Application Note

Digital Audio and Digital Video Broadcasting (DAB/DVB)

Introduction

In response to customer demand for improved quality of audio and video programming, digital transmission systems have been developed (DAB/DVB) to enable the installation of broadcasting networks that provide enhanced bandwidth capabilities, improved geographical coverage, and deliver higher quality to the end customer.

This paper is intended to outline some of the fundamental system considerations that need to be addressed, and solutions to some of the system challenges, in order to maintain system signal integrity important to delivering an effective service.

Precise Time and Frequency, Inc.
50L Audubon Road, Wakefield, MA 01880, USA
Tel: (1) 781-245-9090 • Fax: (1) 781-245-9099 • Toll Free: 866-*ptf*-Inc1 • www.ptfinc.com

System Basic Features

The high quality digital signals are fed to transmitter antennas and transmitted at a range of frequencies around 500MHz. In order to avoid crosstalk between adjacent transmitted channels, there is an allowable pass-band at each transmitted frequency that is approximately 1 Hz (max. offset from nominal).Maintaining accurate control/precision of this pass-band is essential to avoid signal degradation, see figure 1a and 1b below.

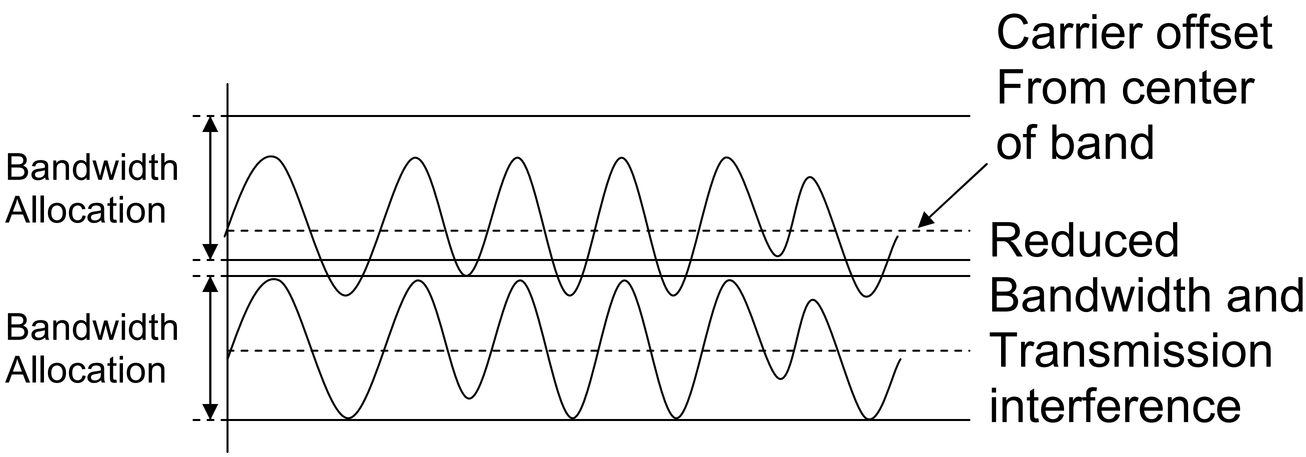

Figure 1a
Incorrect positioning of the carrier results in band overlap, wasting bandwidth, creating crosstalk, degradation of signal quality, and usually subjecting the provider to government imposed fines for transmitting outside of the band allocation.

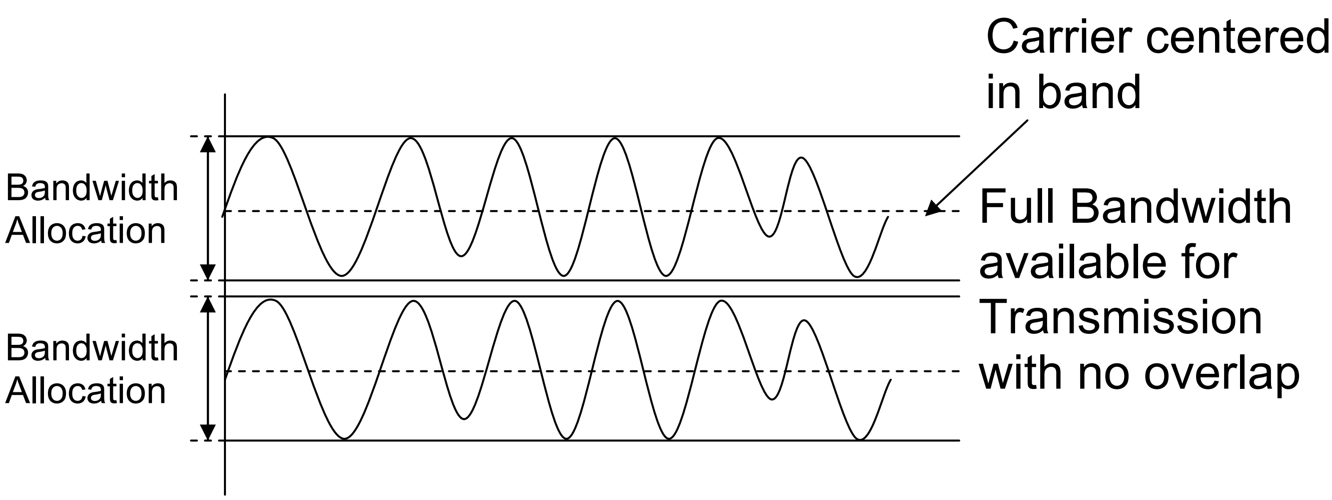

Figure 1b
Correctly (frequency) positioned transmissions allow maximum use of available bandwidth, deliver the highest quality signals to the end customer.

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Additionally, in order to provide effective geographic coverage, adjacent transmitters are positioned a distance apart to insure effective coverage over a complete region. Invariably there will be (by design) overlap of the transmitted signals to insure full coverage. It is important to control the relative carrier frequencies between transmitters to again avoid degradation of signal quality due to off-frequency interference from adjacent transmitters, see figures 2a and 2b below.

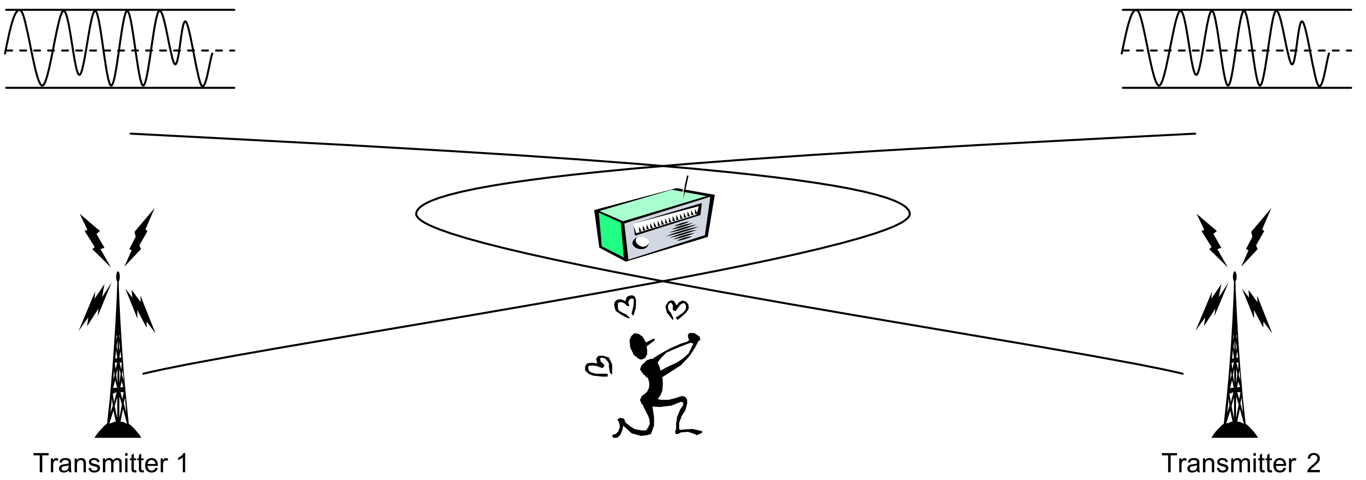

Figure 2a
Both transmitters on frequency

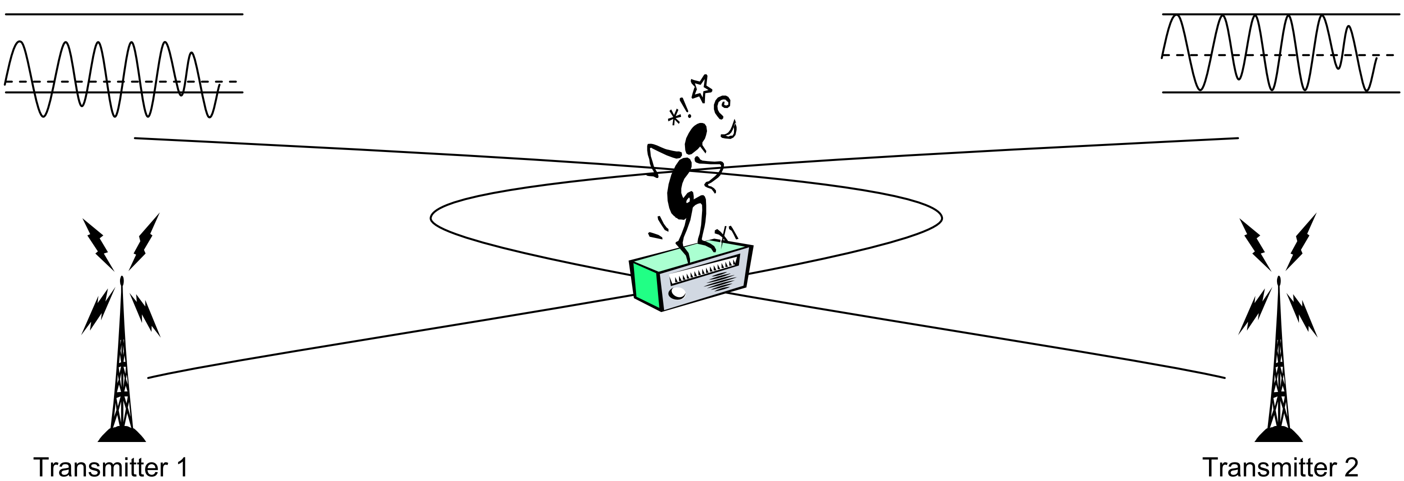

Figure 2b
Transmitter 1 is off-frequency, degrading signal quality in area of overlap

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The key to achieving an effective system rests upon accurate synchronization and frequency control of the transmitted signals. The primary parameters of importance in implementing this are frequency accuracy, and frequency stability, both short term and long term.

Frequency Accuracy.

Typically, the reference frequencies for driving such systems are generated in the region of 10MHz, as technology and components are more readily available to provide the necessary accuracy and stabilities at this frequency. The 10MHz frequency is multiplied up to provide the 500MHz carrier. This means that any accuracy error at the 10MHz level will be multiplied by a factor of ten when viewed at the 500MHz frequency.

Therefore, to determine the accuracy required at 10MHz we need to take the required accuracy at 500MHz (1Hz) and divide by 50 to reference the required accuracy at 10MHz as shown below.

Accuracy @ 500MHz = 1 Hz

Accuracy @ 10MHz = 1 Hz / 50 = 0.02 Hz

A good quartz oscillator will typically have a drift (or “aging”) rate of approximately 1 E-9 per day.

10MHz = 10,000,000 Hz therefore 10,000,000 x 0.000000001 = 0.01 Hz drift per day

This would indicate that if we use a good quality quartz oscillator, the carrier frequency will drift outside of the allowable frequency band within approximately 2 days (not taking into account any additional environmental effects such as temperature).

Clearly this is not an ideal solution, and fortunately there exist a number of technologies (such as the GPS system) which can be used to control the oscillator frequency to a long term absolute accuracy of approximately 1E-12, eliminating this problem.

Frequency Stability

Having addressed the long term frequency accuracy of the system, it is next important to consider the short and medium term “stability” of the frequency reference. This is the amount by which the absolute frequency varies in the short and medium term.

The measure most commonly used to characterize stability is Alan Deviation. This is a mathematical technique that has been developed to define the frequency stability over a given period of time, e.g. Alan Deviation at 100 seconds.

Again we are looking for a reference that provides a short and medium term stability that will not exceed the allowable error band (1Hz) reference to 10MHz (1E-9).

For short and medium term stability, a device such as a timing based GPS receiver relies on the stability of the local oscillator to "smooth out" any short term noise generated as a result of the relatively poor signal/noise of received satellite signals, and therefore in considering using such a device it is important to insure the local oscillator used is of sufficient quality to provide the necessary performance.

A good oven controlled quartz oscillator (OCXO) will provide this with alan deviation performance of 2E-11 to 5E-11 out to 100 seconds, and better than 4E-12 at 1000 seconds and beyond.

Phase Noise

The final consideration when determining a suitable frequency reference is the "purity" of the generated RF sine wave, generally measured in terms of "phase noise".

To relate the phase noise of the RF reference when referred to 500MHz the transformation is slightly different and is described by the equation below;

$\varphi_{(hf)} = \varphi_{(lf)} + 20 \log_{10} n$ where : $\varphi_{(hf)}$= phase noise at high freq.
$\varphi_{(lf)}$ = phase noise of reference
n = multiplication factor

therefore for a 10MHz reference with φ = -120 dBc @ 10Hz offset, being multiplied by 50 to 500MHz;

$$\varphi_{(hf)} = -120 + 20 \log 50 = -120 + 20 \times 1.7 = -120 + 34 = -86 \text{ dBc}$$

Typically the phase noise of the transmitter 10MHz reference should be less than –120dBc (ideally ~-125dBc) at 10Hz offset from the carrier to insure signal quality when multiplying from 10MHz to the 500MHz nominal transmitter signal.

System Synchronization

In addition to the considerations above, the transmitter systems require absolute timing synchronization transmitter to transmitter, to insure the programming content is delivered at the same time from each transmitter in the system.

Again with the available technology, this timing whilst critical, is relatively easy to generate between geographically distant locations, by use of the GPS system which delivers a one second pulse precisely timed from each satellite against the international time reference (UTC), and which can be resolved at a GPS timing receiver to within accuracies of <100 nano seconds.

Reliability

One final consideration for overall system performance is the system reliability. This is important for a number of reasons, not least of which is the fact that many of the transmitter locations may be some distance from available service personnel, and therefore, even if a failure is detected, the response time to repairing a fault can be quite long.

Due to this, most service providers consider redundancy a key feature of the service. By utilizing a redundancy philosophy, the system can continue to function perfectly even after detection of a fault, allowing scheduled maintenance to resolve potential problems in a manageable way. Typically this scheme will consist of two identical systems configured as a primary and a backup channel, with automatic switching between the two in the event of a fault.

Equipment Solution

Through extensive experience in time and frequency markets, Precise Time and Frequency, Inc. has developed equipment solutions to provide the necessary accuracy, timing precision, and redundancy considerations for these applications.

ptf 3203A GlobalTyme

The ptf 3203A GlobalTyme multifunction GPS receiver architecture is based upon a 35MHz microprocessor interfacing to a standard 12 channel GPS receiver and an FPGA to provide the range of functionality.

The GPS receiver input comes from a sturdy, weatherproof, bullet antenna with 35 dB gain (supplied) connected by means of a TNC input connector to the unit chassis.

Position information (required for accurate time capture) is automatically acquired by the unit, or can be manually entered through the set up controls. The local oscillator fitted as standard is a good quality OCXO. The oscillator is locked to the GPS 1PPS signal by means of a phase locked loop and provides a high quality 10MHz sine wave output, buffered through an RF buffer, to give a standard 1V rms, 13 dBm, 50 ohm output impedance RF signal onto a BNC output connector.

GPS status and health is internally monitored and reported on front panel LED,s (power, lock, and fault LED indicators) and also on the Ethernet and RS232 monitor/control i/o ports.

Outputs required from the reference unit include RF sine wave outputs at 10MHz and dependent upon the particular installation there may also be a requirement for 5MHz and 1MHz. Additionally each unit outputs 1PPS synchronized to UTC insuring that geographically remote systems can be synchronized to one another.

ptf 1220A AutoSwitch

The ***ptf*** 1220A Auto Switch is based upon microprocessor and CPLD technology used to intelligently switch a pair of simple relay RF switches to realize a combination of sophisticated control and interpretation functions together with a unit that will “fail safe” in the event of power failure.

The unit accepts two input pairs. Each input pair consists of an RF sine wave and a digital pulse input. The RF input can accommodate frequencies in the range 100kHz to 10MHz while the unit will cater for a digital pulse input range from 1kHz to 0.5 Hz.

Fault detection and switching is controlled by a CPLD. The CPLD monitors both signals of each channel and if the channel selected is unhealthy then the CPLD switches to the other channel, if it is healthy. In addition, the unit continuously monitors the health of the back up channel and provides fault reporting in the event there is a fault on the back up channel, even when not in use.

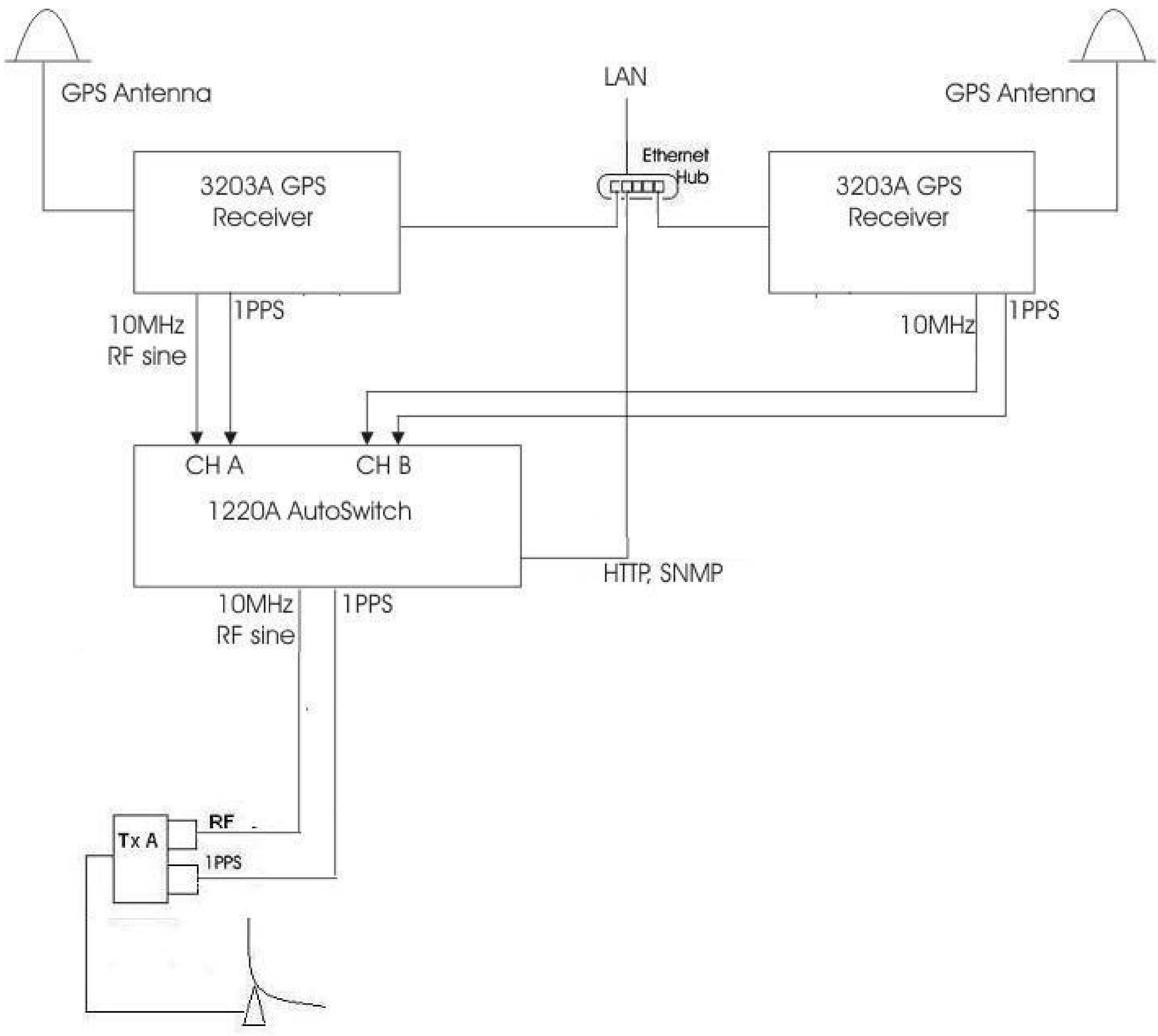
For the PULSE signal the definition of unhealthy is if the signal has not made a positive transition within the expected (selectable) PULSE period. For the RF sine wave signal the definition of unhealthy is if the signal is below a selectable (preset) threshold for a selectable (preset) period.

In addition, if required, the selected RF and Pulse output channel from the switching section can be fed to two sets (one RF and one pulse) of up to 12 channels of signal distribution. Each distribution set also has a “feed-thru” capability where the input made be left un-terminated (high impedance) to allow for additional distribution to be fitted if required.

Channel selection is also available by manual override from the unit front panel.

System Configuration

The diagrams below show a couple of slightly different configurations. The first utilizes a single autoswitch to feed the transmitter input. The second is a slightly more comprehensive system, showing the autoswitch fitted with distribution (model number ptf 1226A), and a complete system configuration resulting in a fully redundant system, with no single point failure



Redundant system with “Failsafe” AutoSwitchover

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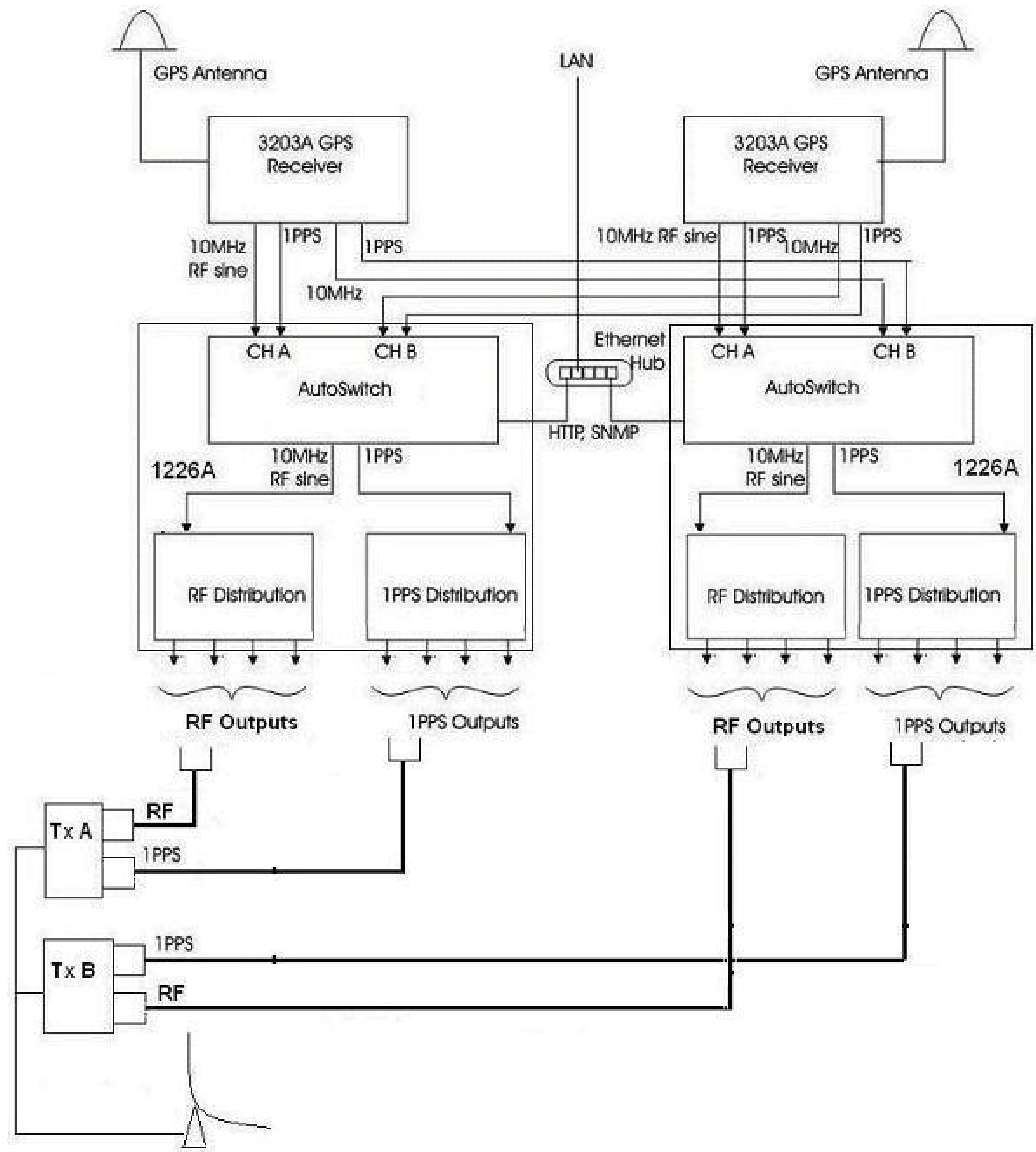

Fully redundant system with no single point failure mechanism

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Additional Features

Both of the systems shown above also provide comprehensive remote monitoring/control functions through a variety of protocols. Remote monitoring and control of the instruments is essential as the transmitter stations are often remote and unmanned.

Remote monitoring enable full management cisibility into system health and status, assuring prompt service responsiveness in the event of system alarms.

Further Information

For further information regarding this application or the described equipment please contact our customer support personnel.

www.ptfinc.com

Tel: (+1) 781 245 9090

Precise Time and Frequency, Inc.
50L Audubon Road
Wakefield, MA 01880
USA