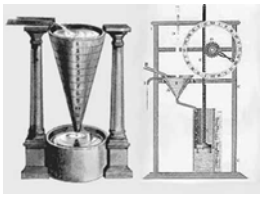
CHAPTER 2

RADIO TIME SIGNALS

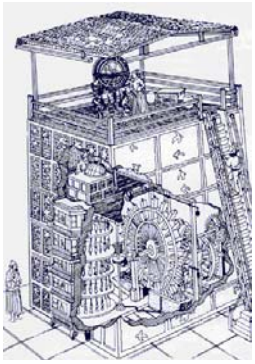
200A. History of Time

Keeping track of time dates as far back as the Ice Age. Over 20,000 years ago hunters scratched lines and made holes in sticks and bones. Scientists believe that they were possibly counting the days between the phases of the moon.



Many civilizations over the years have developed ways to keep track of time but one thing remained the same no matter the location or the century. Time was tracked as equal and constant increments, thus the creation of clocks. Clocks also evolved over time starting with obelisks and the use of complicated water clocks to the atomic clock currently used today.

Obelisks were used in ancient Egypt to tell time and as a result they found the longest and shortest days. The meridian line was also discovered, a line joining north and south by observing the shortest shadow cast by the obelisk that would always point in the same direction regardless of the season. Sundials were created using the obelisk theory, but it was found that these smaller obelisk versions were not as accurate and hard to read.



Sundials only worked on sunny days, so the water clock was created. A container was filled with water and it flowed out at a constant rate and was used to tell time, but it also wasn't very accurate. In 1092, a Chinese monk named Su Sung created a water clock very similar to mechanical clocks known today. This water clock was five stories tall and had a very large water wheel.

The first known mechanical clock invented was in the 13th century very similar to the water clock but used mercury and it controlled the drum at a more constant rate. Galileo Galilei was the first to study the pendulum and Christiaan Huygens used his work to create the first clock using a pendulum. Over time they found that the longer the pendulum, the more accurate the time, so that is why pendulum clocks are a tall rectangular shape. Jost Burgi invented the minute hand in 1577 for an astronomer. In the early 18th century a telecommunications engineer, Warren Marrison, developed a very large, highly accurate clock based on the regular vibrations of a quartz crystal in an electrical circuit, created the first quartz clock.

With the creation of clocks, the problem arose where every city around the world was on their own time, basing noon on when the sun passed over the town. To correct this problem, Great Britain was the first country to standardize time. Greenwich Mean Time (GMT) was the solution. England's Royal Greenwich Observatory located on the zero-degree longitude meridian, became the center of the first time zone and leading the way to the concept of time zones.

In 1884, delegates from 25 countries attended The International Meridian Conference in Washington D.C. where they established time zones one hour apart, referencing solar time (high noon is when the sun reaches the center meridian of that time zone).

The National Institute of Standards and Technology (NIST) in the U.S. built the first atomic clock in 1949. These clocks are the most accurate time and frequency standards known and is based off of atomic physics.

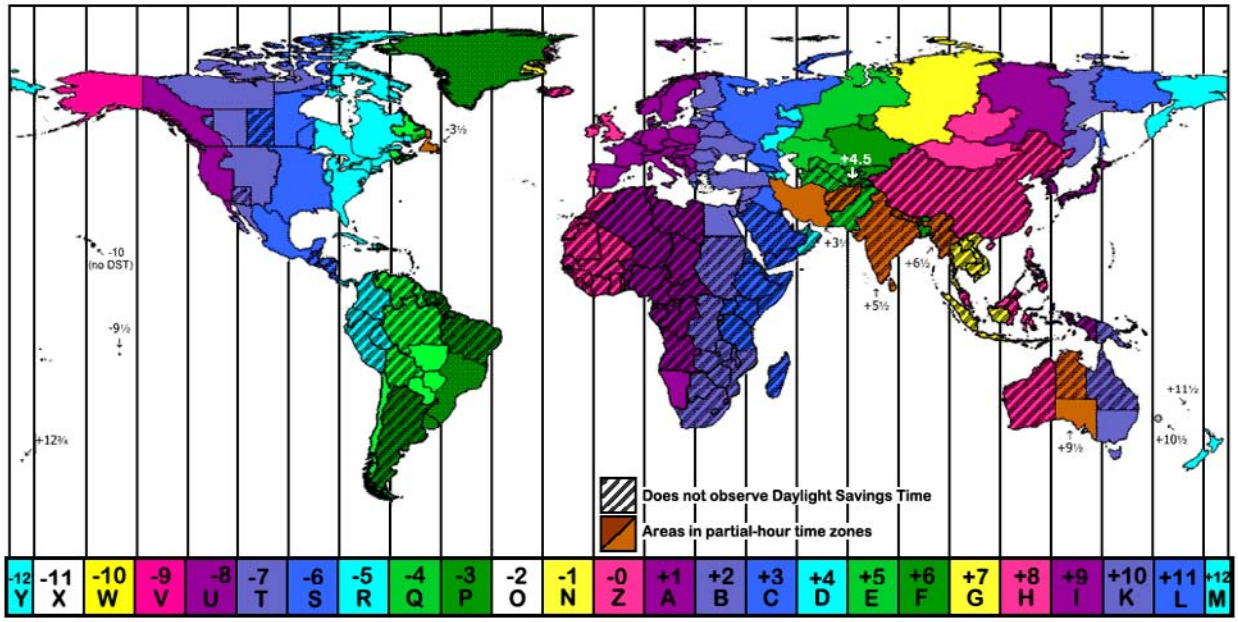
The system of Coordinated Universal Time (UTC) came into use on January 1, 1972. UTC replaced the term GMT but the time remains the same, it differs from your local time by a specific number of hours. The number of hours depends on the number of time zones between your location and the location of the zero meridian (which passes through Greenwich, England). When local time changes from Daylight Saving to Standard Time, or vice versa, UTC does not change. However, the difference between UTC and local time does change-by 1 hour. UTC is a 24-hour clock system. The hours are numbered beginning with 00 hours at midnight through 12 hours at noon to 23 hours and 59 minutes just before the next midnight. *See "The American Practical Navigator" (Bowditch) (Pub. 9) for a full description of UTC.*

200B. Time Zones

Today the world is split up into 25 time zones. The system is centered on zero-degrees longitude in Greenwich, England (See sec. 200A, para 6). The graphic below shows the amount of hours that each area is offset from UTC.

The military uses the phonetic alphabet for time zones; therefore each time zone also has a letter associated with it. The term Zulu is "Z" which is UTC time.

Some countries observe Daylight Savings Time (DST). Each country has its own start/stop days and times.



In the US we have names for our time zones, starting from the east to west they are:

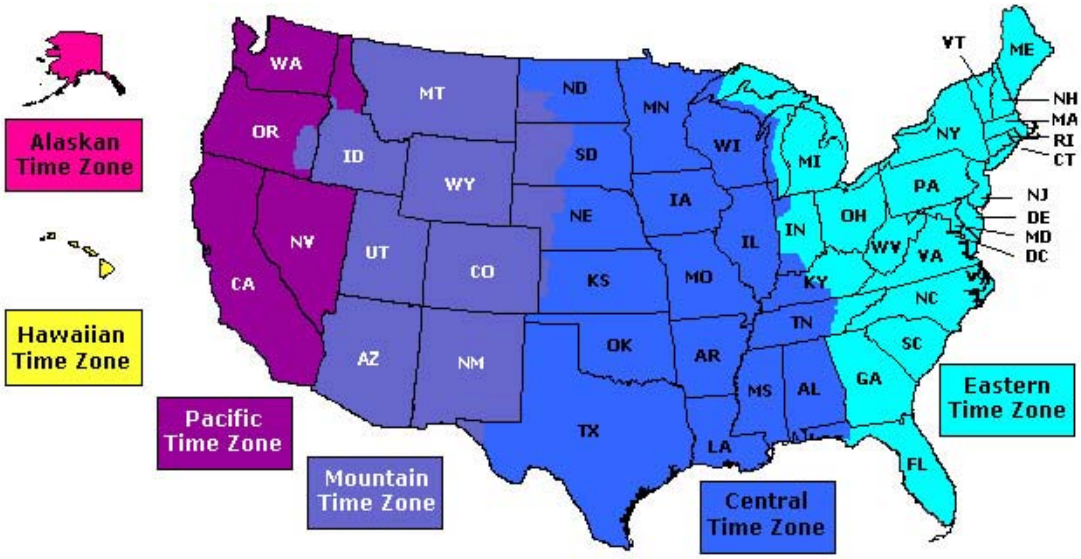
Eastern Standard Time (EST)
Central Standard Time (CST)
Mountain Standard Time (MST)
Pacific Standard Time (PST)
Alaskan Standard Time (AKST)
Hawaii-Aleutian Standard Time (HST)

See graphic below for a map of US time zones.

The US starts daylight savings time at 2am local time on the 2nd Sunday in March and clocks are changed ahead one hour. At 2am on the 1st Sunday in November is when clocks are moved back one hour.

Arizona, Puerto Rico, Hawaii, US Virgin Islands and American Samoa do not observe Daylight Savings Time.

During daylight savings time, the US Time Zones go from "Standard" to "Daylight", for example Eastern Daylight Time (EDT).



200C. The National Institute of Standards and Technology (NIST)-in general

The NIST has two radio stations broadcasting time and frequency information 24-7 for the United States; stations WWV and WWVH. They broadcast time announcements, standard time intervals, standard frequencies, UT1 time corrections (Astronomical time for Universal Time), a BCD (Binary-coded Decimal) time code, geophysical alerts, marine storm warnings, and Global Positioning System (GPS) status reports. They operate in the high frequency (HF) portion of the radio spectrum. Each station radiates 10,000 W on 5, 10, and 15 MHz; and 2500 W on 2.5 and 20 MHz. Each frequency is broadcast from a separate transmitter and carries the same information to ensure one frequency is usable at all times.

200C.1 Time Announcements

Voice announcements are made from WWV and WWVH once every minute. The announced time is "Coordinated Universal Time" (UTC).

200C.2 Standard Time Intervals

The pulses mark the seconds of each minute, except for the 29th and 59th second pulses which are omitted completely.

200C.3 Standard Frequencies

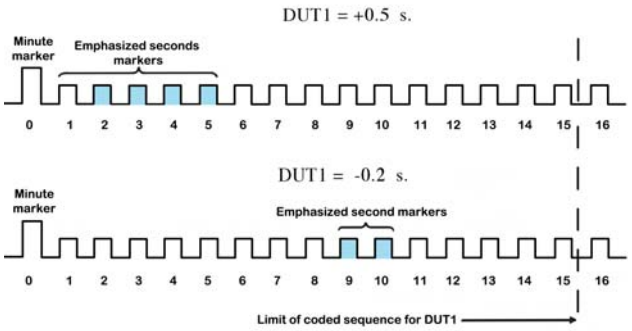
The 440 Hz tone, also known as A440 (A4) is the international standard for musical pitch, musical note A above middle C. The NIST started broadcasting this A440 from WWV in 1936. In 1939 it served as the audio frequency reference for calibration of musical instruments. The 440 Hz tone can be heard on WWV and WWVH stations and is omitted from the first hour of the UTC day.

200C.4 UT1 Time Corrections

UT1 is the Astronomical time for Universal Time (UT). Coordinated Universal Time (UTC) is the mean solar time at zero-degree longitude. UTC time is based on atomic clocks which are more stable than the Earth's rotational rate. The International Earth Rotation and Reference Systems Service (IERS), measures Earth's rotation and publishes the difference between UT1 and UTC. The actual correction is known as a leap second. A leap second is the second (most corrections are tenths of a second) added to UTC in order to keep it synchronized with astronomical time.

200C.5 BCD Time Code

Binary-coded Decimal (BCD) time code is computer time. NIST broadcasts this code on a 100 Hz subcarrier given in a serial fashion at a rate of one pulse per second. The information carried by the time code includes the current minute, hour, and day of year and may be used with the same accuracy as the audio time frequencies. The appropriate seconds markers may be emphasized, for example by lengthening, doubling, splitting or tone modulation of normal seconds markers. Example:



200C.6 Geophysical Alerts

The National Oceanic and Atmospheric Administration (NOAA) broadcasts geophysical alert messages that provide information about solar terrestrial conditions and are updated at 0000, 0300, 0600, 0900, 1200, 1500, 1800, 2100 UTC.

To obtain alerts:
*By phone: (1) 303 497 3235
*Radio station broadcasts: WWV & WWVH
*Space Weather Prediction Center Website: http://www.swpc.noaa.gov
*Tips on viewing the Aurora: http://www.swpc.noaa.gov/Aurora

Definitions:

*A **[A#]** & K indices are measurements of the behavior of the magnetic field in and around the Earth. K ranges from 0-9. A ranges from 0-400. K-index is broadcast at **[K TIME]** 0000, 0300, 0600, 0900, 1200, 1500, 1800, 2100 UTC.

*Geomagnetic storms are disturbances in the geomagnetic field caused by gusts in the solar wind that blows by Earth.

*Radio blackouts are disturbances of the ionosphere caused by X-ray emissions from the Sun.

*Space weather describes the conditions in space that affect Earth and its technological systems. Includes all observed geomagnetic storms, solar radiation storms (proton events) and radio blackouts.

*Solar flux **[#]** is a measurement of the intensity of solar radio emissions with a wavelength of 10.7cm (a frequency of about 2800 Mhz). Range varies from 50 to 300.

*Solar radiation storms are elevated levels of radiation that occur when the numbers of energetic particles increase.

K indices **[K#]**	Geomagnetic Storms	Solar Radiation Storm Level **[S level]**	Radio Blackout Level **[R level]**	Space Weather **[space level]**
K = 9	G5	S5	R5	Extreme
K = 8	G4	S4	R4	Severe
K = 7	G3	S3	R3	Strong
K = 6	G2	S2	R2	Moderate
K = 5	G1	S1	R1	Minor

Message Format:

Sections	Basic Intro	Solar-terrestrial indices for **[DATE]** follow.
1	Current A & K indexes	Solar flux **[#]** and mid-latitude A-index **[A#]**. The mid-latitude K-index at **[K TIME]** on **[DATE]** was **[K#]**.
2	Past 24 hours	Space weather for the past 24 hours has been **[space level]**.
		Solar radiation storms reaching the **[S level]** are **[likely/expected]**.
		Radio blackouts reaching the **[R level]** occurred.
3	Future 24 hours	Space weather for the next 24 hours is predicted to be **[space level]**.
		Solar radiation storms reaching the **[S level]** are **[likely/expected]**.
		Radio blackouts reaching the **[R level]** are **[likely/expected]**.
No observation/Predictions		No space weather storms were observed for the past 24 hours.
		No space weather storms are predicted for the next 24 hours.

Effects of Geomagnetic storms (storm level):

	HF Radio Communications	**Satellite Navigation**	**Low Frequency Radio Navigation**
Extreme	May be impossible in many areas for 1-2 days	May be degraded for days	Can be out for hours
G5			
Severe	Sporadic	Degraded for hours	Disrupted
G4			
Strong	Intermittent	Intermittent	Problems might occur
G3			
Moderate	Can fade at higher latitudes	No effects	No effects
G2			
Minor	No effects	No effects	No effects
G1			

Effects of solar radiation storms (S level):

	HF Radio Communications
S5	Complete blackout and errors possible through the polar regions.
S4	Blackout and errors through the polar regions over several days likely.
S3	Degraded through the polar regions and navigation position errors likely.
S2	Small affects through the polar regions and navigation at polar cap location possibly affected.
S1	Minor impacts in the polar regions.

Effects of radio blackouts (R level):

	HF Radio Communications	Satellite Navigation	Low Frequency Radio Navigation
R5	Complete blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners in this sector	Increased errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side	Experience outages on the sunlit side of Earth for many hours, causing loss in positioning
R4	Blackout on most of the sunlit side of Earth for 1-2 hours	Minor disruptions possible on the sunlit side of Earth	Outages of signals cause increased error in positioning for 1-2 hours
R3	Wide area blackout, loss of radio contact for about an hour on sunlit side of Earth	No effects	Signals degraded for about an hour
R2	Limited blackout on sunlit side, loss of radio contact for tens of minutes	No effects	Degradation of signals for tens of minutes
R1	Weak or minor degradation on sunlit side, occasional loss of radio contact	No effects	Degraded for brief intervals

Inquiries regarding these messages should be addressed to Forecasts and Analysis Branch, Space Environment Center, W/NP9, 325 Broadway, Boulder, CO 80305-3328. Phone: (1) 303 497 3171, e-mail: rwc.boulder@noaa.gov

200C.7 Marine Storm Warnings

Marine storm warnings are broadcast for the Atlantic and Pacific oceans and the Gulf of Mexico by the National Weather Service. Atlantic and Pacific highseas warnings are broadcast by WWV, while WWVH broadcast Pacific highseas warnings. Additional segments are used if there are unusually widespread storm conditions. The storm warnings are based on the most recent forecasts and are updated throughout the day. All marine forecasts rely heavily on the Voluntary Observing Ship (VOS) program for obtaining meteorological observations.

To obtain warnings:
*Radio station broadcasts: WWV & WWVH
*National Weather Service Website: http://www.nws.noaa.gov

Example of a typical storm warning:

> North Atlantic weather West of 35 West at 1700 UTC; Hurricane Donna, intensifying, 24 North, 60 West, moving northwest, 20 knots, winds 75 knots; storm, 65 North, 35 West, moving east, 10 knots; winds 50 knots, seas 15 feet.

For more information about marine storm warnings, write to: National Weather Service, NOAA, 1325 East West Highway, Silver Spring, MD 20910.

200C.8 Notice Advisory to NAVSTAR Users (NANU)-GPS status reports

The United States Coast Guard and the GPS Operations Center (located at Schriever Air Force Base, CO) provide information on the general health of individual satellites in the GPS constellation. With the exception of outages, these messages are released 72 hours prior to planned maintenance.

There are 24 satellites, positioned in 6 orbital planes, circling the Earth twice a day at an altitude of 10,900 nautical miles. The orbits are tilted to the Earth's equator by 55 degrees to cover the polar regions. GPS satellites carry atomic clocks to provide accurate time used in positioning.

Definitions:

*Block is the generation of the operational satellites.

*Plane is the satellite's orbit.

*Pseudo Random Noise Code (PRN) is the unique identifying sequence code that each satellite produces. The complex code guarantees that the receiver won't accidentally pick up another satellite signal, so all the satellites can use the same frequency without jamming each other.

*Slot is the position in the plane.

To obtain advisories-Civilian customers:

*By phone: (1) 703 313 5907

*Radio station broadcasts: WWV & WWVH

*INMARSAT-C broadcasts: NAVAREA IV & XII (see Chapter 3)

*US Coast Guard Website Constellation Status: http://navcen.uscg.gov/?Do=constellationStatus

*Contact/subscriptions: US Coast Guard Navigation Center, NAVCEN MS 7310, 7323 Telegraph Road, Alexandria, VA 20598-7310, phone: 703 313 5900.

To obtain advisories-Military customers:

*By phone: (1) 703 313 5907

*Radio station broadcasts: WWV & WWVH

*AMHS broadcasts: NAVAREA IV, HYDROLANT, HYRDOPAC, HYDROARC & NAVAREA XII (see Chapter 3)

*US Coast Guard Website Constellation Status: http://navcen.uscg.gov/?Do=constellationStatus

*Contact/subscriptions: GPS Operations Center, 300 O'Malley Ave, Suite 41, Colorado Springs, CO 80912-3041, phone: 719 567 2541, DSN 560 2541, e-mail: gps_support@schriever.af.mil.

	Constellation Status
Plane	A through F
Slot	Minimum of 4 satellites to run GPS
SVN	The Space Vehicle Number
PRN	The designated number for each complex code the satellite produces
Block Type	Currently on Block II (IIA, IIR-M, IIF, IIR) Frequencies: 1572.42 mHz & 1227.6 mHz (L-band) 2227.5 mHz (S-band)

200D. U.S. Station WWV Broadcasts

Call sign: WWV

Station number: 2000

Location: 40-40-49N 105-02-27W

Broadcast Frequencies: The station radiates 10,000 W on 5, 10, and 15 MHz; and 2500 W on 2.5 and 20 MHz.

Broadcast Time: Constant.

Antennas (Type & Amount): Half-wave vertical antennas that radiate omnidirectional patterns. There are five antennas at the station site, one for each frequency.

The Breakdown: The hourly broadcast schedule:

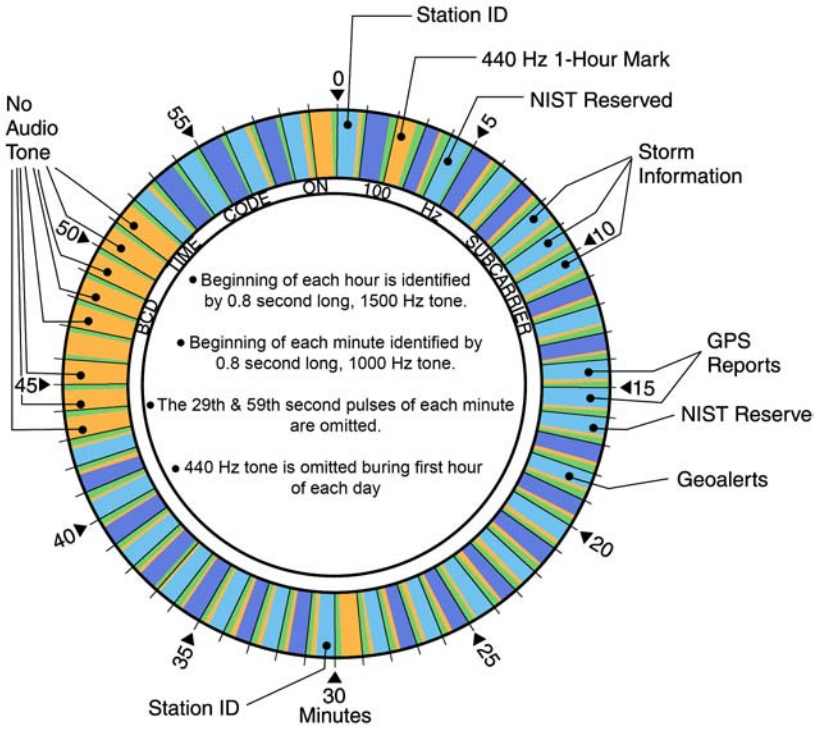
By Phone: (303) 499-7111 (not a toll-free number, 2 min call only) *Delays: using land lines within continental US time announcements are normally delayed by less than 30 ms and the stability (delay variation) is generally < 1 ms. Using mobile phones or voice over IP networks, the delays can be as large as 150 ms. In the very rare instances when the telephone connection is made by satellite, the time is delayed by more than 250 ms.*

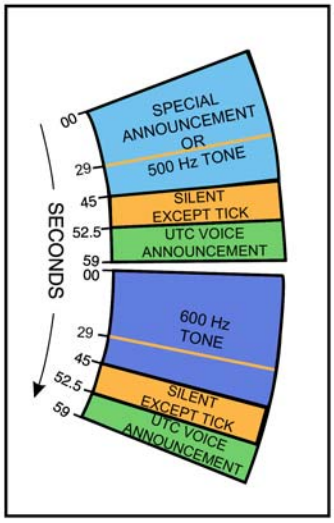
BCD Time Code: Continuously broadcast on a 100 Hz subcarrier.

Storm Warnings: Atlantic 8 & 9 minutes after the hour, Pacific 10 minutes after the hour. The 11th minute mark is for additional time if needed. Forecasts are updated 0500, 1100, 1700, 2300 UTC.

NANU/GPS status: 14 & 15 minutes after the hour. Updated every 3 hours, typically 0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 UTC. More frequent updates are made when necessary.

Contact information: Mailing address: NIST Radio Station WWV, 200 East Country Rd 58, Fort Collins, CO 80524. E-mail: nist.radio@boulder.nist.gov.





200E. U.S. Station WWVH Broadcasts

Call sign: WWVH

Station number: 2001

Location: 21-59-17N 159-45-47W

Broadcast Frequencies: The station radiates 10,000 W on 5, 10, and 15 MHz; and 5000 W on 2.5 MHz.

Broadcast Time: Constant.

Antennas (Type & Amount): Half-wave vertical antennas that radiate omnidirectional patterns. There are five antennas at the station site, one for each frequency.

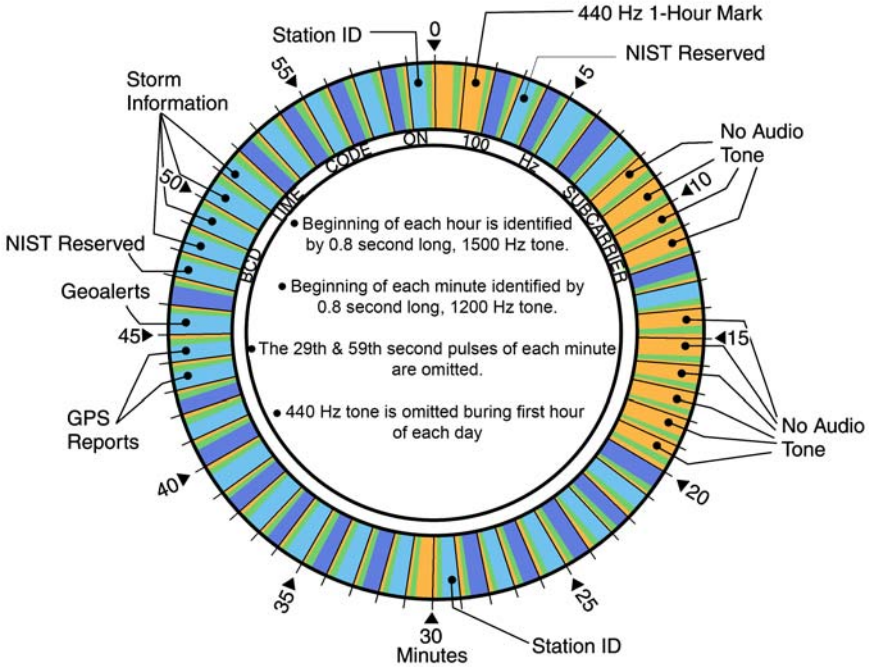
The Breakdown: The hourly broadcast schedule:

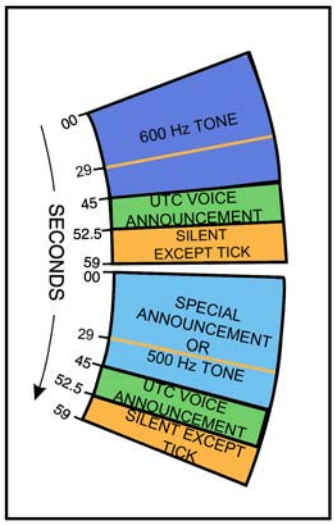
By Phone: (808) 335-4363 (not a toll-free number, 2 min call only) *Delays: using land lines within continental US time announcements are normally delayed by less than 30 ms and the stability (delay variation) is generally < 1 ms. Using mobile phones or voice over IP networks, the delays can be as large as 150 ms. In the very rare instances when the telephone connection is made by satellite, the time is delayed by more than 250 ms.*

BCD Time Code: Continuously broadcast on a 100 Hz subcarrier.

Storm Warnings: Pacific 48 through 51 minutes after the hour. The 52nd minute mark is for additional time if needed. Forecasts are updated 0000, 0600, 1200, 1800 UTC.

NANU/GPS status: 43 & 44 minutes after the hour. Updated every 3 hours, typically 0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 UTC. More frequent updates are made when necessary.





200F. Argentina

Station: 2080-Buenos Aires

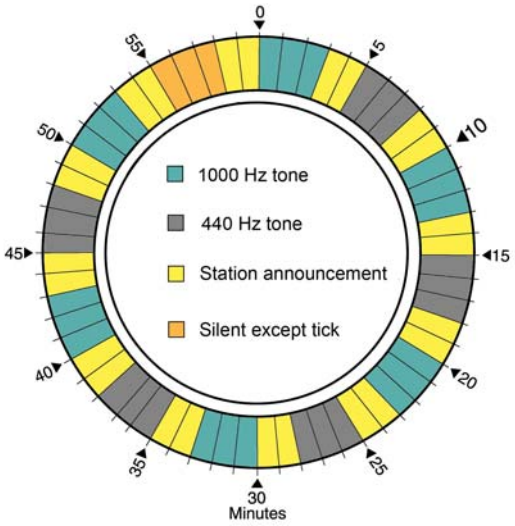
Location: 34-37S 058-21W

Call sign: LOL

Broadcast Frequencies: The station radiates 2 kW on 10,000 kHz.

Broadcast Time: Mon-Fri 1100-1200 local time.

The Breakdown: The hour broadcast schedule is shown below. The station announcement includes station identification with call sign and a voice time announcement.



200G. Belarus

Station: 2150-Molodechno

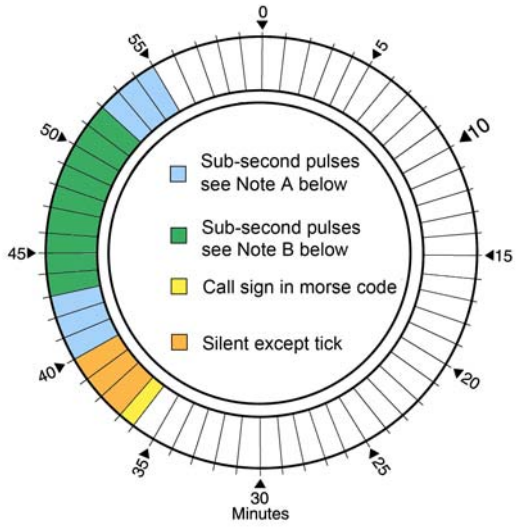
Call sign: RJH69

Location: 54-26N 026-48E

Broadcast Frequencies: The station radiates 25 kHz.

Broadcast Time: 0736-0755 & 1936-1955 local time. Daylight Savings Time (DST) 0836-0855 & 2136-2155 local time. Does not transmit on days 2, 12 and 22 of each month.

The Breakdown:



Note A:

Pulses	Duration
Sub-second pulses every 25ms	12.5ms

Note B:

Pulses	Duration
Sub-second pulses every 100ms	25ms
Second pulses	100ms
10 second pulses	1s
Minute pulses	10s

(1) No.	(2) Name	(3) Hours of Transmission	(4) System	(5) Frequency
		CANADA		
2020	**Ottawa, Ont. (CHU).**	Continuous.	(See below)	3330 kHz, A2A, H3E, 3 kW; 7335 kHz, A2A, H3E, 10 kW; 14670 kHz, A2A, H3E, 3 kW.
	DUT1: Marked seconds indicated by split pulses. SYSTEM: 00s.: 500ms second marker. From 01s. to 28s.: second markers of 300ms each. 29s.: silence. From 30s. to 50s.: second markers of 300ms each. From 51s. to 59s.: station identification and time (+5R). At the beginning of the hour the first second marker lasts for 1s. and 500ms markers for seconds 01 to 09 are omitted. A binary time code is included in second markers 31-39. ANTENNAS: CHU broadcasts from 45-17-47N 75-45-22W using vertical antennas designed to give the best possible coverage for Canadian users.			
		MEXICO		
2040	**Chapultepec (XDD)(XDP).**	Weekdays: 0155-0200, 1555-1600, 1755-1800; Sun. and holidays: 1755-1800.	U.S.	XDP: 4800 kHz, A1A; XDD: 13043 kHz, A1A.
	SYSTEM: From 54m. to 55m.: "VVV DE" station call sign ("XPD" or "XDD"). From 55m. to 60m.: U.S. system, except that the second marker at 28s. is omitted each minute.			
2041	**Tacubaya (XBA).**	Weekdays: 0155-0200, 1555-1600, 1755-1800; Sun. and holidays: 1755-1800.	U.S.	6976.74 kHz, A1A; 13953.6 kHz, A1A.
	SYSTEM: From 54m. to 55m.: "VVV DE XBA". From 55m. to 60m.: U.S. system, except that the second marker at 28s. is omitted each minute.			
		VENEZUELA		
2043	**Observatorio Naval Caracas (YVTO).**	Continuous.	U.S.	5000 kHz, A9W, 10 kW.
	SYSTEM: From 01s. to 29s.: second markers of 100ms each. 30s.: silence. From 31s. to 40s.: second markers of 100ms each. From 40s. to 50s.: station identification, in Spanish. 51s. and 52s.: second markers of 100ms each. From 52s. to 57s.: time announcement, in Spanish. 57s. and 59s.: second markers of 100ms each. 00s.: minute marker of 500ms (800 Hz). Second markers are 1000 Hz tone.			
		ECUADOR		
2051	**Guayaquil (HD2IOA).**	Continuous.	(See below)	1510 kHz.
		0000-1200.		3810 kHz, A1A, A3E, 1 kW.
	SYSTEM: 00s.: minute marker of 300ms. From 01s. to 28s.: second markers of 100ms each. 29s.: silence. From 30s. to 50s.: second markers of 100ms each. 51s.: silence. From 52s. to 58s.: time announcement in voice. 59s.: silence. Call sign transmitted on 3810 kHz from 59m.-15s. to 59m.-50s. of each hour.			
		CZECH REPUBLIC		
2091	**Liblice (OMA).**	Continuous.	(See below)	50 kHz, A1A, 7 kW.
	50 kHz FREQUENCY: SYSTEM: Carrier interruptions of 100ms each second, 500ms each minute. TRANSMITTER: Backup transmitter, 0.05kW, used 0600-1200 first Wed. each month.			
		RUSSIA		
2202	**Moskva (RWM).**	Continuous.	(See below)	4996 kHz, A1A, 5 kW; 9996 kHz, A1A, 5 kW; 14996 kHz, A1A, 8 kW.
	DUT1 AND dUT1: Marked seconds indicated by double pulse with 100ms separation, between 10m.-20m. and 40m.-50m. SYSTEM: From 00m. to 08m.: carrier. From 08m. to 09m.: silence. From 09m. to 10m.: call sign. From 10m. to 20m.: second markers of 100ms each, minute markers of 500ms each. From 20m. to 30m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. From 30m. to 38m.: carrier. From 38m. to 39m.: silence. From 39m. to 40m.: call sign. From 40m. to 50m.: second markers of 100ms each, minute markers of 500ms each. From 50m. to 00m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. Markers omitted between 56s. and 59s. at 14m., 19m., 24m., 29m., 44m., 49m., 54m., 59m. TRANSMITTERS: 4996 kHz off-air 0500-1300 first Wed. each quarter. 9996 kHz off-air 0500-1300 second Wed. each quarter. 14996 kHz off-air 0500-1300 third Wed. every odd month.			
2202.5	**Moskva (RBU).**	January-June: 0252-0313, 0852-0913, 1452-1513, 2052-2113; July-December: 0852-0913, 2052-2113.	(See below)	66.67 kHz, A1A, 10 kW.
	DUT1 AND dUT1: Marked seconds indicated by double pulse with 100ms separation, between 00m.-05m. SYSTEM: From 52m. to 59m.: carrier. From 59m. to 00m.: sub-second markers of 20ms every 100ms, second markers of 40ms, minute markers of 500ms each. From 00m. to 05m.: second markers of 100ms each, minute markers of 500ms each. From 05m. to 06m.: call sign. From 06m. to 13m.: carrier. TRANSMITTER: Off-air 0500-1300 third Tues. each month.			

(1) No.	(2) Name	(3) Hours of Transmission	(4) System	(5) Frequency
2203	**Gorky (RJH99).**	Daylight savings time in effect: 0736-0755, 1436-1455, 1936-1955; Daylight savings time not in effect: 0536-0555, 1336-1355, 1836-1855.	(See below)	25 kHz, A1A, 300 kW.
		Not transmitted on 8th, 18th, 28th of each month.		
	SYSTEM: From 36m. to 37m.: call sign. From 37m. to 40m.: carrier. From 40m. to 43m.: sub-second markers of 12.5ms every 25ms. From 43m. to 52m.: sub-second markers of 25ms every 100ms, second markers of 100ms each, 10-second markers of 1s. each, minute markers of 10s. each. From 52m. to 55m.: sub-second markers of 12.5ms every 25ms.			
2204	**Novosibirsk (RTA).**	0000-0530, 1400-2400.	(See below)	10000 kHz, A1A, 5 kW.
		0630-1330.		15000 kHz, A1A, 5 kW.
		Transmission times 1 hr. later on both frequencies when daylight savings time in effect.		
	DUT1 AND dUT1: Marked seconds indicated by double pulse with 100ms separation, between 00m.-10m. and 30m.-40m. SYSTEM: From 00m. to 10m.: second markers of 100ms each, minute markers of 500ms each. From 10m. to 20m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. From 20m. to 28m.: carrier. From 28m. to 29m.: silence. From 29m. to 30m.: call sign. From 30m. to 40m.: second markers of 100ms each, minute markers of 500ms each. From 40m. to 50m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. From 50m. to 58m.: carrier. From 58m. to 59m.: silence. From 59m. to 00m.: call sign. Markers omitted between 56s. and 59s. at 04m., 09m., 14m., 19m., 34m., 39m., 44m., 49m. TRANSMITTERS: Both frequencies off-air 0000-1000 first and third Thurs. each month.			
2205.5	**Irkutsk (RTZ).**	0000-2100, 2200-2400.	(See below)	50 kHz, A1A, 10 kW.
	DUT1 AND dUT1: Marked seconds indicated by double pulse with 100ms separation, between 00m.-05m. SYSTEM: From 00m. to 05m.: second markers of 100ms each, minute markers of 500ms each. From 05m. to 06m.: call sign. From 06m. to 59m.: carrier. From 59m. to 00m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. TRANSMITTER: Transmitter off-air 0000-0800 first, third, fourth Mon. each month.			
2206	**Khabarovsk (UQC3).**	Daylight savings time in effect: 0236-0255, 0636-0655, 1836-1855; Daylight savings time not in effect: 0036-0055, 0636-0655, 1736-1755.	(See below)	25 kHz, A1A, 300 kW.
		Not transmitted on 10th, 20th, 30th of each month.		
	SYSTEM: From 36m. to 37m.: call sign. From 37m. to 40m.: carrier. From 40m. to 43m.: sub-second markers of 12.5ms every 25ms. From 43m. to 52m.: sub-second markers of 25ms every 100ms, second markers of 100ms each, 10-second markers of 1s. each, minute markers of 10s. each. From 52m. to 55m.: sub-second markers of 12.5ms every 25ms.			
2209	**Arkhangel'sk (RJH77).**	Daylight savings time in effect: 0936-0955, 1236-1255; Daylight savings time not in effect: 0836-0855, 1136-1155.	(See below)	25 kHz, A1A, 300 kW.
		Not transmitted on 4th, 14th, 24th of each month.		
	SYSTEM: From 36m. to 37m.: call sign. From 37m. to 40m.: carrier. From 40m. to 43m.: sub-second markers of 12.5ms every 25ms. From 43m. to 52m.: sub-second markers of 25ms every 100ms, second markers of 100ms each, 10-second markers of 1s. each, minute markers of 10s. each. From 52m. to 55m.: sub-second markers of 12.5ms every 25ms.			
		KYRGYZSTAN		
2211	**Biskek (RJH66).**	Daylight savings time in effect: 0536-0555, 1136-1155, 2336-2355; Daylight savings time not in effect: 0436-0455, 0936-0955, 2136-2155.	(See below)	25 kHz, A1A, 300 kW.
		Not transmitted on 6th, 16th, 26th of each month.		
	SYSTEM: From 36m. to 37m.: call sign. From 37m. to 40m.: carrier. From 40m. to 43m.: sub-second markers of 12.5ms every 25ms. From 43m. to 52m.: sub-second markers of 25ms every 100ms, second markers of 100ms each, 10-second markers of 1s. each, minute markers of 10s. each. From 52m. to 55m.: sub-second markers of 12.5ms every 25ms.			

(1) No.	(2) Name	(3) Hours of Transmission	(4) System	(5) Frequency
		UZBEKISTAN		
2212	**Tashkent (ULW4).**	0000-0400, 0500-2400.	(See below)	2500 kHz, A1A, 1 kW.
		0000-0400, 1400-2400.		5000 kHz, A1A, 1 kW.
		0500-1330.		10000 kHz, A1A, 1 kW.
		1 hr. later when daylight savings time in effect.		

DUT1 AND dUT1: Marked seconds indicated by double pulses with 100ms separation, between 00m.-10m. and 30m.-40m.
SYSTEM: From 00m. to 10m.: second markers of 100ms each, minute markers of 500ms each. From 10m. to 20m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. From 20m. to 28m.: carrier. From 28m. to 29m.: silence. From 29m. to 30m.: call sign. From 30m. to 40m.: second markers of 100ms each, minute markers of 500ms each. From 40m. to 50m.: sub-second markers of 20ms every 100ms, second markers of 40ms each, minute markers of 500ms each. From 50m. to 58m.: carrier. From 58m. to 59m.: silence. From 59m. to 00m.: call sign. Markers between 56s. and 59s. omitted at 04m., 09m., 14m., 19m., 34m., 39m., 44m., 49m.
TRANSMITTERS: All off-air 0100-1100 third Mon. each month.

		GERMANY		
2320	**Mainflingen (DCF77).**	Continuous.	(See below)	77.5 kHz, A1A, A3E, 30 kW.

SYSTEM: 00s.: MÑminute marker. From 01s. to 14s.: BBK and Meteo Time information. 15s.: RÑwhen backup antenna is used. 16s.: A1Ñannouncement of time system change. 17s.: Z1Ñtime system (winter). 18s.: Z2Ñtime system (summer). 19s.: A2Ñannouncement of a leap second at the next hour. 20s.: SÑstart of coded time information. From 21s. to 27s.: minute. 28s.: P1 (parity check)Ñsum of 21s. to 27s. From 29s. to 34s.: hour. 35s.: P2 (parity check)Ñsum of 29s. to 34s. From 36s. to 41s.: day of month. From 42s. to 44s.: day of week. From 45s. to 49s.: month. From 50s. to 57s.: year (07, 08, 09 etc.). 58s.: P3 (parity check)Ñsum of 36s. to 57s. 59s.: no modulation.

		UNITED KINGDOM		
2351	**Anthorn (MSF).**	Continuous.	(See below)	60 kHz, A1A, 15 kW.

SYSTEM: National Physical Laboratory (NPL) Computer Time Service via Modem (NPL Truetime). NPL offers a service which allows a computer to set its clock to within 1/50th of a second by direct telephone connection to the National Time Scale at the NPL in Teddington, Middlesex. A call to the service, at any time of the day or night, allows a computer equipped with a suitable modem and software to correct its clock. The service uses a premium-rate telephone number. For further information contact the Time and Frequency Services, NPL at:
NPL Truetime Telephone: 0906 851 6333 (UK only)
Telephone: (011) 44 208 943 6880
Fax: (011) 44 208 943 6458
E-mail: time@npl.co.uk
Internet: http://www.npl.co.uk/npl/ctm/index.html
TRANSMITTER: see the NPL Website at www.npl.co.uk/time/msf/msfoutages.html for outages due to scheduled maintenance.

2360	**BBC-Radio 1.**	Mon.-Fri.: 0700; Sat.: 1300; Sun.: Nil.	(See below)	97.7-99.8 MHz, F3E (97.1 MHz for Channel Islands).
		1 hr. earlier when daylight savings time in effect.		

SYSTEM: The Greenwich Time Signal (GTS) or BBC pips is a time code heard on some BBC Radio stations. The signal consists of 6 pips (short beeps) which occur on the 5 seconds leading up to the hour and on the hour itself. Each pip, or marker, is a 1 kHz tone.
From 59m.-55s. to 59m.-59s.: second markers of 100ms each. 00m.-00s.: minute marker of 500ms.

2361	**BBC-Radio 2.**	Mon.-Fri.: 0000, 0700, 0800, 1300, 1700; Sat.: 0000, 0700, 0800; Sun.: 0000, 0800, 0900, 1900.	(See below)	88-90.2 MHz, F3E (89.6 MHz for Channel Islands).
		1 hr. earlier when daylight savings time in effect.		

SYSTEM: The Greenwich Time Signal (GTS) or BBC pips is a time code heard on some BBC Radio stations. The signal consists of 6 pips (short beeps) which occur on the 5 seconds leading up to the hour and on the hour itself. Each pip, or marker, is a 1 kHz tone.
From 59m.-55s. to 59m.-59s.: second markers of 100ms each. 00m.-00s.: minute marker of 500ms.

2362	**BBC-Radio 3.**	Mon.-Fri.: 0700, 0800; Sat.: 0600, 0700. Sun.: Nil.	(See below)	90.2-92.4 MHz, F3E (91.1 MHz for Channel Islands).
		1 hr. earlier when daylight savings time in effect.		

SYSTEM: The Greenwich Time Signal (GTS) or BBC pips is a time code heard on some BBC Radio stations. The signal consists of 6 pips (short beeps) which occur on the 5 seconds leading up to the hour and on the hour itself. Each pip, or marker, is a 1 kHz tone.
From 59m.-55s. to 59m.-59s.: second markers of 100ms each. 00m.-00s.: minute marker of 500ms.

(1) No.	(2) Name	(3) Hours of Transmission	(4) System	(5) Frequency
2363	**BBC-Radio 4.**	Mon.-Fri.: 0600, 0700, 0800, 0900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1900, 2200; Sat.: 0700, 0800, 0900, 1000, 1100, 1300, 1400, 1600; Sun.: 0600, 0700, 0800, 0900, 1300, 1700, 2100.	(See Below)	198 kHz, A3E, 50-400 kW; Tyneside: 603 kHz, A3E, 2 kW; London: 720 kHz, A3E, 0.5.kW; N. Ireland: 720 kHz, A3E, 0.25-10 kW; Redruth: 756 kHz, A3E, 2 kW; Plymouth: 774 kHz, A3E, 1 kW; Aberdeen: 1449 kHz, A3E, 2 kW; Carlisle: 1485 kHz, A3E, 1 kW; 92.4-94.6 MHz, F3E (94.8 MHz for Channel Islands).
		1 hr. earlier when daylight savings time in effect.		

SYSTEM: The Greenwich Time Signal (GTS) or BBC pips is a time code heard on some BBC Radio stations. The signal consists of 6 pips (short beeps) which occur on the 5 seconds leading up to the hour and on the hour itself. Each pip, or marker, is a 1 kHz tone.
From 59m.-55s. to 59m.-59s.: second markers of 100ms each. 00m.-00s.: minute marker of 500ms.

2370	**BBC-World Service.**	0000, 0200, 0300, 0400, 0500.	(See below)	198 kHz.
		0000, 0200, 0300, 0600, 0700, 0800, 0900, 1100, 1200, 1300, 1500, 1600, 1700, 1900, 2000, 2200, 2300.		648 kHz.
		0200, 0300, 0600, 2200, 2300.		1296 kHz.
		0400, 0500, 0600.		3955 kHz.
		0200, 0300, 0400, 0500, 0600, 0700, 1500, 1600, 1700, 1800, 1900, 2000, 2200.		6195 kHz.
		0600, 0700, 0800.		7150 kHz.
		0300, 0400.		7230 kHz.
		0000, 0200, 0300, 0700, 0800, 0900, 2000, 2200, 2300.		7325 kHz.
		0200, 0300, 0400, 0500, 0600, 0700, 0800, 0900, 1100, 1200, 1300, 1500, 1600, 1700, 1800, 1900, 2000, 2200, 2300.		9410 kHz.
		0900, 1100, 1200, 1300, 1500.		9750 kHz.
		0700, 0800, 0900, 1100, 1200, 1300, 1500, 1600.		9760 kHz.
		0000, 0200, 0300, 2200, 2300.		9915 kHz.
		0000, 0200, 0300, 0400, 0500, 0600, 0700, 0800, 0900, 1100, 1200, 1300, 1500, 1600, 1700, 1800, 1900, 2000, 2200, 2300.		12095 kHz.
		0000, 0500, 0600, 0700, 0800, 0900, 1100, 1200, 1300, 1500, 1600, 1700, 1800, 1900, 2000, 2200, 2300.		15070 kHz.
		2200, 2300.		15340 kHz.
		0700, 0800, 0900, 1100, 1200, 1300, 1500.		17640 kHz.
		0800, 0900, 1100, 1200, 1300, 1500, 1600.		17705 kHz.

SYSTEM: SYSTEM: The Greenwich Time Signal (GTS) or BBC pips is a time code heard on some BBC Radio stations. The signal consists of 6 pips (short beeps) which occur on the 5 seconds leading up to the hour and on the hour itself. Each pip, or marker, is a 1 kHz tone.
From 59m.-55s. to 59m.-59s.: second markers of 100ms each. 00m.-00s.: minute marker of 500ms.
NOTE: Not intended for precise use. Direct transmissions from United Kingdom will normally be received within 0.1s. of UTC, but signals from overseas relay stations may have additional errors of up to 0.25s.

FRANCE

2380	**France Inter (Allouis) (TDF).**	Continuous, except 0100-0500 each Tues.	(See below)	162 kHz, G1D.

SYSTEM: From 00s. to 20s.: second markers of 100ms each. From 21s. to 58s.: time and date announcement. 59s.: emphasized second marker of 100ms. Other second markers are emphasized to indicate the following: 13s. - the day preceding a holiday; 14s. - holiday; 17s. - local time is -2B; 18s. - local time is -1A.

(1) No.	(2) Name	(3) Hours of Transmission	(4) System	(5) Frequency
		SWITZERLAND		
2400	**Prangins (HBG).**	Continuous.	(See below)	75 kHz, A1A, 20 kW.
	SYSTEM: From 00s. to 15s.: other services information. 16s.: AÑannouncement of time system change. 17s.: EÑset during daylight savings time. 18s.: HÑset during standard time. 19s.: LÑannouncement. 20s.: SÑstart of coded time information. From 21s. to 27s.: minute. 28s.: P1 (parity check)Ñsum of 21s. to 27s. From 29s. to 34s.: hour. 35s.: P2 (parity check)Ñsum of 29s. to 34s. From 36s. to 41s.: day of month. From 42s. to 44s.: day of week. From 45s. to 49s.: month. From 50s. to 57s.: year (07, 08, 09 etc.). 58s.: P3 (parity check)Ñsum of 36s. to 57s. 59s.: no modulation. Note: Carrier interruptions act as markers. Second marker: one 100ms interruption at beginning of each second (except 59s.). Minute marker: two 100ms interruptions at beginning of each minute. Hour marker: three 100ms interruptions at the beginning of each hour. 12-hour marker: four 100ms interruptions at 00h and 12h.			
		ITALY		
2410	**Roma (IAM).**	Mon.-Sat.: 0730-0830, 1030-1130.	(See below)	5000 kHz, A2A, A3E, 1 kW.
		1 hr. earlier when daylight savings time in effect.		
	DUT1: Marked seconds indicated by double pulse. SYSTEM: From 01s. to 59s.: second markers of 5ms each. 00s.: minute marker of 20ms. At 00m., 15m., 30m., 45m.: station identification in morse code and Italian. At 05m., 20m., 35m., 50m.: "IAM IAM IAM", time in morse code.			
		CHILE		
2445	**Valparaiso Playa Ancha Radiomaritima (CBV).**	0055-0100, 1155-1200, 1555-1600, 1955-2000.	U.S.	4228 kHz, A2A; 8677 kHz, A2A.
		PERU		
2461	**Peru National Radio.**	0300, 1300, 1700, 2300.	U.S.	609.5 kHz, J3E; 850 kHz, J3E; 103.9 MHz, J3E.
	SYSTEM: The hour marker of 1s. commences at 59m.-59s.			
2462	**Radio Victoria.**	0300, 1300, 1700, 2300.	U.S.	780 kHz, J3E.
	SYSTEM: The hour marker of 1s. commences at 59m.-59s.			
		INDIA		
2476	**New Delhi (ATA).**	0330-1430 (except from 0430-0830 on Sundays).	(See below)	10000 kHz, A1A, A3E, 8 kW.
	SYSTEM: 00m.: call sign and time in morse code. From 00m. to 04m.: second markers of 5ms 1000 Hz modulation each, minute markers of 100ms 1000 Hz modulation each. From 04m. to 15m.: second markers of 5ms each, minute markers of 100ms each. 15m.: call sign and time in morse code. From 15m. to 19m.: second markers of 5ms 1000 Hz each, minute markers of 100ms 1000 Hz each. From 19m. to 30m.: second markers of 5ms each, minute markers of 100ms each. 30m.: call sign and time in morse code. From 30m. to 34m.: second markers of 5ms 1000 Hz each, minute markers of 100ms 1000 Hz each. From 34m. to 45m.: second markers of 5ms each, minute markers of 100ms each. 45m.: call sign and time in morse code. From 45m. to 49m.: second pulses of 5ms 1000 Hz each, minute markers of 100ms 1000 Hz each. From 49m. to 00m.: second markers of 5ms each, minute markers of 100ms each. All time signals are sent 50ms in advance of UTC.			
		SRI LANKA		
2480	**Colombo (4PB).**	0555-0600, 1325-1330.	English	482 kHz, A2A, 1 kW; 8473 kHz, A1A, 2.5 kW.
	SYSTEM: From 53m./23m. to 55m./25m.: "CQ DE 4PB TIME SIGNALS AS". From 55m./25m. to 00m./30m.: second markers of 100ms each, minute markers of 400ms each.			
		CHINA		
2485.1	**Shanghai (XSG).**	0256-0856.	(See below)	458 kHz, A1A, A2A; 4290 kHz, A1A; 6414.5 kHz, A1A; 6454 kHz, A1A; 8487 kHz, A1A; 8502 kHz, A1A; 12871.5 kHz, A1A; 12954 kHz, A1A; 17002.4 kHZ, A1A.
	SYSTEM: From 59m.-55s. to 59m.-59s.: second markers of 100ms each. 00m.-00s.: minute marker of 100ms.			

(1) No.	(2) Name	(3) Hours of Transmission	(4) System	(5) Frequency
2490	**Xian (BPM).**	0730-0100.	(See below)	2500 kHz, A1A, A3E.
		Continuous.		5000 kHz, A1A, A3E.
		Continuous.		10000 kHz, A1A, A3E.
		0100-0900.		15000 kHz, A1A, A3E.

SYSTEM: From 00m. to 10m.: UTC second markers of 10ms each, UTC minute markers of 300ms each. From 10m. to 15m.: carrier. From 15m. to 25m.: UTC second markers of 10ms each, UTC minute markers of 300ms each. From 25m. to 29m.: UT1 second markers of 100ms each, UT1 minute markers of 300ms each. From 29m.-00s. to 29m.-40s.: "BPM" in morse code. From 29m.-40s. to 30m.-00s.: "BPM" and other station identification in Chinese. From 30m. to 40m.: UTC second markers of 10ms each, UTC minute markers of 300ms each. From 40m. to 45m.: carrier. From 45m. to 55m.: UTC second markers of 10ms each, UTC minute markers of 300ms each. From 55m. to 59m.: UT1 second markers of 100ms each, UT1 minute markers of 300ms each. From 59m.-00s. to 59m.-40s.: "BPM" in morse code. From 59m.-40s. to 00m.-00s.: "BPM" and other station identification in Chinese. All UTC signals are broadcast 20ms in advance of UTC.

JAPAN

2501	**Ohtakadoya-Yama (JJY).**	Continuous.	(See below)	40 kHz, A1B, 10 kW.

SYSTEM: 00s.: MÑminute marker of 200ms. From 01s. to 08s.: minutes. 09s.: P1Ñposition marker of 200ms. From 10s. to 11s.: marker of 800ms each. From 12s. to 18s.: hours. 19s.: P2Ñposition marker of 200ms. From 20s. to 21s.: marker of 800ms each. From 22s. to 28s.: days. 29s.: P3Ñposition marker of 200ms. From 30s. to 33s.: days. From 34s. to 35s.: marker of 800ms each. 36s.: PA1Ñparity check. 37s.: PA2Ñparity check. 38s.: SU1Ñspare bit or summer time information. 39s.: P4Ñposition marker of 200ms. 40s.: SU2Ñspare bit or summer time information. From 41s. to 48s.: years. 49s.: P5Ñposition marker of 200ms. From 50s. to 52s.: day of week. 53s.: LS1Ñleap second information. 54s.: LS2Ñleap second information. From 55s. to 58s.: marker of 800ms each. 59s.: P0Ñposition marker of 200ms. Note: every 15m. and 45m. of each hour the call sign in morse (from 40s. to 48s.) and station maintenance information (from 50s. to 55s.) are transmitted.

2502	**Hagane-Yama (JJY).**	Continuous.	(See below)	60 kHz, A1B, 10 kW.

SYSTEM: 00s.: MÑminute marker of 200ms. From 01s. to 08s.: minutes. 09s.: P1Ñposition marker of 200ms. From 10s. to 11s.: marker of 800ms each. From 12s. to 18s.: hours. 19s.: P2Ñposition marker of 200ms. From 20s. to 21s.: marker of 800ms each. From 22s. to 28s.: days. 29s.: P3Ñposition marker of 200ms. From 30s. to 33s.: days. From 34s. to 35s.: marker of 800ms each. 36s.: PA1Ñparity check. 37s.: PA2Ñparity check. 38s.: SU1Ñspare bit or summer time information. 39s.: P4Ñposition marker of 200ms. 40s.: SU2Ñspare bit or summer time information. From 41s. to 48s.: years. 49s.: P5Ñposition marker of 200ms. From 50s. to 52s.: day of week. 53s.: LS1Ñleap second information. 54s.: LS2Ñleap second information. From 55s. to 58s.: marker of 800ms each. 59s.: P0Ñposition marker of 200ms. Note: every 15m. and 45m. of each hour the call sign in morse (from 40s. to 48s.) and station maintenance information (from 50s. to 55s.) are transmitted.

REPUBLIC OF KOREA

2505	**Taejon (HLA).**	Continuous.	(See below)	5000 kHz, 2kW.

DUT1: Marked seconds indicated by double pulse.
SYSTEM: 00s.: minute marker of 800ms 1800 Hz tone. From 01s. to 28s.: second markers of 800ms 1800 Hz tone each. 29s.: silence. From 30s. to 52s.: second markers of 800ms 1800 Hz tone each. From 53s. to 58s.: time announcement by voice. 59s.: silence. 00m.: hour marker of 800ms 1500 Hz tone. A binary time code is transmitted continuously on a 100 kHz subcarrier.

PHILIPPINES

2530	**Manila (DUW21).**	Every even hour +55m. to +60m.	U.S.	3650 kHz, A1A, 0.5 kW.

INDONESIA

2633	**Jakarta (PKI)(PLC).**	0055-0100.	Modified ONOGO	PKI: 8542 kHz, A1A, 1-3 kW; PLC: 11440 kHz, A1A.