Honeywell

SET/RESET PULSE CIRCUITS FOR MAGNETIC SENSORS

AN-201

Honeywell's line of magnetoresistive permalloy sensors are sensitive to magnetic fields less than 100 µgauss in a ±2 gauss range. In order to achieve this high resolution, the magnetic transducer must first be "set" for maximum sensitivity. This can be achieved by using Honeywell's unique on-chip current strap to set/reset the permalloy film. This technique is also referred to as flipping the film magnetization and does not require external coils. Several methods for implementing a set/reset pulse circuit are described in this application note.

During manufacture, the easy axis (preferred direction of magnetic field) is set to one direction along the length of the film. This allows the maximum change in resistance for an applied field within the permalloy film. However, the influence of a strong magnetic field (more than 10 gauss) along the easy axis could upset, or flip, the polarity of film magnetization, thus changing the sensor characteristics. Following such an upset field, a strong restoring magnetic field must be applied momentarily to restore, or set, the sensor characteristics. This effect will be referred to as applying a set pulse or reset pulse. Polarity of the bridge output signal depends upon the direction of this internal film magnetization and is symmetric about the zero field output.

Honeywell has a patented on-chip current strap for performing this re-magnetization, or flipping, electrically in the sensor application. These straps eliminate the need for bulky external coils. The flipping may be performed manually as required, such as detecting an over-range field condition, or automatically at various time intervals depending upon the application. One option is to drive a single set (or reset) pulse upon power-up or whenever a field over-range condition has passed. A second option is to alternate the sensor output polarity for each measurement in a "flipping" fashion. That is, drive a set pulse, take a reading then drive a reset pulse and take a second reading. Subtracting the two readings will eliminate any temperature induced drift and electronics offsets. This works because the polarity of the sensor output is reversed, and the offsets associated with sensor and signal conditioning electronics is not, and may be synchronously canceled out, giving an output proportional to absolute field. Because offset of the signal conditioning circuitry is eliminated, lower cost electronic components can be used, and fine offset trimming of the sensor may be eliminated.

There are many ways to design the set/reset pulsing circuit, though, budgets and ultimate field resolution will determine which approach will be best for a given application. The first thing to note is that a set and reset pulse have the same effect on the sensor. The only difference is that the sensor output signal changes sign. In order to completely set, or reset, the permalloy film, a current pulse of 3-4 amps is required. This is a very fast process and only requires a 1 µsec current pulse to flip. For the circuits in this applications note the pulse width will be about 2 µsec. This pulse width has a direct effect on the overall power consumption and can be shortened, or done less often, with care. The only requirement is that a single pulse only drives in one direction. If a +4 amp pulse is used to "set" the sensor, the pulse decay should not drop below zero current. Any undershoot of the current pulse will tend to "un-set" the sensor and the sensitivity will not be optimum.

The magnitude of the set/reset current pulse depends on the magnetic noise sensitivity of the system. If the minimum detectable field for a given application is roughly 500 µgauss, then a 3 amp pulse (min) is adequate. If the minimum detectable field is less than 100 µgauss, then a 4 amp pulse (min) is required.

The set/reset straps on the Honeywell magnetic sensors are labeled S/R+ and S/R-. There is no polarity implied since this is simply a metal strap resistance of typically 1.5Ω per sensor. Therefore, for a three axis system, the total series strap resistance is typically 4.5Ω.

If three axis are used, it is recommended that the straps are connected in series to insure the same current pulse flows through all three sensors. Assuming the pulse drive circuitry has a source impedance of 0.5Ω, the set/reset current pulse will effectively drive a 5Ω load. Now to generate a 3-4 amp minimum pulse into a 5Ω load requires a 15-20V supply.

The circuit in Fig. 1 was originally intended for a flash memory programming supply, but it can be easily adapted to the set/reset circuits used throughout this application note. To generate a 20 volt supply in a 5 volt system requires an SO-8 packaged device, a couple Schottky diodes and six caps. The no load operating current is 185 µA (typ) and in shutdown mode is 0.5µA (typ). This circuit is from the Maxim data book.

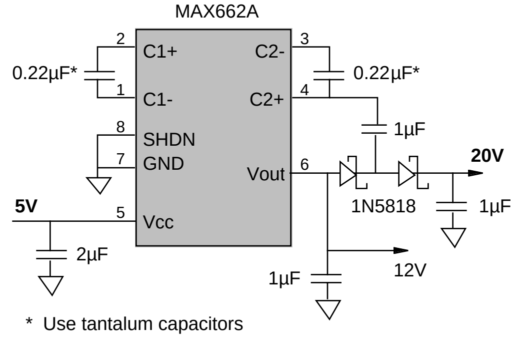

Figure 1 - 5V to 20V Converter

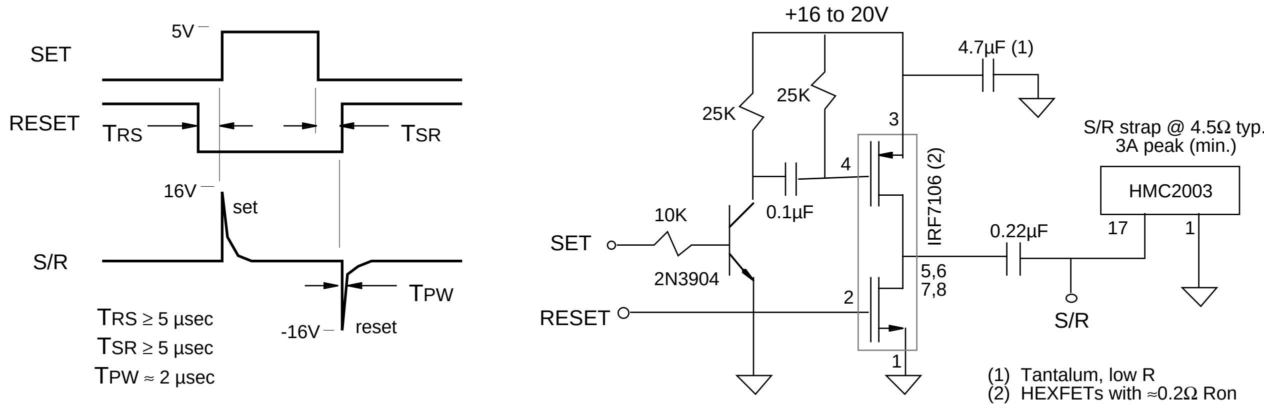

Figure 2 - Set/Reset Pulse With Microprocessor Control

The circuit in Fig. 2 generates a strong set/reset pulse (>4 Amp) under microprocessor control. The SET and RESET signals are generated from a microprocessor and control the P and N channel HEXFET drivers (IRF7106). The purpose of creating the T_{RS} and the T_{SR} delays are to make sure that one HEXFET is off before the other one turns on. Basically, a break-before-make switching pattern. The current pulse is drawn from the 4.7 µF capacitor. If the 5V to 20V converter is used as shown in Fig. 1, then the resultant noise and droop on the 16-20V supply is not an issue. But if the 16-20V supply is used elsewhere in the system, then a series dropping resistor (≈500Ω) should be placed between the 4.7µF capacitor and the supply.

If a microprocessor is not available to create the switching signals, some form of clock is needed to trigger the set and reset pulses (see Fig. 3). The circuit shown in Fig. 4 can be used to create a strong (>4Amp) pulse. The diodes, resistors, capacitors and inverters basically create the T_{RS} and the T_{SR} delays. Now a single signal (Clock) can trigger a set or reset pulse. The minimum timing between the rising and falling edges of Clock are determined by the 25KΩ and 1nF time constant. That is, the minimum high and low time for Clock is ≈25 µs.

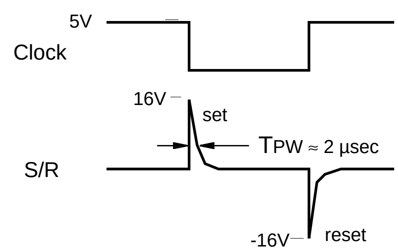

Figure 3 - Single Clock Set/Reset Timing

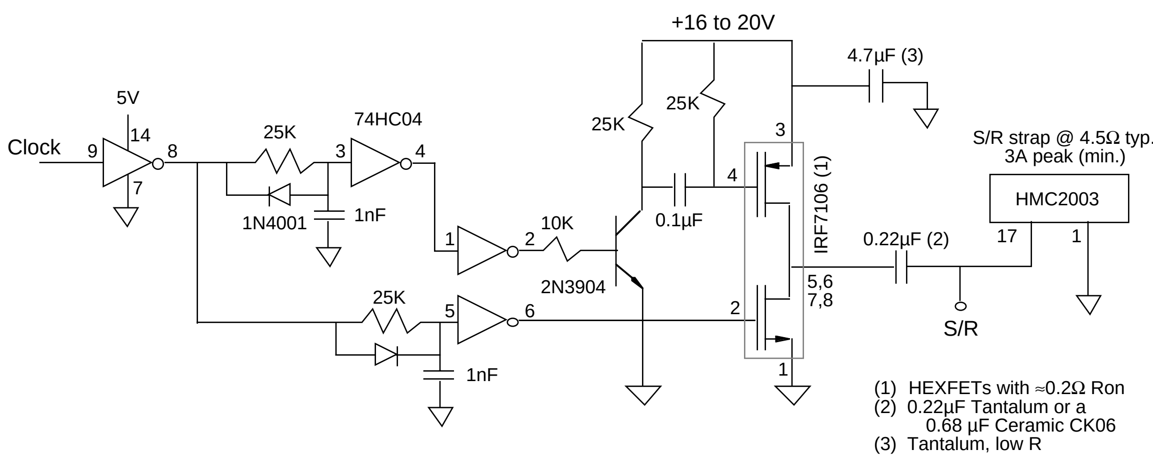

Figure 4 - Single Clock Set/Reset Pulse Circuit

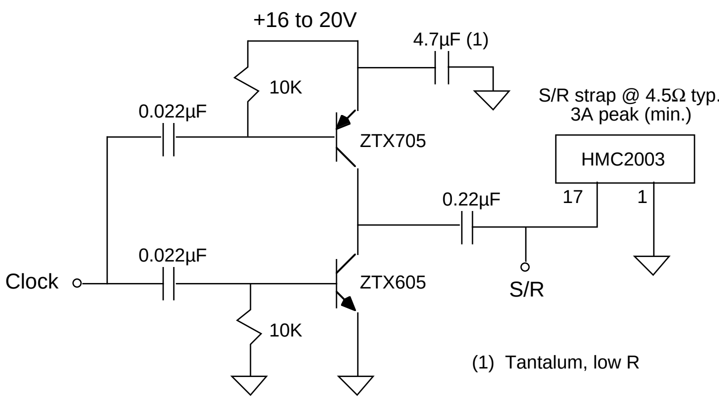

Figure 5 - Single Clock Set/Reset Circuit

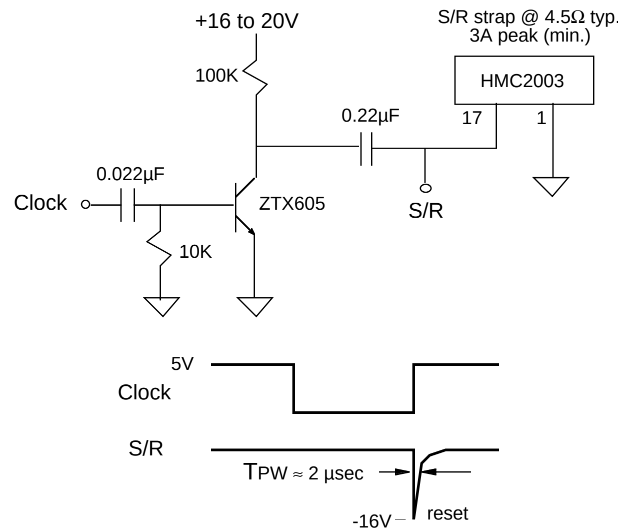

Figure 6 - Single Clock Reset Only Circuit

When measuring 100 µgauss resolution or less, the permalloy film must be completely set, or reset, to insure low noise and repeatable measurements. A current pulse of 4 amps, or more, for just a couple microseconds will ensure this. The circuits in Figures 2 and 4 are recommended for applications that require low noise and high sensitivity magnetic readings.

For minimum field measurements above 500 µgauss, a less elaborate pulsing circuit can be used. In both Figures 5 and 6, the pulse signal is switched using lower cost darlington transistors and fewer components. This circuit may have a more limited temperature range depending on the quality of transistors selected. If accuracy is not an issue and cost is, then the reset only circuit in Fig. 6 will work.

For any magnetic sensor application, if temperature drift is not an issue, then the reset pulse need only be occasionally applied. This will save power and enable the use of digital filtering techniques. Circumstances for a reset pulse would be 1) power on or, 2) field over/under range condition. Any other time the sensor should perform normally.

Customer Support

Customer Service Representative
(612) 954-2888 fax: (612) 954-2582
E-Mail: clr@mn14.ssec.honeywell.com