### WWV Radio Station

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WWV Transmitter Building

WikiMiniAtlas

[40°40′47″N 105°2′33″W﻿ / ﻿40.67972°N 105.04250°W﻿ / 40.67972; -105.04250](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_47_N_105_2_33_W_region:US-CO_type:landmark_dim:400)[Coordinates](http://en.wikipedia.org/wiki/Geographic_coordinate_system): [40°40′47″N 105°2′33″W﻿ / ﻿40.67972°N 105.04250°W﻿ / 40.67972; -105.04250](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_47_N_105_2_33_W_region:US-CO_type:landmark_dim:400)

**WWV** is the [call sign](http://en.wikipedia.org/wiki/Call_sign) of the [United States](http://en.wikipedia.org/wiki/United_States) [National Institute of Standards and Technology](http://en.wikipedia.org/wiki/National_Institute_of_Standards_and_Technology)'s (NIST) [HF](http://en.wikipedia.org/wiki/High_frequency) ("[shortwave](http://en.wikipedia.org/wiki/Shortwave)") [radio](http://en.wikipedia.org/wiki/Radio) station in [Fort Collins, Colorado](http://en.wikipedia.org/wiki/Fort_Collins%2C_Colorado). WWV continuously transmits official U.S. Government [frequency](http://en.wikipedia.org/wiki/Frequency) and [time signals](http://en.wikipedia.org/wiki/Time_signal) on 2.5, 5, 10, 15 and 20 [MHz](http://en.wikipedia.org/wiki/Megahertz). These [carrier frequencies](http://en.wikipedia.org/wiki/Carrier_wave) and time signals are controlled by local [atomic clocks](http://en.wikipedia.org/wiki/Atomic_clock) traceable to NIST's primary standard in [Boulder, Colorado](http://en.wikipedia.org/wiki/Boulder%2C_Colorado) by [GPS](http://en.wikipedia.org/wiki/GPS) common view observations and other [time transfer](http://en.wikipedia.org/wiki/Time_transfer) methods. NIST also operates the very similar radio station [WWVH](http://en.wikipedia.org/wiki/WWVH) in [Kauai](http://en.wikipedia.org/wiki/Kauai), [Hawaii](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/GPS) satellite constellation status and severe oceanic weather warnings. WWV shares its Fort Collins site with radio station [WWVB](http://en.wikipedia.org/wiki/WWVB) that transmits carrier and time code (no voice) on 60 [kHz](http://en.wikipedia.org/wiki/Kilohertz) in the [low frequency (LF)](http://en.wikipedia.org/wiki/Low_frequency) band.

**History**

**Launch**

WWV is the oldest continuously-operating radio station in the [United States](http://en.wikipedia.org/wiki/United_States), first going on the air from [Washington, D.C.](http://en.wikipedia.org/wiki/Washington%2C_D.C.) in May 1920, approximately six months before the launch of [KDKA](http://en.wikipedia.org/wiki/KDKA_%28AM%29). 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](http://en.wikipedia.org/wiki/Morse_code) news reports from the [Department of Agriculture](http://en.wikipedia.org/wiki/United_States_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](http://en.wikipedia.org/wiki/Crystal_oscillator) were invented in the mid-1920s, and they greatly improved the accuracy of WWV's frequency broadcasts.

One of the Beltsville transmitter buildings

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](http://en.wikipedia.org/wiki/Minneapolis) and at [Stanford University](http://en.wikipedia.org/wiki/Stanford_University) and the [Massachusetts Institute of Technology](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/College_Park%2C_Maryland). Broadcasts began on 5 MHz. A year later, the station was moved again, to Department of Agriculture land in [Beltsville, Maryland](http://en.wikipedia.org/wiki/Beltsville%2C_Maryland). Broadcasts were added on 10 and 15 MHz, power was increased, and time signals, an [A440](http://en.wikipedia.org/wiki/A440_%28Concert_A%29) 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 kilometers (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**

A 1940 [QSL card](http://en.wikipedia.org/wiki/QSL_card) for WWV

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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Subcarrier), which is inaudible when using a normal radio (but can be heard using headphones or recorded using a [chart recorder](http://en.wikipedia.org/wiki/Chart_recorder)).

WWV moved to its present location at Fort Collins on December 1, 1966, enabling better reception of its signal throughout the continental United States. [WWVB](http://en.wikipedia.org/wiki/WWVB) signed on in that location three years earlier. In April 1967, WWV stopped using the local time of the transmitter site ([Eastern Time](http://en.wikipedia.org/wiki/Eastern_Time) until 1966, and [Mountain Time](http://en.wikipedia.org/wiki/Mountain_Time) afterwards) and switched to [Coordinated Universal Time](http://en.wikipedia.org/wiki/Coordinated_Universal_Time).

The 20 and 25 MHz broadcasts were discontinued in 1977, but the 20 MHz broadcast was reinstated the next year. The voice used on WWV was that of [Don Elliott Heald](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/John_Doyle_%28announcer%29), but was soon switched to the voice of [KSFO](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Boulder%2C_Colorado). The Time and Frequency Division is part of the NIST's Physics Laboratory, based in [Gaithersburg, Maryland](http://en.wikipedia.org/wiki/Gaithersburg%2C_Maryland). NIST's predecessor, the National Bureau of Standards, previously maintained WWV as a part of the [Department of Agriculture](http://en.wikipedia.org/wiki/United_States_Department_of_Agriculture); NIST is currently part of the [Department of Commerce](http://en.wikipedia.org/wiki/United_States_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](http://en.wikipedia.org/wiki/USSR) [satellite](http://en.wikipedia.org/wiki/Satellite) [Sputnik I](http://en.wikipedia.org/wiki/Sputnik_I) after the craft's onboard electronics failed. Dr. [John D. Kraus](http://en.wikipedia.org/wiki/John_D._Kraus), a professor at [Ohio State University](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Mississippi_River) with a [call sign](http://en.wikipedia.org/wiki/North_American_call_sign) beginning with W. The W call sign stems from the station's early locations in D.C. and [Maryland](http://en.wikipedia.org/wiki/Maryland)—the call sign was maintained when the federal government moved the station to [Colorado](http://en.wikipedia.org/wiki/Colorado)—and the fact that WWV, being a government station, does not fall within the [FCC](http://en.wikipedia.org/wiki/Federal_Communications_Commission)'s jurisdiction with respect to [call signs](http://en.wikipedia.org/wiki/Call_sign). However FCC regulations do dictate that time stations are to be issued call signs beginning with "WWV".

**Broadcast format**

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| --- | --- |
|  | [WWV sample time signal](http://en.wikipedia.org/wiki/File%3AWWV_time_signal_-_20090904.ogg)WWV's time signal, as broadcast from 14:59:52 to 15:02:01 UTC on 4 September 2009. |
| *Problems playing this file? See* [*media help*](http://en.wikipedia.org/wiki/Wikipedia%3AMedia_help)*.* |

On top of the standard carrier frequencies, WWV carries additional information using standard double-sideband [amplitude modulation](http://en.wikipedia.org/wiki/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.

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| WWV/WWVH minute format |
| **Second** | **WWV** | **WWVH** |
| 0–1 | Minute beep (0.8 s) |
| 1–45 | Standard tone or voice announcement |
| 45–52.5 | Silence (except tick) | Voice time announcement |
| 52.5–60 | Voice time announcement | Silence (except tick) |

**Time of day**

WWV transmits the exact time of day in two separate ways:

1. English-language voice announcements.
2. Binary time code, which also gives the date.

The transmitted time is given in [Coordinated Universal Time](http://en.wikipedia.org/wiki/Coordinated_Universal_Time) ([UTC](http://en.wikipedia.org/wiki/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](http://upload.wikimedia.org/wikipedia/commons/1/17/1000Hz.ogg) 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](http://upload.wikimedia.org/wikipedia/commons/e/e2/1500Hz.ogg) 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](http://en.wikipedia.org/wiki/Universal_Time) 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](http://upload.wikimedia.org/wikipedia/commons/5/5e/1200Hz.ogg). 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](http://en.wikipedia.org/wiki/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](http://upload.wikimedia.org/wikipedia/commons/1/19/500Hz.ogg), while [600 Hz](http://upload.wikimedia.org/wikipedia/commons/f/fd/600Hz.ogg) 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](http://upload.wikimedia.org/wikipedia/commons/c/ce/Tone_440Hz.ogg) tone, a [pitch](http://en.wikipedia.org/wiki/Pitch_%28music%29) commonly used in music ([A440](http://en.wikipedia.org/wiki/A440_%28Concert_A%29), the [note](http://en.wikipedia.org/wiki/Note_%28music%29) A above [middle C](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Chart_recorder) 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](http://en.wikipedia.org/wiki/National_Weather_Service), for the [Atlantic Ocean](http://en.wikipedia.org/wiki/Atlantic_Ocean) at :08 and :09 minutes past, and for the [Pacific Ocean](http://en.wikipedia.org/wiki/Pacific_Ocean) at :10 past;
* at :14 and :15 past, GPS [satellite health reports](http://en.wikipedia.org/wiki/Notice_Advisory_to_NAVSTAR_Users) from the [Coast Guard](http://en.wikipedia.org/wiki/United_States_Coast_Guard) Navigation Center;
* at :18 past, a special "geophysical alert" report from [NOAA](http://en.wikipedia.org/wiki/National_Oceanic_and_Atmospheric_Administration) 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](http://tf.nist.gov/stations/wwv-wheel.htm) 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](http://en.wikipedia.org/wiki/Dead_air) when WWVH airs voice announcements, and vice versa. WWVH's storm warnings cover the area around the Hawaiian islands rather than North America.

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| WWV/WWVH hourly schedule[[13]](http://en.wikipedia.org/wiki/WWV_%28radio_station%29#cite_note-WWVInfo-13#cite_note-WWVInfo-13)Second ticks are transmitted over top of signals listed here. |
| **Minute** | **WWV** | **WWVH** |  | **Minute** | **WWV** | **WWVH** |  | **Minute** | **WWV** | **WWVH** |
| 00 | Station identification | Silence | 20 | 500 Hz | 600 Hz | 40 | 500 Hz | 600 Hz |
| 01 | 600 Hz | 440 Hz | 21 | 600 Hz | 500 Hz | 41 | 600 Hz | 500 Hz |
| 02 | 440 Hz | 600 Hz | 22 | 500 Hz | 600 Hz | 42 | 500 Hz | 600 Hz |
| 03 | 600 Hz | (NIST reserved) | 23 | 600 Hz | 500 Hz | 43 | Silence | GPS status |
| 04 | (NIST reserved) | 600 Hz | 24 | 500 Hz | 600 Hz | 44 | Silence | GPS status |
| 05 | 600 Hz | 500 Hz | 25 | 600 Hz | 500 Hz | 45 | Silence | Geophysical alerts |
| 06 | 500 Hz | 600 Hz | 26 | 500 Hz | 600 Hz | 46 | Silence | 600 Hz |
| 07 | 600 Hz | 500 Hz | 27 | 600 Hz | 500 Hz | 47 | Silence | (NIST reserved) |
| 08 | North Atlantic storm warnings | Silence | 28 | 500 Hz | 600 Hz | 48 | Silence | West Pacific storm warnings |
| 09 | North Atlantic storm warnings | Silence | 29 | Silence | Station identification | 49 | Silence | East Pacific storm warnings |
| 10 | Northeast Pacific storm warnings | Silence | 30 | Station identification | Silence | 50 | Silence | South Pacific storm warnings |
| 11 | (Additional storm warnings) | Silence | 31 | 600 Hz | 500 Hz | 51 | Silence | North Pacific storm warnings |
| 12 | 500 Hz | 600 Hz | 32 | 500 Hz | 600 Hz | 52 | Silence | (Additional storm warnings) |
| 13 | 600 Hz | 500 Hz | 33 | 600 Hz | 500 Hz | 53 | 600 Hz | 500 Hz |
| 14 | GPS status | Silence | 34 | 500 Hz | 600 Hz | 54 | 500 Hz | 600 Hz |
| 15 | GPS status | Silence | 35 | 600 Hz | 500 Hz | 55 | 600 Hz | 500 Hz |
| 16 | (NIST reserved) | Silence | 36 | 500 Hz | 600 Hz | 56 | 500 Hz | 600 Hz |
| 17 | 600 Hz | Silence | 37 | 600 Hz | 500 Hz | 57 | 600 Hz | 500 Hz |
| 18 | Geo-alerts discontinuation notice | Silence | 38 | 500 Hz | 600 Hz | 58 | 500 Hz | 600 Hz |
| 19 | Geophysical alerts | Silence | 39 | 600 Hz | 500 Hz | 59 | Silence | Station identification |

**Digital time code**

Time of day is also continuously transmitted using a digital [time code](http://en.wikipedia.org/wiki/Time_code), interpretable by [radio-controlled clocks](http://en.wikipedia.org/wiki/Radio_clock). The time code uses a 100 Hz [subcarrier](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/IRIG_timecode) and the time code that [WWVB](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Time_formatting_and_storage_bugs#Two-digit_year_representations) 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.

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| WWV BCD time code |
| **Bit** | **Weight** | **Meaning** | **Ex** |  | **Bit** | **Weight** | **Meaning** | **Ex** |  | **Bit** | **Weight** | **Meaning** | **Ex** |
| :00 | No 100 Hz (minute mark) | :20 | 1 | Hours*Example: 21* | 1 | :40 | 100 | Day of year (cont.) | 0 |
| :01 | 0 | *Unused, always 0.* | 0 | :21 | 2 | 0 | :41 | 200 | 0 |
| :02 | DST1 | DST in effect at 00:00Z today | 0 | :22 | 4 | 0 | :42 | 0 | *Unused, always 0.* | 0 |
| :03 | LSW | Leap second at end of month | 0 | :23 | 8 | 0 | :43 | 0 | 0 |
| :04 | 1 | Units digit of year*Example: 9* | 1 | :24 | 0 | 0 | :44 | 0 | 0 |
| :05 | 2 | 0 | :25 | 10 | 0 | :45 | 0 | 0 |
| :06 | 4 | 0 | :26 | 20 | 1 | :46 | 0 | 0 |
| :07 | 8 | 1 | :27 | 0 | *Unused, always 0.* | 0 | :47 | 0 | 0 |
| :08 | 0 | *Unused, always 0.* | 0 | :28 | 0 | 0 | :48 | 0 | 0 |
| :09 | P1 | Marker | M | :29 | P3 | Marker | M | :49 | P5 | Marker | M |
| :10 | 1 | Minutes*Example: 30* | 0 | :30 | 1 | [Day of year](http://en.wikipedia.org/wiki/Ordinal_date)1=January 1,32=February 1, etc.*Example: 86* | 0 | :50 | + | [DUT1](http://en.wikipedia.org/wiki/DUT1) sign (1=positive) | 1 |
| :11 | 2 | 0 | :31 | 2 | 1 | :51 | 10 | Tens digit of year*Example: 0* | 0 |
| :12 | 4 | 0 | :32 | 4 | 1 | :52 | 20 | 0 |
| :13 | 8 | 0 | :33 | 8 | 0 | :53 | 40 | 0 |
| :14 | 0 | 0 | :34 | 0 | 0 | :54 | 80 | 0 |
| :15 | 10 | 1 | :35 | 10 | 0 | :55 | DST2 | DST in effect at 24:00Z today | 0 |
| :16 | 20 | 1 | :36 | 20 | 0 | :56 | 0.1 | DUT1 magnitude (0 to 0.7 s).DUT1 = [UT1](http://en.wikipedia.org/wiki/UT1)−UTC.*Example: 0.3 s* | 1 |
| :17 | 40 | 0 | :37 | 40 | 0 | :57 | 0.2 | 1 |
| :18 | 0 | *Unused, always 0.* | 0 | :38 | 80 | 1 | :58 | 0.4 | 0 |
| :19 | P2 | Marker | M | :39 | P4 | Marker | M | :59 | P0 | Marker | M |

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](http://en.wikipedia.org/wiki/Daylight_saving_time) (DST) changes and imminent [leap seconds](http://en.wikipedia.org/wiki/Leap_second).

* 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](http://en.wikipedia.org/wiki/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.

|  |
| --- |
| **WWV antenna coordinates (**[**WGS84**](http://en.wikipedia.org/wiki/WGS84)**)** |
|  2.5 MHz | [40°40′55.0″N 105°02′33.6″W﻿ / ﻿40.681944°N 105.042667°W﻿ / 40.681944; -105.042667﻿ (WWV—2.5 MHz antenna)](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_55.0_N_105_02_33.6_W_region:US&title=WWV%E2%80%942.5+MHz+antenna) |
|  5 MHz | [40°40′41.9″N 105°02′27.2″W﻿ / ﻿40.678306°N 105.040889°W﻿ / 40.678306; -105.040889﻿ (WWV—5 MHz antenna)](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_41.9_N_105_02_27.2_W_region:US&title=WWV%E2%80%945+MHz+antenna) |
| 10 MHz | [40°40′47.7″N 105°02′27.4″W﻿ / ﻿40.679917°N 105.040944°W﻿ / 40.679917; -105.040944﻿ (WWV—10 MHz antenna)](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_47.7_N_105_02_27.4_W_region:US&title=WWV%E2%80%9410+MHz+antenna) |
| 15 MHz | [40°40′44.8″N 105°02′26.9″W﻿ / ﻿40.679111°N 105.040806°W﻿ / 40.679111; -105.040806﻿ (WWV—15 MHz antenna)](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_44.8_N_105_02_26.9_W_region:US&title=WWV%E2%80%9415+MHz+antenna) |
| 20 MHz | [40°40′52.8″N 105°02′30.9″W﻿ / ﻿40.681333°N 105.041917°W﻿ / 40.681333; -105.041917﻿ (WWV—20 MHz antenna)](http://tools.wmflabs.org/geohack/geohack.php?pagename=WWV_(radio_station)&params=40_40_52.8_N_105_02_30.9_W_region:US&title=WWV%E2%80%9420+MHz+antenna) |

**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](http://en.wikipedia.org/wiki/Effective_radiated_power) of 2.5 kW, while those for the other three frequencies use 10 kW of ERP.

WWV's 15 MHz antenna

Each transmitter is connected to a dedicated [antenna](http://en.wikipedia.org/wiki/Antenna_%28radio%29), which has a height corresponding to approximately one-half of its signal's [wavelength](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Guy-wire), connected to the midpoint of the tower and sloped at one-to-one from the ground—with a length of —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:

|  |  |  |
| --- | --- | --- |
| **“** | National Institute of Standards and Technology time: this is Radio Station WWV, Fort Collins Colorado, broadcasting on internationally allocated standard carrier frequencies of two-point-five, five, ten, fifteen, and twenty megahertz, providing time of day, standard time interval, and other related information. Inquiries regarding these transmissions may be directed to the National Institute of Standards and Technology, Radio Station WWV, 2000 East County Road 58, Fort Collins, Colorado, 80524. | **”** |

WWV accepts reception reports sent to the address mentioned in the station ID, and responds with [QSL cards](http://en.wikipedia.org/wiki/QSL_cards).

**Telephone service**

WWV's time signal can also be accessed by telephone by calling +1-303-499-7111 (Colorado Springs, CO). An equivalent time service operated by the [U.S. Naval Observatory](http://en.wikipedia.org/wiki/U.S._Naval_Observatory) can be accessed by calling +1-202-762-1401 (Washington, DC). Telephone calls are limited to two minutes in length, and the signal is delayed by an average of 30 milliseconds.

**See also**

* [Radio clock](http://en.wikipedia.org/wiki/Radio_clock)
* [WWVB](http://en.wikipedia.org/wiki/WWVB)
* [WWVH](http://en.wikipedia.org/wiki/WWVH)

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