TIME AND FREQUENCY BROADCASTS FOR THE MIDDLE EAST REGION BY SATELLITE

Speaker: John Lowe
NIST
325 Broadway
Boulder, CO. 80305
(303) 497-5453
lowe@boulder.nist.gov

Authors John Lowe*, Wayne Hanson*, Mohamed A. Swidan°, Dr. Safaa Samuel[a] and Ahmed Hisham[a]

* National Institute of Standards and Technology, Boulder, CO, USA
° Head of Ground Segment, The Egyptian Satellite Co. Nilesat, 6th October City, Egypt
[a] National Institute for Standards, Cairo, Egypt

Abstract

The Egyptian Satellite Company and the National Institute for Standards (NIS) in Egypt, with technical assistance from the National Institute of Standards and Technology (NIST) in the United States, are collaborating to broadcast frequency and time information to North Africa and the Middle East Region from Nilesat satellites. The existing Nilesat Direct-to-Home broadcasts of television and audio programs will include time and frequency information, enabling users to recover this data with existing antenna and receiver technology. Proper reception and interpretation of these signals will guarantee traceability to NIS standards for time and frequency. This paper discusses the architecture and scope of this system.

Introduction

Nilesat, the Egyptian Satellite Company placed a geostationary satellite in orbit in April of 1998 to provide Direct-to-Home broadcasting services to North Africa and the Middle East. The Egyptian National Institute for Standards (NIS) has proposed using a portion of the transponder bandwidth to broadcast traceable time and frequency information. The Time and Frequency Division at the National Institute of Standards and Technology (NIST) in the United States is acting as consultant through a grant from the US-Egypt Joint Science and Technology Program. NIST has a satellite-based time and frequency dissemination system based over North America on the Geostationary Operational Environmental Satellite (GOES) system and therefore has experience with geostationary satellite broadcast services.

The Egyptian Nilesat System

The Nilesat 101 geostationary satellite is located at 7° west with an uplink frequency band of 17.3-17.7 GHz and a downlink frequency band of 11.7-12.1 GHz. There are 12 transponders each of 33 MHz bandwidth. The effective isotropic radiated power (EIRP) is shown in figure 1, with a maximum EIRP of 50.5 dBW. Table 1 shows the EIRP for several locations across the region. The Nilesat broadcast is a Direct-to-Home service which provides Digital Video Broadcasting (DVB), audio broadcasting, and high-speed data services [1].

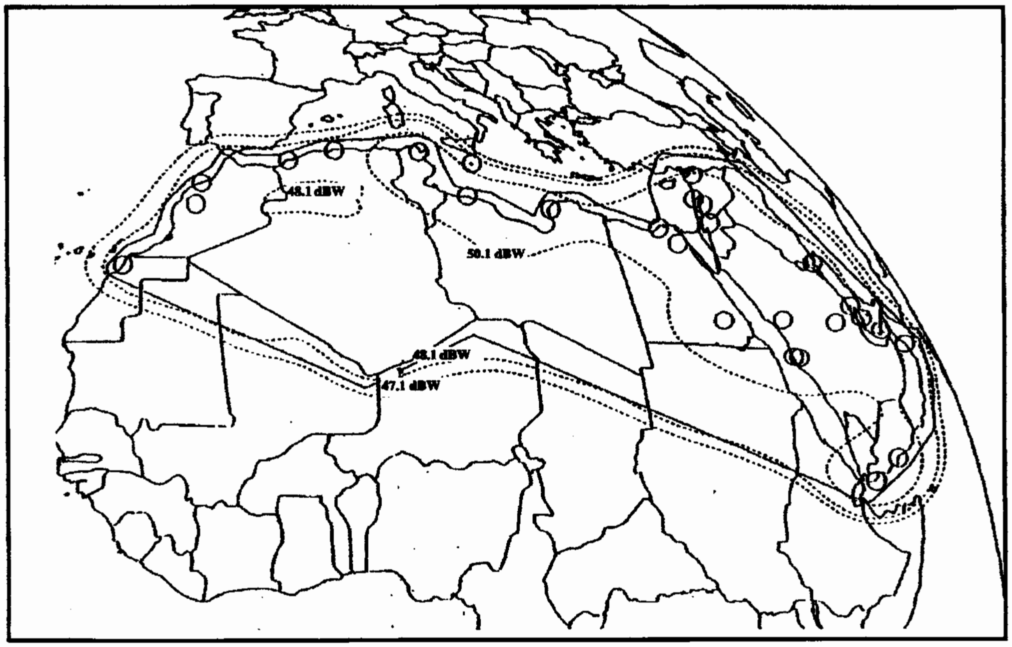

Figure 1. EIRP contour map for Nilesat 101 satellite.

City	EIRP (dBW)	City	EIRP (dBW)
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Cairo	50.5	Doha	49.2
Alexandria	50.3	Muscat	48.0
Aswan	50.2	Abu-Dhabi	48.9
Beirut	50.2	Aden	50.3
Damascus	50.3	Casablanca	47.7
Amman	50.3	Marrakech	47.7
Riyadh	50.3	Algiers	47.3
Mecca	50.1	Tunis	50.2
Kuwait	50.3	Tripoli	50.2
Manama	49.2	Khartoum	48.2
Baghdad	48.2	Nawakshut	47.2
Mogadishu	47.2	Jerusalem	50.2
Djibouti	48.2	Gaza	50.2

Table 1. List of major cities within coverage area and their respective EIRP values.

Time and Frequency Dissemination

We have investigated two methods of broadcasting traceable time and frequency. The first method produces a traceable frequency source using a cesium oscillator on the modulation of the video encryption. The second method is a complete time and frequency dissemination broadcast with a digital time code, using an entire radio segment.

The first case involves having a stable reference (cesium oscillator) used as the frequency source for the modulation process prior to the uplink to the Nilesat satellite (see Figure 2).

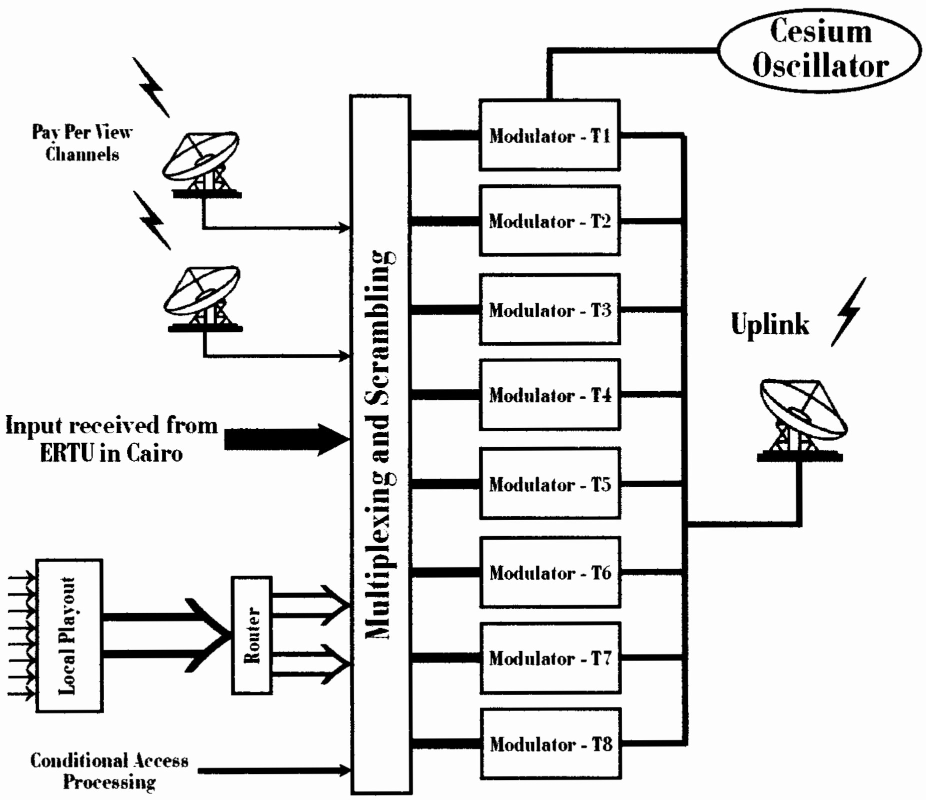

Figure 2. A cesium clock is used in the modulation process prior to uplink.

Upon reception by a receiver dish, the demodulated symbol clock can be recovered from a video card (see Figure 3). This symbol clock frequency is referenced to the cesium oscillator located at the uplink facility in 6th of October City. A common view measurement using the Global Positioning System (GPS) can be made to compare the frequency source at the Nilesat uplink facility to the NIS time scale in Giza. The results will be published by NIS to establish a traceability chain.

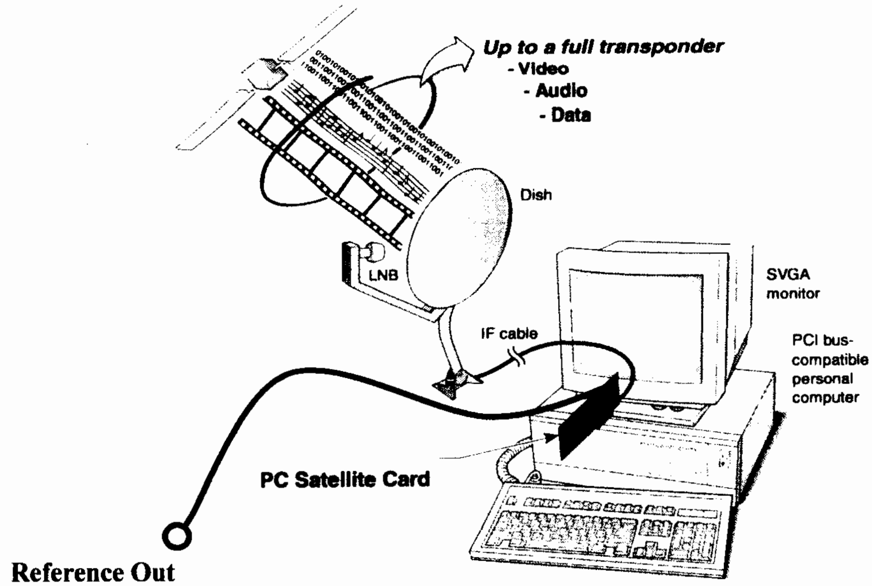

Figure 3. The stable frequency can be recovered from a PC satellite card.

The second proposed method of dissemination requires a full radio channel. Each radio channel is 15 kHz wide. The large available bandwidth allows for a significant amount of information to be broadcast. The broadcast can be split into three sections: a reference frequency, a time code and audio announcements. A 1 kHz reference frequency could be used for direct frequency comparisons. The proposed time code would encode the year, day of year, date, hour, minute, time code accuracy indicators, Daylight Saving Time and leap second indicators, system status information, UT1 correction and the ephemeris position of the satellite. The position information is updated every minute and includes the satellite's latitude, longitude and height above the Earth's surface. The voice announcements would give top of the minute announcements and possibly other announcements such as weather, geo-alert and emergency information. The time code could be sent out early to remove transmission and equipment delays for on-time recovery and the frequency reference could be actively servoed to correct for Doppler shifting due to satellite movement. This method would also require GPS common view measurements by NIS to establish traceability [(2)].

Experiment

A simple experiment has been conducted to test the feasibility of using a radio channel on the Nilesat system.

Two cesium atomic clocks were measured side by side using the NIST Frequency Measurement System to assure proper operation. One cesium clock was moved to the Nilesat uplink facility at the 6th of October City. The 1 pulse per second (pps) output was modulated directly onto a single radio channel and also sent to the start control of a time interval counter (see Figure 4). The radio signal was then received at the uplink facility and the 1 pps signal was recovered and used to control the stop of the time interval counter. A total delay (both transmission and electronic equipment) of 794.42 ms was recorded. This is the approximate amount the time code would need to be advanced for on-time recovery.

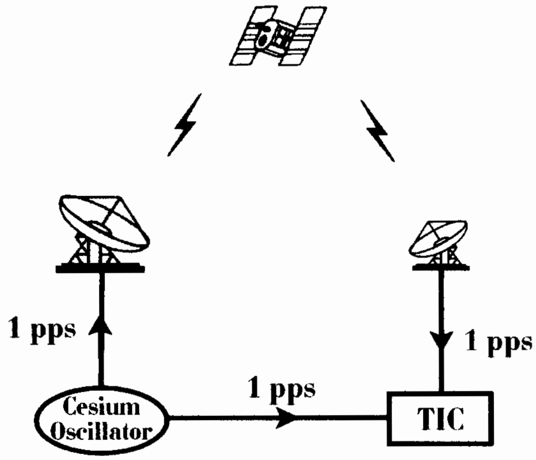

Figure 4. Measuring the delay using a time interval counter (TIC).

A commercially available receiver was then set up at the NIS facility, 20 km away in Giza. The recovered 1 pps signal from the receiver was then compared to one of the original cesium atomic clock. Figure 5 shows 400 hours of phase data from this measurement. Note the frequency offset of approximately 3 x 10^{-9}. This offset is attributed to a rubidium clock presently used as the reference for the uplink facility. Upon continuous operation, the cesium clock traceable to the NIS timescale would be used as the reference, thus stabilizing the modulation frequency.

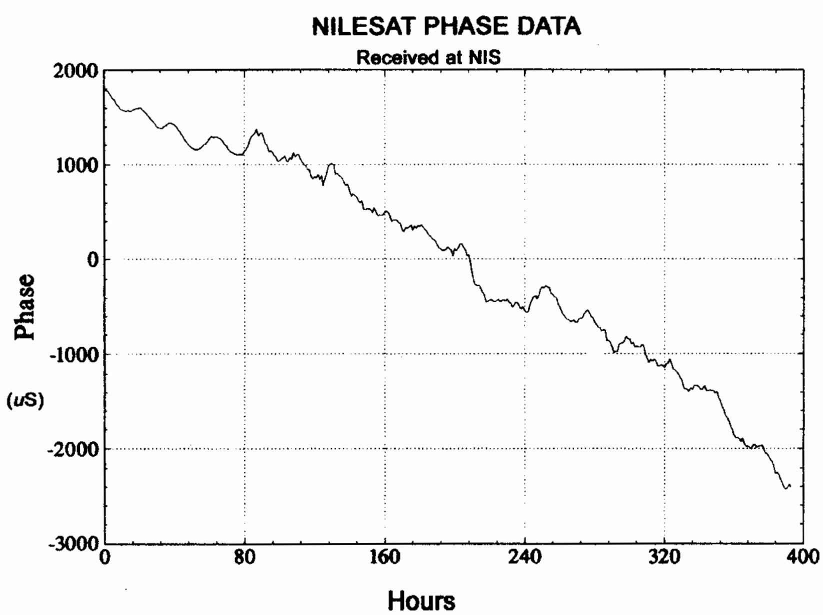

Figure 5. Nilesat phase data.

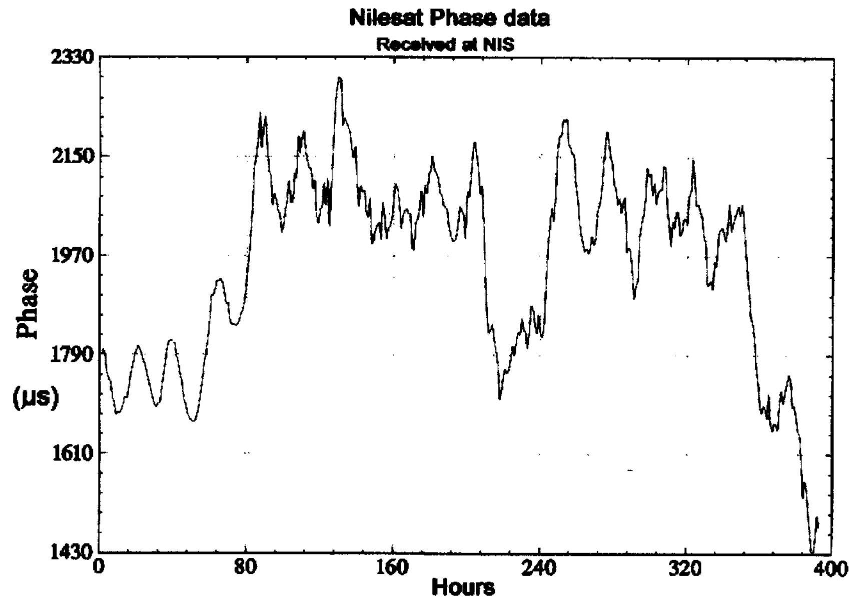

Figure 6. Nilesat phase data with frequency offset removed.

Figure 6 shows the phase data with the frequency offset removed. This shows the phase changes due to movement of the satellite and it looks similar to GOES satellite phase data. For reference, long term GOES phase data is shown in Figure 7. Typical time coded GOES satellite phase data (corrected for Doppler shifting) is shown in Figure 8. This data has had the Doppler errors removed [(3)]. This gives a representation of the expected capability of the Nilesat dissemination system. Figure 9 shows a stability plot of this corrected data. Note that stability in parts in10^{10} can be achieved in 1 day.

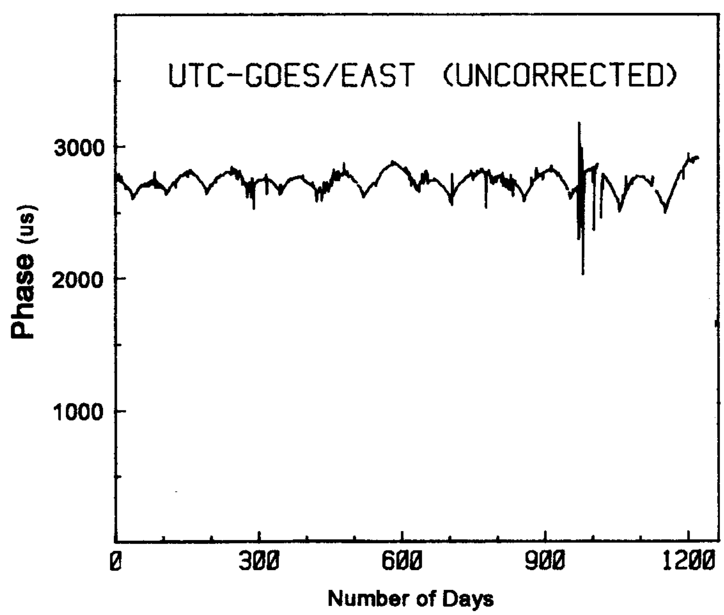

Figure 7. GOES phase data.

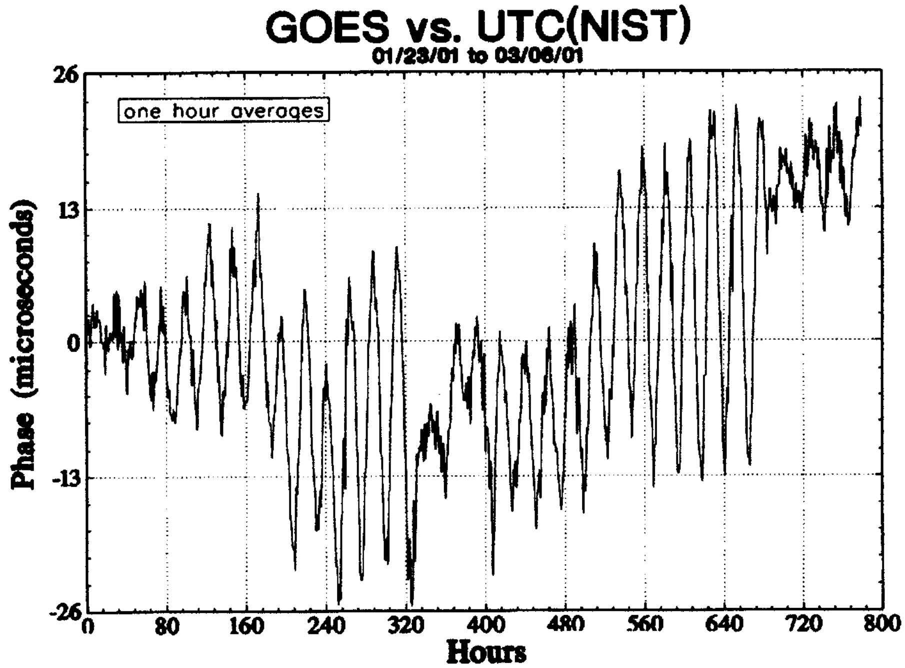

Figure 8. Corrected GOES phase data.

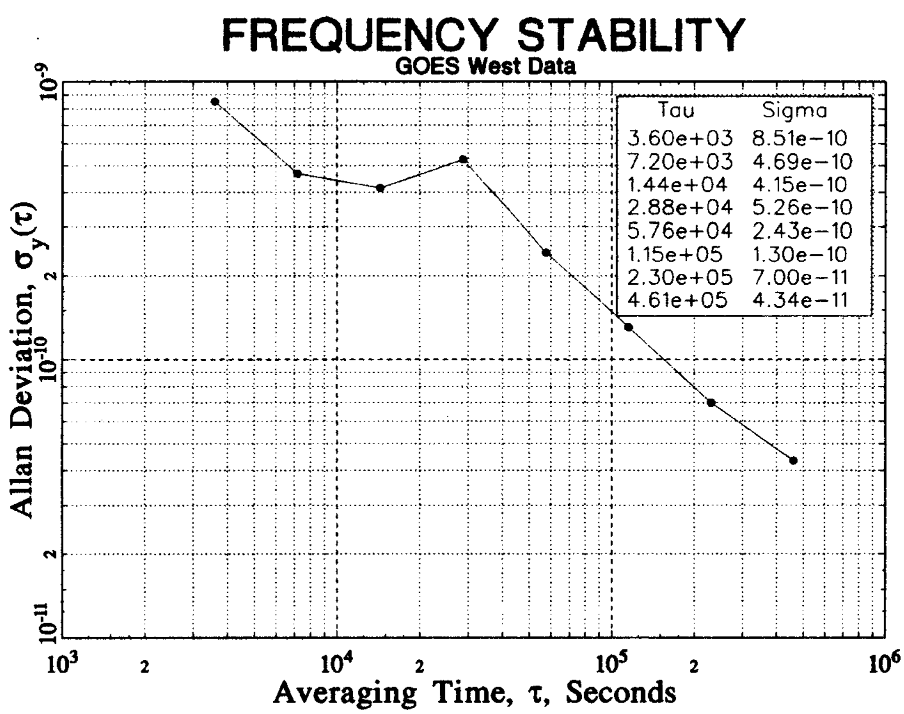

Figure 9. Stability measure of corrected GOES data.

Conclusions

Our work has shown that the Egyptian National Institute for Standards in cooperation with the Egyptian Satellite Company, Nilesat, has the unique opportunity to create a state of the art time and frequency dissemination system. This system would encompass all of North Africa and the Middle East. The system would allow an accurate, wide spread broadcast of time-of-day information to a large segment of the population via voice announcements. It also has the possibility of allowing manufacturers to decode an easily recovered time code to display time-of-day information, synchronize events separated by distance and measure long time intervals. Finally, the system has the ability to provide traceable frequency information through Nilesat and NIS using inexpensive receivers.

References

1) Veldhuis, Jan "*The Nilesat DVB Facilities in Cairo*", International Broadcast Engineer, March 1999, pp. 32-33
2) Lowe, John; Samuel, Safaa "*Annual Performance Report*", US-Egypt Science and Technology Program, April 2001
3) Beehler, Roger; Davis, Dick; Milton, John "*GOES Satellite Time Code Dissemination, Description, and Operation*", NBS Special Publication 250-30, January 1988