FLUXGATE WORLD subsystems

AN-3

APPLICATION NOTE 3

EXCITATION AND SENSE METHODS FOR RING FLUXGATE MAGNETOMETERS

The release of the Evaluation System 1 (EVS-1) by Autonnic Research Ltd in 2004 marked an important milestone in publication of best practice of Circuit Design for these old magnetic devices.

A summary of the EVS-1 findings are as follows:

Excitation:

- It is imperative that the device is operated under near short-circuit conditions and with carefully controlled rates of change of both current and voltage so as to eliminate parasitic resonances.

- Fabrication asymmetries are cancelled by the use of an equal number of Clockwise and Anti-clockwise saturation/desaturation events. The direction refers to the circular field in the ring core.

Sense:

- Offsets due to amplifier input offset, switch charge-injection and asymmetric flux leakage from the excitation field can be cancelled. This is done by taking a second reading after inverting the sense windings and then subtracting from the first so that an input common to both is not from the sensed field.

- The signal path must be shared between all sense axis windings.

This Application Note is the result of more careful and patient studies which have lead to and understanding resulting in simplifications to those original circuits with the benefit of improved simplicity and a reduction of cost and board space. The simplifications come with no loss of precision.

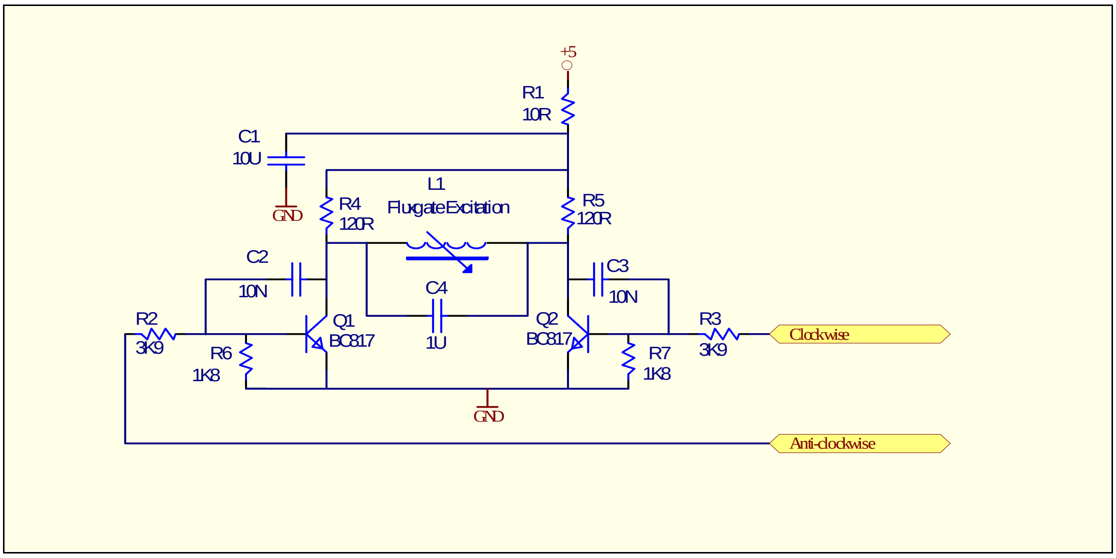

Fig 1 Excitation Circuit Diagram

Fig 1 shows the complete excitation circuit. The inputs, Clockwise and Anti-clockwise are connected to a 5v micro-controller output port pins. The circuit is entirely symmetrical so that there is no difference in the timing nor current values whether operated clockwise or anti-clockwise.

The most significant feature is the large Miller capacitance of C2 (or C3). By adding 10nF to the collector-base junction in series with R2 (or R3) the output moves at a precisely controlled rate of change of voltage. Rate of change of current is simultaneously controlled by the series resistance R4 (or R5) and the large 1µF ceramic capacitor directly across the excitation winding.

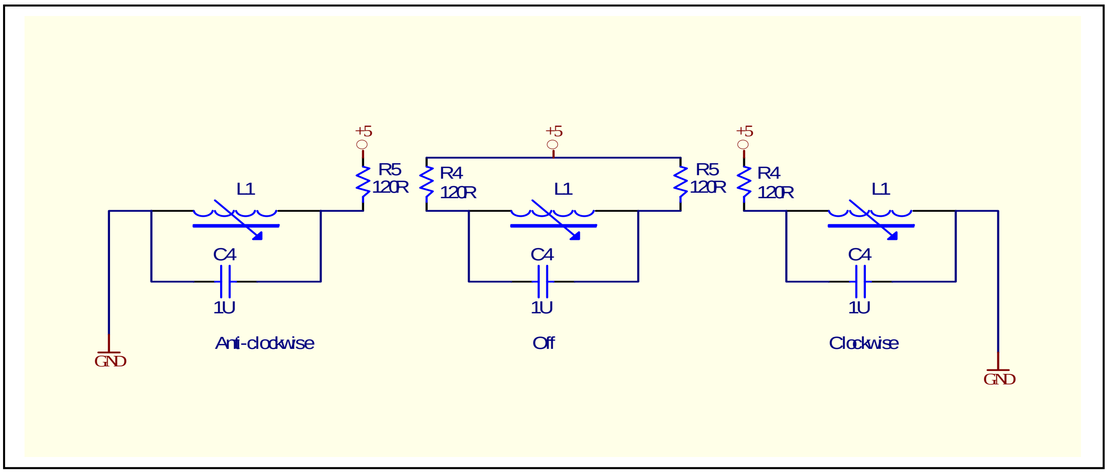

Fig 2 Excitation States

Fig 2 summarises the three steady states. The symbol used to represent the inductor is one with an arrow to show that the value of inductance is variable. The whole point it to drive the core into saturation and to let its permeability return to its unexcited high value of around 100000 in well-controlled manner.

Clockwise ‘on’ and anti-clockwise ‘on’ states are obtained by the build-up of current through the 120R resistors. The series resistance of the winding of about 20R means that the final current is 5/140 = 36mA. The discharge during the ‘off’ state takes place due to the voltage generated across the total resistance of 120+120+20 = 260R and is therefore more rapid.

To view the voltage across the winding it is essential to use a differential scope input and these waveforms are shown in Fig 3 together with the output from a current probe. The initial voltage is higher because of the initial high inductance which collapses as the core saturates but the 1µF across the winding prevents sudden changes of voltage.

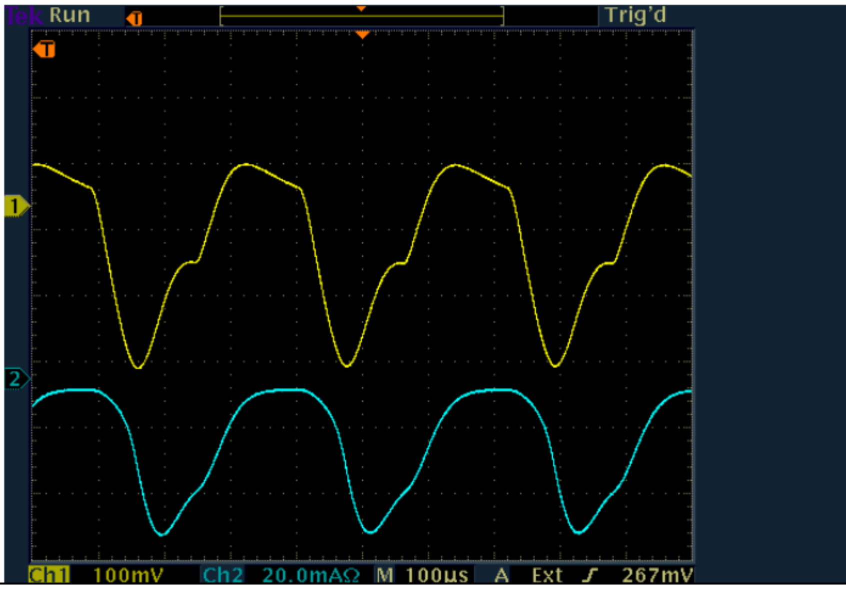

Fig 3 Voltage (upper) on and the current (lower) in the excitation winding.

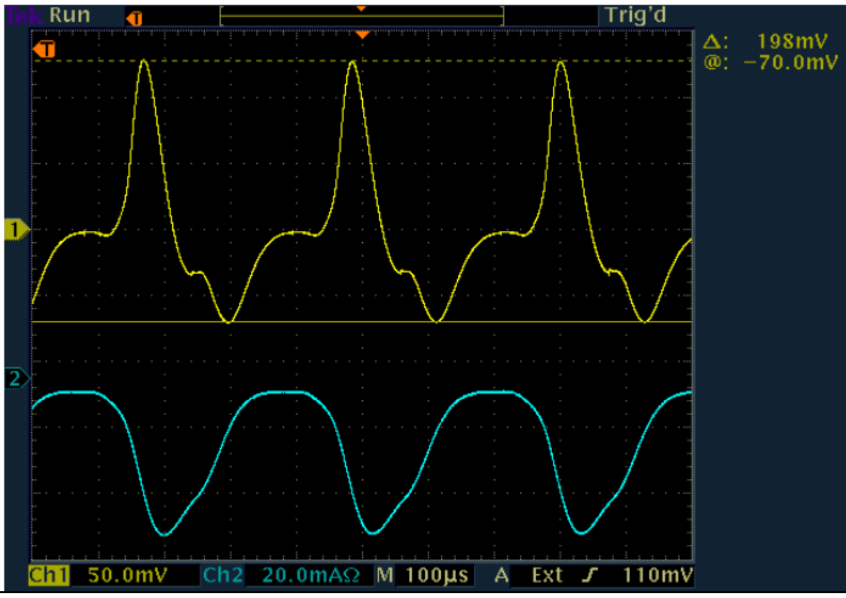

Fig 4 Sense voltage (upper) shown against excitation current (lower)

Sense Circuits

The Sense Circuits are shown in Fig 5

The timings can be taken from Figs 3 and 4

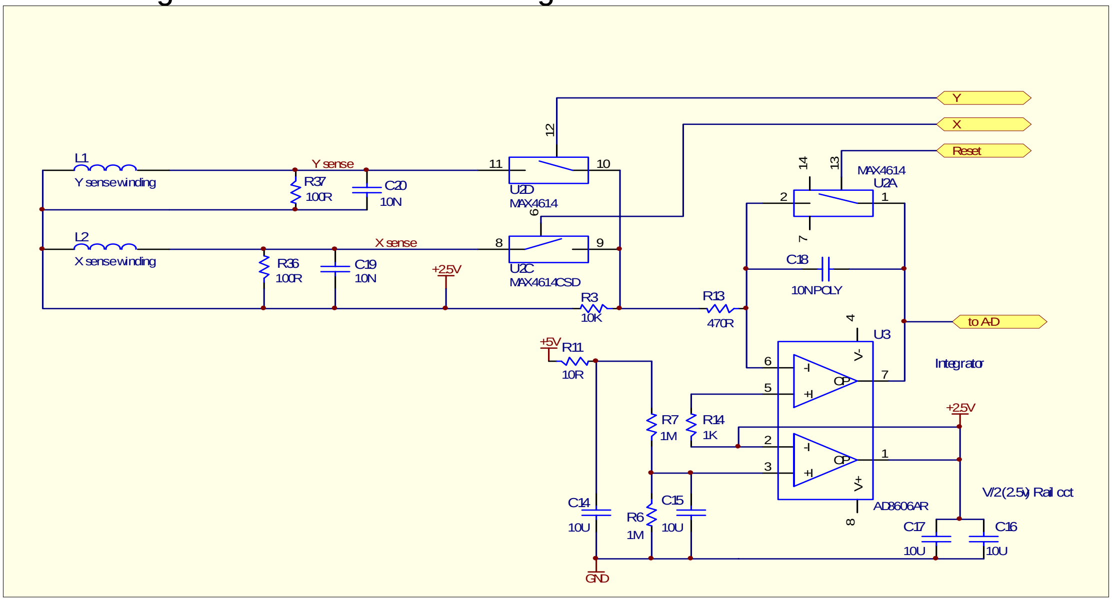

Fig 5 Sense Circuits

The component annotations and values are taken directly from the circuit of the Autonnic OEM Compass A4020 series.

Of particular note are the 100R resistors, R36 and R37, and the capacitors C19 and C20 directly across the sense windings. At no time must the windings be allowed to develop voltages which could induce unwanted signals. The resistors serve two purposes – to reduce the Q of any tuned circuit and to develop a current in a sense winding whenever a voltage is created in it. The current created by the return of the Earth's field creates an opposition to the return which slows the process down. The capacitors dominate any resonant transition and also further delay the rise in voltage so as to give ample time both for the switches to operate as well as a reduction in the rate of change of voltage on the integrator capacitor. The is beneficial as it reduces the demand on the amplifier for both output current and slew-rate.

The amplifier is chosen for its low offset, speed and current drive capability as it is required to charge the integrator capacitor. That capacitor, C18, is chosen for its low hysteresis dielectric.

An additional suggestion involves the timing and power requirements.

Best power arrangement is to provide a regulator for the excitation circuit and a separate one for the sense. If using the A-D inside the micro-controller then that second regulator also powers the controller and its serial communication and we recommend in that case that the fluxgate measurements are done between the communication events.

With the ARxx series of fluxgates and the component values shown in Fig 3, each measurement is a series of 10 excitations – 5 clockwise followed immediately by 5 anti-clockwise. The first of each of the 5 is not used to take a reading. The integrator input is operated only for the last 4 in the each group of 5. This is to allow the magnetic state of the core to the same for each integrator operation. The integrator output is finally therefore the sum of 8 events and a D-A conversion takes place. After which the reset switch is operated and the process repeated. For regions of the earth where the horizontal component of the field is weak, more readings can be taken so as to increase the input to the D-A.

Note that, despite the teachings of EVS-1, there is no sense winding bridge to reverse the signals. A simpler method is to perform a null reading from time to time. Initially and then, we suggest, every minute. This is exactly the same sequence of input gate operations – i.e. a total of 8 and with exactly the same timings but without operating the excitation windings. The D-A conversion is the total of errors due to amplifier offsets and switch charge-injection.

End
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REFERENCES

EVS-1
AR35 data sheet

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