= WWV (radio station) =

WWV is the call sign of the United States National Institute of Standards and Technology 's (NIST) HF (" shortwave ") radio station near Fort Collins , Colorado . WWV continuously transmits official U.S. Government frequency and time signals on 2 @.@ 5 , 5 , 10 , 15 and 20 MHz . These carrier frequencies and time signals are controlled by local atomic clocks traceable to NIST 's primary standard in Boulder , Colorado by GPS common view observations and other time transfer methods . NIST also operates the very similar radio station WWVH in Kauai , Hawaii . WWV and WWVH make recorded announcements ; since they share frequencies , WWV uses a male voice to distinguish itself from WWVH , which uses a female voice . They also make other recorded announcements of general interest , e.g. , the GPS satellite constellation status and severe oceanic weather warnings . WWV shares its site near Fort Collins with radio station WWVB that transmits carrier and time code (no voice) on 60 kHz in the LF (" longwave ") band .

= = History = =

= = = Launch = = =

WWV is the oldest continuously @-@ operating radio station in the United States , first going on the air from Washington , D.C. in May 1920 , approximately six months before the launch of KDKA . The station first broadcast Friday evening concerts on 600 kHz , and its signal could be heard 40 kilometers (25 mi) from Washington . On December 15 , 1920 , WWV began broadcasting on 750 kHz , distributing Morse code news reports from the Department of Agriculture . This signal could be heard up to 300 kilometers (190 mi) from Washington . These news broadcasts ended on April 15 , 1921 .

= = = Standard frequency signals = = =

At the end of 1922 , WWV 's purpose shifted to broadcasting standard frequency signals . These signals were desperately needed by other broadcasters , because equipment limitations at the time meant that the broadcasters could not stay on their assigned frequencies . Testing began on January 29 , 1923 , and frequencies from 200 to 545 kHz were broadcast . Frequency broadcasts officially began on March 6 , 1923 . The frequencies were accurate to " better than three @-@ tenths of one percent . " At first , the transmitter had to be manually switched from one frequency to the next , using a wavemeter . The first quartz oscillators were invented in the mid @-@ 1920s , and they greatly improved the accuracy of WWV 's frequency broadcasts .

In 1926 , WWV was nearly shut down . Its signal could only cover the eastern half of the United States , and other stations located in Minneapolis and at Stanford University and the Massachusetts Institute of Technology were slowly making WWV redundant . The station 's impending shutdown was announced in 1926 , but it was saved by a flood of protests from citizens who relied on the service . Later , in 1931 , WWV underwent an upgrade . Its transmitter , now directly controlled by a quartz oscillator , was moved to College Park , Maryland . Broadcasts began on 5 MHz . A year later , the station was moved again , to Department of Agriculture land in Beltsville , Maryland . Broadcasts were added on 10 and 15 MHz , power was increased , and time signals , an A440 tone , and ionosphere reports were all added to the broadcast in June 1937 .

WWV was nearly destroyed by a fire on November 6 , 1940 . The frequency and transmitting equipment was recovered , and the station was back on the air (with reduced power) on November 11 . Congress funded a new station in July 1941 , and it was built 5 kilometres (3 @.@ 1 mi) south of the former location , still referred to as Beltsville (although in 1961 the name used for the transmitter location would be changed to Greenbelt , Maryland) . WWV resumed normal broadcasts on 2 @.@ 5 , 5 , 10 , and 15 MHz on August 1 , 1943 .

= = = Time signals = = =

WWV 's primary purpose today (and for most of its existence) is to disseminate the " official U.S. time " (provided by government entities such as NIST and USNO) to ensure that uniform time is maintained throughout the United States and around the world . The time signals generated by WWV allow time @-@ keeping devices such as radio @-@ controlled clocks to automatically maintain accurate time without the need for manual adjustment . These time signals are used by commercial and institutional interests where accuracy is essential and time plays a vital role in daily operations - these include shipping , transport , technology , research , education , military , public safety and telecommunications . It is of particular importance in broadcasting , whether it be commercial , public , or private interests such as amateur radio operators . WWV provides a public service by making time information readily available at all hours and at no monetary charge (other than the cost of the receiving equipment itself) .

WWV had been broadcasting second pulses since 1937 , but these pulses were not tied to actual time . In June 1944 , the United States Naval Observatory allowed WWV to use the USNO 's clock as a source for its time signals . Over a year later , in October 1945 , WWV broadcast Morse code time announcements every five minutes . Voice announcements started on January 1 , 1950 , and were broadcast every five minutes . Frequencies of 600 Hz and 440 Hz were broadcast during alternating minutes . By this time , WWV was broadcasting on 2 @.@ 5 , 5 , 10 , 15 , 20 , 25 , 30 , and 35 MHz . The 30 and 35 MHz broadcasts were ended in 1953 .

A binary @-@ coded decimal time code began testing in 1960 , and became permanent in 1961 . This " NASA time code " was modulated onto a 1000 Hz audio tone at 100 Hz , sounding somewhat like a monotonous repeated " baaga @-@ bong " . The code was also described as sounding like a " buzz @-@ saw " . On July 1 , 1971 , the time code 's broadcast was changed to the present 100 Hz subcarrier , which is inaudible when using a normal radio (but can be heard using headphones or recorded using a chart recorder) .

WWV moved to its present location near Fort Collins on December 1 , 1966 , enabling better reception of its signal throughout the continental United States . WWVB signed on in that location three years earlier . In April 1967 , WWV stopped using the local time of the transmitter site (Eastern Time until 1966 , and Mountain Time afterwards) and switched to broadcasting Greenwich Mean Time or GMT . The station switched again , to Coordinated Universal Time (UTC) , in 1974 .

The 20 and 25 MHz broadcasts were discontinued in 1977 , but the 20 MHz broadcast was reinstated the next year . As of April 4 , 2014 , the 25 MHz signal has been back on the air in an ' experimental ' mode . The voice used on WWV was that of Don Elliott Heald until August 13 , 1991 , when equipment changes required rerecording the announcer 's voice . The one used at that time was that of John Doyle , but was soon switched to the voice of KSFO morning host Lee Rodgers .

The radio signals of WWV , WWVB and WWVH , along with the atomic clocks that their time signals derive from , are maintained by NIST 's Time and Frequency Division , which is based in nearby Boulder , Colorado . The Time and Frequency Division is part of the NIST 's Physics Laboratory , based in Gaithersburg , Maryland . NIST 's predecessor , the National Bureau of Standards , previously maintained WWV as a part of the Department of Agriculture ; NIST is currently part of the Department of Commerce .

= = = WWV and Sputnik = = =

WWV 's 20 MHz signal was used for a unique purpose in 1958 : to track the disintegration of Russian satellite Sputnik I after the craft 's onboard electronics failed . Dr. John D. Kraus , a professor at Ohio State University , knew that a meteor entering the upper atmosphere leaves in its wake a small amount of ionized air . This air reflects a stray radio signal back to Earth , strengthening the signal at the surface for a few seconds . This effect is known as meteor scatter . Dr. Kraus figured that what was left of Sputnik would exhibit the same effect , but on a larger scale . His prediction was correct ; WWV 's signal was noticeably strengthened for durations lasting over a minute . In addition , the strengthening came from a direction and at a time of day that agreed with

predictions of the paths of Sputnik 's last orbits . Using this information , Dr. Kraus was able to draw up a complete timeline of Sputnik 's disintegration . In particular , he observed that satellites do not fall as one unit ; instead , the spacecraft broke up into its component parts as it moved closer to Earth .

= = = Call Sign = = =

WWV is one of a small number of radio stations west of the Mississippi River with a call sign beginning with W. The W call sign stems from the station 's early locations in D.C. and Maryland ? the call sign was maintained when the federal government moved the station to Colorado ? and the fact that WWV , being a government station , does not fall within the FCC 's jurisdiction with respect to call signs . How and why the call sign WWV was assigned to the time signal station are not known . However FCC regulations do dictate that time stations are to be issued call signs beginning with " WWV " .

= = Broadcast format = =

On top of the standard carrier frequencies , WWV carries additional information using standard double @-@ sideband amplitude modulation . WWV 's transmissions follow a regular pattern repeating each minute . They are coordinated with its sister station WWVH to limit interference between them . Because they are so similar , both are described here .

= = = Date and time = = =

WWV transmits the date and exact time as follows :
English @-@ language voice announcements of time .
Binary @-@ coded decimal time code of date and time , transmitted as varying length pulses of 100 Hz tone , one bit per second .
In both cases the transmitted time is given in Coordinated Universal Time (UTC) .

= = = Per @-@ second ticks and minute markers = = =

WWV transmits audio " ticks " once per second , to allow for accurate manual clock synchronization . These ticks are always transmitted , even during voice announcements and silent periods . Each tick begins on the second , lasts 5 ms and consists of 5 cycles of a 1000 Hz sine wave . To make the tick stand out more , all other signals are suppressed for 40 ms , from 10 ms before the second until 30 ms after (25 ms after the tick) . As an exception , no tick (and no silent interval) is transmitted at 29 or 59 seconds past the minute . In the event of a leap second , no tick is transmitted during second 60 of the minute , either .
On the minute , the tick is extended to a 0 @.@ 8 second long beep , followed by 0 @.@ 2 s of silence . On the hour , this minute pulse is transmitted at 1500 Hz rather than 1000 . The beginning of the tone corresponds to the start of the minute .
Between seconds one and sixteen inclusive past the minute , the current difference between UTC and UT1 is transmitted by doubling some of the once @-@ per @-@ second ticks , transmitting a second tick 100 ms after the first . (The second tick preempts other transmissions , but does not get a silent zone .) The absolute value of this difference , in tenths of a second , is determined by the number of doubled ticks . The sign is determined by the position : If the doubled ticks begin at second one , UT1 is ahead of UTC ; if they begin at second nine , UT1 is behind UTC .
WWVH transmits similar 5 ms ticks , but they are sent as 6 cycles of 1200 Hz . The minute beep is also 1200 Hz , except on the hour when it is 1500 Hz .
The ticks and minute tones are transmitted at 100 % modulation (0 dBFS) .

= = = Voice time announcements = = =

Voice announcements of time of day are made at the end of every minute , giving the time of the following minute beep . The format for the voice announcement is , " At the tone , X hours , Y minute (s) , Coordinated Universal Time . " The announcement is in a male voice and begins 7 @.@ 5 seconds before the minute tone .

WWVH makes an identical time announcement , starting 15 seconds before the minute tone , in a female voice .

When voice announcements were first instituted , they were phrased as follows : " National Bureau of Standards , WWV ; when the tone returns , [time] Eastern Standard Time . " After the 1967 switch to UTC , the announcement changed to " National Bureau of Standards , WWV , Fort Collins , Colorado ; next tone begins at X hours , Y minute (s) , Greenwich Mean Time . " However , this format would be short @-@ lived . The announcement was changed again to the current format in 1971 .

Voice time announcements are sent at 75 % modulation , i.e. the carrier varies between 25 % and 175 % of nominal power .

= = = Standard frequencies = = =

WWV and WWVH transmit 44 seconds of audio tone in most minutes . It begins after the 1 @-@ second minute mark and continues until the beginning of the WWVH time announcement 45 seconds after the minute .

Even minutes (except for minute 2) transmit 500 Hz , while 600 Hz is heard during odd minutes . The tone is interrupted for 40 ms each second by the second ticks . WWVH is similar , but exchanges the two tones : 600 Hz during even minutes and 500 Hz during odd .

WWV also transmits a 440 Hz tone , a pitch commonly used in music (A440 , the note A above middle C) during minute : 02 of each hour , except for the first hour of the UTC day . Since the 440 Hz tone is only transmitted once per hour , many chart recorders may use this tone to mark off each hour of the day , and likewise , the omission of the 440 Hz tone once per day can be used to mark off each twenty @-@ four @-@ hour period . WWVH transmits the same tone during minute : 01 of each hour .

No tone is transmitted during voice announcements from either WWV or WWVH ; the latter causes WWV to transmit no tone during minutes : 43 ? : 51 (inclusive) and minutes : 29 and : 59 of each hour . Likewise , WWVH transmits no tone during minutes : 00 , : 30 , : 08 ? : 10 and : 14 ? : 19 .

Audio tones and other voice announcements are sent at 50 % modulation .

= = = Other voice announcements = = =

WWV transmits the following 44 @-@ second voice announcements (in lieu of the standard frequency tones) on an hourly schedule :

A station identification at : 00 and : 30 past each hour ;

marine storm warnings , provided by the National Weather Service , for the Atlantic Ocean at : 08 and : 09 minutes past , and for the Pacific Ocean at : 10 past ;

at : 14 and : 15 past , GPS satellite health reports from the Coast Guard Navigation Center ;

at : 18 past , a special " geophysical alert " report from NOAA is transmitted , containing information on solar activity and shortwave radio propagation conditions . These particular alerts were to be discontinued on September 6 , 2011 . However , as of June 17 , 2011 , WWV is announcing at : 18 past that the decision has been retracted and that the geophysical alert reports " will continue for the foreseeable future " .

Additional time slots are normally transmitted as a standard frequency tone , but can be preempted by voice messages if necessary :

At : 04 and : 16 past the hour , NIST broadcasts any announcements regarding a manual change in the operation of WWV and WWVH , such as leap second announcements . These minutes are marked in the broadcast schedule as " NIST Reserved " . When not used , a 500 Hz tone is

broadcast .
Minute 11 is used for additional storm warnings if necessary . If not , a 600 Hz tone is transmitted .
WWVH transmits the same information on a different schedule . WWV and WWVH 's voice announcements are timed to avoid crosstalk ; WWV airs dead air when WWVH airs voice announcements , and vice versa . WWVH 's storm warnings cover the area around the Hawaiian islands and the Far East rather than North America .

= = = = Digital time code = = = =

Time of day is also continuously transmitted using a digital time code , interpretable by radio @-@ controlled clocks . The time code uses a 100 Hz subcarrier of the main signal . That is , it is an additional low @-@ level 100 Hz tone added to the other AM audio signals .
This code is similar to , and has the same framework as , the IRIG H time code and the time code that WWVB transmits , except the individual fields of the code are rearranged and are transmitted with the least significant bit sent first . Like the IRIG timecode , the time transmitted is the time of the start of the minute . Also like the IRIG timecode , numeric data (minute , hour , day of year , and last two digits of year) are sent in binary @-@ coded decimal (BCD) format rather than as simple binary integers : Each decimal digit is sent as two , three , or four bits (depending on its possible range of values) .

= = = = = Bit encoding = = = = =

The 100 Hz subcarrier is transmitted at ? 15 dBFS (18 % modulation) beginning at 30 ms from the start of the second (the first 30 ms are reserved for the seconds tick) , and then reduced by 15 dB (to ? 30 dBFS , 3 % modulation) at one of three times within the second . The duration of the high amplitude 100 Hz subcarrier encodes a data bit of 0 , a data bit of 1 , or a " marker " , as follows :
If the subcarrier is reduced 800 ms past the second , this indicates a " marker . "
If the subcarrier is reduced 500 ms past the second , this indicates a data bit with value one .
If the subcarrier is reduced 200 ms past the second , this indicates a data bit with value zero .
A single bit or marker is sent in this way in every second of each minute except the first (second : 00) . The first second of each minute is reserved for the minute marker , previously described .
In the diagram above , the red and yellow bars indicate the presence of the 100 Hz subcarrier , with yellow representing the higher strength subcarrier (? 15 dB referenced to 100 % modulation) and red the lower strength subcarrier (? 30 dB referenced to 100 % modulation) . The widest yellow bars represent the markers , the narrowest represent data bits with value 0 , and those of intermediate width represent data bits with value 1 .

= = = = = Interpretation = = = = =

It takes one minute to transmit a complete time code . Most of the bits encode UTC time , day of year , year of century , and UT1 correction up to ± 0 @.@ 7 s .
Like the WWVB time code , only the tens and units digits of the year are transmitted ; unlike the WWVB time code , there is no direct indication for leap year . Thus , receivers assuming that year 00 is a leap year (correct for year 2000) will be incorrect in the year 2100 . On the other hand , receivers that assume year 00 is not a leap year will be correct for 2001 through 2399 .
The table below shows the interpretation of each bit , with the " Ex " column being the values from the example above .
The example shown encodes day 86 (March 27) of 2009 , at 21 : 30 : 00 UTC . DUT1 is + 0 @.@ 3 , so UT1 is 21 : 30 : 00 @.@ 3 . Daylight Saving Time was not in effect at the previous 00 : 00 UTC (DST1 = 0) , and will not be in effect at the next 00 : 00 UTC (DST2 = 0) . There is no leap second scheduled (LSW = 0) . The day of year normally runs from 1 (January 1) through 365 (December 31) , but in leap years , December 31 would be day 366 , and day 86 would be March 26 instead of March 27 .

= = = = = Daylight saving time and leap seconds = = = = =

The time code contains three bits announcing daylight saving time (DST) changes and imminent leap seconds .
Bit : 03 is set near the beginning of the month which is scheduled to end in a leap second . It is cleared when the leap second occurs .
Bit : 55 (DST2) is set at UTC midnight just before DST comes into effect . It is cleared at UTC midnight just before standard time resumes .
Bit : 02 (DST1) is set at UTC midnight just after DST comes into effect , and cleared at UTC midnight just after standard time resumes .
If the DST1 and DST2 bits differ , DST is changing during the current UTC day , at the next 02 : 00 local time . Before the next 02 : 00 local time after that , the bits will be the same . Each change in the DST bits happens at 00 : 00 UTC and so will first be received in the mainland United States between 16 : 00 (PST) and 20 : 00 (EDT) , depending on local time zone and on whether DST is about to begin or end . A receiver in the Eastern time zone (UTC ? 5) must therefore correctly receive the " DST is changing " indication within the seven hours before DST begins , and six hours before DST ends , if it is to change the local time display at the correct time . Receivers in the Central , Mountain , and Pacific time zones have one , two , and three more hours of advance notice , respectively .
During a leap second , a binary zero is transmitted in the time code ; in this case , the minute will not be preceded by a marker .

= = = Levels of modulation = = =

The once @-@ per @-@ second " ticks " and minute and hour tones are modulated onto the carrier signal at 100 percent , or 0 dBc . The time code and audio tones are modulated at 50 percent , or approximately ? 3 dBc , and the maximum modulation level for the voice recordings is 75 percent , or approximately ? 1 @.@ 25 dBc .

= = Transmission system = =

WWV broadcasts its signal on five transmitters , one per frequency . The transmitters for 2 @.@ 5 MHz and 20 MHz put out an ERP of 2 @.@ 5 kW , while those for the other three frequencies use 10 kW of ERP . The experimental 25 MHz signal uses a sixth transmitter , with 2 @.@ 5 kW of radiated power .
Each transmitter is connected to a dedicated antenna , which has a height corresponding to approximately one @-@ half of its signal 's wavelength , and the signal radiation patterns from each antenna are omnidirectional . The top half of each antenna tower contains a quarter @-@ wavelength radiating element , and the bottom half uses nine guy wires , connected to the midpoint of the tower and sloped at one @-@ to @-@ one from the ground ? with a length of <formula> ? as additional radiating elements .

= = Half @-@ hourly station identification announcement = =

WWV identifies itself twice each hour , at 0 and 30 minutes past the hour . The text of the identification is as follows :
WWV accepts reception reports sent to the address mentioned in the station ID , and responds with QSL cards .

= = Telephone service = =

WWV 's time signal can also be accessed by telephone by calling + 1 (303) 499 @-@ 7111 (

Boulder , Colorado) . An equivalent time service operated by the U.S. Naval Observatory can be accessed by calling + 1 (202) 762 @-@ 1401 (Washington , D.C.) . Telephone calls are limited to two minutes in length , and the signal is delayed by an average of 30 milliseconds .