

Antenna radiation pattern measurement using a drone

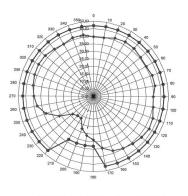
20-23 April 2021, FM22 #55



Why measure using drone ?

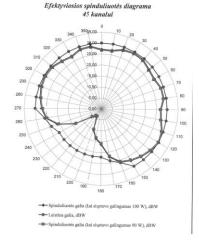
One antenna for 3 DVB-T channels Different theoretical diagrams

Efektyviosios spinduliuotės diagrama 60 kanalui



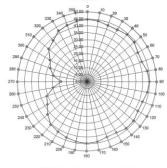
----- Spinduliuotės galia (kai siųstuvo galingumas 1300 W), dBW

---- Leistina galia, dBW





Efektyviosios spinduliuotės diagrama 29 kanalui



----Spinduliuotės galia (kai siųstuvo galingumas 2400 W), dBW

---Leistina galia, dBW



Experiments with different setups



Drone



Hexacopter and flight service provided by Space Science and Technology Institute:

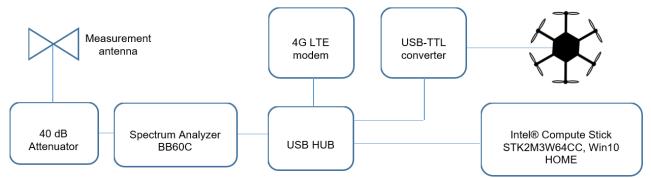
- Payload 2 kg, flight time 20 min
- Pixhawk autopilot controller
- GPS/Compass Ublox M8N
- Telemetry modules 866 MHz
- Additional manual 2,4 GHz control
- Laptop with Mission Planner software



Measurement system

Assembled by RRT :

- Spectrum analyzer BB60C, weight 500 g
- Stick PC STK2M3W64CC with Spike spectrum analyzer software
- Homemade biconical dipole, weight 40 g
- LTE modem for remote control



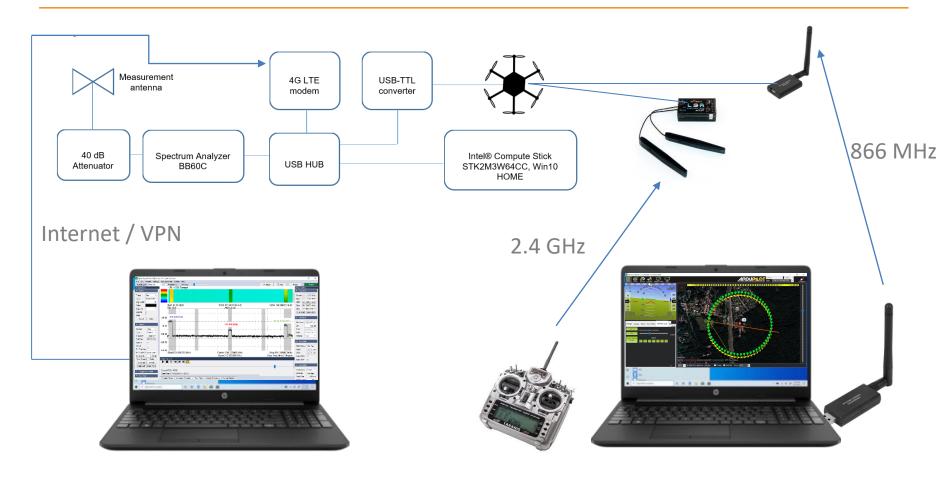




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General setup



Measurement remote control

Drone control



• Mission Planner for drone control and flight telemetry data logging





• Spike Spectrum Analyzer – controlling spectrum analyzer, channel power logging

M Spike: Signal Hound Spectrum A	Analyzer Software			- 0 ×					
	nalysis Mode Utilities Help			Durat	Channel	Power	Version	1	
Spectrogram Enabled Measurements	Persistence Intensity 156 / 1000 Sweeps	-	→! Single (Auto F	Recal Preset Sweep Settings	Main	Channel	Center	Freq	666000000
▲ Traces				 Frequency 			Bandwidth		
Trace One 👻				Center 🔺 🔻 00 MHz	Main	Channel		800000	
Type Clear & Wrive				Span A T 100 MHz	Channel	1	Offset	7200000	
Avg Count 10	Ref -40.00 dBm	RBW 100.000000 kHz	VBW 100.000000 kHz	Start 531.000000 MHz Stop 301.000000 MHz	Channel	1	Bandwidth	8000000	
Copy To	Div 10.0	Atten Auto		Step 20.000000 MHz Full Span Zero Span	Channel	2	Offset	12000000	
Hide	60.00 29 k (538 MHz)			Amplitude	Channel	2	Bandwidth	8000000	
Export Clear	80.00		786 60 k (786 MHz)	Ref Level	Channel	3	Offset	128000000	
	80.00	45 k (666 MHz)	/m	Div 10.0 dB	Channel	3	Bandwidth	8000000	
Marker One -		<u> </u>		Gain Auto Gain 💌					
Type Normal • Place On Trace On•	00.00	hinaliwanananana Unita na matang		Atten Auto Atten V Preamp Auto V	Date	Time	Main Channel	Channel1 Lower	Channel1 Upper
Set Freq 00000 GHz Update ✓ -1	20.00			 Bandwidth 	13-10-2020	09:59:52:104			
Active				RBW Shape Flat Top -	13-10-2020	09:59:52:120	-50,83111132	-50,37667563	-51,66727571
Pk Tracking -1 Pk Threshok 0.000 dBr	40.00 Start 531.000000 MHz	Center 666.000000 MHz	Stop 801.000000 MHz	RBW A THZ	13-10-2020	09:59:52:151	-51,16258078	-50,5486946	-51,72021815
Pk Excurs. 6.00 dB Peak Search Delta Sw	ieep Playback	Span 270.000000 MHz	Swp Time Oms (13k pts)	Auto RBW 🗸	13-10-2020	09:59:52:182	-50,79394129	-50,28912661	-51,24062422
					13-10-2020	09:59:52:214	-51,06927838	-50,42987179	-51,77491259
Peak Left Peak Right				Acquisition Video Units Power	13-10-2020	09:59:52:261	-51,0005482	-50,45473714	-51,30800305
Occupied Bandwidth	weep: 6992 / 10669 late/Time: 13/10/2020 10:11:32:721			- Detector Average -	13-10-2020	09:59:52:276	-50,9357795	-50,22156479	-51,37349363
Trace Math	Channel Power Intermod Distortion Peak Table S	weep Recording Sweep Playback	,	Swp Time 1.000 ms			1	Lances and ready for the first state	



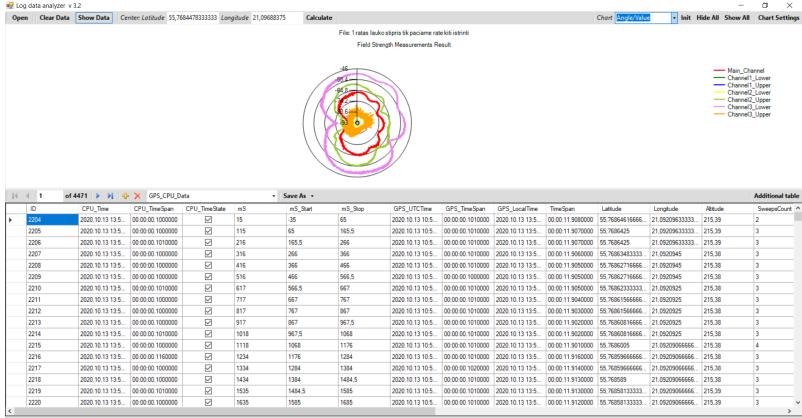
• Tera Term – GNSS data logging



[2020-10-13 09:59:52.057] \$GPGGA,065939.946,5545.96565,N,02105.90332,E,1,06,02.0,0016.47,M,0.0,M,,*52 [2020-10-13 09:59:52.073] \$GPRMC,065939.946,A,5545.96565,N,02105.90332,E,0.24,333.13,131020,,*08 [2020-10-13 09:59:52.151] \$GPGGA,065940.046,5545.96565,N,02105.90332,E,1,06,02.0,0016.44,M,0.0,M,,*56 [2020-10-13 09:59:52.167] \$GPRMC,065940.046,A,5545.96565,N,02105.90332,E,0.23,333.61,131020,,*08 [2020-10-13 09:59:52.261] \$GPGGA,065940.146,5545.96565,N,02105.90332,E,1,06,02.0,0016.42,M,0.0,M,,*51 [2020-10-13 09:59:52.261] \$GPRGC,065940.146,A,5545.96565,N,02105.90332,E,0.23,333.67,131020,,*09 [2020-10-13 09:59:52.354] \$GPRGC,065940.146,A,5545.96565,N,02105.90332,E,0.23,333.67,131020,,*09



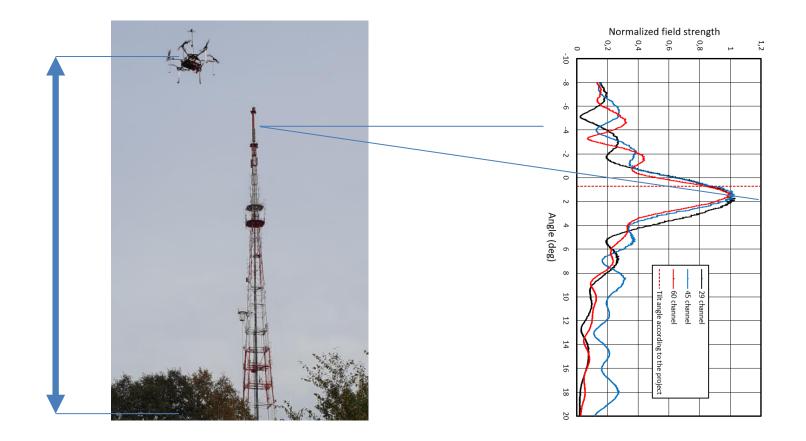
 Lod data analyzer – merge channel power and GNSS log files, draw polar diagram (created by RRT)





Measurement steps

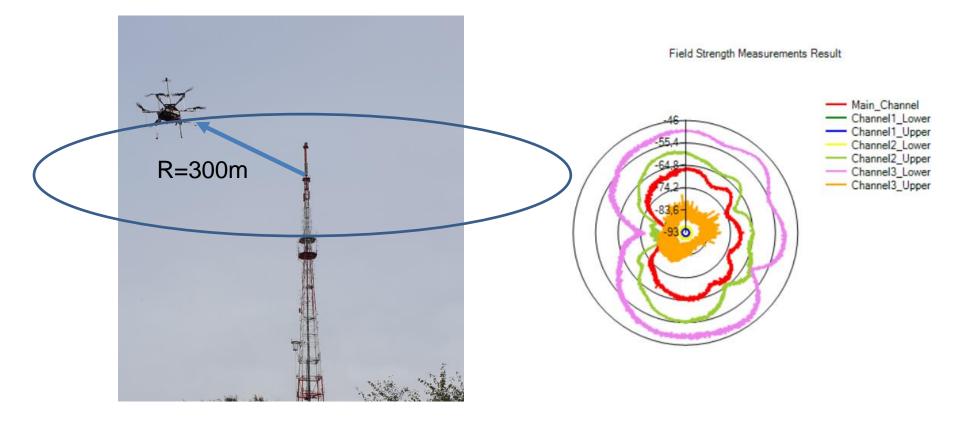
1. Measure vertical diagram - drone took off strictly vertically above transmitting antenna and descended vertically.



RRT

Measurement steps

2. Measure horizontal diagram - drone took off to the height of maximum field strength, then flew around antenna maintaining constant height



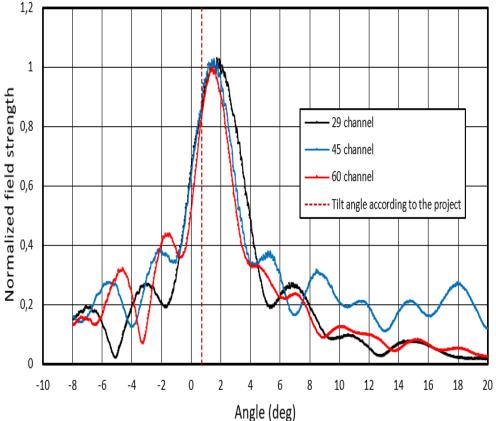


Measurement results

Vertical diagram:

- beam tilt differs significantly from the design (project);
- the width of the main lobe is in good agreement with the project value:

Channel number	Project data	Measured data	
29	4.52°	4.33°	
45	3.29°	3.62°	
60	2.84°	3.07°	

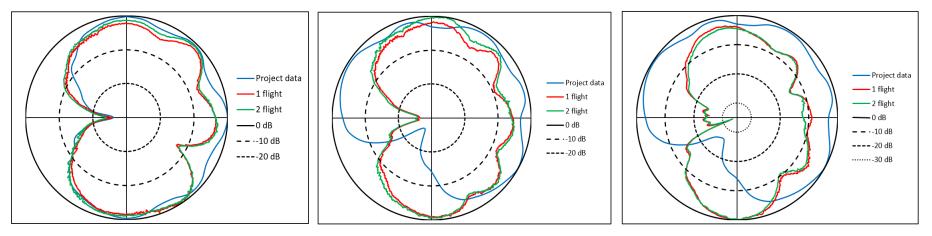




Measurement results

Horizontal diagrams:

- For channel 29 is close to project data
- For channels 45 and 60 are rotated by about 60 degrees
- Measurements we repeated, results of two flights overlap within 2 dB



Channel 29

Channel 45

Channel 60



Issues to consider

- Measurement accuracy more repeated measurements needed, accuracy of GNSS, need of RTK;
- Flight time extension helicopter with petrol engine ?
- EMC issues compass failure; LTE modem drone controller interference;
- Remote link to measurement computer on drone (Wi-Fi, LTE);
- New EU regulations, possibility to use certified drone ?



Questions?

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