TUPPC090

Digital Control System of High Extensibility for KAGRA

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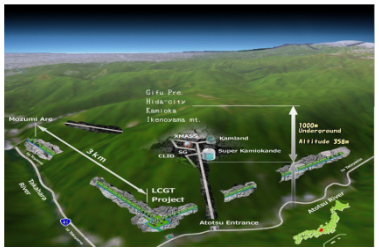
Abstract

KAGRA is large scale cryogenic gravitational wave telescope project in Japan It is developed and constructed by ICRR of The University of Tokyo. Hitachi Zosen produced PCI Express I/O chassis and the anti-aliasing (AA) and anti-imaging (AI) filter board for KAGRA digital control system. These products are very important for KAGRA interferometer from the point of view of low noise operation. This poster reports these products performance.

KAGRA Project

Large-scale Cryogenic Gravitational wave Telescope, that poplar name is KAGRA, has been constructing at 1000m underground (in maximum) the mountain in Kamioka, Gifu-prefecture in Japan. KAGRA under construction is 3km scale optical cavities located all under the ground. Such underground construction has the advantage of using very hard bedrock in Kamioka, which reduces effect of vibration on ground surface. Therefore, high accuracy of observation is able to be expected. Furthermore, to achieve higher accuracy of observation, we have various plans, longer the optical cavity by utilizing of Fabry-Perot Interferometer, cooling mirrors to -253 degrees Celsius by cryostat for preventing thermal noise, providing suspension system for preventing vibration mirrors, adopting high power and high coherency laser and low noise electrical circuit. Therefore, KAGRA achieves target of accuracy of 10^{-19} m/ square root Hz.



DIGITAL SYSTEM DESIGN

KAGRA digital system contains of RTFE.The signals from various sensors of the interferometer are fed back to the actuators of the interferometer through the ADC, the DAC, several signal filters and the computer. The computer of the RTFE and IFO are connected by fast transfer network.

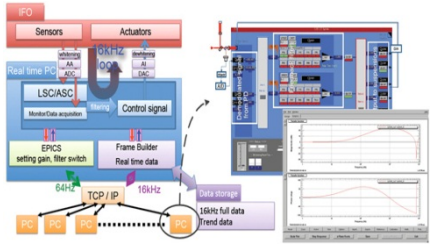


Figure: The design concept of the KAGRA digital system

PCI Express IO Chassis

This consists of a PCIe backplane, a PCIe chassis interface board, ADC adapter cards, DAC adapter cards and a timing slave module. We adopted BPX6806-EPS of Trenton Technology as a PCIe backplane that is same as LIGO. PCIe I/O chassis can be inputted not only from a normal AC power but also direct DC from a stabilization power supply.

Item	Description
Enclosure	4U, 19 inch rack mount type (EIA)
Max expansion slot number	18 x16 PCIe cards
Power supply	ATX silence power supply (natural cooling type)
Cooling	Fan, installed front panel
Dimension	483(W)×177.0(H)×772.0(D)
Material	Electro galvanized zinc plated steel (SPCC)
Weight	17kg

AA/AI Filter Board

The AA/AI filter board is a notch filter and third-order low-pass filter to prevent quantization effect (Aliasing) of analog to digital conversion. The frequency of analog to digital conversion is 2^{16} (65536) multiplied from 1PPS signal. Anti-Aliasing filter prevents high order band signal which is included in the analog signal from effecting on low frequency side.

Item	Description
Number of filter circuit	8 circuits/board
Input signal character	Less +or- 10V, differential
Output signal character	Less +or- 10V, differential
Connecter type	D-sub 9
LED	Power indicator
Circuit gain	1
Notch filter character	Signal attenuation: Less -75dB @65536Hz
Low-pass filter character	Order: Third Cutoff frequency: 10kHz(-3dB)

INSPECTION OF PERFORMANCE

AA/AI filter board

We evaluated performance of filtering circuit 10 kHz cutoff frequency about BLPF and SNF. The power supply unit for inspection of performance is a low noise transistor type power supply. The transfer function (gain, phase) of the AA/AI filter board is measured by oscillator sweeping from10Hz to 100kHz.
Both meet evaluation judgment value as following list enough together. the evaluation of the eliminative performance meets enough.

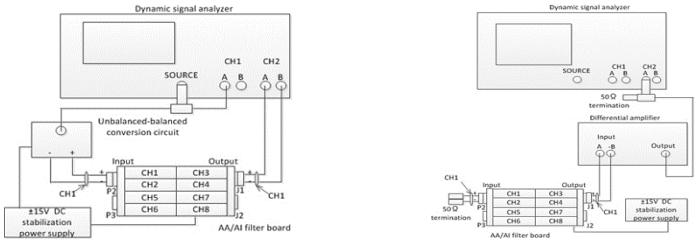
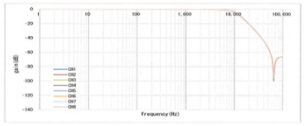
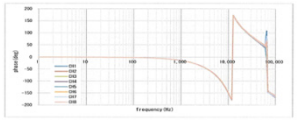


Figure: Block diagram of inspection of AA/AI filter board performance.
Left figure is Evaluation of the transfer function of LPF and SNF filter signal performance
Right figure is Measurement of equivalent input noise

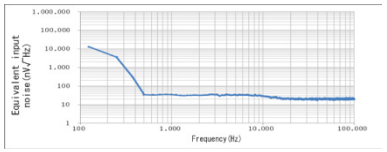
Item	Description
Notch filter stopband attenuation (gain) evaluation	Required spec <-75dB at 65536Hz
Attenuation (gain) and bode diagram evaluation at 1kHz	Required spec Gain/Phase=0dB/165deg
Attenuation (gain) and bode diagram evaluation at 10kHz	Required spec Gain/Phase=-4.8dB/25deg
Output voltage density against input noise(thermal noise)	Output voltage density is less 70nV/sqrt(Hz) at 50Hz-700Hz and less 50nV/sqrt(Hz) at 7000Hz-100kHz



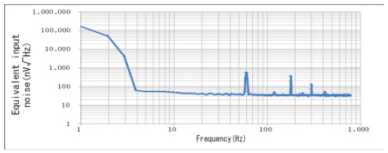
Graph: Measurement of frequency characteristic performance of LPF and SNF functions



Graph: Measurement of frequency characteristic performance of LPF and SNF functions



Graph: Sno.1 CH1 Measurement of equivalent input noise (scope of 0-10kHz)



Graph: Sno.1 Measurement of equivalent input noise (scope of 0-1kHz)

The several channels of same boards exceeded judgment level. It is thought that the individual difference of a differential amplifier produced a burst noise. Therefore, we switched from differential amplifier LT1492 to AD8622 with a few burst noises. However, defectiveness was found in even the board which implemented AD8622 by the thermal noise measurement. A similar burst noise occurred in op-amp THS4131D which we used in BLPF and as a result of having changed it, was good.

PCIe I/O Chassis

As an evaluation of the simple substance of RTFE, we carried out a computer and the connection examination between the PCIe I/O chassis. The cable length of both tested it at 50cm And 2m. We used lspci command and the application for detection systems (x1x14, x1vex) to evaluate.
In the examination of the metal cable, when a 2m metal cable was used, it occurred that the normally recognized with the lspci command and application will be about 1 time per ten starting processes.
Since the transfer speed of GEN2 is 5.0 Gbps per one lane, this surmises the construction state of the metal cable had influenced the transmission signal.
In the examination of the optical fiber cable, the optical cable by 100m length connected between SHB and host cable adapter board. It did not drive.
In the current model (auto negotiation of GEN1 and GEN2) did not also operate.
Next, it examined by the 10m cable of the modified version. Although it was used in the environment of auto negotiation, since there was much frequency where starting was poor, it has been recognized as fixing to GEN1 and examining by the basic input output system (BIOS) of a computer, with the optical cable.

Conclusion

We gave high precision, the treatment for the low noise in the production of electronic circuits in charge of in KAGRA digital system. In the future plan, We perform RTFE system and the loopback through the AA/AI filter and am going to examine the performance evaluation. In addition, in PCIe I/O chassis and the optical fiber cable connection between the host and it, stability can start only when we fix setting of GEN1 by the present conditions, the BIOS setting on the computer. Even if GEN1 fixed setting uses the computer which is not done, it is stable and thinks about working by optical fiber cable connection.

スライド 2

mi4 「hitzはKAGRAのデジタルシステムを担当しています。
私たちは高い精度で～」のような分け方をしてはどうでしょうか。
miyuki ishizuka, 2013/10/05

mi6 分割しましょう。
miyuki ishizuka, 2013/10/05

mi7 必要ないと思います。
miyuki ishizuka, 2013/10/05

mi8 we
miyuki ishizuka, 2013/10/05

mi9 ”and”でしょうか。
miyuki ishizuka, 2013/10/05

mi10 主語と動詞が分かりにくいです。
おそらく主語はGEN1だと思いますが。。。
miyuki ishizuka, 2013/10/05

mi11 「考慮する」ということでしょうか？
miyuki ishizuka, 2013/10/05

mi13 ″it″が何をさしているのか、分かりにくいです。
miyuki ishizuka, 2013/10/05

mi14 文章を分けてはどうでしょうか？
miyuki ishizuka, 2013/10/05