Theoretical consideration of SIS up-converters for frequency division multiplexing

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Abstract— In radio astronomy there is a strong interest in large-scale multi-pixel heterodyne receivers, which enable wide field-of-view observations with high spectral resolutions. So far, multi-pixel heterodyne receivers have been developed by several institutes. The maximum pixel number is 64 achieved by "SuperCam" to explore astrophysically important emission and absorption lines within the 850 micron atmospheric window. Further increase of the pixel number to as many as 1000 is now being considered. In this case one of the issues would be the total power consumption of a large number of cryogenic low noise amplifiers (LNAs). Given that a typical LNA consumes several milliwatts, for example, refrigerators with several watts of cooling capacity at the 4-K stage are necessary, which would be impractical. To overcome this issue, we propose to use a frequency division multiplexing (FDM) technique for reducing the number of amplifiers at 4 K. The concept is the following; Each SIS mixer corresponding to each pixel outputs an intermediate frequency (IF) signal at microwave frequencies that is up-converted with different local oscillator (LO) frequencies (e.g. frequency comb signals) where the frequency differences of LOs (the comb frequency interval) should be larger than the IF signal bandwidth. These up-converted signals of multiple pixels could be combined by an FDM, then amplified by an amplifier which has a wideband at a much higher frequency than the IF. One of the key elements to make this scheme possible is the up-converter which should have a gain larger than unity to prevent degradation of the receiver performance due to extra losses before the LNA. We consider SIS mixers as a good candidate for the up-converter because positive conversion gains could be expected by quantum effects. For the feasibility study, we calculated up-conversion characteristics of SIS mixers based on the Tucker theory. Analytical results will be shown to find operating conditions of SIS mixers as up-converters for a workable FDM scheme.