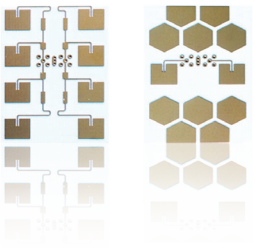
InnoSenT

SMR-3x3 Application Note V1.1

Version 1.1 - 13.07.2020

relevant for **SMR-3x3**



DESCRIPTION

Pulsed Operation of SMR

This Application Note provides some information on how to operate the SMR module in a low current mode, which is especially useful in battery powered applications.

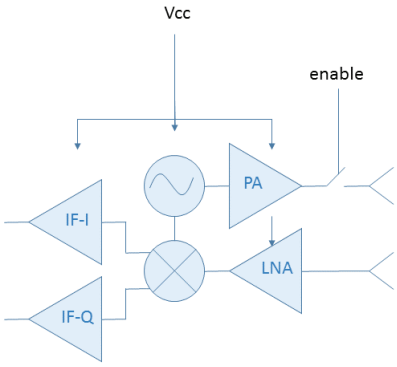


Fig 1.Simplified Block Diagram of SMR-3xy:

The SMR module is equipped with a power control input.

"enable" (Pin 5) switches the RF-power, but has no impact on current consumption. For continuous operation "enable" can be normally left open.

If power consumption is an issue – as it is in battery powered systems – the sensor module can be operated intermittently with a very low duty cycle, bringing down the average current consumption to a few microamps. This requires an external switching transistor (e.g. a P-Channel MOSFET) to interrupt the power supply and external sample and hold circuits, if additional amplifiers are required.

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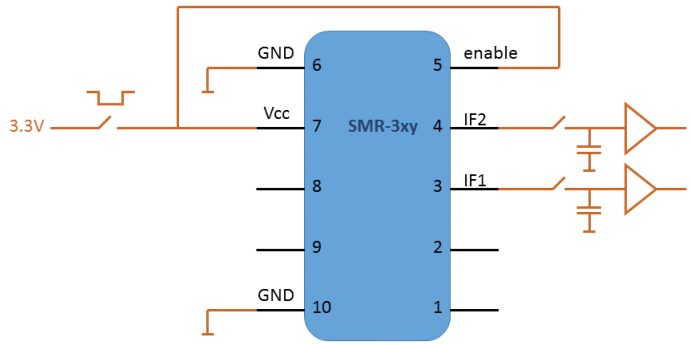

Fig 2. External circuitry for pulsed operation:

Period and pulse length of the pulse-signal, which needs to be applied to the switching transistor, depend on the application and the required current reduction.

The pulse frequency should be at least twice the highest doppler frequency to be measured (Nyquist criterion), the pulse length is recommended to be 2µs or longer.

As an example, monitoring pedestrians with a maximum speed of 10km/h requires a sampling frequency of 2*10 * 44Hz = 880Hz which is a period of 1.13ms. The current consumption of the module is 47mA as a typical value. In order to reduce the average current to 100µA a pulse length of 2.4µs must be chosen.

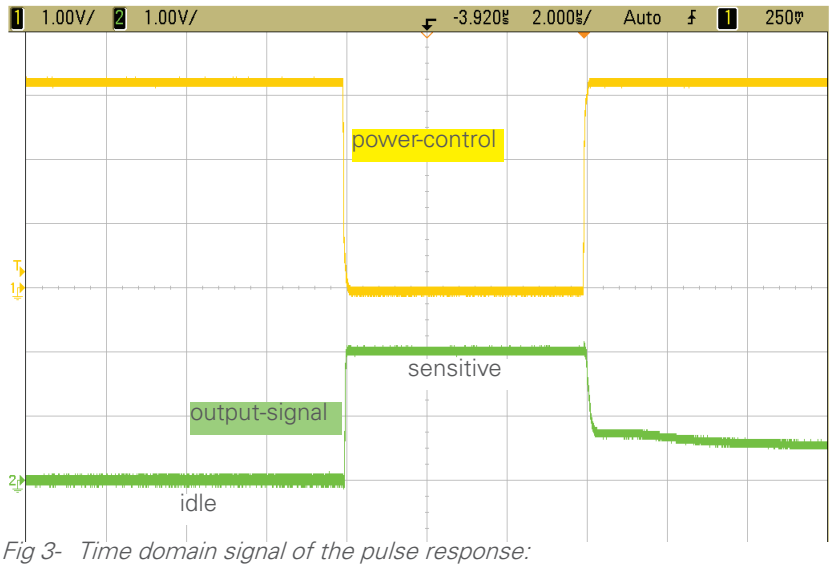

Fig 3- Time domain signal of the pulse response:

The oscillogram Fig 3 shows the power control signal in yellow, which is active low, and the response of the output signal (I or Q) in green. The output signal follows immediately, the sensor is ready for reception within less than 1 µs.

Sampling of the output signal should be done close to the end of the pulse to ensure best possible settling.

It is not recommended to leave "enable" unconnected in pulsed mode, because this could cause unpredictable transitions or delays.

"enable", Pin5, can be directly connected to Vcc, the switched supply voltage, as shown in Fig 2, but an even more sophisticated procedure would be using an additional clock signal with appropriate time shift in order to turn the RF-power on after applying the supply voltage for the module and turn it off before disabling the supply. This provides a cleaner and narrower spectrum.

An exemplary timing diagram is shown in Fig 4:

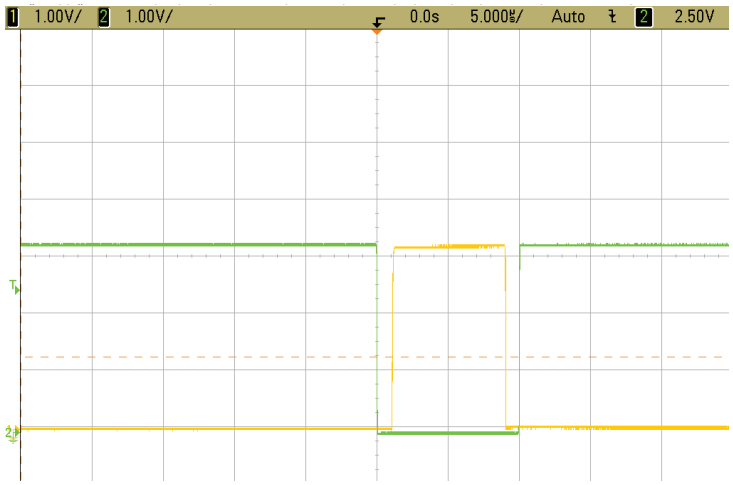

Fig 4. "power control" (green) and "enable"(yellow)

"enable" (yellow) is switched on 1µ after enabling the supply (green) and switched off 1µs before shutting down the device.

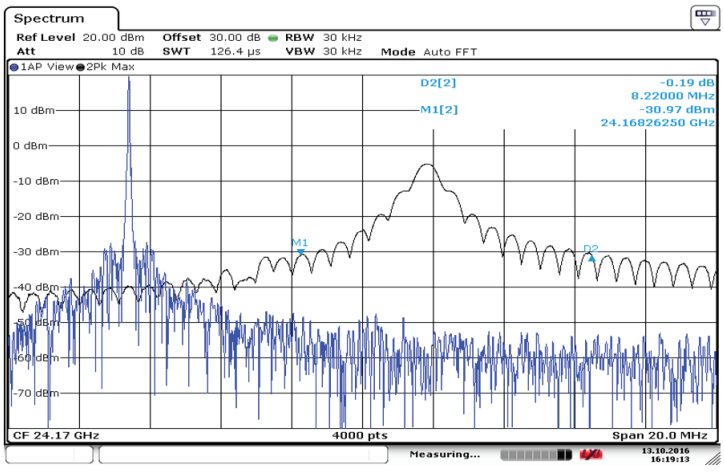

Fig 5. Spectrum of continuous and pulsed signal:

The spectrogram Fig 5 shows the spectrum of the continuously operated SMR in blue and the pulse spectrum in black. The frequency is shifted to a slightly higher value, which is due to thermal effects. The energy is spread over frequency, which lowers the average power. The above measurement was taken in 30kHz measurement bandwidth as recommended in the European standard EN 300440.

If an external amplifier is used for IF-I and IF-Q, which is usually the case, and the SMR shall be operated in a pulsed condition, sampling circuits must be used directly at the outputs of the module. Otherwise the signal would be protracted and strongly attenuated, because the settling times of the IF filters and OP-amps are usually much longer than the pulse duration.

Since the OP-amps need to be operated continuously, special low power types must be chosen.

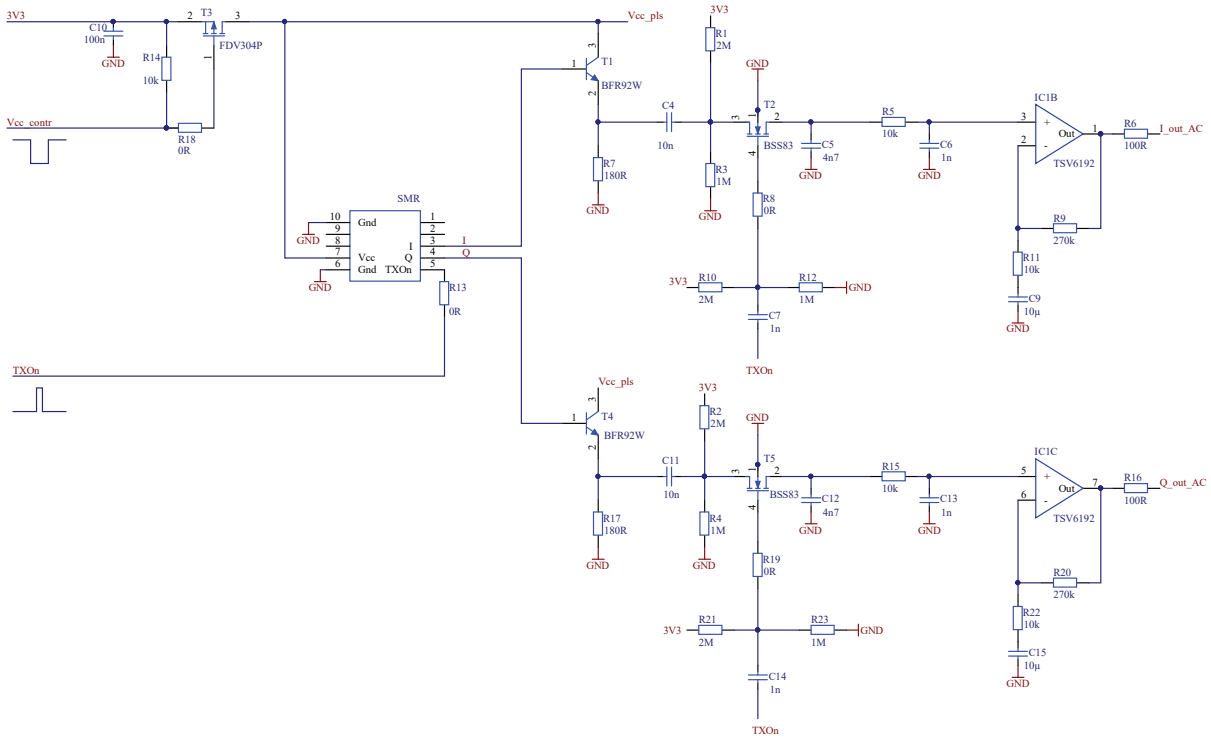

Fig 6. SMR with pulse- and sampling circuit:

Fig6 shows an example for a circuit including sample and hold amplifiers, which has been successfully used in combination with SMR-modules.

Additional OP-amp stages may be added if necessary. The switching transistors T2/T5 need to be N-channel MOSFETs or J-FETs with a low cutoff voltage and low reverse transfer capacitance. Emitter followers T1/T4 are used to further enhance isolation. They are also supplied by the switched power Vcc_pls and therefore do not contribute significantly to the average current.

The "TX_ON"-signal is also used as a sampling pulse.

Noise considerations:

The benefit of low current consumption is achieved unfortunately not for free.

In order to form the short pulses the receiver must provide a high signal bandwidth, but also provides broadband noise at its output, which is sampled with a low rate. The additional noise which is generated by the aliasing effect can be estimated by

$$\Delta N = 10 \cdot \log \frac{t_s}{t_p}$$

while tp is the pulse length and ts is the time between two successive pulses. The increase of noise is therefore proportional to the duty cycle.

If a reduction of current by a factor 100 is desired, the degradation of S/N would be as high as 20dB.

On top of that additional noise must be tolerated because low power Op-amps usually do not have low noise performance.

VERSION	DATE	COMMENT
1.0	18.11.2016	initial release
1.1	13.07.2020	new picture, new layout