VE7BQH Antenna Tables

White Paper

for calculations based on the revised August 2025 issue.

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DG7YBN

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1. Rules and Regulations

In order to give access to the increasing complexity of the mathematics operating inside the adaptive VE7BQH Antenna Tables we are issuing a White Paper.

Rules for new changes and additions to the Antenna Tables:

- Set of formulas

  The full set of formulas must be provided in both clear written form and as MS Excel formula.

- Units equations for all formulas applied

  A unit equation must be provided.

- Example calculation per step

  An example wise calculation with real values must be provided.

- The VE7BQH Antenna Tables seek equality to the output of the Antenna Temperature and G/Ta computing programs in values and nomination of data, and also the values given by the ITU-R to promote acceptance among users.

2. Abbreviations and Notation

Abbrev.	Explanation	Units
avg	Average Gain of an Antenna	/
B	Bandwidth	Hz
c_{band}	Extrapolation factor per band for calculating T_a	/
dB	Unit for Decibel	-
dBi	Unit for Gain against an Isotropic Radiator in Decibel	-
G	Gain, numerical value	/
$G_{(dB)}$	Gain in Decibel	dB
$G_{(dBi)}$	Gain against an Isotropic Radiator in Decibel	dBi
G/T	Gain-to-Temperature Ration	dB
G/T_a	Antenna Gain-to-Temperature-Ratio	dB
G/T_{sys}	Receiving systems Gain-to-Temperature-Ratio	dB
ITU-R	International Telecommunication Union, Radiocommunication Sector	/
J	Joule: Watt Second (1 J = 1 W·s)	J
K	Unit for Temperature in Kelvin	-
k_B	Boltzmann Constant	1.380649×10^{-23} J/K
NF_{sys}	Noise Figure of complete receiver excluding the antenna	dB
P_{noise}	System noise power, complete system including Antenna Temp.	W
P_{signal}	Power of received signal at the antenna terminals	W
Pr	Same as P_{signal} from different source of formula	W
'S'	Extrapolation parameter	K
S/N	Signal-to-Noise Ratio	dB
SNR	Signal-to-Noise Ratio, other common abbreviation for S/N	dB
T	Temperature in Kelvin	K
T_{total}	Antenna Temperature (also T_a … includes T_{loss})	K
T_{earth}	Radiation or brightness temperature of the earth hemisphere*	K
T_{loss}	Loss Temperature of antenna	K
$T_{pattern}$	Temperature of Antenna Pattern	K
T_{sky}	Radiation or brightness temperature of the sky hemisphere*	K

Indexes	Explanation
new	Target parameter setting for an extrapolation based on base parameter 'old'
old	Base parameter for extrapolating
sys	Complete receiver including antenna, LNA NF and all = System

*) As in the bi-hemispherical model for computing T_{total} with common programs (TANT, AGTC)

3. Interactive Antenna Total Temperature T_{total}

Old Reference:
Tsky=200K Tearth=1000K
New Reference: Tsky=290K

Reference: Estimated Values for man-made noise (Tearth) on

Rural =	1600	K
Residential =	5400	K
City =	14.550	K

Enter Tsky > 290 K   Enter Tearth > 5400 K

	1 Ant			DL6WU Optimal Stacking 4 Antennas					
Length (m)	GAIN (dBi)	E (m)	H (m)	G_A (dBi)	T_{loss} (K)	T_{total} (K)	G/T_A (dB/K)	G/T_{sys} (dB/K)	S/N (dB)
0,00	0,00	N/A	N/A	0,00	0,01	2844,94	-34,54	-34,62	-53,01
0,89	13,25	3,50	2,00	18,95	3,95	446,43	-7,55	-8,05	-26,44
1,08	9,23	2,13	1,57	15,22	1,60	698,06	-13,22	-13,55	-31,94
1,22	10,06	2,68	1,74	16,14	2,03	609,71	-11,71	-12,08	-30,47

Internal use only
Tpattern computed using
Tsky = 200 K, Tearth = 1000 K

Tpattern	"S"	Avg Gain
599,999	499,9994	1,0000
224,823	31,0294	0,9866
264,238	80,2975	0,9945
250,404	63,0052	0,9930

Enter Tsky > 290 K   Enter Tearth > 5400 K

For entered values of T_{sky} and T_{earth} the Antenna Temperature T_{total} is extrapolated from the base values on the far right. Being functions of T_{total} the G/T_A, G/T_{sys} and NF_{sys} adapt to the actual input.

The extrapolation is based on $T_{pattern}$ computed at the old reference temperatures and a factor 'S'. $T_{pattern}$ in the column on the far-right is derived by analysing the antenna models Far Field Table with the AGTC program at 'Old reference T_{sky} and T_{earth}'. The value of *avg* or *Avg gain* is also taken from the AGTC Far Field Pattern analysis. In case the antenna model requires Convergence Correction the computed Gain and Average Gain must be corrected using the set of formulas by KF2YN (calculator sheet).

Formula in the Excel Sheet, example 144.1 MHz Table:

T_{total} = ((X304/1000*H$8+(1-X304/1000)*D$8)+290*(1/Y304-1))*Y304

Formula in mathematic writing:

$$T_{total} = \left(\frac{S}{T_{earth,old}} \cdot T_{earth} + \left(1 - \frac{S}{T_{earth,old}}\right) \cdot T_{Sky} + 290\,K \cdot \left(\frac{1}{Avg} - 1\right)\right) \cdot Avg \qquad (3.1)$$

In this the inner term

$$\frac{S}{T_{earth,old}} \cdot T_{earth} + \left(1 - \frac{S}{T_{earth,old}}\right) \cdot T_{Sky} + 290\,K \cdot \left(\frac{1}{Avg} - 1\right)$$

equals T_a normalised against the 100 % of efficiency of the ideal isotropic radiator. By multiplying that with the average gain of the antenna, the T_{total} is calculated.

For 'S' see chapter 6.

Example 144.1 MHz, DJ9BV BVO2-4WL stacked at E=4.24 m, H= 4.02 m (100% DL6WU):

Numbers and Notations taken from the MS Excel™ sheet:
Tsky, new ref.: = 290 K, Tearth = 5400 K (residential); Tsky_old = 200 K, Tearth_old = 1000 K, NF = 0.75 dB
Ga = 22.29 dBi for the bay; Tloss = 6.96 K, Ta = 543.52 K, Tpattern(old ref. Temps) = 240.643 K, 'S' = 50.8033, Avg = 0.9766

$$T_{total} = \left(\left(\frac{50.8033\ K}{1000\ K} \cdot 5400\ K + \left(1 - \frac{50.8033\ K}{1000\ K}\right) \cdot 290\ K\right) + 290\ K \cdot \left(\frac{1}{0.9766} - 1\right)\right) \cdot 0.9766 \qquad (E3.1)$$

Single terms:

$$\left(\frac{50.8033\ K}{1000\ K} \cdot 5400\ K + \left(1 - \frac{50.8033\ K}{1000\ K}\right) \cdot 290\ K\right) = (274.338\ K + 275.267\ K) = 549.605\ K$$

$$290\ K \cdot \left(\frac{1}{0.9766} - 1\right) = 6.949\ K$$

Entering the results of the single terms into E4.1:

$$T_{total} = (549.605\ K + 6.949\ K) \cdot 0.9766 = 543.5306\ K$$

4. Antenna Gain to Temperature Ratio G/Ta

$$Basic\ formula: \quad G/T_a = G_{(dBi)} - 10\log(T_{ant}) \qquad (4.1)$$

Formula in the Excel Sheet, example 144.1 MHz Table:

G/Ta = F65-10*LOG(H65)

Formula in mathematic writing:

$$G/T_a = G_{a\,(dBi)} - 10\log(T_{total}) \qquad (4.2)$$

Example: 144 MHz DJ9BV 1.8 wl, Gain =19.43 dBi, Ta (Tsky = 290 K, Tearth = 1000 K) = 342.80 K, Avg. Gain = 0,9810, no Convergence Correction needed.

$$G/T_a = 19.43 - 10\log(342.80\,K) = 19.43 - 25.3504 = -5.92041\ {}^{dB}/_{K} \qquad (E4.2)$$

$$Units: \ G/T_a = dBi - dB = dB \ldots \ or\ if\ you\ will\ = dBi - K = {}^{dB}/_{K}$$

5. System Gain to Temperature Ratio G/Tsys

The VE7BQH Antenna Tables were started to list Antenna Gain-to-Temperature-Ratios, G/T_a (3.1) of various antennas to enable operators to select useful antennas for Moon Bounce. Then, moving towards compliance with the ITU-R by adding Noise Figure of the receiver system to the formula. This is the complete receiving systems Gain to Temperature ratio G/T_{sys}:

$$Basic\ formula \quad G/T_{sys} = G_{(dBi)} - 10\log(T_{ant} + T_{receiver}) \qquad (5.1)$$

$$with \quad T_{receiver} = T_0\left(10^{\left(\frac{NF_{Sys(dB)}}{10}\right)} - 1\right) \qquad with\ T_0 = 290\,K \qquad (5.2)$$

Formula in the Excel Sheet, example 144.1 MHz Table:

G/Tsys =F65-10*LOG(H65+290*((10^(N$8/10)-1)))

With N$8 = Receiver systems Noise Figure excluding the Antenna.

$$G/T_{sys} = G_{a\,(dBi)} - 10\log\left(T_{total} + T_0\left(10^{\left(\frac{NF_{Sys(dB)}}{10}\right)} - 1\right)\right) \qquad (5.3)$$

Example: 144 MHz DJ9BV 1.8 wl, Gain =19.43 dBi, Ta (Tsky = 290 K, Tearth = 1000 K) = 342.80 K, Avg. Gain = 0,9810, no Convergence Correction needed. NF = 0.75 dB.

$$G/T_{sys} = 19.43 - 10\log\left(342.80\,K + 290\,K \cdot \left(10^{\left(\frac{0.75\,dB}{10}\right)} - 1\right)\right) \qquad (E5.3)$$

$$G/T_{sys} = 19.43 - 10\log(342.80\,K + 290\,K \cdot 0.18850223)$$

$$G/T_{sys} = 19.43 - 10\log(397.466\,K) = 19.43\,dB - 25.993\,dB = -6.563\,dB$$

Exceptions:

- Variations of columns holding the editable T_{earth}, T_{sky} and *System NF*

144 MHz + 432 MHz tables:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1																
2	~~Issue: May 16, 2025~~					VE7BQH Antenna Table										
3	Test YBN 2025-08-10															
4		Reference Temperatures				Estimated Values for man made noise (Tearth) on 432.1 MHz:										
5		Old: Tsky=20K Tearth=350				Rural =		760	K							
6		New: Tsky=27K				Residential =		1800	K							
7						City =		8200	K					Enter RX System NF > (dB)		
8			Enter Tsky >	27	K	Enter Tearth >		8200	K					0,00		
9												1 Ant.				
10			1 Ant.			4 Antennas						<	H Plane	>		
11	TYPE OF	Length	GAIN	E	H	GA	Tloss	TAtotal	G/TA	G/Tsys	S/N	F/R	1st SL	2nd SL	Z	e
12	ANTENNA	(m)	(dBi)	(m)	(m)	(dBi)	(K)	(K)	(dB/K)	(dB/K)	(dB)	(dB)	(dB)	(dB)	(ohms)	(dB)
13																
14	F5FOD Isotropic Lossless Radiator	0,00	0,00	N/A	N/A	0,00	0,01	4113,42	-36,14	-36,14	-54,53	N/A	N/A	N/A	N/A	N/A
15	KF2YN Boxkite 4	0,31	13,24	1,20	0,85	19,30	5,02	732,62	-9,35	-9,35	-27,74	26,10	21,5	none	52,5	-0,01

50 MHz table:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2	~~Issue: May 16, 2025~~																	
3	Test YBN 2025-08-10	Old Reference: Tsky = 1700 K, Tearth = 9000 K																
4		~~Old Reference: Tsky = 4225 K, Tearth = 6000 K~~																
5		New Reference: Tsky = 5640 K						Rural =		29700	K							
6								Residential =		100600	K							
7								City =		270800	K							
8				Enter Tsky >		5640	K	Enter Tearth >		100600	K			Enter Receive System NF >			0,75	dB
9								DL6WU Optimal Stacking						Compromise 75% Stacking				
10			1 Ant			4 Antennas						2E Ant	2H Ant	Spacing		4 Ant	2E Ant	2H Ant
11	TYPE OF	Length	GAIN	E	H	GA	Tloss	TAtotal	G/TA	G/Tsys	S/N	GA	GA	E	H	GA	GA	GA
12	ANTENNA	m	(dBi)	(m)	(m)	(dBi)	(K)	(K)	(dB/K)	(dB/K)	(dB)	(dBi)	(dBi)	(m)	(m)	(dBi)	(dBi)	(dBi)
13																		
14	Isotropic Lossless Radiator	0,00	0,00	N/A	N/A	0,00	0,007	53118,6	-47,25	-47,26	-52,64	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	PY1MHZ 2	0,40	6,63	5,39	3,34	13,26	1,8	17664,5	-29,21	-29,22	-34,60	9,68	10,06	4,04	2,51	11,83	9,16	9,20
16	G0KSC 2 LFA-Q	0,42	7,49	5,17	3,715	13,84	2,9	13790,7	-27,56	-27,57	-32,95	10,34	10,67	3,98	2,79	12,23	9,78	9,73

- Variations of columns holding the extrapolation parameters *S* and *avg_gain*:

144.1 and 432.1 MHz tables:

V	W	X	Y
	Internal use only		
	Tpat computed using		
	Tsky = 20 K, Tearth = 350 K		
	Tpattern	"S"	Avg Gain
	185,0005	175,0005	1,0000
	48,7996	30,5450	0,9830
	35,1054	16,0208	0,9719

50.1 MHz table:

AB	AC	AD	AE
	Internal use only		
	Tpat computed using		
	Tsky = 1700 K, Tearth = 9000 K		
	Tpattern	"S"	Avg Gain
	5349,993	4499,992	1,0000
	2632,827	1150,061	0,9937
	2337,030	785,379	0,9900

Example 432.1 MHz Table:

= ((**W**15/350*H$8+(1-**W**15/350)*D$8)+ …
(1/**X**15)

Example 50.1 MHz Table:

= ((**AC**15/9000*J$8+(1-**AC**15/9000)*F$8)+ …
(1/**AD**15)

6. Extrapolation factor 'S' and c_{band}

'S' is a factor used in extrapolating Antenna Temperature for an actually chosen set of T_{earth} and T_{sky} from the Antenna Pattern Temperature $T_{pattern}$ derived with applying the old reference temperatures for the frequency band to the antenna models Far Field Table in AGTC:

$$S = (T_{Pattern} - T_{sky,old}) \cdot c_{band} \qquad with\ T_{pattern}(T_{earth,old}, T_{sky,old}) \qquad (6.1)$$

$$units\ only: \quad (K - K) = K$$

Factor *c* is found by making use of the fact, that any lossless antenna with a free space pattern symmetrical to the ground plane (Elevation Plot), with boresight beam at null elevation (φ = 0°) gathers an equal amount of noise from each of the two hemispheres of our theoretical noise model.

Thus, a simplified formula gives the Antenna Temperature $T_{pattern}$ for antennas at φ = 0°:

$$T_{pattern}(\varphi = 0°) = \frac{T_{earth} + T_{sky}}{2} \qquad (6.2)$$

$T_{pattern}$ can also be derived by using the core of the extrapolation formula (see chapter 3):

$$T_{pattern} = \frac{S}{T_{earth,old}} \cdot T_{earth} + \left(1 - \frac{S}{T_{earth,old}}\right) \cdot T_{Sky} \qquad with\ S = (T_{Pattern} - T_{sky,old}) \cdot c \qquad (6.3)$$

with

$$T_{pattern} = T_a - T_{loss} \qquad (6.4)$$

In the Tables all the values entered for antennas are at 30 degrees of elevation (φ = 30°). The *Lossless Isotropic Radiator*'s T_A does not change for whatever angle φ of elevation. Consequently its T_A(φ = 0°) is equal to its T_A(φ = 30°). This property we use for exterminating *c*.

Equation 6.4 rearranged and 6.3 inserted:

$$T_a = \frac{S}{T_{earth,old}} \cdot T_{earth} + \left(1 - \frac{S}{T_{earth,old}}\right) \cdot T_{Sky} = \frac{S}{T_{earth,old}} \cdot T_{earth} + T_{Sky} - \frac{S}{T_{earth,old}} \cdot T_{Sky} \qquad (6.5)$$

With

$$T_{pattern}(Lossless\ Iso.Rad.) = T_A \qquad (6.4.1)$$

$$T_a - T_{Sky} = S\left(\frac{T_{earth}}{T_{earth,old}} - \frac{T_{Sky}}{T_{earth,old}}\right) \qquad (6.5.1)$$

$$S = (T_{Pattern} - T_{sky,old}) \cdot c = \frac{T_a - T_{Sky}}{\frac{T_{earth}}{T_{earth,old}} - \frac{T_{Sky}}{T_{earth,old}}} \qquad (6.5.2)$$

$$c = \frac{T_a - T_{Sky}}{\left(\frac{T_{earth}}{T_{earth,old}} - \frac{T_{Sky}}{T_{earth,old}}\right) \cdot (T_{Pattern} - T_{sky,old})} \qquad (6.5.3)$$

Tpattern('Old reference $T_{sky,old}$ = 200 K, $T_{earth,old}$ = 1000 K') = 600 K:

$$T_a(isotropic\ lossless\ Rad., old\ Ref.) = \frac{1000\ K + 200\ K}{2} = 600\ K \qquad (E6.1)$$

Tpattern(Entered Tsky = 290 K, Tearth = 5400 K') = 2845 K:

$$T_a(isotropic\ lossless\ Rad.) = \frac{5400\ K + 290\ K}{2} = 2845\ K \qquad (E6.2)$$

Equation 6.5.3 with E6.1 and E6.2 with values from the 144 MHz Table for the *Lossless Isotropic Radiator*:

$$c = \frac{2845\ K - 290\ K}{\left(\frac{5400\ K}{1000\ K} - \frac{290\ K}{1000\ K}\right) \cdot (600\ K - 200K)} = \frac{2555\ K}{(5.4 - 0.29) \cdot 400\ K} = \frac{2555\ K}{2044\ K} = 1.25000000 \qquad (E6.3)$$

Radio Band	$T_{sky, old}$	$T_{earth, old}$		*Extrapolation factor c*
70 cm	20 K	350 K	>	1.060606061
2 m	200 K	1000 K	>	1.250000000
6 m	1700 K	9000 K	>	1.232876712

Table: Reference Temperatures $T_{sky,old}$, $T_{earth, old}$, c per band

7. Signal to Noise Ratio S/N

To calculate S/N or SNR we need to divide a signal power by a noise power. To calculate signal power we need a signal defined by power and antenna gain, transmitted somewhere, and a link budget between transmitter and receiver, to determine how much power arrives at the receiver's antenna. In this particular case we have no declared transmitter power and transmit antenna gain at hand.

We do have a link budget for the main use of the antenna tables, which is the distance Earth-Moon-Earth; a coarsely valued -250 dB. Assuming the received signal as reflected by the moon quantum of transmitted power may be at the detection threshold of CW passed through a narrow filter or WSJT JT65 or similar, which is coarsely -30 dB. The total received power in front of the receiving antennas equivalent aperture area at this level may coarsely be equal to 5E-22 W or -183 dBm (2 m, 70 cm) or 1E-20 W = 170 dBm (6 m) when typical station sizes are used both sides of the connection.

Formula, extracted from the 432 MHz tables Excel:

S/N=10*LOG((10^(F15/10)*5E-22/X15)/(1,380649E-23*(W15/350*H$8+(1-W15/350)*D$8+290*(10^(M$8/10)/X15-1))*2500))

Extracting the blue term as A:

A = 10*LOG((10^(F15/10)*5E-22/X15)

Extracting the green term as B:

B = 1,380649E-23*(W15/350*H$8+(1-W15/350)*D$8+290*(10^(M$8/10)/X15-1))*2500)

We may look upon this as the basic formula for SNR respectively S/N

$$S/N\,(dB) = 10\log\left(\frac{P_{signal}}{P_{noise}}\right) = 10\log\left(\frac{A}{B}\right) \qquad (7.1)$$

P_{signal} = Power of received signal at the antenna terminals
P_{noise} = System noise power; complete system including antenna temperature
T_0 = 290 K

So, term A represents signal power from the antenna, term B represents noise power from antenna plus receiver. The formula from the Excel transferred to a mathematical style of writing:

$$S/N\,(dB) = 10\log\left(\frac{\frac{10^{\frac{G_{a(dBi)}}{10}}}{avg}\cdot 5\cdot 10^{-22}w}{k_B\cdot\left(\frac{S}{T_{earth,old}}\cdot T_{earth}+\left(1-\frac{S}{T_{earth,old}}\right)\cdot T_{sky}+T_0\left(\frac{10^{\frac{NF_{dB}}{10}}}{avg}-1\right)\right)\cdot B}\right) \qquad (7.2)$$

$$S/N\,(dB) = 10\log\left(\frac{\frac{10^{\frac{G_{a(dBi)}}{10}}}{avg}\cdot 5\cdot 10^{-22}w}{k_B\cdot\left(T_{pattern,new}+T_0\left(\frac{10^{\frac{NF_{dB}}{10}}}{avg}-1\right)\right)\cdot B}\right) \qquad (7.3)$$

$5\,E^{-22}$ = watts, power of received signal ex. the antennas gain= -183 dBm (144, 432 MHz), use 1^{-20} W for 50 MHz

Note: The difference in S/N between two antennas to be compared stays the same, no matter the signal power as long as the same signal power is applied to both. So, we could argue about the actual value of the signal but it does not change the delta in S/N between the to be compared antennas. It only lowers, respectively lifts the bar for all the antennas.

k_b = Boltzmann-Constant = 1.380649 x 10^{-23} J/K
B = Band width = 2500 Hz

Value for P_r

Freq. (MHz)	Signal power	Log. value
50.1	1E-20 W	-170 dBm
144.1	5E-22 W	-183 dBm
432.1	5E-22 W	-183 dBm

$$T_0\left(10^{\frac{NF_{dB}}{10}}-1\right) = Noise\ Figure\ to\ Noise\ Temperature\ of\ a\ Device\ in\ Kelvin; \qquad with\ T_0 = 290\ K \qquad (7.4)$$

Compare this to a formula from a university lecture by Dr. Nikolova [4]:

Mind this formula describes a complete link budget including mismatch losses on both transmit and receive side. We do not have that for the application in the table's computations. We may simplify the formula to seek an equivalent.

$$SNR_{num} = \frac{P_r}{P_N} = \frac{(1-|\Gamma_t|^2)\cdot(1-|\Gamma_r|^2)\cdot PLF\cdot G_t(\theta_t,\varphi_t)\cdot G_r(\theta_r,\varphi_r)\cdot P_t}{k_B\cdot T_{sys}\cdot B} \qquad Nikolova\ (7.70)\ from\ [4]$$

With

Index r = Receiver; index t = transceiver

$$T_{sys} = T_A + T_p\left(\frac{1}{e_A}-1\right) + \frac{1}{e_A}T_{Lp}\left(\frac{1}{e_L}-1\right) + \frac{1}{e_A e_L}T_R \qquad Nikolova\ (7.52)\ from\ [4]$$

T_a = Temperature of Antenna, external [ant. Temp. due to being exposed to T_{earth}, T_{sky}]

$T_p\left(\frac{1}{e_A}-1\right)$ = Temperature Antenna, internal [loss temperature due to internal losses]

$\frac{1}{e_A}T_{Lp}\left(\frac{1}{e_L}-1\right)$ = Temperature, Transmission Line

$\frac{1}{e_A e_L}T_R$ = Temperature of Receiver

$(1-|\Gamma_t|^2), (1-|\Gamma_r|^2)$ = Mismatch factors for Receiver resp. Transmitter side antennas, *s. Nikolova [5]*

PLF = 0.5 = value of the PLF = factor for linear Polarization (as noise is unpolarized, noise power picked up by a linear polarized antenna is down by -3 dB or in numerical values half of the noise).

G_t = Gain of transmitter antenna, numerical value at beam angles Θ, φ.

G_r = Gain of receiver antenna, numerical value at beam angles Θ, φ.

Neglecting Mismatch Loss, gain of transmitter antenna, the PLF factor and assuming that the receiver antenna points into bore sight direction i. e. maximum gain and pattern for 30 degrees of elevation ($T_{pattern}$) the *Nikolova (7.70),2023[4]* may be reduced to

$$SNR_{dB} = 10\log\left(\frac{G_r\cdot P_{signal\ as\ it\ gets\ into\ the\ RX-antenna}}{k_B\cdot T_{sys}\cdot B}\right) \qquad reduced, transfered\ to\ dB\ Nikolova\ (7.70) \qquad (7.5)$$

Now compare this to the formula given in the tables by UR5EAZ, edited by DG7YBN (terms in light blue belong to or have their origin in the extrapolation scheme):

$$S/N\,(dB) = 10\log\left(\frac{\frac{10^{\frac{G_{a(dBi)}}{10}}}{avg}\cdot 5\cdot 10^{-22}\,W}{k_B\cdot\left(T_{pattern,new} + T_0\left(\frac{10^{\frac{NF_{dB}}{10}}}{avg}-1\right)\right)\cdot B}\right) \qquad with\ T_0 = 290\,K \qquad (7.6)$$

$$S/N\,(dB) = 10\log\left(\frac{\frac{G_{a,num}}{avg}\cdot P_{signal\ as\ it\ gets\ into\ the\ RX-antenna}}{k_B\cdot T_{sys,new}\cdot B}\right) \qquad (7.7)$$

Calculation example for which the tables show a S/N = -19.12 dB:

Example 432.1 MHz, YU7EF EF7011B-5:

Numbers and Notations taken from the MS Excel™ sheet: Tsky, new ref.: = 27 K, T_{earth} = 1800 K (residential); $T_{sky,old}$ = 20 K, $T_{earth,old}$ = 350 K, NF = 0.75 dB Ga = 21.00 dBi for the bay; Tloss = 4.78 K, TA = 36,69 K, $T_{a,old}$ = 36.100 K, $T_{pat,old}$ = 31.9173, S = 12.639467, avg = 0.9838

$$S/N\,(dB) = 10\log\left(\frac{\frac{10^{\frac{G_{a(dBi)}}{10}}}{avg}\cdot 5\cdot 10^{-22}\,W}{k_B\cdot\left(T_{pattern,new}+T_0\left(\frac{10^{\frac{NF_{dB}}{10}}}{avg}-1\right)\right)\cdot B}\right) \qquad (Repeated\ 7.6)$$

- $P_{received}$:

$$10^{\frac{G_{a(dBi)}}{10}} = 10^{\frac{21.00\,dBi}{10}} = 125.8925$$

$$\frac{10^{\frac{G_{a(dBi)}}{10}}}{avg}\cdot 5\cdot 10^{-22}\,W = \frac{125.8925}{0.9838}\cdot 5\cdot 10^{-22}\,W = 127.9665\cdot 5\cdot 10^{-22}\,W = 6.39832\cdot 10^{-20}\,W$$

- $T_{pattern,\,new}$:

$$\frac{new\_S}{T_{earth,old}}\cdot T_{earth} + \left(1-\frac{new_S}{T_{earth,old}}\right)\cdot T_{sky} = \frac{12.639467\,K}{350\,K}\cdot 1800\,K + \left(1-\frac{12.639467\,K}{350\,K}\right)\cdot 27\,K$$

$$= 65.003\,K + (1-0.036113)\cdot 27\,K = 91.028\,K$$

- $T_{Receiver}$:

$$290\,K\left(\frac{10^{\frac{NF_{dB}}{10}}}{avg}-1\right) = 290\,K\left(\frac{10^{\frac{0.75\,dB}{10}}}{0.9838}-1\right) = 290\,K\left(\frac{1.188503}{0.9838}-1\right) = 290\,K\,(0.208073) = 60.3412\,K$$

- Inserting terms into (7.6):

$$S/N\,(dB) = 10\log\left(\frac{6.39832\cdot 10^{-20}\,W}{1.380649\cdot 10^{-23}\frac{J}{K}\cdot(91.028\,K+60.3412\,K)\cdot 2500\,Hz}\right)$$

$$S/N\,(dB) = 10\log\left(\frac{6.39832\cdot 10^{-20}\,W}{1.380649\cdot 10^{-23}\frac{J}{K}\cdot(151.3692\,K)\cdot 2500\,Hz}\right)$$

$$S/N\,(dB) = 10\log\left(\frac{6.39832\cdot 10^{-20}\,W}{5.22469\cdot 10^{-18}\,W}\right) = -19.12\,dB$$

8. Antenna Internal Loss Temperature T_{loss}

Loss in the antenna structure as Input Loss Temperature is calculated through

$$T_{loss} = T_0 \left(\frac{1}{avg} - 1\right) \quad with\ T_0 = 290\,K \quad (8.1)$$

$$units\ only: \quad K = K \cdot \left(\frac{1}{/} - 1\right)$$

avg = Average Gain (/)

Note: $$T_{loss,out} = avg_{num} \cdot T_{loss,in} \quad (8.2)$$

Example for an antenna with Average Gain (*avg*) of 0.9830:

$$T_{loss} = 290\,K \cdot \left(\frac{1}{0.9830} - 1\right) = 290\,K \cdot 0.017294 = 5.0153\,K$$

9. Efficiency e

Formula, extracted from the 432 MHz tables Excel:

=10*LOG10((1-((P15-1)/(P15+1))^2))

$$\eta_{mismatch} = 1 - \left(\frac{VSWR - 1}{VSWR + 1}\right)^2 \quad (9.1)$$

Efficiency *e* as maximum Mismatch Loss in dB over the bandwidth used by VSWR Bandwidth

$$e_{dB} = 10\log\left(1 - \left(\frac{VSWR_{Bandwidth} - 1}{VSWR_{Bandwidth} + 1}\right)^2\right) \quad (9.2)$$

Example, 432.1 MHz:

$$e_{dB} = 10\log\left(1 - \left(\frac{1.83 - 1}{1.83 + 1}\right)^2\right) \quad (E9.1)$$

$$e_{dB} = 10\log\left(1 - \left(\frac{0.83}{2.83}\right)^2\right) = 10\log(1 - 0.086017) = -0.39062\,dB$$

Note that the amount of e_{dB} can straight away subtracted from Gain, and thus G/T and S/N for a Yagi operated at the worst VSWR over the bandwidth. Which could serve as an estimation when the Yagi is fully wet or covered in a thin layer of ice.

10. Radiation and Antenna Efficiency η

These formulas are not included in the Antenna Tables, they may give hints only.

Radiation Efficiency:

Formula in Excel would be: =(1-(G15/290))*100

with

$$\eta_{radiation} = \left(1 - \frac{T_{loss}}{T_0}\right) \quad with\ T_0 = 290\ K \qquad (10.1)$$

We do not have a VSWR at the operating frequency in the tables. But it is understood that for a properly build Yagi the VSWR will very near to 1:1. Hence influence of $\eta_{mismatch}$ could be neglected on the operating frequency 432.1 MHz, 144.1 MHz, 50.1 MHz.

$$\eta_{total,op.-freq.}(\%) \approx \eta_{radiation}(\%) = \left(1 - \frac{T_{loss}}{T_0}\right) \cdot 100 \quad with\ T_0 = 290\ K; \qquad units:\ 1 - \frac{K}{K} = (/)$$

Example, 144.1 MHz:

$$\eta_{radiation}(\%) = \left(1 - \frac{3.95\ K}{290\ K}\right) \cdot 100 \quad = 98.634\ \%$$

Antenna Efficiency:

Antenna Efficiency as sum of Mismatch and Radiation Efficiency:

$$\eta_{total} = \eta_{mismatch} \cdot \eta_{radiation}$$

$$\eta_{total}(\%) = (\eta_{mismatch} \cdot \eta_{radiation}) \cdot 100$$

11. Default values of T_{sky}, T_{earth} for issuing tables

When post

50.1 MHz issue 35,
144.1 MHz issue 103
432.1 MHz issue 10
antenna tables are issued, T_{Sky} and T_{Earth} are preset to values, that represent a T_{Sky} per [2,3] and T_{Earth} in *residential areas* per [1] as default:

Radio Frq.	*T_{sky}*	*T_{earth}*
432 MHz	27 K	1800 K
144 MHz	290 K	5400 K
50 MHz	5640 K	100600 K

12. TANT vs. AGTC

It is known that TANT produces slightly different values of Antenna Temperature and G/T_a then AGTC, mainly at elevation angles θ apart from 0° and 90°.

While the source code of TANT seems lost, the code for AGTC is fully available and for download. The formulas and how they are derived is published in Dubus in full including a comparison with what DJ9BV gave in his breaking article 'Effective Noise Temperatures of 4-Yagi-Arrays for 432 MHz EME' in Dubus 4/87.

See Antenna G/T Calculators with Open Source Code, Part 1-4, F5FOD with DG7YBN, Dubus 1/2017, 2/2017, 3/2017 and 4/2017.

Source Code and download of the AGTC Program:
http://dg7ybn.de/Ant_soft/Antenna_GT_f5fod.htm

For further details see
TANT Manual v. 1.4, 12/2017
ttps://www.dxmaps.com/docs/TANT_manual.pdf

13. Credits

Lossless Isotropic Radiator:
Far Field Table model of the *Lossless Isotropic Radiator*: F5FOD

Chapter 3, Extrapolated Antenna Temperature T_a:
Equation (3.1) for extrapolation of new T_{ant} from $T_{pattern}$(Reference, Old T_{sky}, T_{earth}) for varying T_{sky}, T_{earth}: UR5EAZ. Extended to $T_{A,\ total}$ by DG7YBN.

Chapter 6, Extrapolation Factor c *and thus* 'S':
Equation (6.1) extrapolation factor *c* and formula to derive *S* per band and general idea to use the isotropic radiator as basis for deriving factor *c*: UR5EAZ.

Chapter 7, Signal to Noise Ratio S/N:
Equation (7.3) in its functionality, UR5EAZ; rearranging by DG7YBN.

Chapter 9, Efficiency e:
Equation (9.2) in its functionality, UR5EAZ; modified to Mismatch Loss in dB by DG7YBN

14. References

1: Man-Made Noise in Our Living Environments, U.R.S.I. Radio Science Bulletins No. 334, 09.2010

2: Reich, P., Reich, W.: A map of spectral indices of the Galactic radio continuum emission between 408 and 1420 MHz for the entire northern sky, Astronomy & Astrophysics

3: Tsky for 50.15 MHz is produced from the ITU recommendations P.372-13

4: Nikolova, N: Lecture 7: Antenna Noise Temperature and System Signal-to-Noise Ratiohttps://www.ece.mcmaster.ca/faculty/nikolova/antenna_dload/current_lectures/L07_Noise.pdf, McMaster University, Canada, 2023

5: Nikolova, N: Lecture 6: Friis Transmission Equation and Radar Range Equationhttps://www.ece.mcmaster.ca/faculty/nikolova/antenna_dload/current_lectures/L06_Friis.pdf, McMaster University, Canada, 2023

15. Associated Read

International Telecommunication Union: Recommendation ITU-R P.372-16 Radio Noise, 08/2022, https://www.itu.int/rec/R-REC-P.372

Klüver, H., DG7YBN: Update to Sky and Earth Temperatures for VHF/UHF Amateur Radio Bands, Dubus 2/2019

Waymel, J.-P., F5FOD, Klüver, H., DG7YBN: Antenna G/T Calculators with Open-Source Code, Part 4, Dubus 4/2017

Klüver, H., DG7YBN: TANT Appendix - Towards the G/T Table -, Dec. 2017, https://www.dxmaps.com/docs/TANT_Manual_Appendix_v1_1.pdf

Klüver, H., DG7YBN: Notes on VHF/UHF Antenna G/T, Dubus 2/2012 & Dubus Technik XII