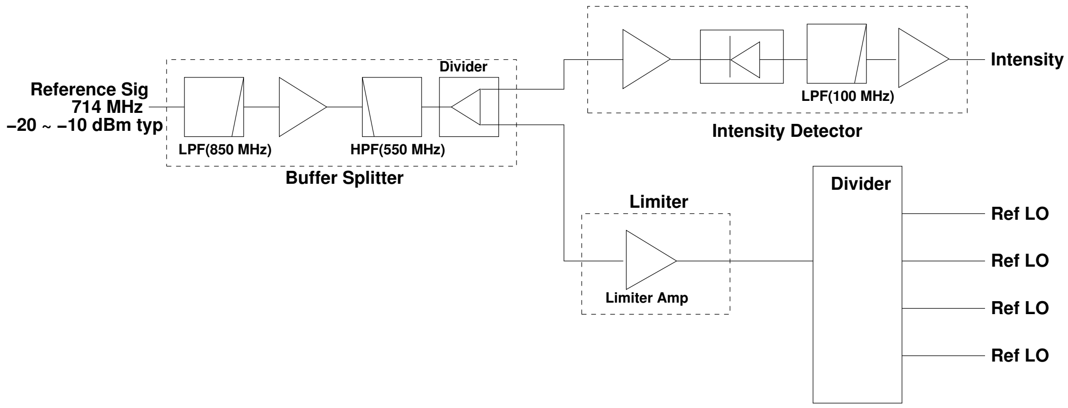

Figure 7.6: Block Diagram of Limiter Detector

Locked LO Generator 5.712 GHz used for first down conversion is generated from locked LO generator. This generator outputs 5.712 GHz signal locked to external input, which is DR accelerating 714 MHz signal. It generates octuple signal of input 714 MHz using non-linearity of the electronics. When amplifier saturates and its output signal is distorted, higher harmonics of the fundamental frequency occur, including octuple frequency. The octuple signal is selected by a band pass filter, and is output from the generator.

Limiter Detector Reference signal enters the limiter detector before used for phase detection. Limiter detector has 2 main functions. First is to output 714 MHz signal of constant amplitude used for phase detection. Second is to monitor the amplitude of reference signal, in order to monitor beam charge. Reference signal is split into 2 and while one enters a limiter amplifier, the other is detected by a diode. Schematics of the limiter detector are shown in Figure 7.6.

Phase Detector The sensor and reference 714 MHz signals are transported a long way to where we call the "eel's bedroom", and enters the phase detector. At the phase detector, 714 MHz sensor signal is mixed with 714 MHz reference signal generated from the limiter detector. As discussed in advance, signal phase is detected in this method. The 714 MHz reference signal is split into 2 and one is $\pi/2$ shifted in phase against the other. The 2 reference signals are mixed with sensor signals, which are also split into 2. By this method, we can obtain 2 signals, I and Q, different for $\pi/2$ in phase. We used a phase shifter of the detector to shift the phase of reference signal, which details are discussed later. Schematics of the phase detector are shown in Figure 7.7. Actually there are 4 outputs from the phase detector to acquire phase information, which are 0, 45, 90 and 135 degrees. However as shown in (7.12), a set of 2 signals different for 90 degrees is enough to determine signal phase. Also from limitation of ADC channels, we used only 0 and 90, which we call I and Q, respectively.

7.1.2 Digital Detection

The scheme of digital phase detection is shown in Figure 7.8. Components used for phase detection is the same as analog detection, so their details are omitted.

In this case, both sensor signals and reference signal are detected by a common unlocked LO 714 MHz signal at second down conversion. Using common LO, phase relation of the two is maintained. It is unlocked to the beam, since it is generated by a signal generator. Thus detected signal at the phase detector would be,

$$\begin{aligned}
I_{sen} &= A_{sen}\sin(\phi_{sen} - \phi_{LO} - \phi_{unlockedLO}) \\
Q_{sen} &= A_{sen}\cos(\phi_{sen} - \phi_{LO} - \phi_{unlockedLO}) \\
I_{ref} &= A_{ref}\sin(\phi_{ref} - \phi_{LO} - \phi_{unlockedLO}) \\
Q_{ref} &= A_{ref}\cos(\phi_{ref} - \phi_{LO} - \phi_{unlockedLO}),
\end{aligned} \tag{7.13}$$