Nolan King

15 May 2018

Mentor: Dick Gustafson, Keita Kawabe

RF Noise Sources and GPS Jitter at LHO

The detection of gravitational waves by interferometer requires measuring interference patterns in which the change in intensity of light is very small compared to the average intensity of the source. To meet this required sensitivity, a feedback and control system has been implemented that utilizes radio frequency (RF) control signals and GPS originated precision timing signals to lock the interferometer into stable and sensitive operation.

It has been found that in the control room of the observatory, RF oscillators are radiating noise into these control signals, and other adjacent subsystems. This has resulted in the presence of undesirable side bands in the control signal spectrum. Acceptable noise levels are on the order of 1 mV. We will need to reduce currently present noise beneath this limit. For the first 4 weeks of the program we will seek to determine through which components the signals are coupling and correct the behavior.

To accomplish this, we will be utilizing spectrum analyzers to measure the strength of undesirable signals while injecting test signals representative of those present during operation of the interferometer. We will investigate the presence of possible ground loops, and failures or imperfections in the shielding of equipment and transmission lines. The group's previous work has decreased the amount of leakage in the ground isolation units of the ISC racks by modifying the capacitance of a set of ground isolation units. It was found that two capacitor networks were effectively placed

in series in the design of the ground isolation unit, reducing the attenuation of the high pass filter. Additional capacitance was added to the enclosure restoring the desired filtering behavior. Similarly, we will make use of software models and circuit simulations of instrumentation to explore potential modifications of components to reduce noise coupling once additional culprits have been identified.

For the remainder of the program we will address the GPS timing noise. The group previously discovered that the GPS timing signal from which the RF oscillators are locked (or disciplined) exhibits a time varying phase shift (known as “jitter”) on the order of nanoseconds. It was determined that the jitter was non-gaussian, suggesting it is not wholly due to random noise. An error free timing signal is necessary for the accurate correlation and flagging of noise in auxiliary signals with response from the interferometer. This process is crucial in determining the reliability of collected data. While the current timing signal is sufficient for short duration measurements, this jitter may result in an error accumulation over longer time scales, such as durations necessary for continuous wave measurements.

This jitter could originate in the transmission media of the timing signal, local instrumentation, or the GPS receiver itself. We will utilize an oscilloscope and reference oscillators to compare jitter at various places in the signal path to determine the origin of the jitter. It is also feasible to measure the jitter of the GPS receiver directly to determine if it is responsible. Once the source of the jitter is identified correction measures will be explored. Ideally, the jitter should be lowered to less than a nanosecond.