Development of Chopper Systems for ISIS Target Station 2

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Abstract

ISIS Target Station 2 (TS2) was constructed and became operational on 3/8/08. Seven new neutron beamlines where built, six of which had totally new chopper systems installed. This paper showcases some of the new developments for the chopper systems that have been designed, built and commissioned in-house by ISIS Engineers and Technicians for the those beamlines.

Chopper System

Figure 1 is a diagram showing the overall chopper system. It shows how the chopper, drive cabinet and chopper control system interact. The drive system supplies power to the motors of the choppers in order to run them at a multiple or sub-multiple of the ISIS neutron pulse frequency. The chopper timing system takes timing signals from the ISIS accelerator to create a drive pulse. This drive pulse is distributed to the Chopper controllers. The Chopper controller takes this pulse and a derived rotor pulse from the chopper's rotor pick-up and feeds them to the drive system, along with positional feedback from the chopper. These signals are required to synchronise the phase of the choppers with the ISIS accelerator. Monitoring of chopper temperature and cooling water flow rate is carried out for interlock purposes.

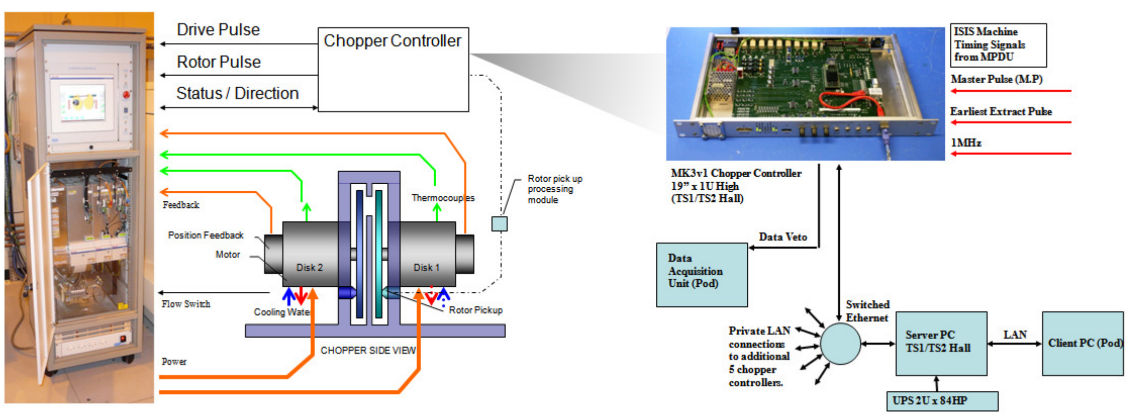

Figure 1 - Overview of Chopper System

Mechanical Development for the WISH Large Disc Choppers

Part of the development of choppers for TS2 involved designing large disc choppers for an Instrument called WISH (Wide angle In a Single Histogram). This instrument is a diffractometer with a glass guide measuring 40 metres long and elliptical in profile. At the two chopper positions the cross section of the neutron beam measures 77mm x 152mm and 83mm x 172mm. Figure 2 shows two isometric views of WISH Beamline.

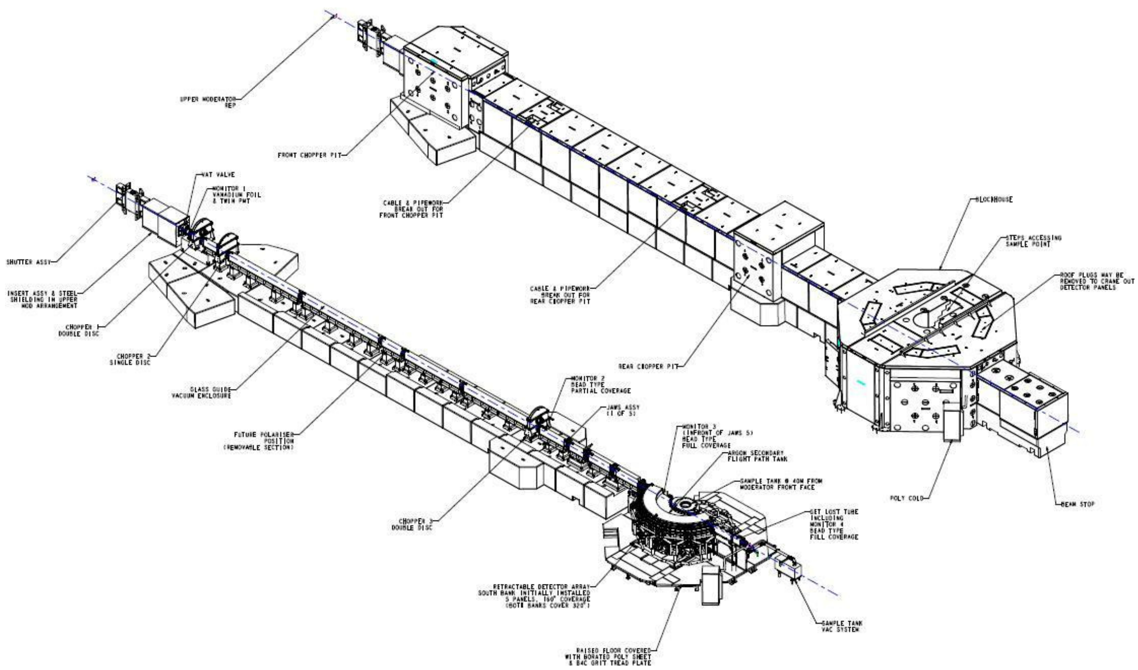

Figure 2 - Isometric Views of WISH Beamline

The cross section of the beam at the chopper positions is over three times larger than any other beam cross section within ISIS, the next largest being MERLIN instrument in Target Station 1, see figure 3. To accommodate the size of the beam and to giving adequate provision for balancing the discs led to a completely new design of chopper – the large disc chopper. The disc of the chopper measures 1.2 m in diameter and is made from aluminium. A standard ISIS disc is about 0.6 m in diameter. Figure 4 shows the large disc next to a standard ISIS disc. Figures 5 and 6 respectively show a model and photo of the large disc chopper. Careful consideration had to be given to the machining of the discs in order to obtain tight tolerances and to avoid warping the disc. The angle openings have been precisely machined (±0.125 degrees) and equate to a variation of 34.7µs for a disc spinning at 20 Hz. The

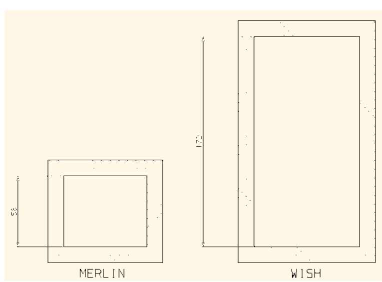

Figure 3 - MERLIN and WISH Beamlines compared

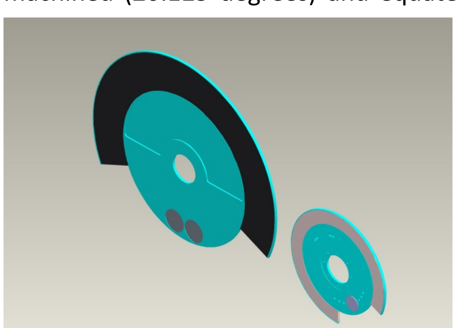

Figure 4 - WISH and Standard ISIS Disc Comparison

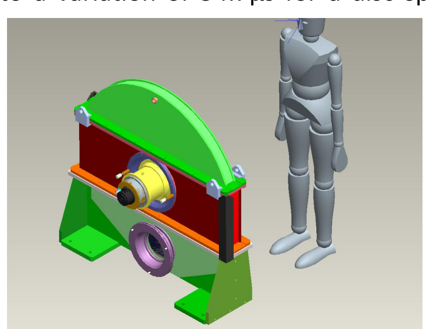

Figure 5 - Model of Large Disc Chopper

Figure 6 - Photo of Large Disc Chopper

beam blocking portion of the chopper disc has been coated in Boron 10 (^{10}B)which involved electro spraying a suspension of ^{10}B. The WISH beamline would benefit by having choppers that operate in a vacuum so the design has been carried out with this potential upgrade in mind. The choppers on WISH as well as all the other beamlines have been fitted with a condition monitoring system to allow technicians to carry out fully predictive maintenance. This allows recognition of early wear of parts and also means that unnecessary maintenance is not carried out. Fully predictive maintenance aids in reducing lost beam time and reducing exposure to radiation in chopper pits.

Drive Systems

The IndraDrive cabinet is the latest drive cabinet produced by ISIS. Figures 7, 8 and 9 are pictures of the predecessors and the IndraDrive.

Figure 7, 8 and 9 - Cortina Drive, Diax04 and IndraDrive

Some of the Cortina drives are over 20 years old. The original 30 kW systems are large and cumbersome and the reliability has deteriorated as time has gone on. The next generation of drive cabinets produced for use in ISIS was the Diax04 Indramat drive (Diax04). These drives were designed in-house, were PLC driven and had a user interface to monitor status information at the cabinet. They also had the advantage of being more compact, modular and fitted inside a 19 inch rack. The move to the IndraDrive system was prompted by several things. New features were desired for the chopper systems, and the drive units for the Diax04 were becoming obsolete. The new IndraDrive cabinets have increased reliability over the Diax04 and Cortina drives, and parts are more readily available. The drive cabinet employs a user interface which is user friendly when compared with older systems; it has a touch screen, which enables the user interface to be designed intuitively. Figure 10 shows one page of the touch screen display. The drive cabinet also features over-speed protection, independent control of the discs in double disc choppers and reduces phase errors (±1μs at 10Hz). The reduction of phase errors has been obtained by a combination of eliminating the drive belt and the new

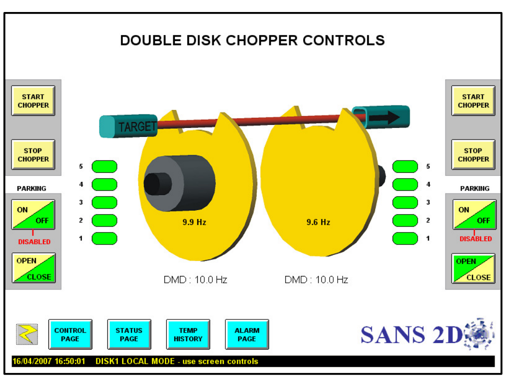

Figure 10 - Touch Screen Display on the IndraDrive

drive system. See figure 11 showing the jitter from a Diax04 belt driven T-zero chopper and an IndraDrive direct drive T-zero chopper running at 5Hz. The Diax04 shows a jitter of ±80µs while the IndraDrive shows ±2µs.

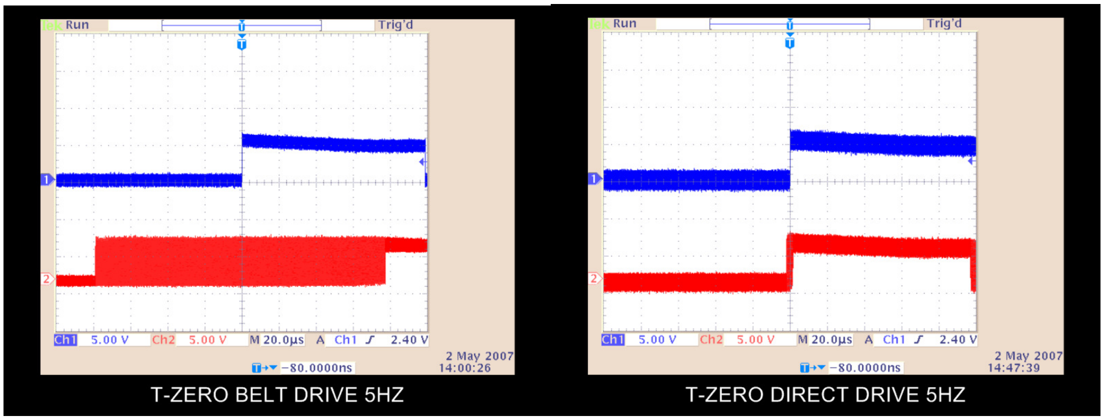

Figure 11 - T-Zero Belt-Driven Indramat Drive and T-Zero Direct Drive IndraDrive Chopper Phase Error Comparison

Chopper Controllers

The chopper controllers have been upgraded as part of the Target Station 2 build. The new Mark 3 controllers have several benefits over the old Mark 2 version 2 systems. The new system is smaller - 1U rather than 3U. It can be accessed remotely via Ethernet and can accept the timing signal via fibre optic. See figures 12 and 13 for pictures of the chopper controllers.

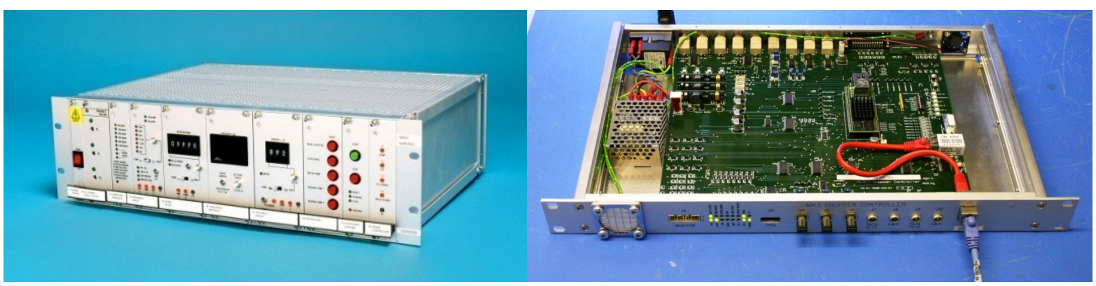

Figure 12 and 13 - Mark 2 Version 2 and Mark 3 Chopper Controllers

Timing Systems

The ISIS machine produces a 50Hz pulse of protons. Target Station 2 takes every fifth pulse (i.e. 10Hz). Figure 14 shows how the Ideal Extract Pulse signal is passed to the MPDU1 (Master Pulse Distribution Unit). At MPDU1 a master pulse (MP) is derived and passed to Target Station 2 (MPDU2) via an electrical optical converter. From there the signal is passed to the chopper controllers on the beamlines.

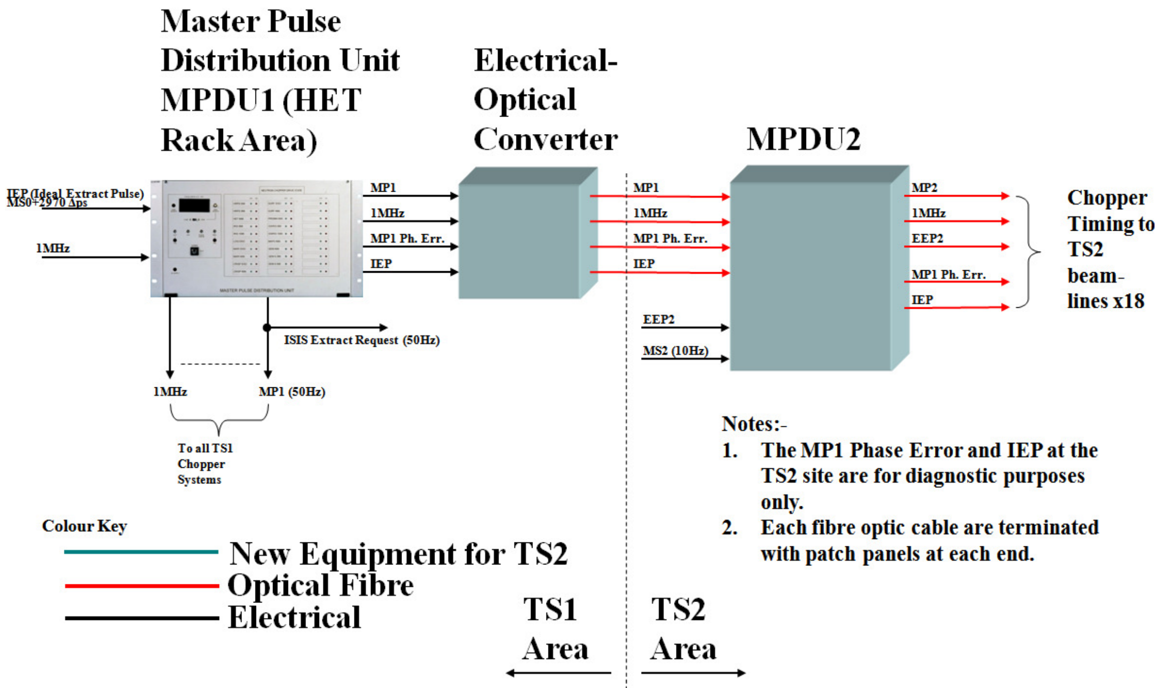

Figure 14 – Routing of Ideal Extract pulse to Target Station 2

Optical fibre has been used to transmit the signals from the MPDU to the chopper racks in order to reduce signal degradation over the long cabling distance, prevent common grounding problems associated with screened cables and to prevent any electrical noise pickup.

Figure 15 shows how the Master Pulse (MP2) is generated for timing of all TS2 chopper systems. During normal use, the main ISIS machine is triggered by an Extract Request signal. This is the same signal as the MPDU1 generated MP1 for Target Station 1. Target Station 2 only takes 1 in 5 of the pulses. It is therefore necessary to select the correct 1 in 5 MP1s for TS2 chopper timing. This is achieved by taking the existing MP1 and gating it with a stretched version of the MS2 pulse to give MP2

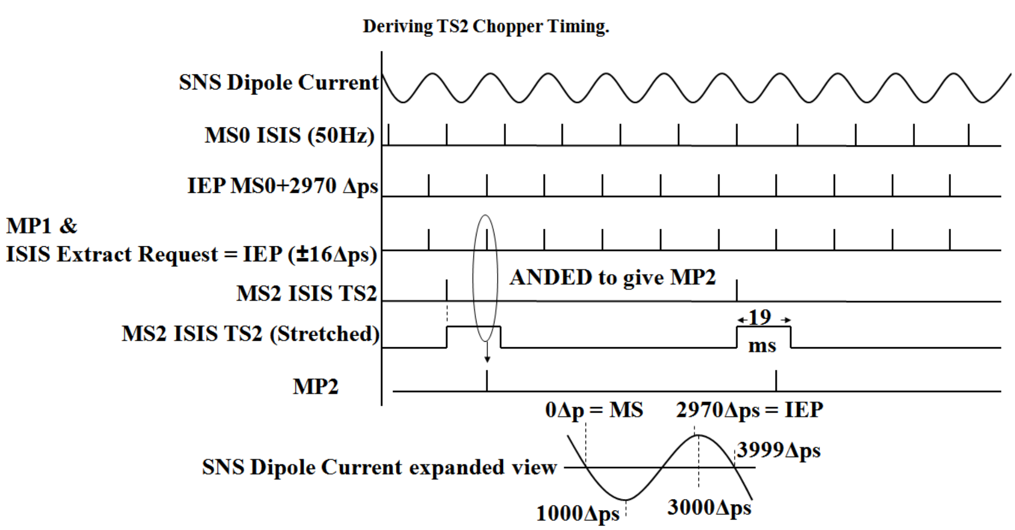

Figure 15 - Chopper Timing Derivation