

## A magnetic pick-up and release system for moving lightweight samples

Robotic sample handling systems often require some form of sample pickup and sample release mechanism. We describe here an arrangement based on a solenoid electromagnet found useful for transporting lightweight samples, such as cell holder/dish used in our irradiation system on an accelerator. We use linear stages to transport the cell dish, shown in Figure 1, between irradiation imaging and holding locations on our installation.

We use a three-point kinematic location mechanism, consisting of three steel spheres in the bottom of the dish holder. These spheres locate in three sets of parallel round cross-section rails, ensuring a very high degree of repeatability ( $<\pm 50$  nm) when samples are returned to one of the locations. A soft-iron keeper is used in conjunction with an electromagnet, which lifts and releases the dish when the linear stages drive the dish to the appropriate location.

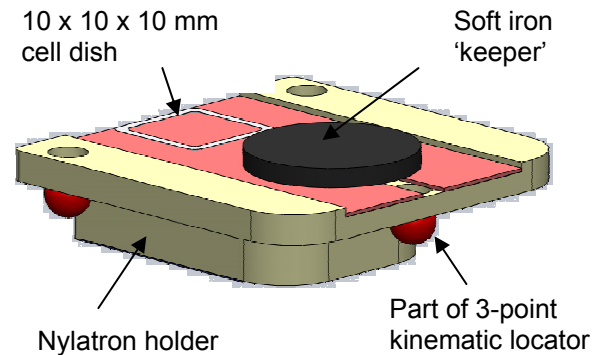


Figure 1: The cell dish holder.

We use a small 17 mm diameter electromagnet, available from Solentec Ltd (All Saints Industrial Estate, Shildon County, Durham, DL4 2RD, UK) to lift and release the holder.

The remanent magnetization of the keeper (and the solenoid magnet poles) is made to be as low as possible; however, it is not zero and it was found that a small coercive field was required to return the magnetisation of the keeper to close to zero following pick-up of the sample by energising the electromagnet. The low weight ( $<50$  grams) of the dish contributes to the need for this: gravity is just not strong enough to reliably separate the dish from the electromagnet when attempting to release it. Matters are made slightly worse by the fact that we wanted to reliably pick up the holder from a 1-2 mm height: the required solenoid current is then higher (greater 'move' up the B-H curve) and the remanence is also consequently higher.

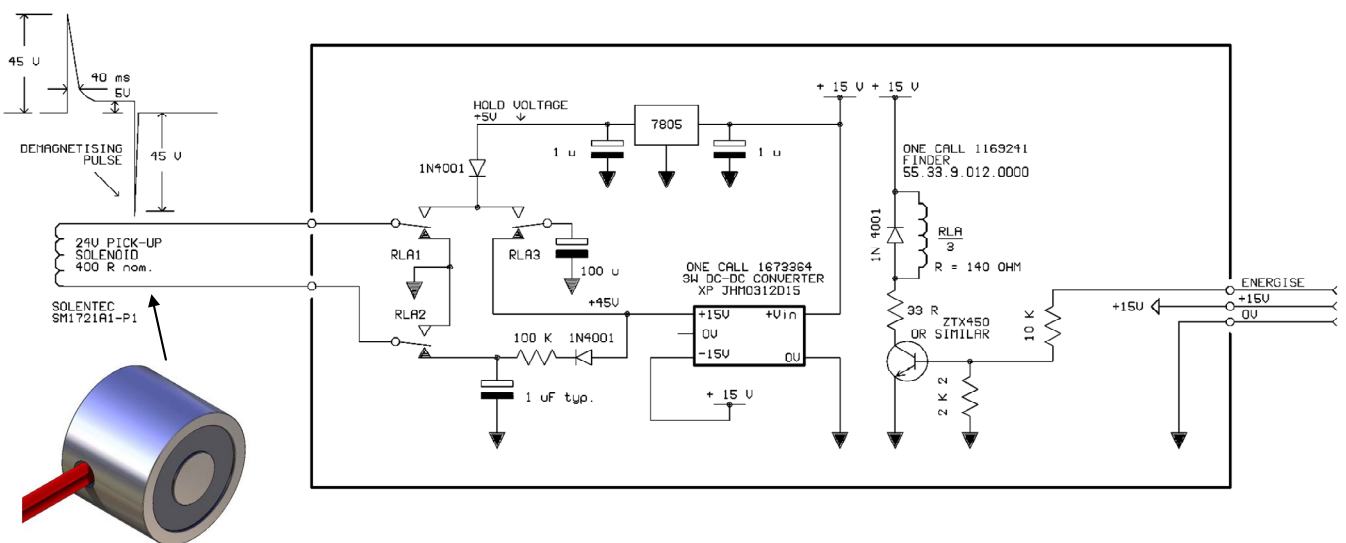


Figure 2: The solenoid (left) and the electromagnet driver and demagnetising circuit.

The circuit shown in Figure 2 was found useful to deal with this situation. A high (+45 V) voltage is applied to the electromagnet (rated at +24V nominal) for a very short time (a few tens of

milliseconds) after which a +5V holding voltage is applied. This sequence ensures reliable pick-up. When the sample is to be released, a high (-45V) negative voltage is applied to the electromagnet for a few hundred microseconds. This is high enough to ensure demagnetization, but this demagnetising pulse does not last long enough for the keeper to become magnetized again (in the opposite direction) and holding on to the sample. The actual voltages and time constants are of course dependent on the application and should be varied to suit: we determined our requirements empirically.

We implemented our circuit with a 3-pole electromagnetic relay: two poles (RLA1 and RLA2 in Figure 2) are used to reverse the electromagnet connections, while the third (RLA3 in Figure 2) is used to apply the +45V magnetising (pick-up) pulse. We use +15V to drive an isolated DC-DC converter circuit (delivering +30V, on top of the +15V) and a single transistor TTL input relay driver. The +45V charges both a 100  $\mu$ F electromagnet energizing capacitor and a 1  $\mu$ F capacitor used during de-energisation. A large resistor (100 k $\Omega$ ) in the demagnetizing circuit ensures that a minimal current flows through the electromagnet when in the quiescent (sample released or demagnetized) condition, i.e. when the relay is de-energised and the contacts are in the positions shown in Figure 2.

The use of an electromagnetic relay may be considered somewhat old-fashioned and there are doubtless more reliable and indeed efficient ways of achieving a similar operation, e.g. by using two push-pull drivers or a split supply H-bridge driver chip. However, in our situation, neither timing accuracy nor high repetition rates were particularly important. Although the response time of the relay is of the order of 15 ms, this is still much shorter than the sample pick-up time, typically 50 ms. We were fortunate to have almost all the components available in our 'box of spares' and this defined the design to some extent.

The specific electromagnet used (Solentec 1721A1-P1) was selected because of its particularly small dimensions, well matched to the cell dish holder. If larger electromagnets can be tolerated, they can be obtained either from the Solentec, or perhaps more readily from RS Components, 346-075 part number GHMX 025 X00 A01 or from Farnell 7200833, part number 58 - 0125 24.

We trust that this circuit or at least the principles behind it may be of interest to readers who have problems with electromagnet remanence

*B. Vojnovic and R.G. Newman were responsible respectively for design and construction of this arrangement. D. Martins and IDC Tullis devised the kinematic mount and electromagnet sample handling system and thanks are due to S Gilchrist for extensive testing and inclusion into the sample handling servo software system.*

*This document was prepared by B. Vojnovic in May 2011 and updated in August 2011 by RG Newman and D Martins.*

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