measurement Volume and Sensitivity

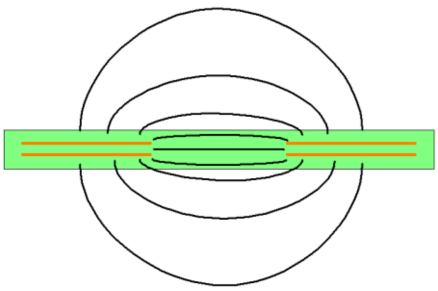
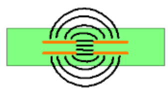
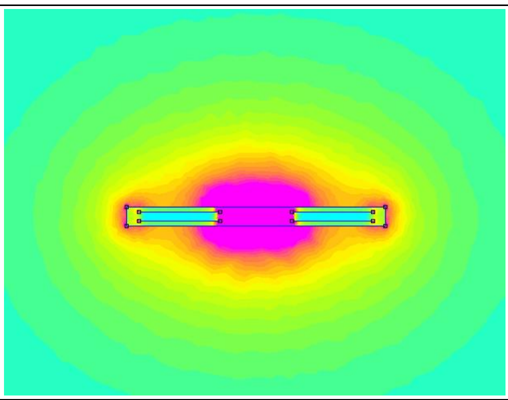
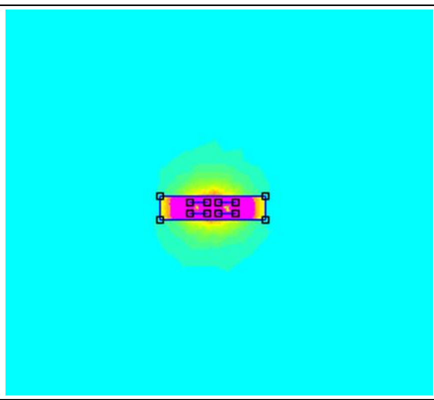
Both sensors are based on a capacitive measurement principle. Two electrodes form a capacitor. A part of the electric field between the electrodes is penetrating the surrounding soil. The total capacitance of the electrodes depends on the water content of the soil. The electronic circuit measures the capacitance value of the electrodes and computes the corresponding soil water content.

However, the sensitivity of the sensor towards water and the measurement volume of the sensor depend on the geometry of the electrodes (size, shape and distance).

In the table below is a model of both sensors which shows the cross sectional view of the electrodes. The electrodes are copper areas within the green PCBs. The SMT50 has larger electrodes and a wider distance between the electrodes which results in a large electric fringing field and an excellent sensitivity towards water in the soil.

The VH400 has small electrodes very close to each other. The major part of the generated fringing field remains inside the green PCB and therefore reduces the sensitivity towards water in the soil. Only water which is very close to the surface of the VH400 can be measured. Especially in granular materials this is a limitation of the sensor.

Both sensors have been simulated in detail. The calculated electric field pattern is shown below the models in the table. The resulting larger measurement volume of the SMT50 makes the sensor less sensitive to inhomogeneities of the soil.

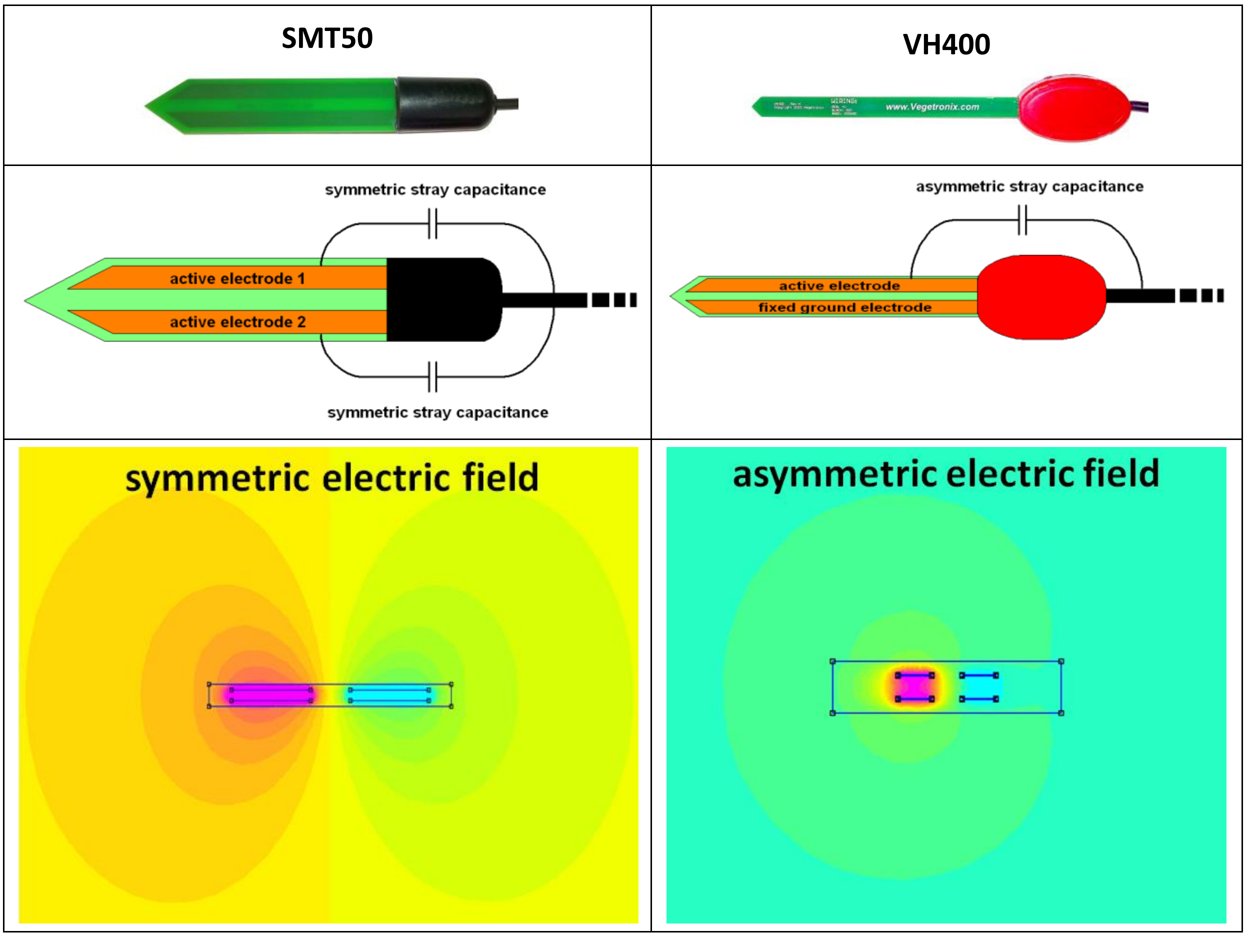
SMT50	**VH400**
	
	
	

Measurement Signal Analysis

Both sensors excite an alternating electric field which changes its polarity at a very high frequency. However, there is a difference between the SMT50 and the VH400 in the way the electrodes are configured.

The SMT50 is a completely balanced sensor which excites a symmetric electric field. Both electrodes are used as active measurement electrodes and both electrodes are internally evaluated by the electronic circuit. This ensures a symmetric measurement volume around the sensor. In addition any side effects such as stray capacitance completely cancel out due to the balanced measurement principle. For this reason it is possible to use an unshielded cable without introducing any errors in the measurement signal.

The VH400 is an unbalanced sensor which only uses one of the two electrodes for generating the electric field. The second electrode is internally fixed to ground potential. For this reason the resulting measurement volume of the sensor is not symmetric. In addition all stray capacitances of the electrode towards ground influence the measurement result of the sensor. This can be seen when the sensor VH400 is put into soil and the cable is touched or moved. The required shielding of the cable reduces the side effects but cannot fully suppress measurement errors. It is not possible to use unshielded cables with the VH400.



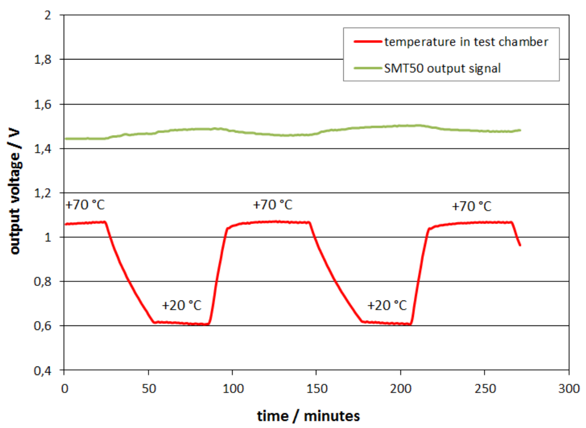
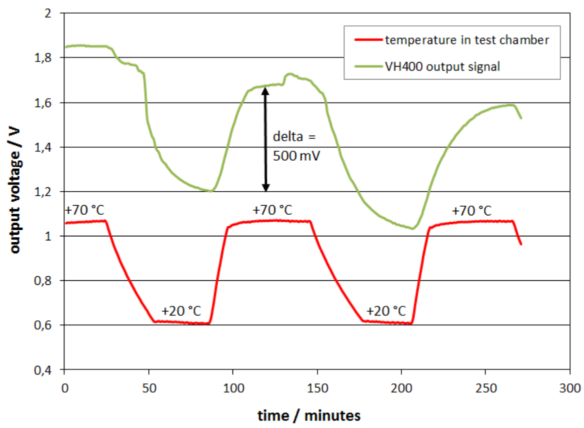
Temperature Drift

All electronic circuits are affected by ambient temperature drift. For this reason a stable electronic sensor circuit should internally be compensated for the temperature effects.

The microcontroller inside the SMT50 measures the ambient temperature and uses a smart compensation algorithm which leads to a very stable sensor with minimized drift of the output signal.

The VH400 uses no built-in temperature sensor and does not compensate for temperature drift effects. The result is a very large influence of the ambient temperature to the measurement signal.

Both sensors have been tested inside a temperature chamber which cycled the ambient temperature between 20 °C and 70°C.

SMT50	VH400
	
	

Output Signal Analysis

Both sensors use a high frequency measurement signal which penetrates the soil. The measurement signal should be kept inside the sensor and is not allowed to spread across the power cord. Therefore the electronic circuit of the sensor must be designed in such a way, that either the measurement signal is blocked from traveling along the power cord or the measurement signal excitation must be designed in such a way that all effects cancel out.

The SMT50 uses a symmetric signal excitation with bipolar signals. Due to the symmetric shape of both electrodes and the balanced circuit the measurement signals are kept inside the sensor circuit. The sensor output line does not show any ripple caused by the high frequency measurement signal.

The VH400 uses a unipolar and asymmetric electrode configuration. For this reason a strong voltage signal ripple can be seen on the sensor output line. The ripple cannot be measured with a standard multimeter but can easily be visualized by using an oscilloscope. The ripple has a high frequency (80 MHz) and spreads along the cable with an amplitude of approximately 100 mV.

SMT50	VH400