Nucleus Paging Transmitters Product Description

Introduction to Motorola’s Nucleus Paging Transmitters

Motorola’s Nucleus paging transmitters combine advanced technology, proven reliability, and exceptional customer convenience. Designed to meet the needs of the world wide paging marketplace, Nucleus transmitters embrace a full complement of frequency and power options.

The Nucleus transmitter family consists of two models—the Nucleus and Nucleus II (see Figure 1).

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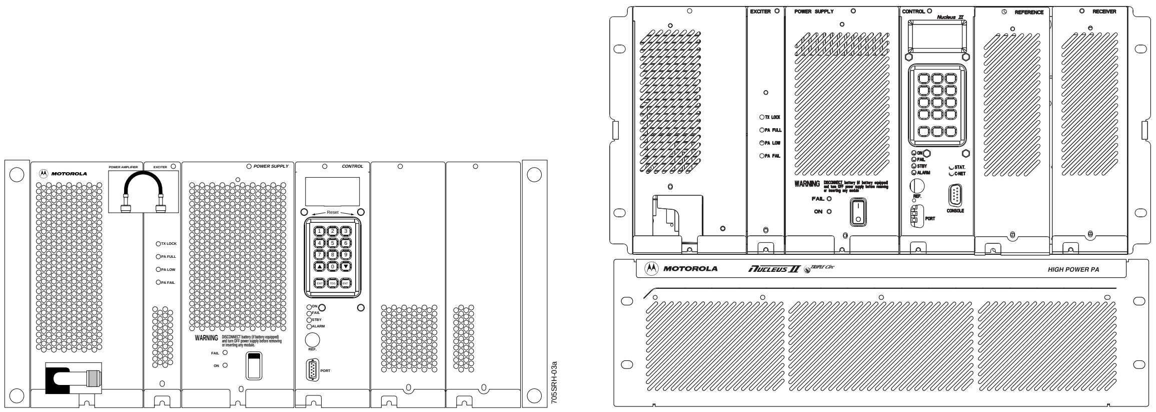

Nucleus **Nucleus II**

Figure 1: Nucleus and Nucleus II

Nucleus transmitters operate in various frequency bands from 132 to 941 MHz and are available in standard-power (25–125 W) and high-power (300–350 W) models.

Nucleus II transmitters operate in the 927– 941MHz frequency band and are available in high-power (250-300 W) models only.

A complete listing of the available frequency bands and power ranges for the Nucleus and Nucleus II is provided below (see Table 1 and Table 2).

Table 1: Nucleus Transmitters

Frequency (MHz)	Power Output (W)	New Model Number (Old Model Number)	Dimensions (H x W x D)	Weight
132–154 (VHF)	125 W (variable to 20 W)	PT1148A standard power (T5481 with X195AA)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
132–154 (VHF)	25 W (variable to 5 W)	PT1146A standard power (T5481 with X330AC)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
144–160 (VHF)	350 W (variable to 100 W)	PT1150A high power (T5482 with X830AD)	14 x 19 x 20 in. 35 x 48 x 51 cm	105 lb 48 kg
150–174 (VHF)	125 W (variable to 20 W)	PT1149A standard power (X5481 with X195AB)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
150–174 (VHF)	25 W (variable to 5 W)	PT1147A standard power (T5481 with X330AC)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
158–174 (VHF)	350 W (variable to 100 W)	PT1151A high power (T5482 with X830AE)	14 x 19 x 20 in. 35 x 48 x 51 cm	105 lb 48 kg
276–284	125 W (variable to 20 W)	PT1142A standard power (T5481 with X213AA)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
276–284	300 W (variable to 100 W)	PT1143A high power (T5482 with X214AA)	14 x 19 x 20 in. 36 x 48 x 51 cm	105 lb 48 kg
438–470 (UHF)	100 W (variable to 25 W)	PT1158A standard power (T5481 with X640AH)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
929–941	100 W (variable to 20 W)	PT1161A standard power (T5481 with X660AB)	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg

Table 2: Nucleus II Transmitters

Frequency (MHz)	Power Output (W)	Model Number	Dimensions (H x W x D)	Weight
929–941	300 W (variable to 100 W)[1]	PT1104 high power (T5482 x/X201AA)	14 x 19 x 20 in. 36 x 48 x 51 cm	105 lb 48 kg
929–941	250 W[1]	PT1105 high power with triple circulator (PT1104 with X677)	14 x 19 x 20 in. 36 x 48 x 51 cm	105 lb 48 kg
929–941	300 W (variable to 100 W)[1]	PT1173 high power (42–72 Vdc power supply)	14 x 19 x 20 in. 36 x 48 x 51 cm	105 lb 48 kg
929–941	300 W (variable to 100 W)[1]	PT1174 high power (23–34 Vdc)	14 x 19 x 20 in. 36 x 48 x 51 cm	105 lb 48 kg

1. Measured at output of power amplifier (PA) cable.

Table 3: Nucleus Transmitters—Asia Model Designations[1]

Frequency (MHz)/Control	Power Output (W)	Model Number	Dimensions (H x W x D)	Weight
132–154 (VHF) RF-Baton!	125 W (variable to 20 W)	PT1231A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
132–154 (VHF) NAC	125 W (variable to 20 W)	PT1232A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
132–154 (VHF) C-NET	125 W (variable to 20 W))	PT1233A	14 x 19 x 20 in. 35 x 48 x 51 cm	105 lb 48 kg
150–174 (VHF) RF-Baton!	125 W (variable to 20 W)	PT1236A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
150–174 (VHF) NAC	125 W (variable to 20 W)	PT1237A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
150–174 (VHF) C-NET	125 W (variable to 20 W))	PT1238A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
276–286 RF-Baton!	125 W (variable to 20 W)	PT1226A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
276–286 NAC	125 W (variable to 20 W))	PT1127A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
276–286 C-NET	125 W (variable to 20 W)	PT1128A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg
929–941 C-NET	100 W (variable to 20 W)	PT1143A	8.75 x 19 x 20 in. 23 x 48 x 51 cm	60 lb 27 kg

1. Asia model designations refer to a Nucleus transmitter in combination with a controller.

Features

In order to attain our goal of 100 percent customer satisfaction, the Motorola paging infrastructure team has made continuous quality improvements the centerpiece of its product design effort. We want to be sure our products deliver (and continue to deliver) what our customers want—high reliability, reduced cost, and technologically advanced performance. Features that have been put in the Nucleus product line as a result of our continuing focus on customer needs are described below.

High-Speed Performance For Maximized Capacity

The transmitters that make up the Nucleus line allow far more subscribers per channel than competing products. A Nucleus transmitter can seamlessly employ paging signaling schemes of up to 6400 bps with 4-level modulation when using the FLEX protocol or process 2-level modulation up to 3200 bps to service POCSAG and GSC pagers. The 2-level deviations can be set by the user and are very flexible with settings from 1 Hz to 5000 Hz. The 4-level deviations are factory set for FLEX 6400. The frequency offsets also can be set by the user for even more flexibility in the field.

The Nucleus product line features a digital signal processor-based modulator that provides precise waveshaping for high-speed FLEX operation. The microprocessor sends the deviation information to the modulator, which sets the modulation electronically. This method ensures a high degree of accuracy over an extended time period.

Reliability

The Dual Device Modules (DDMs) that make up the power amplifier section of the Nucleus products are built in a parallel architecture, which produces more reliable operation. The individual DDMs are designed to have a very high level of reliability, but if one does fail the station can continue to transmit pages, although at a lower power output.

Changes have been made to the routing of cooling air within the Nucleus products in order to improve the overall reliability of electrical components. The components in the power supplies have been isolated from the cooling air flow so that the air only flows over the heat sinks. This keeps the components cleaner which and thus their performance life is maximized. In the power amplifiers, the graphite flange to which t the devices are attached is an excellent heat dissipater. Once the heat is pulled away from the device, it is pulled down through the aluminum heat sink to the fins where fans blow cool air from the front of the station to the rear. This front-to-back cooling design allows the station to be thermally independent from other equipment.

Robust Design

The Nucleus products are designed to perform reliably in unheated and uncooled environments, and in unfavorable atmospheric conditions such as salt air and high humidity.

All of the models that make up the Nucleus line are put through several months of rigorous environmental testing that includes salt, fog, temperature-cycling, dust, vibration, electrostatic discharge, impact, line transients, and temperature shock. The goal of this testing program is to ensure not only conformance to Motorola's stringent product quality specifications, but to also guarantee a high level of customer satisfaction with the way the products perform in actual field conditions.

Efficiency

Motorola considers efficiency to be a major performance objective for its transmitters. Therefore, the transmitters that make up the Nucleus line are continually updated and improved. The design of the power supply, for example, was recently improved to make it 10 percent more efficient. The AC-to-DC converter circuitry has also been improved to be more robust and efficient.

The 300-W, 900-MHz power amplifier also has been made more efficient. The design of the combiner circuitry has been improved, which decreases the amount of power lost in the RF runners. The triple stage circulator was also redesigned for more efficiency and less loss. The low pass filter and internal wattmeter have also been enhanced to be more efficient and to draw less current and therefore less heat, which makes them last longer.

Modularity and Field Replaceable Units

Fundamental to the success of the Nucleus product line is its building block design. Each function of the transmitter is located in a distinct, easily removable module. By isolating the functions of the transmitter, several of the modules are common to different frequency bands and power levels. This modular approach offers several advantages:

- Reduces spare parts requirements for operators using different models in their network
- Allows easy upgrading as you grow your network
- Facilitates easy installation and service because technicians only need to learn one paging station design
- Allows next-generation diagnostics and maintenance features

The station alarms inform the technician of a problem in easy to understand terms such as “Power Supply Failed”. Each module is an independent Field Replaceable Unit and is clearly labeled by function. With the exception of the power amplifier, all modules attach to the backplane by means of gold-plated connectors that can be quickly disengaged. (The power amplifier is connected by a cable, which is also easily disengaged.) In the event of a failure, the technician can go to the site with the proper replacement module in hand, quickly replace the failed module, and immediately verify that the failure has been corrected by checking the LEDs on the module’s front panel.

Compact Size

The compact size of the Nucleus transmitters provides easy installation and reduces facility costs. The high-power models are 14 inches tall and weigh 105 lbs. in a rack-mount configuration. Standard-power models are 8.75 inches tall and weigh 60 lbs.

Power Control Software and Auto Power Calibration

In the Nucleus II, the transmitter is self-calibrating, using power control software to maximize the power output setting. This power control software helps protect the power amplifier by making sure that the station is always transmitting at or below the maximum power output level. There is a wattmeter at the output of the power amplifier that constantly monitors and sends the performance information back to the power control software, which prevents an overdrive condition. To make installation easier, the maximum power settings for the station are set at the factory. This eliminates the guesswork and possible errors that may occur with setting the power manually.

Another feature of electronically controlled power output is the ability to offer a battery revert option. When battery revert is selected, the control section of the transmitter, including the SCM, the NIU and the exciter, is backed up with battery power. This will allow the Nucleus II to maintain NIU synchronization and alarm reporting capabilities in the event of a power failure.

Multiple Power Configurations and Channel Mapped Power

If a service provider has two frequencies (i.e., nationwide and regional licenses), he can set the power output for each channel individually. The system will switch channels and change power levels between the channels seamlessly. This is advantageous if the required effective radiated power differs between the two channels.

Alarm Reporting

All Nucleus models support a wide variety of alarms for quick and easy trouble-shooting (see Table 4).

Table 4: Nucleus Alarms

Alarm Name	Interpretation	Programmable	Condition that Clears the Alarm
Low Forward Power	Forward power is below a threshold	Yes	Station keys at correct power (above threshold)
High Reflected Power	Reflected power is above a threshold	Yes	Station keys at correct power (below threshold)
External Low Forward Power	Forward power is below a threshold measured at the external wattmeter (requires external wattmeter)	Yes	Station keys at correct power (above threshold)
External High Reflected Power	Reflected power is above a threshold measured at the external wattmeter (requires external wattmeter)	Yes	Station keys at correct power (below threshold)
PA Fan	Power amplifier fan has failed	No	Fan is operational
Synthesizer Out of Lock	Synthesizer is not locked with the programmed frequency	No	Synthesizer locks on the programmed frequency
Battery Revert	System has reverted to battery power	No	Station switches to AC power
System Timer Expired	System timer has expired	No	System keys, or reset from the ALRM menu
PA Fail	System has determined that the power amplifier has failed	No	Power amplifier is functional

Table 4: Nucleus Alarms

Alarm Name	Interpretation	Programmable	Condition that Clears the Alarm
Station Reset	System has performed a reset	No	Cleared from ALRM menu
High Stability Reference Failure	High stability reference oscillator or the ultra high stability reference oscillator has failed	No	High stability reference oscillator or the ultra high stability reference oscillator is functional
Alignment ID Mismatched	Station control module and exciter are not aligned	No	Cleared from ALRM menu
High Forward Power	Power output poorly aligned; forward power 5% more than the rated amplifier power	No	Power is calibrated
PA Not Aligned	Power amplifier is not aligned with station control module	No	Start-up occurs with matched pair
Exciter Setup Failure	Problem occurred during exciter module setup or problem with receiver module	No	Exciter starts without problem

Components

All Nucleus models are installed in a standard 19-inch EIA electronics cabinet and contain (with the exception of the NAC model) the modules listed below.

- Station control module (SCM)—The SCM consists of a front panel module and a circuit board. The front panel module contains displays and a keyboard that are used by the operator to input configuration and alarm settings. The circuit board, which is called the station control board, supports operator input functions as well as processing incoming paging signals from the controller. (On models with the NAC option installed, this component is called the NAC module. See the description under Options.)
- Exciter—The exciter converts the digital information into a modulated RF signal with carrier frequency for the transmitter.
- Power supply—The power supply provides +5Vdc, +14Vdc, and +28Vdc power. High-power units have two power supplies.
- Power amplifier (PA)—The power amplifier enhances the RF signal to high-power output and sends it to the antenna.
- Reference module—The reference module provides a known reference signal to stabilize transmitter output.
- Transmitter controller—The transmitter controller provides an interface to the network control device. (This module is not applicable to units withthe NAC option installed. Transmitter controller functions for NAC models are included on the NAC board.) The transmitter controller is one of the following:
  - RF-Baton!™ (RF-B!) transmitter controller (requires WIB board)
  - Internal Network Interface Unit (NIU)
  - External NIU (requires WIB board)

In addition, the optional receiver module, which can function either as a link receiver or as a receiver monitor, may be included as part of the transmitter package. (See description of receiver module under Options.)

The arrangement of components for a standard-power unit is shown in Figure 1-2, and the arrangement for a high-power unit is shown in Figure 1-3.

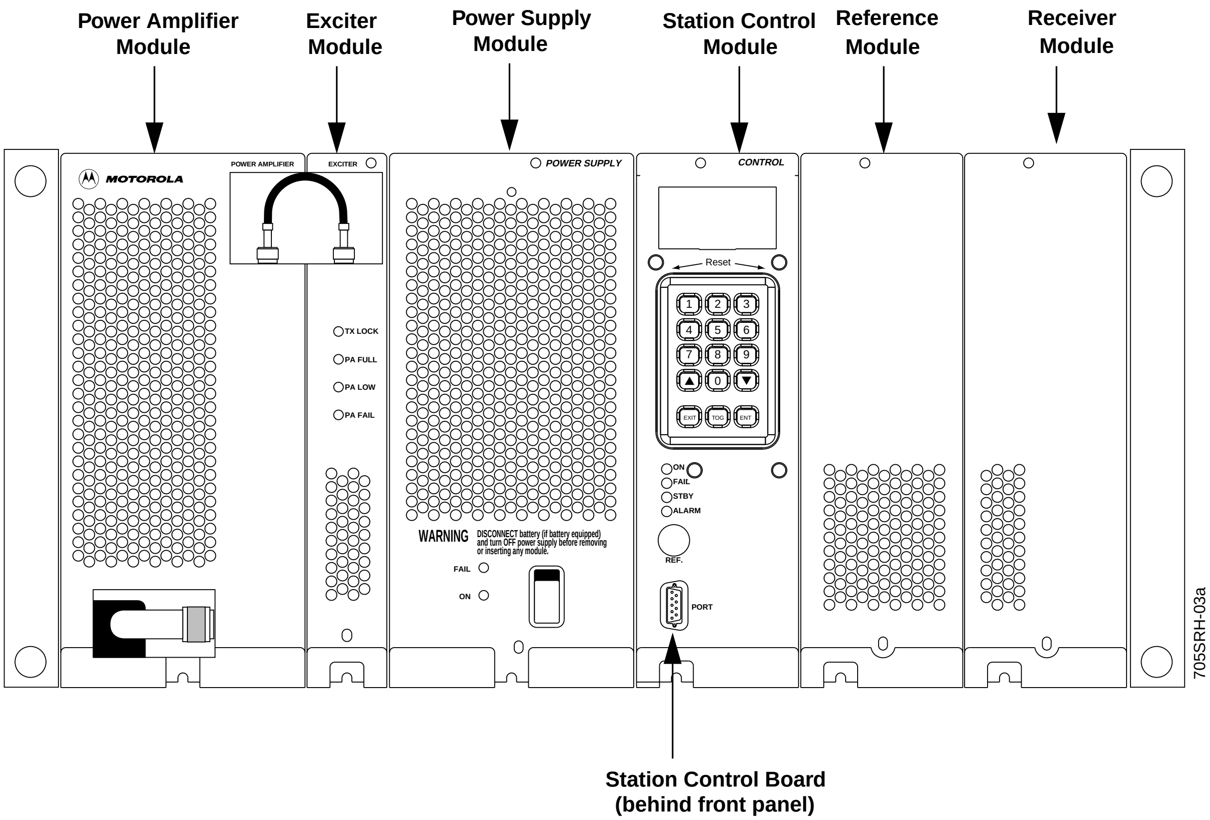

Figure 1-5: Standard-Power Nucleus Hardware Configuration

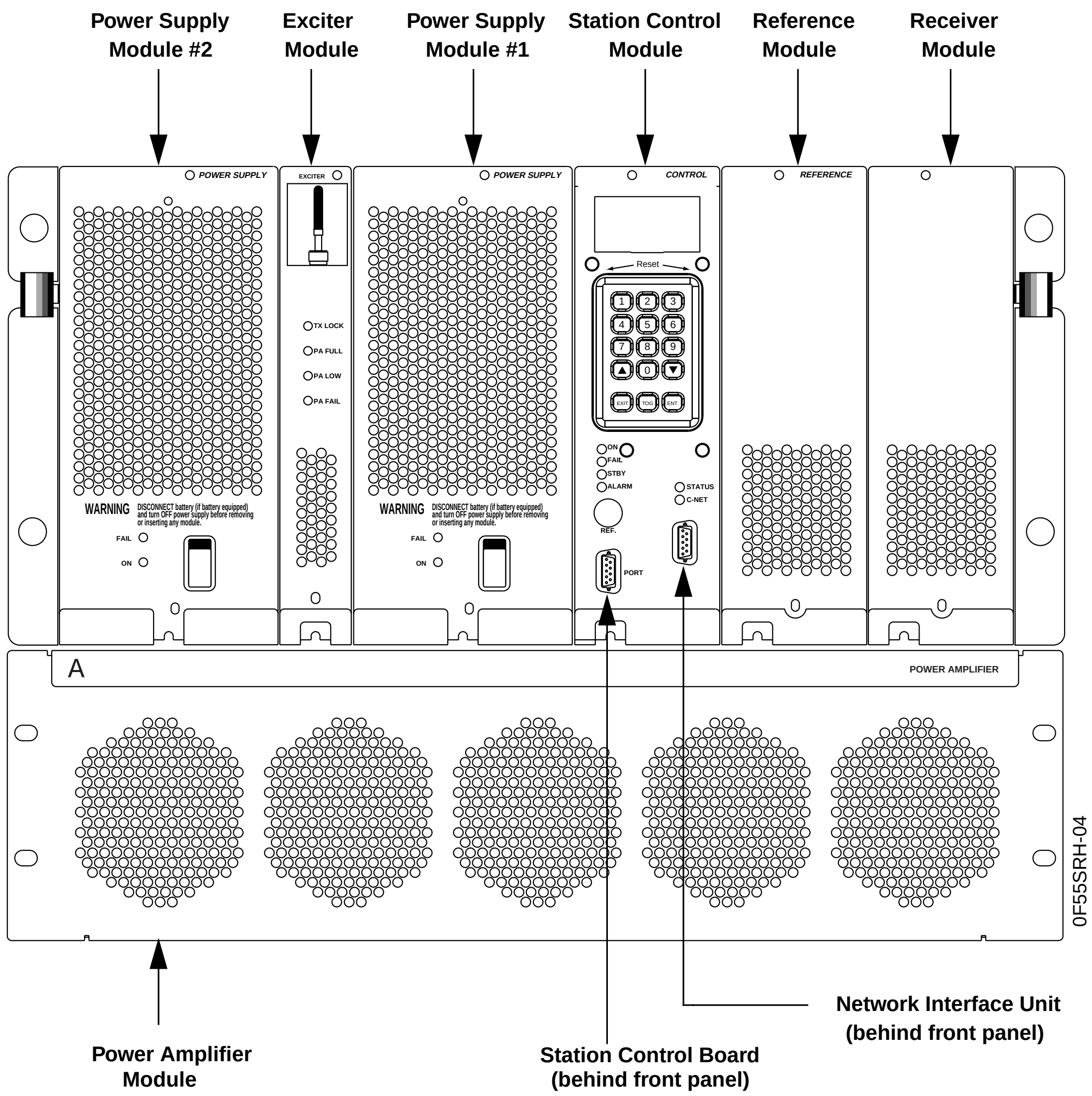

Figure 1-6: High-Power Nucleus Hardware Configuration

Station Control Module

The SCM has several functions:

- Controls the transmitter including setting all operating parameters
- Provides the mode, clock, and data to the exciter
- Polls all internal modules to determine their status and reports alarm information to the network controller

- Maintains communication with the receiver

The SCM consists of an SCM front panel and a station control board. Each front panel includes a 15-pushbutton keypad and an LED display (See Figure 1-7). An operator can enter commands and configuration data for the transmitter through the keypad and can confirm data on the display.

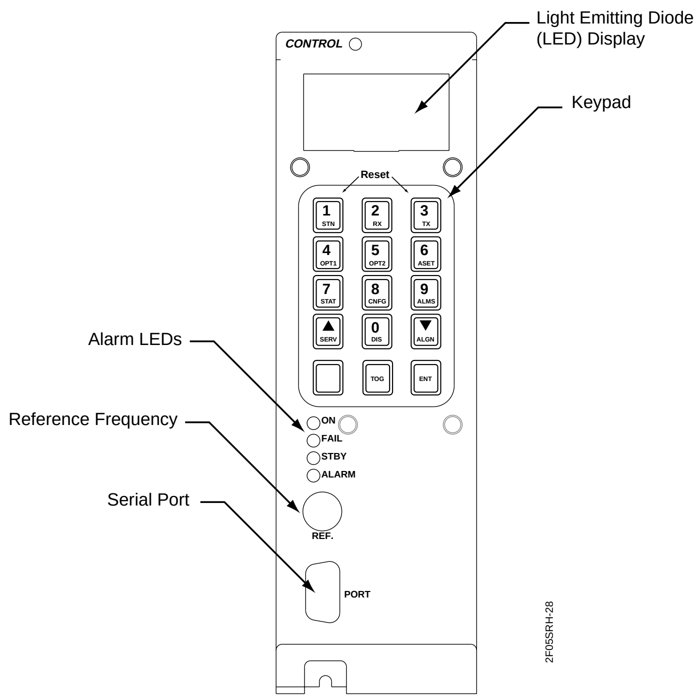

Figure 1-7: Station Control Module

The station control board includes a digital signal processor (DSP), a DSP application-specific integrated circuit (DSP ASIC), and an ASIC interface (See Figure 1-8). The output of the station control board consists of three signals:

- VCO MOD, which controls the impulse response of the exciter
- REF MOD, which modulates the reference frequency for long-term deviation accuracy
- 16.8 MHz REF, which provides a 16.8-MHz reference signal to the exciter

The DSP also contains a splatter filter to prevent the transmit signal from interfering with adjacent transmit channels. This feature gives the Nucleus paging station optimal simulcast performance. A variety of splatter filter designs can be configured by the operator through the keypad on the SCM front panel.

The host microprocessor controls the transmission of pages. The host microprocessor reads Nucleus paging station software and configuration data from memory. For example, the power level that is to be applied to the channel is controlled by software settings provided through the keypad on the SCM front panel. The microprocessor exchanges addresses and data with the host ASIC. The host ASIC communicates with memory and the SCM front panel through a serial peripheral interface (SPI) bus. For module status and alarm reporting, the SPI bus communicates with the other modules on the backplane

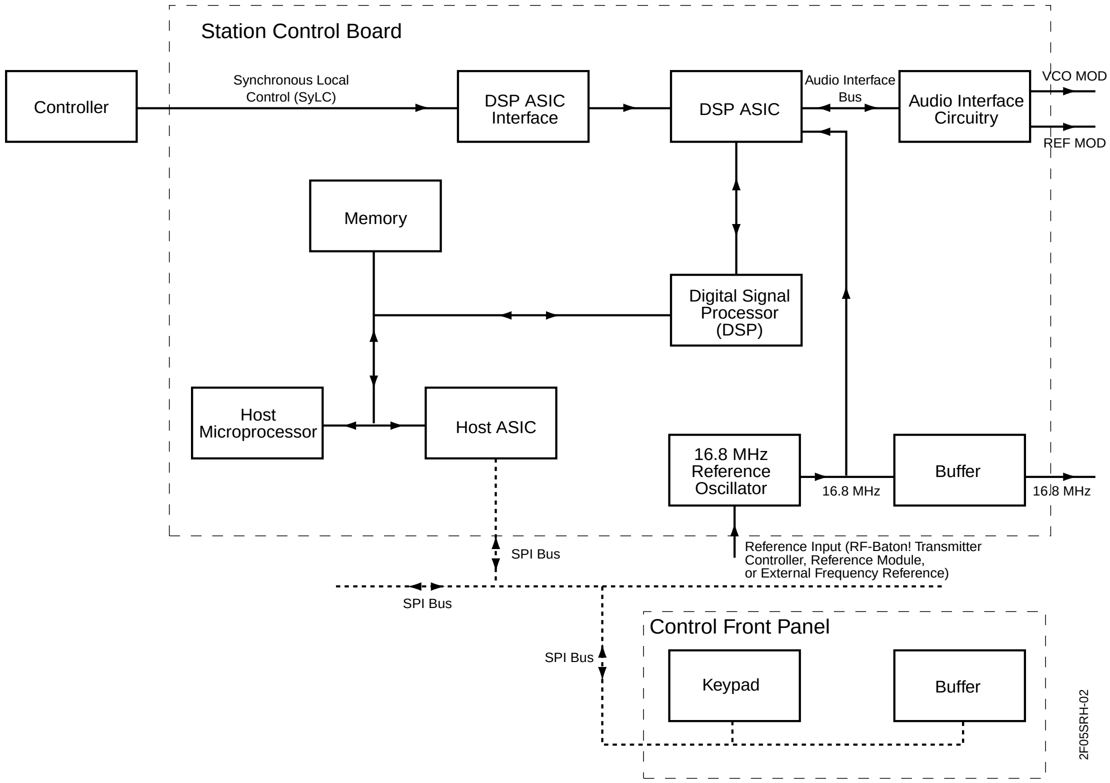

Figure 1-8: Station Control Board Block Diagram

SCM Front Panel Keypad and LED Display

The SCM front panel contains an LED display and keypad that provide a convenient means of viewing and entering configuration data and alarm settings.

Keypad Functions

The keypad has 15 keys (see Table 9). The top 12 keys serve two functions:

- Menu functions (in the menu select mode)
- Date entry functions (in the edit mode)

Three keys at the bottom allow the operator to change between modes, change menus, or to enter keyed in values.

Table 9: SCM Control Panel Keypad Functions

Key Label	Edit Mode Function	Select Mode Function
1 STN	Type the value 1	View or configure station parameters
2 RX	Type the value 2	View or configure receiver parameters
3 Tx	Type the value 3	View or configure transmitter parameters
4 OPT1	Type the value 4	View or configure station options
5 OPT2	Type the value 5 (NAC only)	View or configure communication options
6 ASET	Type the value 6	Configure alarms
7 STAT	Type the value 7	View station status
8 CNFG	Type the value 8	View and configure other parameters
9 ALMS	Type the value 9	View or clear alarms
SERV	Move up one menu selection	Enter the service mode
0 Dis	Type the value 0	Disable remote keying during local control; view disable status
ALGN	Move down one menu selection	Perform station alignment from the keypad and read power output

Table 9: SCM Control Panel Keypad Functions

Key Label	Edit Mode Function	Select Mode Function
EXIT	Return to the menu select mode	Move one menu level
TOG	Toggle between the edit mode and the menu select mode	
ENT	Store keyed-in values	Move in one menu level or begin an edit session

SCM Front Panel LEDs

The SCM front panel has four LEDs for the SCM (see Table 10). All LEDs momentarily light during power-up or reset

Table 10: SCM Control Panel LED Functions and Definitions

LED Name	Color	On	Flashing	Off
On	Green	SCM fully functional	Not used	SCM failure
Fail	Red	SCM failure	Software checksum failure	Fully functional SCM
Disable	Red	Disabled by remote keying (maintenance access or paging access disabled)	Shorted DRAM address lines are open	Enabled and fully functional SCM
Alarm	Red	Active station alarm (see Alarms menu)	Shorted DRAM address lines	Fully functional SCM

Exciter

The exciter generates modulated RF paging signals at the appropriate messaging frequency and sends the messaging signals to the PA. To do this, the exciter mixes the messaging data with the carrier frequency. The exciter is frequency-specific for the transmitter. The exciter consists of a reference modulator, a synthesizer, a voltage-controlled oscillator (VCO), an RF switch circuit, and a transmitter power circuit (see Figure 1-11). The exciter runs is controlled by its own microprocessor. The exciter synthesizer and microprocessor communicate with the host ASIC on the SCM through the SPI bus.

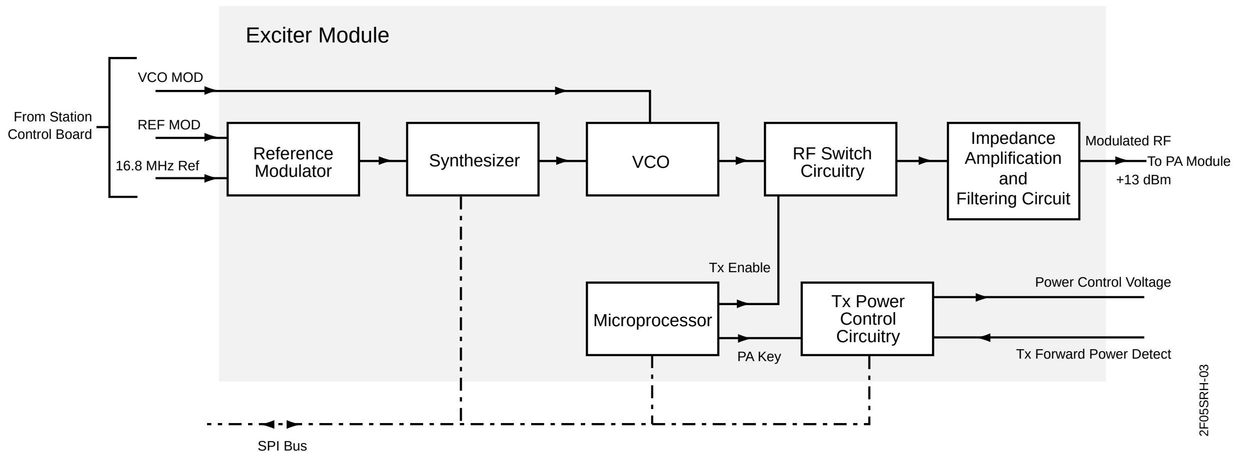

Figure 1-11: Exciter Block Diagram

The reference modulator receives the 16.8-MHz reference signal from the reference oscillator on the SCM. The reference modulator receives the reference modulation signal from the audio interface circuitry on the SCM. The reference modulator combines the two signals and sends the modulated reference signal to the synthesizer. The synthesizer compares the modulated reference signal with the feedback sample from the VCO. The synthesizer increases or decreases the frequency by generating correction pulses. The synthesizer feeds the correction pulses to an internal charge pump. The charge pump creates a DC correction voltage.

The synthesizer uses the correction voltage to correct the output to the RF switch circuit. The corrected frequency passes to the VCO. The VCO also receives audio and data modulation (VCO MOD) from the audio interface circuit on the station control board. The VCO uses this information to create a modulated low-power RF carrier signal. The modulated low-power RF carrier signal then passes through an impedance, amplification, and filtering circuit and then to the PA. The exciter microprocessor generates a Tx Enable signal and sends it to the RF switch circuit upon proper operation.

When it receives a key command, the microprocessor also generates a PA Key signal and a modulated signal. It transmits these to the transmitter power control circuitry in case there is any need to provide a power cutback, for example, if there exists a cutback condition in the station (such as a high temperature condition).

The transmitter power control circuitry generates the power control voltage. The transmitter power control circuitry reads the Tx Forward Power Detect signal and uses it to modify the power control voltage.

Exciter LEDs

The LEDs on the exciter front panel are described below (See Table 12).

Table 12: Exciter LED Functions and Definitions

LED Name	Color	Lighted	Off
TX Lock	Green	Exciter synthesizer is locked; exciter is fully functional.	Synthesizer is out of lock or +5V or +14.2V or both are absent
PA Full	Green	Transmitter is keyed and PA output power is at expected power level	PA not keyed or PA keyed but PA output power is more than 95% of expected power
PA Low	Yellow	Transmitter is keyed and PA output power is less than expected power level but not shut down	PA not keyed or PA keyed and PA output power is less than 95% of expected power
PA Fail (On)	Red	No PA output power (example: PA shutdown mode), LED status is latched (status during current key or for previous key), fault in one or more of the PA fans, or final PA VSWR Alarm is activated	PA output power is at expected level or at specific cutback levels (any level other than shutdown), LED status is latched (status during current key or for previous key)
PA Fail (Flashing)	Red	PA test mode is active	PA is functioning normally

Power Amplifier

The power amplifier (PA) takes the modulated RF messaging signal and amplifies it in preparation for transmission. The structure of the PA depends on the station power level: standard-power Nucleus paging station (100 to 125 W) or high-power Nucleus paging station (250 to 350 W).

The output power level for the PA (at full power) varies with the frequency ranges for the PA, the exciter, and the transmitter (see Tables 1-1 and 1-2).

Power Amplifier for a Standard Power-Nucleus Paging Station

The standard-power PA consists of the following elements (see Figure 1-13).

- Intermediate power amplifier
- Driver power amplifier
- Final power amplifier number 1
- Circulator
- Harmonic filter/coupler

- Impedance amplification and filtering circuit

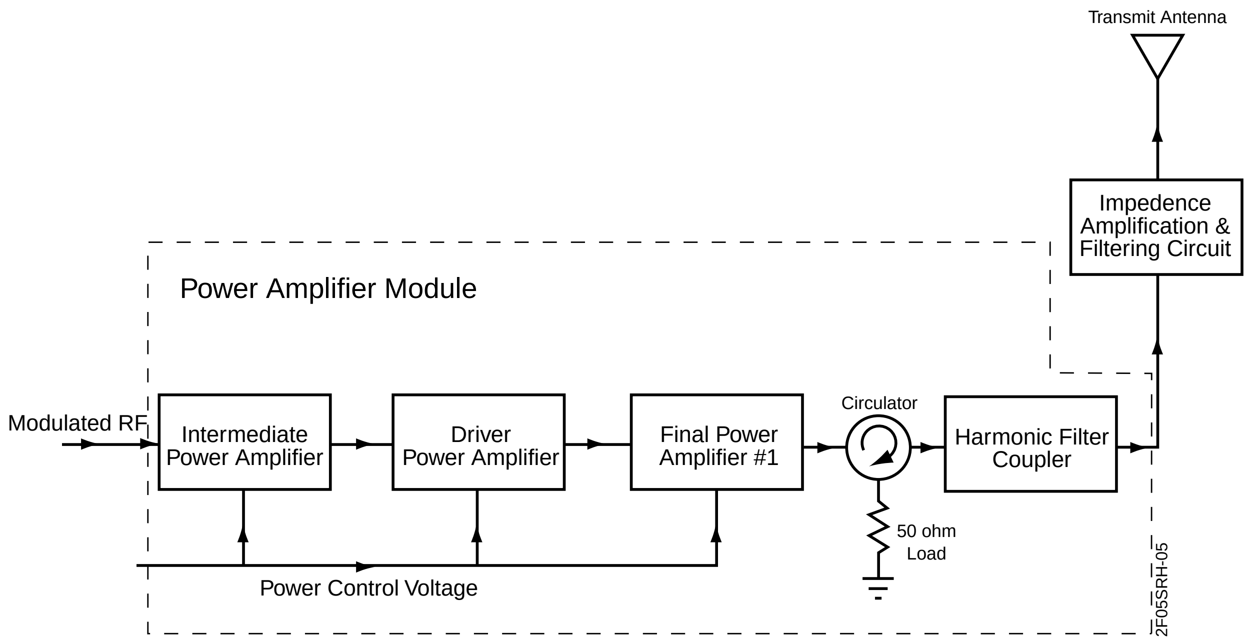

Figure 1-13: PA Block Diagram for a Standard Power Nucleus Station

In the standard-power system, the modulated RF passes through the intermediate power amplifier, the driver power amplifier, and the final amplifier number 1. A power control voltage signal modifies the performance of each chip to ensure the proper signal processing. The circulator provides 20 dB isolation between the power amplifier circuitry and the transmit antenna system. The circulator junction allows forward RF energy to pass through to the output and routes reflected RF energy to the 50-Ohm load.

If the heat sink temperature exceeds a preset threshold (set at approximately 45° C), the PA reduces output. If overheating persists until it reaches 60° C, the PA shuts down completely.

An internal wattmeter sends RF power and voltage standing-wave ratio (VSWR) information to the front panel. The SPI bus transmits this wattmeter reading to the SCM.

An option for the standard-power system is a double circulator that provides a low-loss path for RF signals from the combined output to the low-pass harmonics filter and wattmeter, resulting in an additional 20dB of isolation. The double circulator absorbs high reflected RF signals from the antenna port, thus preventing the power amplifier from being damaged. The harmonic filter reduces circulator harmonics. The signal passes through an impedance amplification and filtering circuit on its way to the transmit antenna.

Power Amplifier for a High Power Nucleus Paging Station

The high power supply consists of the following elements (see Figure 2-2):

- Intermediate power amplifier

- Driver power amplifier
- Power splitter
- Three final power amplifiers
- Power combiner
- Circulator
- Harmonic filter / coupler
- Impedance amplification and filtering circuit

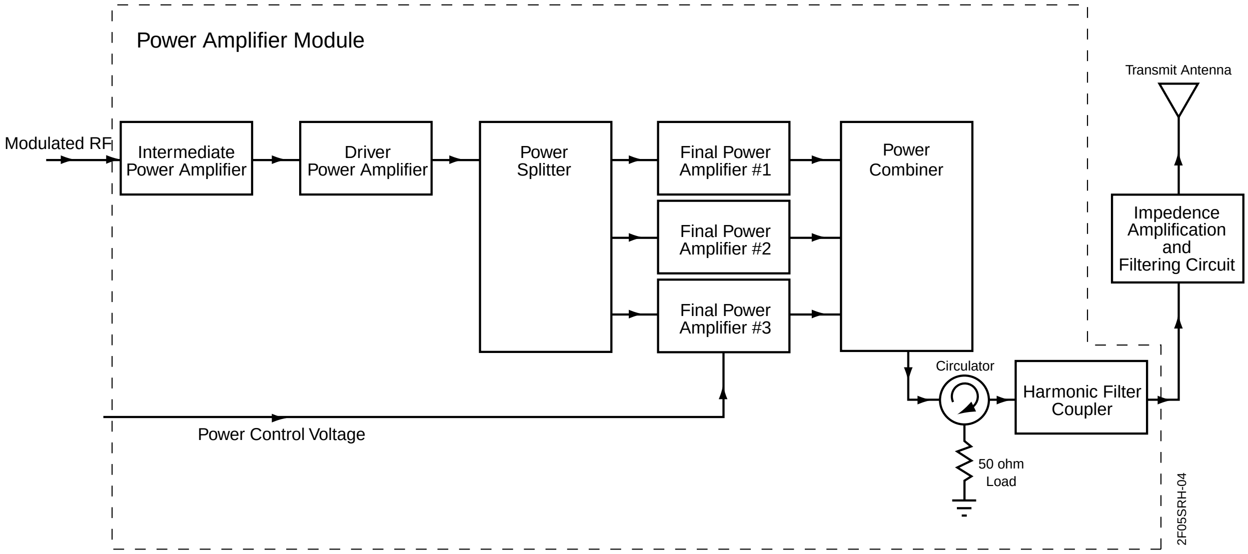

Figure 1-14: PA Block Diagram for a High Power Nucleus Station

The modulated RF passes through the intermediate power amplifier and the driver power amplifier into the power splitter. The power splitter divides the power output into three and sends the three outputs to the final power amplifiers. Each power amplifier sends its output to a power combiner and then to a circulator. Depending on the model, the high power Nucleus paging station has a double or triple circulator option that provides a low-loss path for RF signals from the combined output to the low-pass harmonics filter and wattmeter. The double or triple circulator absorbs high reflected RF signals from the antenna port. This arrangement prevents the power amplifier from being damaged.

The circulator provides 20 dB of isolation between the power combiner circuitry and the transmit antenna system. The circulator junction allows forward RF energy to pass through to the output and routes reflected RF energy to the 50-Ohm load.

If the heat sink temperature exceeds a preset threshold, the PA reduces output. If overheating persists, the PA shuts down completely. The harmonic filter reduces circulator harmonics. An internal Wattmeter sends RF power VSWR information to the front panel. This Wattmeter reading is transmitted on the SPI bus to the SCM.

Power Supply

The power supplies provide DC voltages for the station modules. The high-power station has two power supply modules; the low-power station has one. Each power supply uses the voltage available at the customer site. This voltage enters through a switching circuit that adjusts to the source. The regulator circuits create three output voltages:

- +5 Vdc
- +14 Vdc
- +28 Vdc

Here, +5Vdc and +14 Vdc are used for all circuit board modules (exciter, SCM, NAC, reference module and receiver module), while +28 Vdc is used to drive the power amplifier.

Power Supply LEDs

Each power supply has two LEDs (see Table 15). The Module Fail LED on each power supply lights during start-up and then turns off. The high-power station has two power supplies. Each power supply has the LEDs described below.

Table 15: Power Supply LED Functions and Definitions (All Power Supplies)

LED name	Color	Lighted	Off
Module Fail	Red	Power supply malfunction such as shorted output, current limit exceeded, or loss of communication with backplane and other modules	Normal operation
Power On	Green	AC input power present and system turned on	AC power not present or system turned off

Reference Module

Nucleus paging stations use one of two reference modules: reference module with the GPS receiver (used only for stations with internal NIUs) or reference module with oscillator (used for stations without internal NIUs).

Systems that use GPS synchronization require reference modules with a GPS receiver. The GPS signal arrives on a GPS antenna. This is a 1.57542 GHz signal. The GPS receiver uses its location information and the timing signal from the satellites to precisely set the timing pulse output (1 pps to the SCM). This is used for store-and-forward paging launch times at the transmitter.

System that do not use GPS signals and do not use internal NIUs require one of two oscillator-driven reference modules:

- The reference module with a high speed oscillator (HSO) (5 ppb).

- The reference module with an ultra-high speed oscillator (UHSO) (30 ppb).

Each reference module contains a D / A converter, an A / D converter, and the oscillator itself. The converters communicate with the SPI bus. The 5-MHz frequency generated by the oscillator goes to the SCM to stabilize the 16.8-MHz reference oscillator signal that passes to the exciter. Typically, the HSO is used for VHF, 280-Mhz and UHF paging systems. The UHSO, with greater stability, is used for higher speed 900-Mhz paging system.

Transmitter Controllers

This section describes Nucleus paging stations' transmitter controllers. The available transmitter controllers and their interfaces include the following:

- The internal NIU, installed in the Nucleus paging station, uses a direct interconnect with the SCM.
- The external NIU connects to the SCM through the wildcard interface board.
- The RF-Baton! controller connects to the SCM through the wildcard interface board
- The wildcard interface board (WIB), installed in Nucleus paging stations, uses external RF-B! transmitter controllers or external NIUs.

Internal Network Interface Unit

The internal NIU occupies the slot next to the station control board (behind the front panel) and communicates through the backplane with the rest of the Nucleus paging station.

The internal NIU provides the decoding of the C-NET control stream and acts as the source of station software downloads. NIU signals to the Nucleus paging station consist of messaging data, stream data, and maintenance and configuration data. Nucleus paging station outputs to the NIU consist of alarms.

With dual-flash NIUs, the Nucleus station allows multiplexing up to 19.6 kbps on a satellite path as well as advanced alarm reporting capabilities to the C-NET Platinum Controller. Power, frequency, and parameter settings are microprocessor controlled with settings stored in non-volatile memory. The NIU is synchronous and does not utilize IP addresses. In cases where a an asynchronous or IP Band VSAT distribution is desired, the RF-Baton! would be required as the controller.

External Network Interface Unit

The external NIU is functionally similar to the internal NIU but is designed to so that it need not be physically located with the Nucleus transmitter. The external NIU interfaces with the Nucleus through the WIB board. Just as with the internal NIU, he external NIU can be configured with dual-flash memory.

RF-Baton!

The RF-Baton! offers high-speed processing capability (more than 3.5 times that of other station controller products), and thus provides Simple Network Management Protocol functionality. It offers the highest speed control path modem capabilities in the market today in a design that features IP network connectivity. The RF-Baton! also includes an Ultra High Stability Oscillator (UHSO) for long-term transmitter frequency stability, as well as the GPS receiver for accurate store-and-forward paging launch times. Because it is asynchronous and uses IP addresses, The RF-Baton! is ideal for use with advanced satellite systems, such as VSAT.

Nucleus paging stations that use the RF-Baton! require the Wildcard Interface Board. The WIB occupies the slot beside the station control board (behind the SCM control panel) and communicates through the backplane to the rest of the Nucleus paging station.

The RF-Baton! is a 19-inch wide, 3.5 inch high, rack mounted module and weighs about 30 lbs.

Wildcard Interface Board (WIB)

The WIB processes and routes wireline audio signals between the station and land-line equipment such as consoles and modems (See Figure 1-16.)

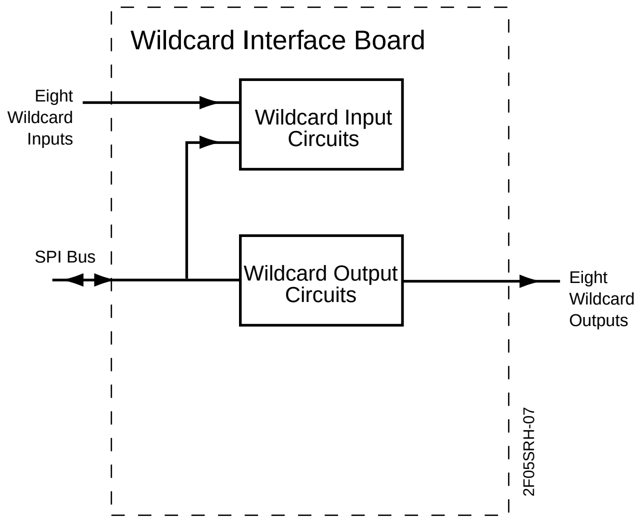

Figure 1-16: Wildcard Interface Board

The Wildcard Interface Board (WIB) for a NAC station is a slightly different design from the WIB used with the RF-Baton!. The NAC WIB interfaces customer telephone lines with the Nucleus paging station.

The WIB interface consists of the following elements:

- Eight inputs that the Nucleus paging station uses to monitor external site equipment
- Eight open-collector outputs which may be used to indicate alarms

The WIB output drives the following types of transistor-transistor (TTL) and complementary metal-oxide semiconductor (CMOS) logic:

- Low-power Schottkey (LS) TTL
- Advanced Low-power Schottkey (ALS) TTL
- Fast TTL
- CMOS logic

The WIB uses Synchronous Local Control (SyLC) protocol. The SyLC protocol is synchronous and uses three TTL-compatible lines:

- Tx Baud Clock-runs at the symbol rate and indicates the symbol boundaries.
- Tx Data Clock-runs at the bit rate and clocks Tx Data bits from the Tx Data Line.
- Tx Data-runs at the clocked rate from Tx Data Clock

The WIB provides eight software-controlled WIB inputs (active low). The WIB input interface effectively looks like a 28 k pullup resistor that can be pulled up to +5 V. WIB inputs are typically at 1.5 V in the idle state as a result of an internal resistor divider network. For the WIB to read an input successfully, the input must be stable for 40 ms.

Optional Features and Equipment

I-20 Interface

I-20 is a communications protocol that was developed by the European ERMES committee and was designed for limited remote control and status monitoring of a transmitter. The first I-20 protocol developed by this committee is defined as “Basic I-20”. Basic I-20 is very limited as to the control and status monitoring allowed. Basic I-20 allows the following:

- Adjustment and monitoring of forward power up to 250 watts
- Monitoring of reflected power
- Programming and monitoring of the transmitter frequency
- Programming and monitoring of the transmitter frequency offset
- Monitoring of six alarms, four of which can be set by the user
  - Maximum output power limit (set by user; maximum setting +255 watts)
  - Minimum output power limit (set by the user)
  - Reflected maximum power limit (set by the user)
  - Reflected minimum power limit (set by the user)
  - Exciter temperature
  - I-20 status

Motorola has gone a step further with the I-20 communications protocol in order to provide additional flexibility for our customers. We have developed an extended I-20 that includes the following additional control and monitoring commands:

- Adjustment and monitoring of forward power up to 300 watts
- Programming and monitoring of 20 individual channels
- Programming and monitoring of deviation and deviation offset
- Additional monitoring of critical transmitter parameters
- Ability to download exciter software using the Network Manager

The I-20 Interface is an available option for both the Nucleus and Nucleus II. This is a hardware and software enhancement to the SCM that adds a db15 connector at the backplane of the Nucleus for communication to the I-20 capable base station controller (BSC).

Internal Triple Circulator

The Nucleus II is available with an internal triple circulator integrated into the power amplifier. With this option there is more efficiency and higher power output with less insertion loss. Since the triple circulators are inside the PA, the wattmeter readings at the output of the PA more closely match the readings shown on the front panel LCD. With improved design, the internal triple circulator provides better performance over the specified temperature range. Also, because the triple circulator is internal, there won't be any extra connections and hardware in the rear of the station, making the unit easier to install and repair.

DC Models

All the improvements and enhancements that are currently available on the 300-Watt, 900-MHz Nucleus II are also available in DC power capability for those countries with DC power needs. The stations are now available with a -48-Vdc or -24-Vdc power supply.

Nucleus Advanced Control

The Nucleus Advanced Control (NAC) option provides a low-speed, low-cost transmitter configuration suitable for small simulcast paging systems. With this option the station control board is replaced by the NAC board. A transmitter controller such as an NIU or RF-Baton! is not required because the NAC board accepts inputs directly from the network controller, which in this type of system is an Advance Simulcast Controller (ASC).

NAC Module

With NAC, the NAC module replaces the station control module.The the NAC module consists of an NAC board and NAC front panel. The NAC board has the same basic design as the SCM with some additional circuits:

- An input gain set controls the gain from the interface to the DSP.
- An MDC encoder controls a line 2 audio input to the interface.
- A data latch in the data line controls buffers input from the keypad and the data line to the display.
- A user audio circuit reads and controls audio inputs from the front panel.

The NAC board accepts input from the ASC and provides transmitter control. Control input from the ASC comes through either an audio wireline, an optional RF link receiver, or digital data via satellite.

System parameters or functions can be entered or verified using the NAC front panel, which includes a 15-pushbutton keypad and LED display.

To prevent the transmit signal from “splattering” into adjacent transmit channels, a splatter filter in the NAC’s DSP eliminates higher frequency modulation. The particular splatter filter (140 or 250 s) can be chosen by using the NAC front panel to match other paging stations being simulcast with the that particular station.

The reference modulation signal, which is used to modulate the exciter reference frequency, is also sent from the NAC’s DSP circuitry to the audio interface circuitry, and then output to the exciter module as the REF MOD signal.

The Host Microprocessor controls the operation of the station as determined by the station software and parameter.

The Serial Peripheral Interface (SPI) bus is used as a general-purpose communications bus to allow the Host Microprocessor to communicate with other modules in the station, via the Host ASIC. This allows alarm information to be displayed on the control front panel.

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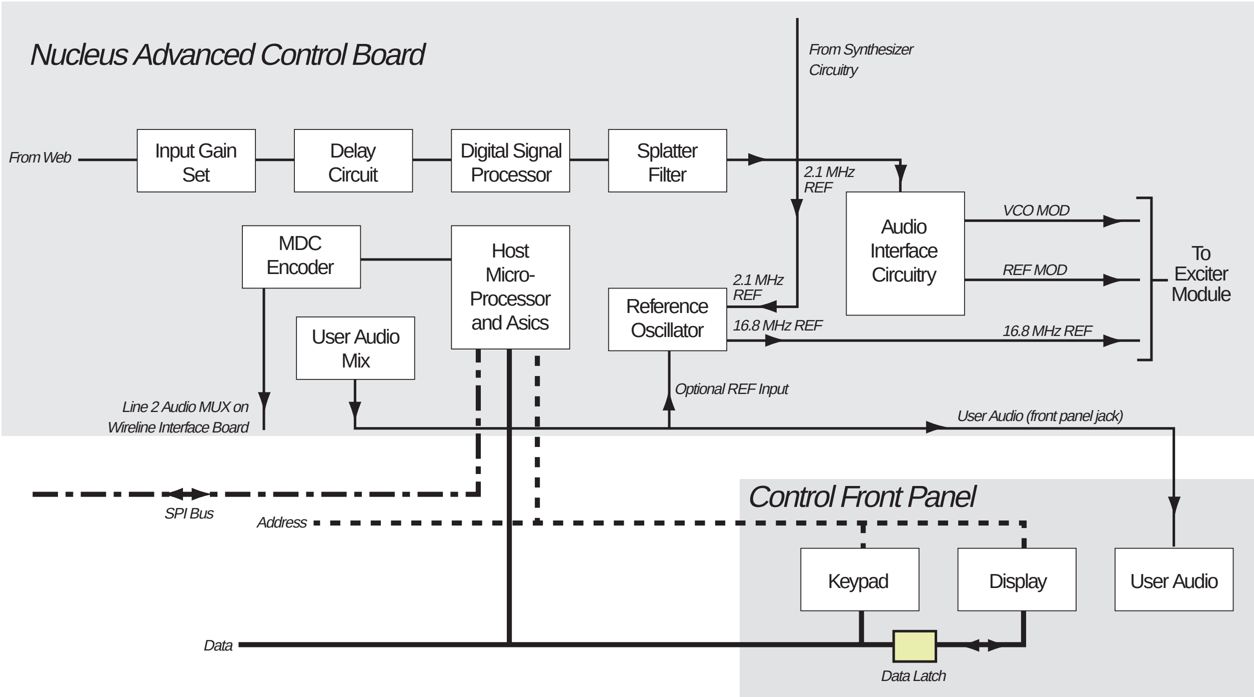

Figure 1-17: NAC Board and NAC Front Panel Block Diagram

NAC Front Panel LEDs

The NAC font panel has eight LEDs (see Table 18). All LEDs momentarily light during power-up or reset.

Table 18: NAC Front Panel LED Functions and Definitions

LED Name	Color	On	Flashing	Off
Fail	Red	NAC failure	Software checksum failure	NAC fully functional
On	Green	NAC fully functional	Not used	NAC failure
Disable	Red	Disabled by remote keying (maintenance access or messaging access disabled)	Shorted DRAM address lines are open	Enabled and fully functional NAC module
Alarm	Red	Active station alarm	Shorted DRAM address lines	Fully functional NAC module no alarms
Mdc1Rx Ft. Dec	Yellow	Receiving an MDC message or decoding function tones	Not used	Not used
MDT Rx	Yellow	Transmitting MDC	Not used	Not used
Bin	Yellow	Station keyed in binary mode	Not used	Not used
Key	Yellow	Station has a key request	Not used	Not used

RF Receiver

RF receivers are available for use with the Nucleus and Nucleus II. An RF receiver may be configured either as a link receiver or as a monitor receiver.

Link Receiver

Networks that use link transmitters to cover large distances use link receivers at the Nucleus paging station site. The controller sends the paging data stream to the link paging station. The transmission may be via land line or satellite. The link transmitter sends the messaging data stream to the other transmitters in the network. A link receiver at each destination transmitter receives an RF messaging signal from a link transmitter and converts it to messaging data for the destination.

Monitor Receiver

Networks that use maintenance signals to synchronize transmitters also use monitor receivers.

The controller sends a paging data stream to a transmitter. At various times during the day, the controller also sends a maintenance signal to the transmitter. The transmitter responds to the maintenance signal by transmitting the maintenance signal. The monitor receiver receives the response and logs the time when the response is received. The monitor receiver sends the responses of all the transmitters back to the network controller for analysis to determine whether each transmitter is responding and whether the paging station is synchronized with the other transmitters.

Receiver Frequencies

The following receivers are available:

- Midpoint (72-76 MHz) link receiver only
- VHF (132-154 MHz and 150-174 MHz) link receivers and monitor receivers
- 280 MHz (276-286 MHz) monitor receiver only
- UHF (403-433 MHz, 438-470 MHz, 470-494 MHz, and 494-520 MHz) link receivers and monitor receivers
- 900 MHz (922-941 MHz and 941-960 MHz) link receivers and monitor receivers

Receiver Operation

The installer configures the receiver module as a link receiver or a monitor receiver from the SCM (or NAC) front panel. The receiver module is located in the paging station cage. It consists of the following items:

- Receiver board
- Preselector
- Receiver front panel
- Control/receiver interface board (CRIB) mounted on the station control board

The receiver board consists of a preselector filter, a mixer, a bandpass filter, a custom receiver integrated circuit, and a differential driver. These circuits take the RF signal, process it, and send it to the IC interface on the CRIB. The CRIB processes the differential signal to the appropriate output to be read at the SCM (see Figure 1-19).

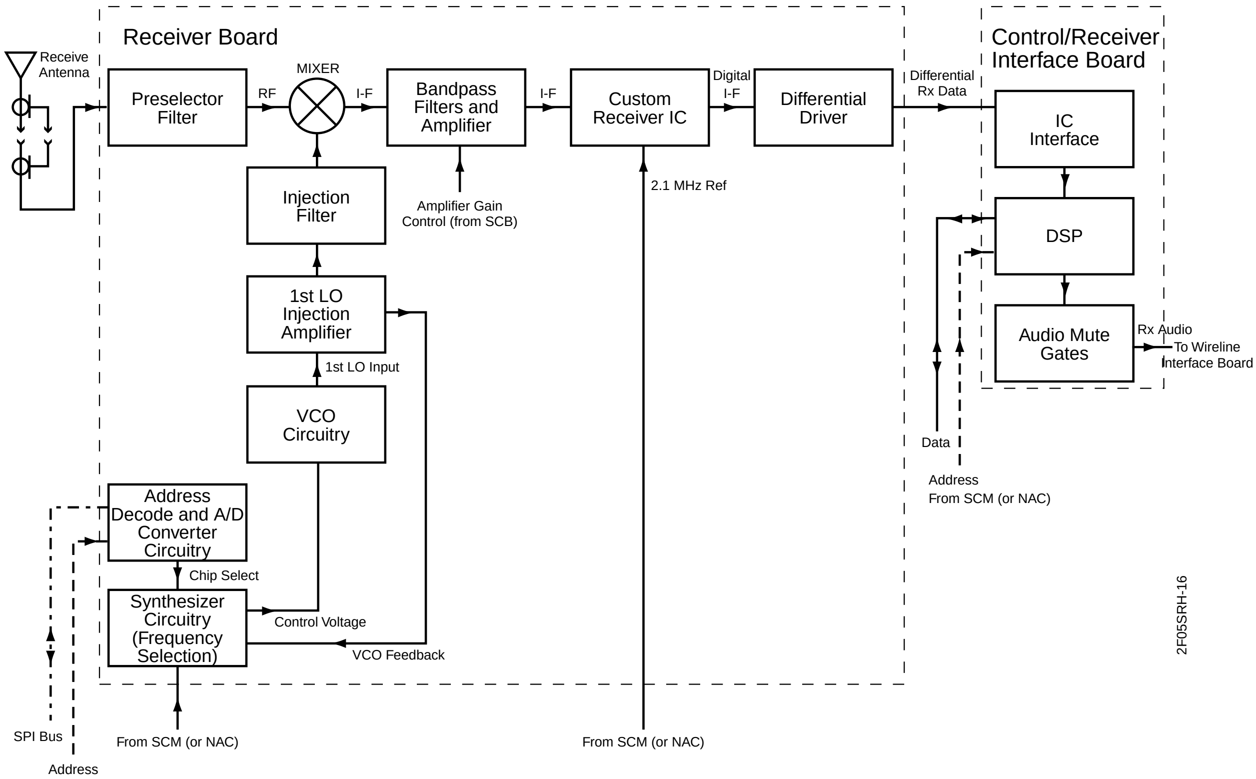

Figure 1-19: Receiver Module and CRIB Block Diagram

The SCM or NAC module controls processing of the receiver board at the mixer through the SPI bus and an address decoder and A/D converter circuit. The address decode and A/D converter control a synthesizer to create a control voltage to the mixer. A VCO circuit, first low-injection amplifier, and injection filter control the mixer. The first low-injection amplifier provides feedback to the VCO. The CRIB receives the differential Rx data at an IC interface and passes the signal to a DSP. The DSP receives address and data from the transmitter controller. When the SCM requests the data, the DSP sends the Rx audio to the SCM.

Circuitry

A receiver consists of a preselector and a receiver. In addition, a CRIB resides on the SCM. The preselector assembly provides a bandpass filter for the receive RF input signal. The filter assembly is mounted on the front of the receiver housing and provides mini-UHF connectors for input from the receive antenna and output to the receiver. The filter assembly has tuning screws for filter tuning.

The receiver contains the following circuitry:

- The receiver front end filters and amplifies the receiver RF signal and performs the first down conversion for the received RF signal.
- The receiver's integrated circuit (IC) is a custom IC. It performs the second down conversion. It also filters and amplifies the received signal and performs A/D conversion on the signal.
- The synthesizer contains a phase-locked loop (PLL).

- The voltage controlled oscillator (VCO) circuit contains two VCOs and a band-shift switch. The VCO circuit generates a signal that passes to the first low-injection amplifier in the receiver's front end.
- The address decoder and A/D converter decodes addresses and provides memory board and chip select signals. This circuitry also converts analog status signals to digital format for transfer to the SCM.
- The local power supply regulation circuit accepts +14.2 Vdc input and creates +10-Vdc and +5-Vdc operating voltages.

CRIB Circuitry

The CRIB contains the following circuitry:

- The DSP converts the digital signal from the receiver to the desired audio output.
- The interface controls the audio path of the desired audio signal.

The CRIB processes the digitized receive signal into an analog audio output. For a link receiver, the CRIB gates the audio to LINK_RX_AUDIO. For a monitor receiver, the CRIB gates the audio to MONITOR_RX_AUDIO.

Physical Packaging and Environmental Specifications

Cabinet Configurations

Nucleus and Nucleus II transmitters are packaged in modules that mount in 19 inch, EIA standard cabinets. Possible cabinet configurations are shown in Table 20.

Table 20: Cabinet Capacity

Cabinet Options	Cabinet Dimensions (H x W x D)	Maximum Number of Stations	Cabinet Weight
X92	25 x 22 x 21.25 in. (64 x 56 x 54 cm)	Two 8.75 in. standard-power models One 14 in. high-power model	59 lb. 27 kg
X308	46 x 22 x 21.25 in. (117 x 56 x 54 cm)	Four 8.75 in. standard-power models Two 14 in. high-power models	125 lb. 57 kg
C307 (indoor)	70 x 23.8 x 21.5 in. (178 x 60 x 55 cm)	Five 8.75 in. standard-power models Three 14 in. high-power models	200 lb. 91 kg

Environmental Requirements

The environmental conditions required for the equipment are shown inTable 21.

Table 21: Required Environmental Conditions at the Site

Environmental Condition	Requirement
Operating temperature	-30˚C to +60˚C (-22˚F to +140˚F)
Humidity	Not to exceed 95% relative humidity at 50˚C
Air quality	If the area is environmentally controlled: Airborne particulates level must not exceed 25 $\mu g/m^3$. If the area is not environmentally controlled: Airborne particulates level must not exceed 90 $\mu g/m^3$.

The PA module and power supply module have cooling fans to provide forced convection cooling. The air flow is front to back, allowing several cages to be stacked within a rack or cabinet. When planning the installation, observe the following ventilation guidelines:

- The operating range of the equipment is -30˚ C to +60˚ C (-22˚ F to +140˚ F).
- Customer-supplied cabinets must have adequate ventilation slots or openings in the front (for air entry) and back (for air to exit).
- All cabinets must have at least six inches of open space between the air vents and walls or other cabinets.
- Cabinets must be separated to ensure that the air intake of one cabinet does not take in exhaust from an adjacent cabinet.

- Motorola recommends an air conditioning system in locations where the climate or the proximity of other equipment threatens the temperature maximum.

Input Power Requirements

Nucleus paging stations have one or two AC power supplies (90 to 280 V rms, 50 Hz or 60 Hz) or a DC-to-DC power supply (21 to 34.5 Vdc or 41 to 72 Vdc). All AC power supplies have automatic range and line frequency selection. Motorola recommends a standard 3-wire grounded electrical outlet as the AC source.

For a 125-W station and a nominal 110-Vac input, the AC source must supply five amps. The AC source should be protected by a circuit breaker rated at 15 amps. For a nominal 220-Vac input, the AC source must supply approximately 2.5 amps. The high-power (250 to 350 watts) stations use two power supplies. These power supplies draw a total of 13 amps at 110 Vac, 60 Hz. They require a circuit breaker rated at 20 amps. For a 24 Vdc or 48 / 60 Vdc source, Motorola provides appropriate cabling from the DC power source to the backplane (located at rear of the station).

The power requirements of the different Nucleus and Nucleus II models are shown below (See Table 22).

Table 22: Power Requirements for the Nucleus and Nucleus II Paging Transmitters

Frequency (MHz)	Standard or High Power	Operating State	AC Power (120 V, 60 Hz)	AC with Battery Revert (24 Vdc)	DC Power (48/60 Vdc)
132-154	Standard	Transmit Standby	472 W 66 W	422 W 66 W	525 W 77 W
150-174	Standard	Transmit Standby	472 W 66 W	422 W 66 W	525 W 77 W
144-160	High	Transmit Standby	1180 W 133 W	NA	1270 W 85 W
158-174	High	Transmit Standby	1180 W 133 W	NA	1270 W 85 W
276-286	Standard	Transmit Standby	540 W 66 W	500 W 66 W	515 W 77 W
276-286	High	Transmit Standby	1245 W 133 W	NA	1200 W 89 W
438-470	Standard	Transmit Standby	593 W 66 W	550 W 66 W	605 W 77 W
927-941	Standard	Transmit Standby	593 W 66 W	550 W 66 W	605 W 77 W
927-941	High	Transmit Standby	1546 W 133 W	NA	1422 W 89 W