July 23, 1997

Federal Communications Commission
Experimental Licensing Branch
Suite 230
2000 M Street
MS1300E1
Washington, D.C. 20554

Re: Experimental License to Harris Corporation
Call Sign: WA2XHK
File Number: 5515-EX-PL-96

Dear Sir:

Attached is a progress report for the period covering January 1997 to July 1997, as required by the above - referenced Experimental License. It is requested that this material be withheld from public inspection or release under FCC rules, Section 0.459. The progress report describes the design and operation of the Harris personal locator products and system. This material is considered a Harris trade secret and is accordingly customarily guarded from release by Harris Corporation. Release of this information would surely place Harris at a severe competitive disadvantage in the LMS market. Release to a competitor would allow that competitor to freely copy and use the Harris design, thereby giving the competition a material and unfair advantage in competing against Harris. Further, Harris contends that the provisions of 47 CFR 0.457 (Records Not Routinely Available For Public Inspection), subsection (D) also applies to this submittal.

For the reason set forth above, Harris respectfully requests that the Federal Communications Commission withhold this information from public inspection or disclosure. Please advise whether this request is accepted or denied.

Sincerely,

Arthur L. Stewart
Program Manager

ALS/awd

PROGRESS REPORT

to the

Federal Communications Commission

on

Experimental License
(5515-EX-PL-96)

Covering the Period from January 1997 to July 1997

Arthur L. Stewart

July 15, 1997

Harris Corporation
Government Communication Systems Division
P.O. Box 91000
Melbourne, Florida 32901

Confidential / Proprietary / Trade Secret

PROGRESS REPORT

to the

Federal Communications Commission

on

Experimental License
(5515-EX-PL-96)

This report summarizes the development status and preliminary test results of mobile transmitters associated with our wide area tracking and location prototype system development. Although system level testing has not yet been initiated, prototype versions of our mobile transmitters have been completed. Lab test results provided herein give preliminary indications of spectral performance including our compliance with Part 90 and Part 15 emission mask designations. As we move into the summer months we will begin system integration and testing, initially with our receive towers installed in the Melbourne, Florida area. Our next test report will detail the results of this system level testing.

Section 1.0 of this report will provide a theory of operations for the Personal Locator (mobile transmitters). Section 2.0 will present lab test results attained from our prototype personal locator units.

SECTION 1.0 - THEORY OF OPERATIONS

The Harris Micro-Trax™[1] Personal Locator is a component of the Micro-Trax™ System. It is intended to be attached to objects or worn or carried by individuals. Coupled with the capabilities of a local or wide area Micro-Trax™ system (required for operation), the Personal Locator provides the user, through a service provider, with the location of the device at intervals established at the time of activation. For personal use, the Personal Locator also provides a "Panic" feature. When activated, this feature initiates immediate and frequent transmissions which include a notification that the "Panic" button has been pressed. Upon receipt of these transmissions, the service provider can take action based upon a user profile established at the time of activation.

The Personal Locator is a radio-frequency transmitter which sends an extremely low energy transmission to a network of radio receivers. These receivers measure the time and angle of arrival of the transmission and relay this information, along with the identification number of the device and any data (e.g.,panic, battery status) to a central

[1] MicroTrax™ is a trademark of the Harris Corporation.

location. The central location uses sophisticated algorithms to determine the location of the transmitter and store it for retrieval by the user. The signal from the transmitter is a state-of-the-art spread-spectrum waveform similar to those used by sophisticated government and military communications systems and provides significant improvements in location accuracy and range over conventional techniques.

1.1 Personal Locator Block Diagram

The Harris Micro-Trax™ Personal Locator comprises four major components -- a digital printed wiring board assembly, an RF / antenna printed wiring board assembly, a case assembly, and a battery. A block diagram is provided in Figure 1. Under normal operating circumstances, the transmitter sends a series of spread spectrum symbols, each of which convey 5 bits of data. The spreading sequence causes the transmission to occupy a bandwidth of 4 MHz while transmitting data at an effective rate of 500 bits per second. The parabolic phase spreading sequence is modulated on the carrier by an I/Q modulator controlled by a programmable ASIC. The programmable ASIC is also capable, on command, of sending a CW signal at the low edge, center, and high edge of the band. CW transmission is not available while the device is in normal operation, but is provided as a test capability accessible only by being enabled when downloading a program into the device. All operation is supervised by a program downloaded into a microcontroller which provides a core control capability, programmable parameters storage, and programmable behavior within the constraints of the core control capability. The microcontroller operates directly from the battery on a wake/sleep cycle to conserve battery power. On approximately one-second intervals based on an internal timer which counts a 55 Hz oscillator, it wakes up, starts a 2MHz clock oscillator, and executes a program to determine if any action is required. The external panic button can also cause the microcontroller to wake. If, upon waking, the microprocessor determines that no transmission is required, it returns to sleep. If, however, it determines that it is time for a transmission, it begins the transmit process by turning on power to the rest of the circuits except for the power amplifier. It downloads necessary parameters into the divider/phase detector to set the transmit frequency and then monitors the operation of the circuits to ensure that all are ready for transmission. When all setup is complete and the synthesizer reports lock, the transmission begins. The microcontroller turns on the power amplifier, commands the programmable ASIC for the type of transmission, and enables transmission. The programmable ASIC starts the transmission of the first spread spectrum symbol and requests the data for the second symbol from the microcontroller. This sequence continues with the programmable ASIC effecting the transmission of one symbol and requesting data for the next from the microcontroller until six symbols have been sent. At this time the microcontroller turns off the power and goes to sleep.

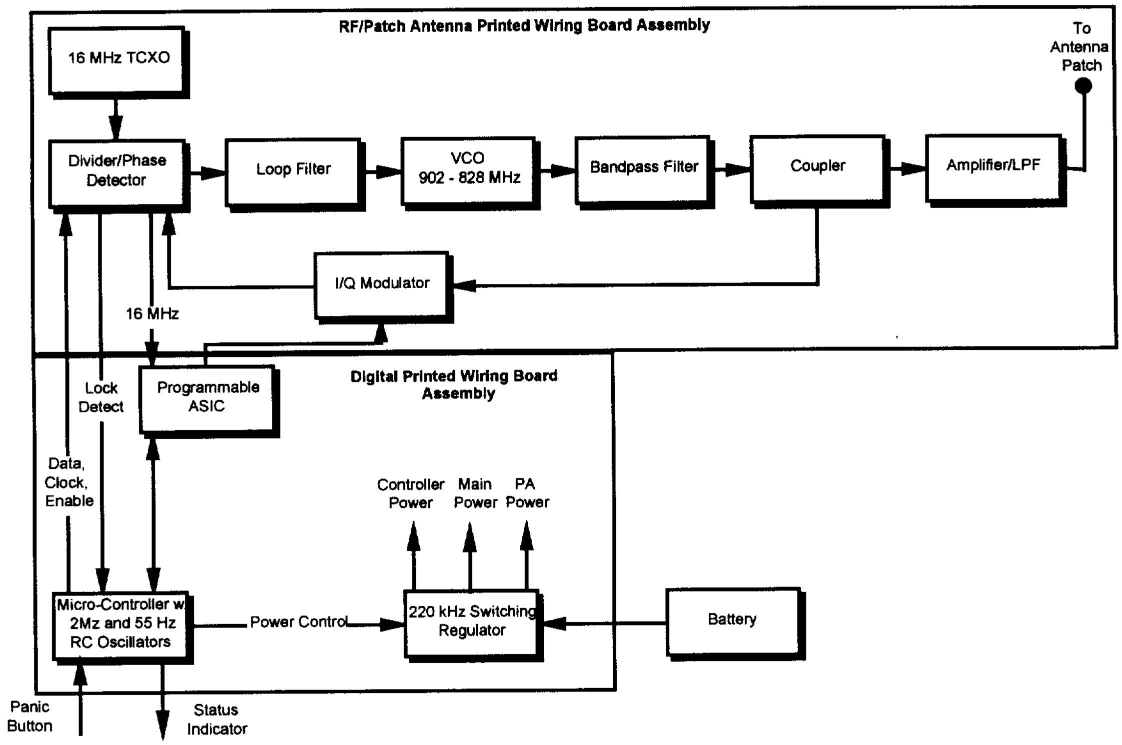

Figure 1, Personal Locator Block Diagram

1.2 Frequency Control

All frequencies and time intervals within individual messages are synchronized to a 16 MHz temperature compensated crystal oscillator with a frequency stability of 2.5 parts per million over the operating temperature range. This oscillator stability was chosen specifically to meet current Part 90 requirements. As will be discussed in the results section, our output waveform is well within the Part 90 emission mask using oscillators with stability relaxed by more than an order of magnitude. The output of the TCXO is delivered to a divider/phase detector which generates reference frequencies needed by the programmable ASIC and phase detector. The output of a 902 - 928 MHz voltage controlled oscillator is sampled in a coupler and fed through the I/Q modulator to the divider/phase detector. The phase detector charge pump output is fed to a passive loop filter which generates a control voltage for the voltage controlled oscillator. This implements an indirect frequency synthesizer to generate a carrier at the center frequency for the 4MHz spread spectrum transmission. The center frequency can be calculated from the following equation:

$$Fc = (P*B + A)*16\ \text{MHz}/R$$

where A, B, P, and R are programmable parameters. For example, for A = 11, B = 14, P = 64, and R = 16, the output frequency is 907 MHz.

1.3 Modulation

Modulation of the output signal is accomplished by the I/Q modulator operating on the sampled output of the voltage controlled oscillator in the feedback path of the synthesizer phase-locked-loop. The modulator has the capability to deviate the phase of the sampled signal on 45 degree intervals at a 16 MHz rate. The spreading sequence data applied to the modulator for each 8 millisecond symbol to be transmitted causes a parabolic variation in phase which is equivalent to varying the frequency over a 4 MHz range. The starting point for each symbol is chosen from one of 32 possible to convey 5 bits of data. The effect of modulating the feedback path of the phase-locked-loop is that the loop tries to cancel out the modulation by sweeping the voltage controlled oscillator in the opposite direction from the modulation. The loop filter smoothes the phase transitions from the modulator thereby suppressing the spectral effects of the 16 MHz rate 45 degree phase modulation to levels compliant with the spectral masks for FCC Regulations in Parts 15 and 90. The +7 dBm output from the voltage controlled oscillator is fed through the coupler either to the antenna at a reduced level for Part 15.249 devices or to a power amplifier which provides an output to the antenna of -2 dBw, nominal. This level of output is suitable for operation under experimental licenses, Part 90, or Part 15.247.

A message consists of one or more frames of 6 symbols (one reference symbol followed by 5 data symbols, each conveying 5 bits of data) for a total of 25 data bits per frame. Provision has been made for concatenation of frames when greater quantities of data are required to be transmitted. The device provides an accessory connector which allows the delivery of data for modulation in this manner. The accessory connector also provides for entry of programming data, external event sensing, and delivery of external power.

Transmission quality is ensured by the microcontroller which monitors synthesizer lock, programmable ASIC operation, transmission length and other parameters to provide the capability to stop transmission unless operation proceeds normally.

The modulation circuitry has been purposely designed to also provide an alternative means of narrowband data transmission under Part 90 LMS rules. It is easily adaptable to transmit data at rates exceeding 9600 bits per second. To provide this capability a different waveform will be used. Power efficiency is the primary constraint affecting modulation type of this link when it is operating off of the internal battery. While BPSK and QPSK have equivalent performance, the current tag architecture is readily adaptable to FSK waveforms. 4-FSK exhibits a performance improvement of approximately 3 dB over FSK, with the same bandwidth efficiency. The existing design's programmable ASIC can be modified to modulate the phase of the carrier in such a manner to produce a 4-FSK signal which can be demodulated by a separate, inexpensive receiver at the receive sites.

1.4 Power Supply

This device is battery operated. Power is provided by a 2/3 A Lithium battery, type 5017LC. This battery provides sufficient energy to last for up to 6 months while transmitting once per 15 minutes. A switching regulator operating at 220 kHz provides all voltages necessary for operation. The microcontroller operates down to a cell voltage of 2 volts, a point at which there is insufficient energy to transmit. When the battery voltage declines to a point at which reliable transmission can not be assured, the microcontroller will not allow transmissions. Prior to this, when the battery terminal voltage passes below a pre-set alarm threshold voltage the device will include a battery-low alarm in all subsequent transmissions. An operator initiated status check reports battery status through an LED status indicator. Since proper controller action is required to initialize the synthesizer and turn on power to the transmitter, if there is insufficient power to operate the microcontroller, transmissions will not occur. All of these features operate to ensure that any transmissions will be within requirements for operation as specified by applicable FCC regulations.

1.5 Operation

This device, when delivered to a user, will operate as prescribed by a behavior program which cannot be altered by the user. The program will control the transition of the device between four operating states --IDLE, LOW RATE TRANSMIT, HIGH RATE TRANSMIT, and EMERGENCY TRANSMIT. In the idle state, no transmissions are made. The device monitors its environment (external signals, panic button, etc.) and moves to one of the other states as prescribed by the program. In the LOW RATE TRANSMIT state, the device transmits a message periodically at a rate which is programmed at activation to be between one message each 15 minutes and one message per day. In the HIGH RATE TRANSMIT state, the device will transmit a message periodically at a rate which is programmed at activation to be between one message per hour and one message per second. In the EMERGENCY TRANSMIT state, operation is the same as in the HIGH RATE TRANSMIT state except that a bit indicating emergency is set and different criteria for exiting the state apply. One such behavior program, suitable for a personal locator device is depicted in Figure 2. Under this program, when the battery is installed, the device delays two seconds, verifies battery voltage above threshold, makes a normal transmission, verifies battery status under load, reports the status and operating mode (NORMAL or EMERGENCY, NORMAL only for power up) to the operator via the status LED, and transitions to the LOW RATE TRANSMIT state. A short press of the panic button from this state will reinitiate the status check process. A long press (>2 seconds) of the panic button puts the device in the EMERGENCY TRANSMIT state which increases the transmit rate and sets the emergency bit in the data message. While in the EMERGENCY TRANSMIT state, a short press will initiate status check and a long press will cancel EMERGENCY TRANSMIT. Note that, in this program, the IDLE and HIGH RATE TRANSMIT states are not used. These states were included to support other tracking scenarios. Additional programs will be developed and included in the program library to support tracking of items of interest including other categories of individuals, such as patients, parolees, and prisoners, as well as cargo, vehicles, and valuable assets. Because of the varying nature of these missions, the exact structure of these programs and their required ancillary devices (motion detector, proximity detector, etc.) cannot be predetermined. At no time, however, will these programs cause operation to occur outside the parameters set by the programmable ASIC which have been previously described, and established to ensure compliance with applicable FCC regulations.

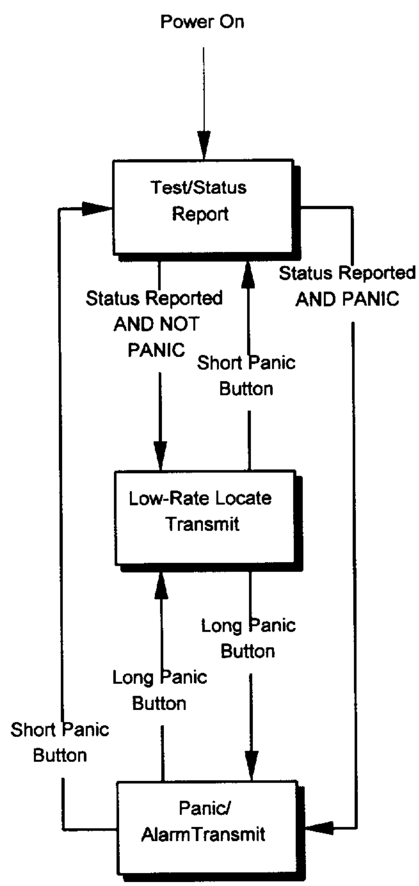

Figure 2, Personal Locator Behavior Program

1.6 Specifications:

Operating Frequency:	Single Frequency, 902 - 928 MHz (Set by Service Provider at Activation)
Occupied Bandwidth:	4 MHz
Modulation:	Digital Phase Modulation, 45 degree resolution, 16 MHz rate
Emission Designator:	4M00G1D
Spectral Purity:	Designed for compliance to FCC regulations Parts 90.210, 15.247, or 15.249 (low power)
Frequency Stability:	2.5 ppm
Data Rate:	500 bits per second
Message Length:	50 ms, normal, extended messages modulo 50 ms.
Output Power:	+2 dBm (nominal for 50 mV/m at 3 m) Part 15.249 Version 0 dBw (maximum) to antenna Part 90 or 15.247 Version
Antenna Gain:	-2 dBi, nominal
Temperature:	-20 to +70 C
Shock and Vibration:	Designed to 47 CFR 68.302 (compliance not required)

SECTION 2.0 - PRELIMINARY TEST RESULTS

The first prototype locator tags achieved a good start at attaining our size and power consumption objectives for the MicroTrax system. Photographs of the actual units we will submit for FCC certification are pictured in Figure 2.0. The first photograph is the entire tag package, the second shows both the RF / Antenna circuit card and the digital controller circuit card that comprise the locator tag electronics.

The phase lock loop based transmitter design resulted in an output waveform with good fidelity. The transmit spectrum provided preliminary indications that we will be in compliance with emission masks associated with Part 15.247, 15.249 and Part 90. Testing did indicate some potential problems with power dissipation when running continuously for test purposes. The transmit message is normally at such a low duty cycle (48ms once every 15 minutes nominal) that running in continuous mode depletes our battery in 15 minutes (15 minutes continuous equates to 6 months at once per 15 minute transmission rate). We will be evaluating ways to provide for continuous mode testing and investigating in particular if continuous mode stresses our power amplifier.

2.1 High Power Test Results - Part 90 and 15.247

The high power tag was tested with a battery and with external power. Spurious emissions were the same in both cases. The following data was taken in continuous transmit mode, with a 4MHz spread spectrum waveform centered at 907MHz, and an uncalibrated receive dipole antenna connected to a spectrum analyzer.

- Current Consumption = 730mA
- Pin = -13.3dBm (relative power measured at uncalibrated antenna)
- Spur at 903.8MHz = -40dBc, all other spurs below noise floor. This spur does not exist in CW mode.
- 2nd Harmonic = <-54dBc
- 3rd Harmonic = < -58dBc
- 4th through 7th harmonics =< -60dBc

Figure 2.1 provides a printout from the spectrum analyzer showing our emission mask compliance. It should be noted that our oscillator stability can be relaxed in excess of 10 parts per million and still be in compliance with the emission mask due to our occupied bandwidth of 4.064Mhz within a sub band of 5.5Mhz.

2.2 Low Power Test Results - Part 15.249

A low power locator tag intended for use in unlicensed systems authorized under Part 15.249 has been implemented by removing the power amplifier and padding the output. The low power tag was tested with a battery and with external power. Spurious was the same in both cases. The following data was taken in continuous transmit mode, with a 4MHz spread spectrum waveform centered at 907MHz, and an uncalibrated receive dipole antenna connected to a spectrum analyzer.

- Current Consumption = 120mA
- Pin = -38.2dBm (relative power measured at uncalibrated antenna)
- Spur at 903.8MHz = -40dBc, all other spurs below noise floor. This spur does not exist in CW mode.
- 2nd Harmonic = <-19.8dBc
- 3rd Harmonic = < -29dBc
- 4th through 7th harmonics =< -30dBc

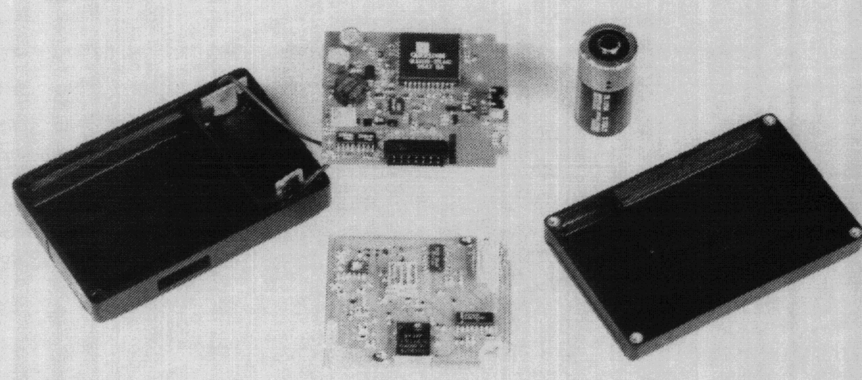

Figure 2.0 Locator Tag Photographs

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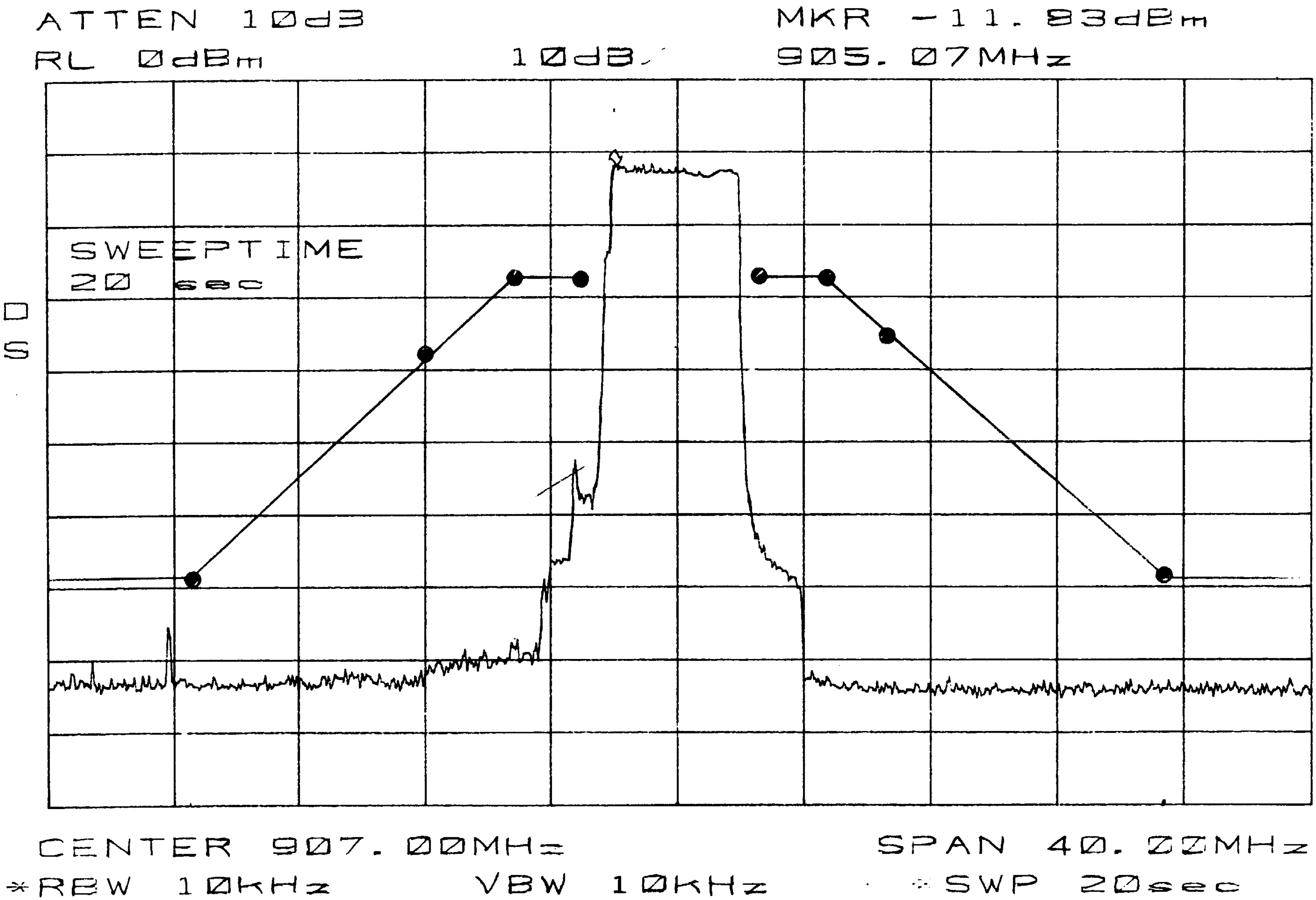

Figure 2.1 Spectrum Analyzer Plot

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