A SEGMENTED CHIRPED-PULSE FOURIER TRANSFORM MM-WAVE SPECTROMETER (260-295 GHZ) WITH REAL-TIME SIGNAL AVERAGING CAPABILITY

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The design and performance of a 260-295 GHz segmented chirped-pulse Fourier transform mm-wave spectrometer is presented. The spectrometer uses an arbitrary waveform generator to create an excitation and detection waveform. The excitation waveform is a series of chirped pulses with 720 MHz bandwidth at mm-wave and about 200 ns pulse duration. The excitation pulses are produced using an x24 active multiplier chain with a peak power of 30 mW. Following a chirped pulse excitation, the molecular emission from all transitions in the excitation bandwidth is detected using heterodyne detection. The free induction decay (FID) is collected for about 1.5 microseconds and each segment measurement time period is 2 microseconds. The local oscillator for the detection in each segment is also created from the arbitrary waveform generator. The full excitation waveform contains 50 segments that scan the chirped pulse frequency and LO frequency across the 260-295 GHz frequency range in a total measurement time of 100 microseconds. The FID from each measurement segment is digitized at 4 GSamples/s, for a record length of 400 kpts. Signal averaging is performed by accumulating the FID signals from each sweep through the spectrum in a 32-bit FPGA. This allows the acquisition of 16 million sequential 260-295 GHz spectra in real time. The final spectrum is produced from fast Fourier transform of the FID in each measurement segment with the frequency calculated using the segment's LO frequency. The agility of the arbitrary waveform generator light source makes it possible to perform several coherent spectroscopic measurements to speed the analysis of the spectrum. In particular, high-sensitivity double-resonance measurements can be performed by applying a pi-pulse to a selected molecular transition and observing the changes to all other transitions in the 260-295 GHz frequency range of the spectrometer. In this mode of operation, up to 50 double-resonance frequencies can be used in each segment with the double-resonance signal collection taking place in real time.