The World Below 160 Meters

Including Two New Ham Bands

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The Spectrum at and Below 160

- 160 Meters is in the upper portion of the Medium Frequency (MF) or Medium Wave (MW) Band
- Sub-bands:
 - High Frequency (HF or SW) 3 30 MHz
 - Medium Frequency (MF or MW) 300 kHz 3 MHz
 - Low Frequency (LF or LW) 30 300 kHz
 - Very Low Frequency (VLF) 3 30 kHz
 - Ultra Low Frequency (ULF) 300 Hz 3 kHz
 - Super Low Frequency (SLF) 30 Hz to 300 Hz
 - Extremely Low Frequency (ELF) 3 to 30 Hz

UNITED

STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM







0 Hz to 300 kHz



2200 Meters

- 135.7 to 137.8 kHz (2.1 kHz of spectrum)
- Max 1 Watt EIRP
- General Class and higher
- Permissible Modes CW, RTTY, Data, Phone and Image
- Must inform power company prior to operation. Must prevent interference to existing PLC systems on their electric power transmission lines
 - <u>https://utc.org/plc-database-amateur-notification-process/</u>
- Max antenna height 60 meters (197 feet)

2200 Meter Band Plan

• 135.7–136.0 kHz

- Station Tests and transatlantic reception window
- 136.0–137.4 kHz
 - Telegraphy

• 137.4–137.6 kHz

- Non-Telegraphy digital modes
- 137.6–137.8 kHz
 - Very slow telegraphy centered on 137.7 kHz
- JT9/FST4/WSPR/FST4W 136.0 kHz

WSPR Contacts on 2200 Meters

Local (y-m-d)	тх	txGrid	RX	rxGrid	MHz	W	SNR	drift	km	Az°	mode	km/W	spotQ	version
2023-01-09 22:10	N4WLO	EM50vj	WV5L	EM74sc	0.137473	0.1	-25	0	542	40	2	5420	1656	
2023-01-09 22:10	DC0DX	JO31lk	DARCT13	JN47wn	0.137425	0.2	-19	0	480	153	2	2400	1133	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	DF1DR	JO31rm	0.137425	0.2	-2	0	36	75	2	180	170	WD_3.0.3.4
2023-01-09 22:10	DC0DX	JO31lk	F1EYG	JN18ar	0.137425	0.2	-21	0	462	231	2	2310	963	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	DF8FH	JO33pm	0.137425	0.2	-7	0	233	5	2	1165	938	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	MM3NDH	IO86ha	0.137425	0.2	-28	0	848	311	2	4240	942	WD_3.0.4
2023-01-09 22:10	DC0DX	JO31lk	M0XDK	IO92ne	0.137425	0.2	-26	0	545	282	2	2725	757	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	EA3IHV/KIWI	JN11bi	0.137425	0.2	-22	0	1180	200	2	5900	2294	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	PD00HW	JO33lc	0.137425	0.2	-11	0	185	0	2	925	642	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	OE9GHV	JN47wk	0.137425	0.2	-25	0	492	154	2	2460	752	WD_3.0.5
2023-01-09 22:10	DC0DX	JO31lk	ON5KQ	JO10os	0.137425	0.2	-10	0	272	256	2	1360	982	WD_3.0.6
2023-01-09 22:10	DC0DX	JO31lk	G4ZFQ	IO90ir	0.137425	0.2	-17	0	581	265	2	2905	1533	WD_3.0.5
2023-01-09 22:10	DC0DX	JO31lk	SWL1/JO21	JO21jn	0.137425	0.2	-7	0	151	276	2	755	608	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	SWL/TNS1	JN48or	0.137425	0.2	-25	0	341	151	2	1705	521	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	PA1JMS	JO21cx	0.137425	0.2	-10	0	199	289	2	995	719	
2023-01-09 22:10	DC0DX	JO31lk	DC5AL-R	JO31lk	0.137425	0.2	34	0	0	0	2	0	0	
2023-01-09 22:10	DC0DX	JO31lk	PAORDT	JO11tm	0.137425	0.2	-7	0	231	274	2	1155	930	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	DC1RDB	JN58ss	0.137424	0.2	-22	0	441	130	2	2205	858	WD_3.0.5
2023-01-09 22:10	W5GNB	DM73vb	SWLDM63ID	DM63id	0.137502	2	-26	0	287	273	2	144	40	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	G0VQH	JO02fe	0.137425	0.2	-13	0	454	283	2	2270	1450	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	HB9TTU	JN47jj	0.137424	0.2	-25	0	469	163	2	2345	717	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	DH0GFW	JN48vc	0.137425	0.2	-27	0	423	150	2	2115	529	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	2E0ILY/KIWI	IO82qv	0.137425	0.2	-20	0	673	288	2	3365	1496	WD_2.10k
2023-01-09 22:10	DC0DX	JO31lk	G0EZY/SDR1	IO93In	0.137424	0.2	-11	0	590	297	2	2950	2049	1.4A Kiwi
2023-01-09 22:10	DC0DX	JO31lk	PA1W/P	JO21xs	0.137425	0.2	-14	0	78	299	2	390	238	1.4A Kiwi
2023-01-09 22:10	N4WLO	EM50vj	SWLEM3	EM03rf	0.137473	0.1	-27	0	1025	291	2	10250	2563	2.5.4
2023-01-09 22:10	DC0DX	JO31lk	F4ASK	IN96ij	0.137425	0.2	-22	0	822	230	2	4110	1598	2.1.0-rc14
2023-01-09 22:10	DC0DX	JO31lk	SM2DJK	KP03au	0.137425	0.2	-18	0	1578	24	2	7890	3945	2.3.0
2023-01-09 22:10	DC0DX	JO31lk	DK8FT	JN580e	0.137425	0.2	-17	0	473	138	2	2365	1248	
2023-01-09 22:10	DC0DX	JO31lk	SM3LNM	JP82qg	0.137433	0.2	-18	0	1357	23	2	6785	3393	2.4.0
2023-01-09 22:10	DC0DX	JO31lk	DL0AO	JN59vk	0.137425	0.2	-7	0	408	121	2	2040	1643	
2023-01-09 22:10	DC0DX	JO31lk	2E0ILY/AFED	IO82qv	0.137425	0.2	-18	0	673	288	2	3365	1683	2.5.3
2023-01-09 22:10	DC0DX	JO31lk	DL6OW-MH	JO31kk	0.137424	0.2	17	0	6	270	2	30	44	1.4A Kiwi

300 kHz to 3 MHz



630 Meters

- Why? Because it is there. Long ground wave propagation. Different from HF skywave propagation
- 472 to 479 kHz (7 kHz of spectrum)
- Max 5 Watt EIRP
- General Class and higher
- Permissible Modes CW, QRSS CW, RTTY, Data (JT9, WSPR, FST4, FST4W, FT8), Phone and Image
- Must inform power company prior to operation. Must prevent interference to existing PLC systems on their electric power transmission lines
 - <u>https://utc.org/plc-database-amateur-notification-process/</u>
- Max antenna height 60 meters (197 feet)
- 472 kHz.org Great resource website: <u>https://www.youtube.com/watch?v=tlpoJl_I8Gc</u>

630 Meter Band Plan



Courtesy W1FR

CW calling frequency - 474.2 kHz WSPR/FST4W – 475.7 kHz or 474.2 kHz JT9/FST4 – 474.2 kHz

Transmitters/Transverters

- <u>https://www.minikits.com.au/eme223</u>
- <u>https://sites.google.com/site/g3xbmqrp3</u> /mflf/472khz_tvtr





Transmitters/Transverters

• A limited number of commercial HF transceivers will transmit on 630 m, but most of them with low power, so you might still need a power amplifier:

Brand - type (alphabetical order)	Output power @ 472 kHz	Remarks							
Elecraft K3S	0.5 - 1.0 mW	KBPF3A option required							
ICOM IC-703	100 mW	modification required: Full transmit HF + additional LPF!							
ICOM IC-706	2 W	power setting: "L" in the IC706's "Q1 RF POWER" menu							
ICOM IC-735	95 W	modification required: Modifying an IC735 for the 630m band							
ICOM IC-7100	up to 50 W	modification required: frequency range modification							
ICOM IC-7300	30 W	modification required: Wide Band Modification							
ICOM IC-756PRO II	low power only!	modification required: ICOM IC-756PRO II - TX expand mod							
ICOM IC-7850 / IC-7851		modification required: Expanding TX/RX frequency Coverage							
Kenwood TS590S	1 mW	Ver.2 (or more recent) firmware update required							
Kenwood TS990S	1 mW	Ver. 1.08 (or more recent) firmware update required							
SoftRock RXTX 1 W		modification required: Modification for 2200, 630 and 160 m							

630 Meter Antennas

- Loaded 160, 80 or 40 meter antenna
 - The vertical section is the main radiator; the horizontal wires of the antenna are the capacitive hat for loading a physically short antenna
 - In my case, I have a 160 meter doublet. The vertical section of 450 ohm ladder line is 85 feet with each top hat measuring 130 feet
 - The impedance of this antenna is around 75 ohms wit around 900 pF of capacitive reactance. This should no be difficult to match to 50 ohms
 - Large loading coils will likely be needed for shorter antennas
 - A good ground radial system is required



630 Meter Antennas Come to the Workshop DOUBLET 33 ft. 33 ft. 000 000 Drooping ends shown to fit 33 ft. average city lot Balanced 33 ft. Feedline 50 ft. balanced ladder or window line (Ladderline) 80 meter dipole or Antenna system tuning unit Single point ground (Windowline) connection connection Tuner Tuner Trans Trans Robust grout system Robust ground system

WSPR Contacts on 630 meters

Local (y-m-d)	тх	txGrid	RX	rxGrid	MHz	W	SNR	drift	km	Az°	mode	km/W	spotQ	version
2023-01-08 23:00	WD8DAS	EN52hx	WV5L	EM74sc	0.475719	1	-25	0	1075	155	2	1075	328	
2023-01-08 23:00	M0DMC	JO02be	G0VQH	JO02fe	0.475772	0.1	-22	0	23	90	2	230	89	1.4A Kiwi
2023-01-08 23:00	VA3VOR	FN03	KX4AZ/T	EN74gc	0.475608	5	-21	0	520	280	2	104	43	WD_3.0.3.4
2023-01-08 23:00	WD8DAS	EN52hx	KX4AZ/T	EN74gc	0.475719	1	-23	0	340	67	2	340	123	WD_3.0.3.4
2023-01-08 23:00	WD8DAS	EN52hx	KA7OEI-1	DN31uo	0.475719	1	-32	0	1885	273	2	1885	209	WD_3.0.3.2
2023-01-08 23:00	AC7GZ	DM43	KA7OEI-1	DN31uo	0.475761	0.2	-19	0	910	353	2	4550	2149	WD_3.0.3.2
2023-01-08 23:00	VA3VOR	FN03	N8OOU	EM68es	0.475608	5	-24	0	889	237	2	178	59	1.4A Kiwi
2023-01-08 23:00	WD8DAS	EN52hx	VE3HOA	FN15xg	0.475719	1	-18	0	1093	72	2	1093	547	1.4A Kiwi
2023-01-08 23:00	WD8DAS	EN52hx	N8OOU	EM68es	0.475719	1	-15	0	490	162	2	490	286	1.4A Kiwi
2023-01-08 23:00	VA3VOR	FN03	VE3HOA	FN15xg	0.475608	5	-12	0	311	49	2	62	41	1.4A Kiwi
2023-01-08 23:00	WD8DAS	EN52hx	KD9QZO	EN52xi	0.475719	1	-15	0	129	122	2	129	75	1.4A Kiwi
2023-01-08 23:00	VA3VOR	FN03	K1VL	FN33om	0.475608	5	-23	0	504	87	2	101	36	1.4A Kiwi
2023-01-08 23:00	WD8DAS	EN52hx	N9AWU	EM69sm	0.475719	1	-22	0	455	147	2	455	177	1.4A Kiwi
2023-01-08 23:00	N4WLO	EM50vj	WA2N	EM85rt	0.475684	0.2	-20	0	801	40	2	4005	1780	WD_3.0.6
2023-01-08 23:00	VA3VOR	FN03	K1RA-PI	FM18cr	0.475608	5	-28	0	538	168	2	108	24	DS_0.35.1
2023-01-08 23:00	VA3VOR	FN03	KD2OM	FN12gx	0.475608	5	-15	0	140	113	2	28	16	WD_3.0.5
2023-01-08 23:00	N4WLO	EM50vj	KD2OM	FN12gx	0.475684	0.2	-21	0	1693	31	2	8465	3527	WD_3.0.5
2023-01-08 23:00	WD8DAS	EN52hx	KD2OM	FN12gx	0.475719	1	-30	0	969	86	2	969	162	WD_3.0.5
2023-01-08 23:00	VA3VOR	FN03	WA2ZKD	FN13ed	0.475608	5	-19	0	120	107	2	24	11	WD_3.0.6
2023-01-08 23:00	WD8DAS	EN52hx	WA2ZKD	FN13ed	0.475719	1	-31	0	954	85	2	954	133	WD_3.0.6
2023-01-08 23:00	VA3VOR	FN03	WA2TP	FN30lu	0.475608	5	-20	0	574	119	2	115	51	WD_3.0.6
2023-01-08 23:00	N4WLO	EM50vj	WB0TEM	EN12rt	0.475684	0.2	-19	0	1566	334	2	7830	3698	2.5.4
2023-01-08 23:00	N4WLO	EM50vj	N6GN/K	DN70jo	0.475684	0.2	-26	0	1907	311	2	9535	2649	WD_3.0.5
2023-01-08 23:00	WD8DAS	EN52hx	N6GN/K	DN70jo	0.475719	1	-19	0	1337	264	2	1337	631	WD_3.0.5
2023-01-08 23:00	N4WLO	EM50vj	W3PM	EM64or	0.475685	0.2	-10	0	500	15	2	2500	1806	2.4.0
2023-01-08 23:00	WD8DAS	EN52hx	WA9NWW	EN60wj	0.475722	1	-7	0	394	136	2	394	317	2.5.4
2023-01-08 23:00	VA3VOR	FN03	WA9NWW	EN60wj	0.475611	5	-16	0	678	242	2	136	76	2.5.4
2023-01-08 23:00	WD8DAS	EN52hx	N9RU	EM57mp	0.475719	1	-16	0	594	176	2	594	330	2.6.0
2023-01-08 23:00	WD8DAS	EN52hx	KB9JJA	EM48xn	0.475719	1	-5	0	494	187	2	494	425	2.5.4

Non Directional Beacons 190 – 535 kHz

- Used for aircraft navigation. Very old omnidirectional system. Single antenna location usually 5 miles downrange from the main runway. Large airports are phasing them out. Still very useful for smaller airports
- Beacon List: <u>https://www.dxinfocentre.com/ndb.htm</u>
- Some recordings include:
 - JA Jacksonville, FL 344 kHz (400W)
 - CH Charleston, SC 329 kHz (400W)
 - TX Briscoe Field 419 kHz (25W)
 - EMR Augusta, GA 385 kHz (400W) no recording
 - EOE Newberry, SC 278 kHz (25W)
 - OUK Calhoun, GA 323 kHz (25W)



WWVB – Time Signal Station 60 kHz

- Because of its low frequency, propagation is primarily ground wave
- Time code is purely digital, no voice like WWV and WWVH
- There are coverage variations due to time-of-day. Refer to some of these maps



• Link to what WWVB sounds like https://www.youtube.com/watch?v=tlpoJl_l8Gc

Travelers Information Service (TIS)

- These are predominantly on 1610 kHz and 530 kHz
 - Maximum power of 10 Watts
 - Talking ONLY...No music!
 - Buford Dam has a TIS on 1610 kHz for the dam release times
- Others are located in the expanded AM band from 1620 to 1700 kHz
- Still others, like Hartsfield-Jackson International Airport has parking information on 830 kHz
- Antennas are vertically polarized and are about 15 feet long for the higher frequencies and 25 feet long for 530 kHz
 - During the 1996 Summer Olympics, there were several 530 kHz TIS transmitters on various Interstate highways including a few on I-85
 - During the I-985/85 expansion, there was a temporary TIS station on a trailer with a solar panel on 530 kHz. It was located at the old I-85 northbound rest area (now a GSP station). Coverage was from I-85/Old Peachtree to past the Mall of GA

LowFERs – Low Frequency Experimental Radio

- <u>https://en.wikipedia.org/wiki/LowFER</u>
- Unlicensed experimenters
- 160 to 190 kHz
- Max power output from transmitter 1 Watt
- Max transmission cable and antenna length combined 15 meters or 49.2 feet
- Most common modes are CW and digital
 - AM and SSB voice communications are allowed
- MedFER license free operation on the AM BCB
 - Power 100 mW
 - Antenna length 3 meters maximum

Natural Phenomenon

- Lightning (a type of spheric) static crashes that we are all too familiar with. These impulses create other phenomenon such as:
 - Whistlers caused by lightning
- Dawn Chorus believed to be caused by magnetic storms
- Sunspots and their effect on propagation (geomagnetic storms)
- Earth-Ionosphere Waveguide
 - ELF and VLF frequencies propagate efficiently between the D layer and ground
 - Hams use this feature between the E and F layers to achieve long-distance communications or "skip"
 - This waveguide produces resonances
- Schumann Resonance

Whistlers

- Caused by lightning
- Found from 1 to 30 kHz with peaks between 3 and 5 kHz
- Lightning impulse travels along the Earth's magnetic field lines from one hemisphere to the other
- Impulse slows down through the plasma environments of the ionosphere and magnetosphere
- Voyagers 1 and 2 discovered whistlers during their Jupiter flybys
- <u>https://www.youtube.com/wat</u> <u>ch?v=FeuI8AJMIxU&t=3s</u>



Sunspots Effect on Low Frequencies

- Higher incidence of solar flares, CMEs, etc.
 - Geomagnetic storms
 - Auroras
 - Radio blackouts
 - Higher RF background noise level

Dawn Chorus

- Occurs during magnetic storms
- Related to Auroral Chorus
- Typically between 1000 and 3000 Hz
- Believed to be an interaction between high energy electrons and ambient background VLF noise
- Sounds like bird's dawn chorus
- <u>https://www.youtube.com/w</u> <u>atch?v=KD3CBY2CnXg</u>



Schumann Resonances

- Occurs at ELF frequencies
- Generated by lightning activity in the Earthlonosphere Waveguide
- Animation of this phenomenon is in this link:
 - <u>https://en.wikipedia.org/wiki/Schumann</u> <u>resonances</u>
- See ELF spectrum analysis screenshot





Extremely Low Frequency Phenomenon

- Schumann Resonances (already covered)
- 50 & 60 Hz Power Grid
- 16.7 Hz Euro Railway Grid
- ELF communications



References

- FCC Frequency Allocation Chart https://ntia.gov/sites/default/files/publications/january_2016 spectrum wall https://ntia.gov/sites/default/files/publications/
- New Bands <a href="https://www.arrl.org/news/new-bands-fcc-issues-amateur-radio-service-rules-for-630-meters-and-2-200-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-radio-service-rules-for-630-meters-amateur-rules-for-630-meters-amateur-ru
- VLF Submarine Operations https://nuke.fas.org/guide/usa/c3i/vlf.htm
- WWVB <u>https://www.nist.gov/pml/time-and-frequency-division/time-distribution/radio-station-wwvb/help-wwvb-radio-controlled#:~:text=WWVB%20broadcasts%20on%20a%20frequency,which%20stands%20for%20low%20frequency.</u>
- WWVB Sounds Like https://www.youtube.com/watch?v=tlpoJl_l8Gc
- WWVB Coverage <u>https://tf.nist.gov/stations/wwvbcoverage.htm</u>
- NDB List https://www.dxinfocentre.com/ndb.htm
- 472kHz.org <u>http://www.472khz.org/pages/about-472-khz/getting-started.php</u>
- 630 band Info: <u>https://www.amateurradio.com/getting-started-on-the-new-lf-and-mf-bands/</u>
- More 630 band info:
 - <u>https://www.qsl.net/ve7sl/gettingstarted.html</u>
 - <u>http://www.wb4jwm.com/</u>
- 630 Meter transverters: <u>https://www.minikits.com.au/eme223</u>
- Utility Registration: <u>https://utc.org/plc-database-amateur-notification-process/</u>
- 2200 meter band: <u>https://en.wikipedia.org/wiki/2200-meter_band</u>
- WSPR Reporter: <u>https://www.wsprnet.org/drupal/</u>
- DX Summit: <u>http://dxsummit.fi/#/?include=LF</u>

More References

- LowFER <u>https://en.wikipedia.org/wiki/LowFER</u>
- <u>Schumann Resonances https://en.wikipedia.org/wiki/Schumann_resonances</u>
- ELF Receiver https://www.celnav.de/hamradio/ELF.htm
- ELF <u>https://en.wikipedia.org/wiki/Extremely low frequency</u>
- Whistlers https://en.wikipedia.org/wiki/Whistler_(radio)
- Dawn Chorus (VLF) <u>https://en.wikipedia.org/wiki/Dawn_chorus_(electromagnetic)</u>
- Spherics https://en.wikipedia.org/wiki/Radio_atmospheric_signal
- Earth-Ionosphere Waveguide <u>https://en.wikipedia.org/wiki/Earth%E2%80%93ionosphere_waveguide</u>
- Schumann Resonances <u>https://en.wikipedia.org/wiki/Schumann_resonances</u>