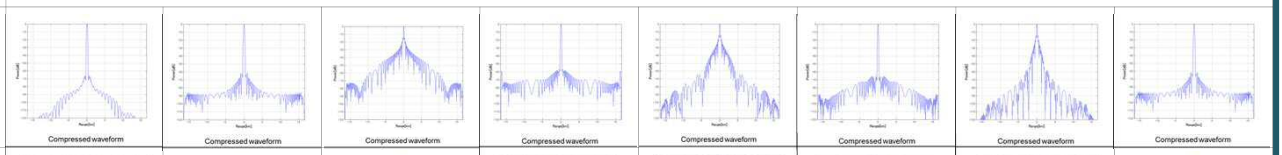
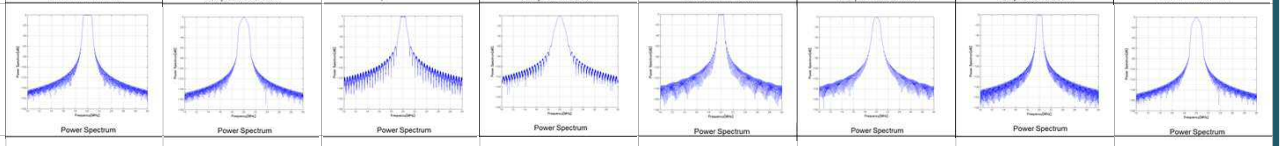
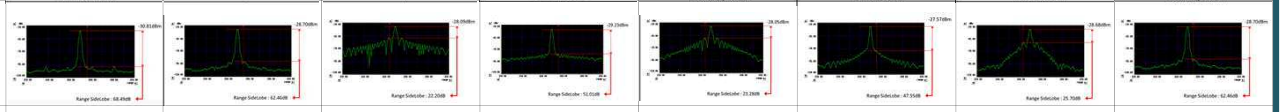
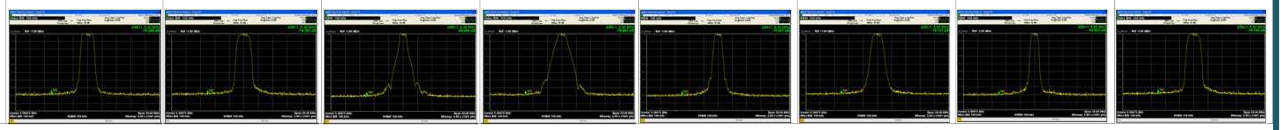
Performance of LFM and NFLM in Loopback Test

- **LFM** (Linear Frequency Moduration)
  For reduction of range side lobe up to 60 dB : using the Blackman-Harris window function
  ⇒ **Window function process loss results disadvantage in power efficiency and sensitivity**
- **NLFM** (NonLinear Frequency Moduration)
  For reduction of range side lobe up to 60 dB : **No need for window function**

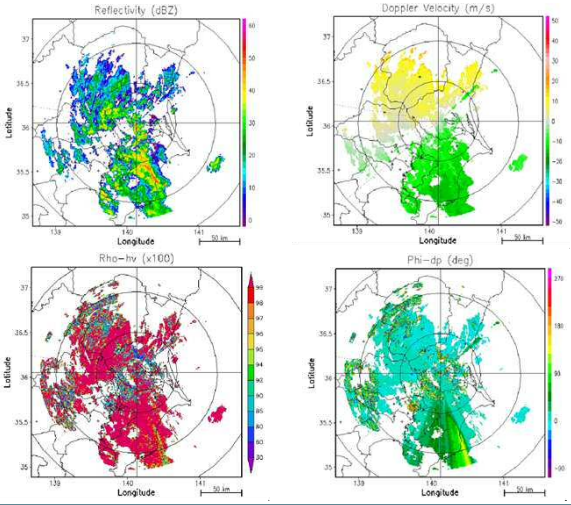
Waveform Parameters and Test Result

Parameter	Test case 1		Test case 2 (no-window)					
Modulation	LFM	NLFM	LFM	NLFM	LFM	NLFM	LFM	NLFM
Chirp type	Up Chirp	Down Chirp	Up Chirp	Down Chirp	Up Chirp	Down Chirp	Up Chirp	Down Chirp
Swept Bandwidth	1.63 MHz	1.63 MHz	0.91 MHz	1.63 MHz	0.94 MHz	1.63 MHz	1.00 MHz	1.63 MHz
Raised cosine	10 %		2%		5%		10%	
Pulse width	111 µs							
Sampling frequency	2 MHz (Ref), 80 MHz (Drive)							
Center frequency	0 MHz (Ref), 20 MHz (Drive)							
Window function	Blackman-Harris	No window	No window					
Range resolution(3dB)	150m							
Compressed waveform (theoretical)								
Power spectrum (theoretical)								
Range sidelobe								
Peak sidelobe level	-68.49 dB	-62.46 dB	-22.20 dB	-51.01 dB	-23.28 dB	-47.55 dB	-25.70 dB	-62.46 dB
Spurious emission (±5MHz)	-76.57 dB	-78.18 dB	-80.41 dB	-78.88 dB	-79.91 dB	-78.76 dB	-80.82 dB	-78.18 dB
Window function loss	2.56 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB	0 dB
Transmission loss	0.58 dB	0.58 dB	0.11 dB	0.11 dB	0.28 dB	0.28 dB	0.58 dB	0.58 dB
Waveform (Loop-back)								

Actual Observstion

By using MRI radar, we observed weather phenomena with NLFM.
Following figure shows the September 4th 2013, 03:59:42 JST rain event near Tsukuba, Japan. From the south side, convective rainfall is observed.

Raised Cosine 10%, Swept bandwidth 1.63MHz, No-window



Conclusion and Future Work

A description of experimental results was presented in this paper. The sensitivity of radar was improved by using NLFM with sufficient range-sidelobe reduction (more than 60dB). Moreover, the nature of Solid-State weather radar, and "Made in Japan quality" produced results approaching the theoretical level.
The waveform optimization technique developed by ARRC-OU has the ability to build in pre-distortion into the design for hardware optimization (Kurdzo et al 2013). Additional improvements can be expected with the hardware response included in the optimization process. For future development, we will apply the pre-distortion function to MRI radars to further improve the waveform performance. Also, we are planning to apply the OFM technique to Phased-Array Weather Radars..

Acknowledgments

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