Analysis of the 24 ft TFD Array in Terms of Galactic Background Temperature Delivered to the Receiver

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Following work by Typinski (1,2,3) I was interested in determining the temperature from the galactic background delivered to a receiver (or multicoupler) from a 24 ft TFD array as a function of frequency.

The TFD dipole element contains a 16:1 balun and an 800 ohm load resistor which makes the element broadband but less than 100% efficient. Given a skyside temperature from the galactic background the TFD dipole delivers a lower temperature to the antenna feedpoint due to its inefficiency.

Key to this analysis are Typinski's efficiency measurements of a 24 ft TFD dipole in the frequency range 14 to 33 MHz. His measurements were carried out against a standard dipole at each frequency which is assumed to be 100% efficient.

14	124.5	-15	0.03	3.94
15	104.4	-13	0.05	5.23
16	88.5	-11	0.08	7.03
17	75.8	-9.4	0.11	8.70
18	65.4	-8	0.16	10.37
19	57.0	-6.8	0.21	11.91
20	50.0	-5.8	0.26	13.14
21	44.1	-4.9	0.32	14.27
22	39.2	-4.2	0.38	14.89
23	34.9	-3.6	0.44	15.25
24	31.3	-3.1	0.49	15.35
25	28.2	-2.7	0.54	15.16
26	25.5	-2.5	0.56	14.36
27	23.2	-2.4	0.58	13.34
28	21.1	-2.4	0.58	12.15
29	19.3	-2.5	0.56	10.86
30	17.7	-2.7	0.54	9.51
31	16.3	-3	0.50	8.16
32	15.0	-3.5	0.45	6.70
33	13.9	-4	0.40	5.52
	kK	dB		kk
				ant
MHz	sky side	efficiency	ratio	temp
		24' TFD		24' TFD

Table 1 The first column is frequency in MHz, second column is the skyside temperature from the galactic background in kK, third column is the TFD dipole efficiency in dB, column 4 is the efficiency as a ratio, and the fifth column is the antenna temperature (at the dipole feedpoint in kK).

Given the antenna feedpoint temperature in kK the next step is to follow the signal from the dipole feedpoint to the receiver. Some components have an attenuation that is essentially independent of frequency in the 14-33 MHz range while other components (like coax cable) have attenuation that is frequency dependent.

Component	**Description**	**Loss (14-33 MHz)**
Element feed line	24 ft RG-58A	Frequency dependent
Combiner	Mini Circuits ZSC-2-1W+	0.22 dB
Time delay cable	Typical 6 ft RG-58A	Frequency dependent
Main feedline cable	200 ft LMR400	Frequency dependent
Surge suppressor	Polyphaser IS-50NX-C0	0.1 dB
Feedline to Hybrid	RG-58A typical 10 ft	Frequency dependent
90 deg Hybrid	Synergy 0QK-701B	Frequency dependent
Feedline to receiver	RG-58A typical 10 ft	Frequency dependent

Table 2. Components making up the signal flow path from the 24’ TFD antenna to the receiver.

I have assumed an installation with a total of 50’ of RG-58A and 200’ of LMR400.

14	124.5	-15	0.03	3.94	1.00	0.77	0.34	2.11	1.63	2.42
15	104.4	-13	0.05	5.23	1.00	0.79	0.35	2.14	1.64	3.20
16	88.5	-11	0.08	7.03	1.10	0.82	0.36	2.28	1.69	4.16
17	75.8	-9.4	0.11	8.70	1.10	0.85	0.37	2.32	1.71	5.10
18	65.4	-8	0.16	10.37	1.20	0.88	0.38	2.46	1.76	5.89
19	57.0	-6.8	0.21	11.91	1.20	0.90	0.385	2.49	1.77	6.72
20	50.0	-5.8	0.26	13.14	1.20	0.92	0.39	2.51	1.78	7.37
21	44.1	-4.9	0.32	14.27	1.30	0.95	0.395	2.65	1.84	7.76
22	39.2	-4.2	0.38	14.89	1.30	0.97	0.4	2.67	1.85	8.05
23	34.9	-3.6	0.44	15.25	1.30	1.00	0.405	2.71	1.86	8.18
24	31.3	-3.1	0.49	15.35	1.30	1.02	0.41	2.73	1.87	8.19
25	28.2	-2.7	0.54	15.16	1.40	1.04	0.41	2.85	1.93	7.86
26	25.5	-2.5	0.56	14.36	1.40	1.06	0.41	2.87	1.94	7.41
27	23.2	-2.4	0.58	13.34	1.40	1.08	0.405	2.89	1.94	6.86
28	21.1	-2.4	0.58	12.15	1.50	1.11	0.4	3.01	2.00	6.08
29	19.3	-2.5	0.56	10.86	1.50	1.13	0.395	3.03	2.01	5.41
30	17.7	-2.7	0.54	9.51	1.50	1.15	0.395	3.05	2.02	4.71
31	16.3	-3	0.50	8.16	1.50	1.17	0.385	3.06	2.02	4.04
32	15.0	-3.5	0.45	6.70	1.60	1.19	0.38	3.17	2.07	3.23
33	13.9	-4	0.40	5.52	1.60	1.21	0.375	3.19	2.08	2.65
	kK	dB		kk	dB	dB	dB	dB		kK
MHz	SkySide	TFD efficy	Ratio	ant temp	200' LMR400	50' RG58A	comb+ Hybrid	Total Loss	Ratio	Rx Input temp

Table 3 Temperatures in kK and component loss numbers in dB vs frequency.

Figure 1 below shows the Skyside galactic background temperature vs frequency as well as the temperature at the feedpoint of an individual dipole and the temperature reaching the receiver input port after passing thru cables, combiners, the lightning suppressor, and the hybrid.

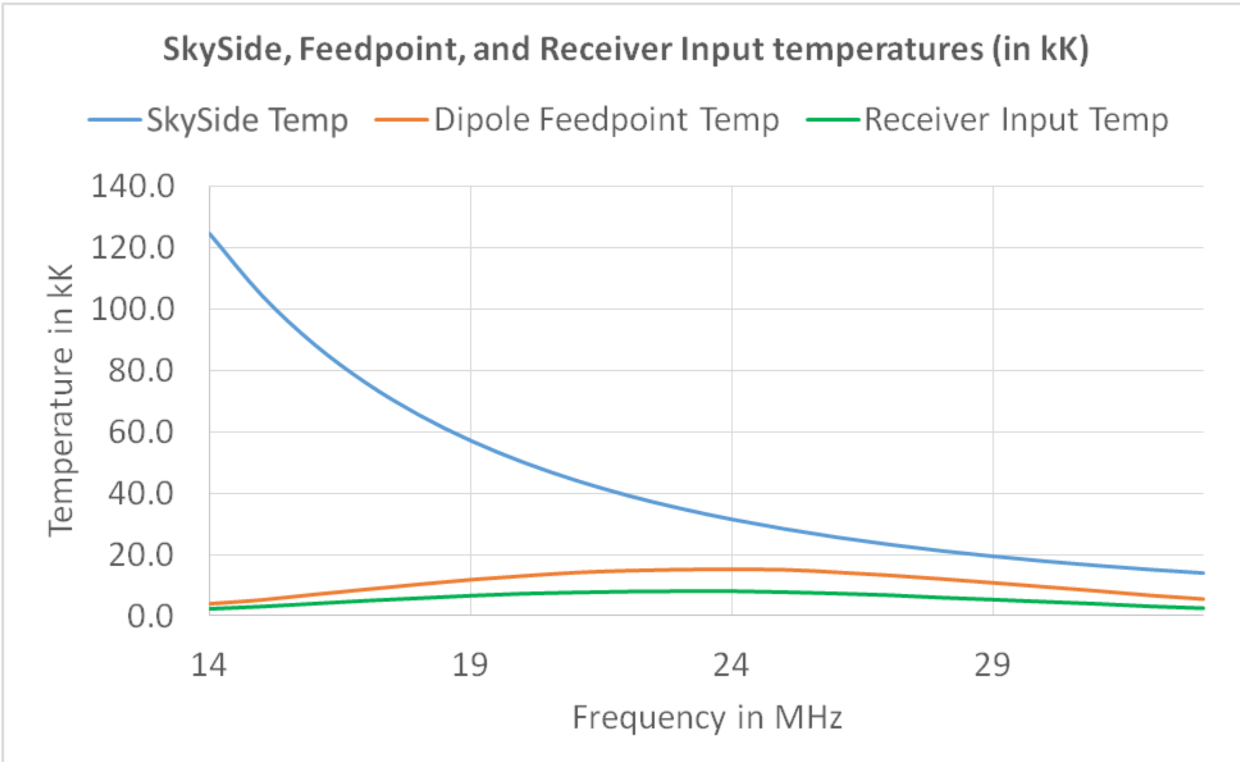


Figure 1. The large gap between Skyside and feedpoint temperature at low frequencies is due to the high value of TFD inefficiency due to the relatively short dipole length.

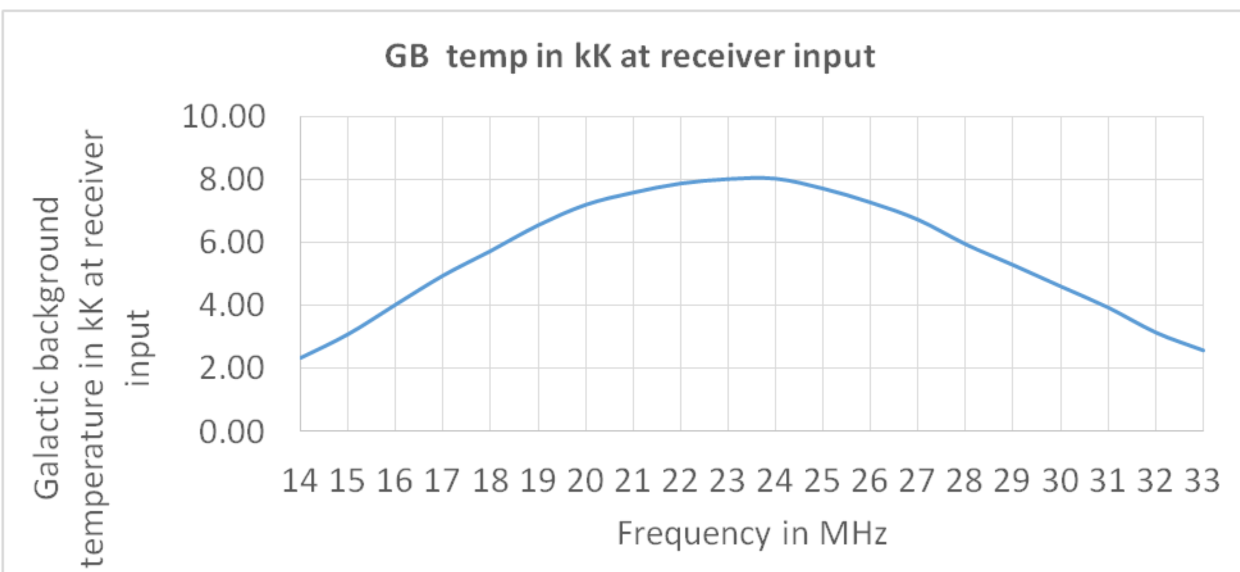
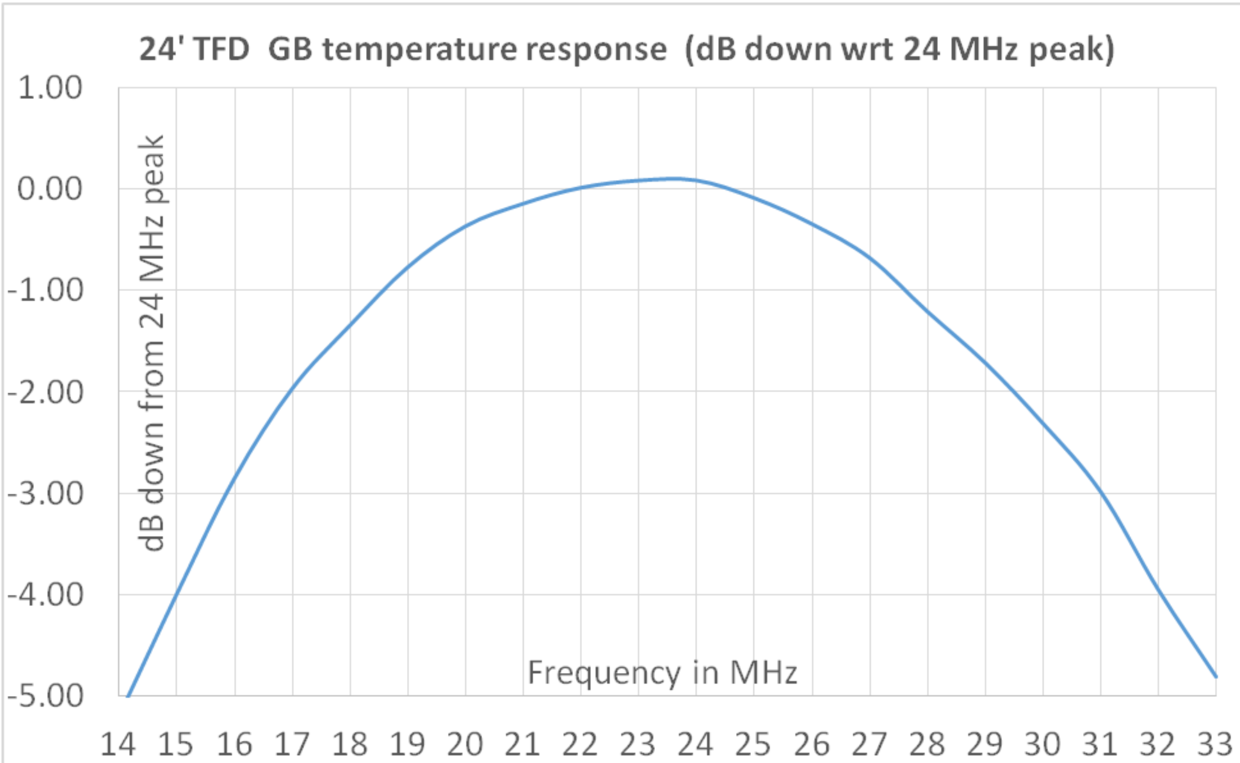


Figure 2 Expanded view of the galactic background temperature expected at the receiver input. GB input temperatures peak around 23-24 MHz. At 20 MHz the expected temp is about 7 kK.

The primary concern about these relatively low temperatures is that a receiver with a high noise figure will contribute a significant amount of noise which has the effect of degrading the signal plus noise to noise ratio. For example the SDRPlay RSP1A has a noise figure of 15 dB which equates to a noise temperature of 8.8 kK. This means that over half the noise displayed in a spectrogram at 20 MHz is due to the receiver itself, not the galactic background.



In Figure 3 we see the response curve of Figure 2 expressed in terms of signal strength in dB down from the peak at 24 MHz. Signal strength droops down from the 24 MHz peak by 3 dB at 16 and 31 MHz

One remedy is to drive the RSP1A thru the low noise multicoupler which has 3 and 10 dB gain ports. The choice of ports is a balancing act between receiving system noise contribution and dynamic range. The 10 dB port will result in the best sensitivity but the worst dynamic range. See SDRPlay RSP1-A Response Curves With and Without a Multicoupler, Flagg (2021).

The curve in Figure 3 suggests the importance of applying a correction curve in RSS which will have the effect of flattening the RSS spectrogram color response across the frequency range.

References

1. 24 ft TFD Square Array Manual, Typinski (2020)
2. TFD Element Efficiency Analysis, Typinski (2020)
3. The Galactic Background in the Upper HF Band, Typinski (2013)