4 Indicators and Controls

4.1 Indicators

NOTE: Labeled photo or diagram of front panel to be added

4.1.1 Power LED

The green power LED indicates that primary power is present, the 12V power supply, 5V local control unit regulator is working and that the microcontroller has successfully initialized.

4.1.2 Receive LED

The yellow RX LED indicates that an RF signal is detected that is above the programmed minimum receive threshold.

4.1.3 Transmit LED

The yellow TX LED indicates that the transmitter is drawing current and generating RF energy greater than +15 dBm.

4.1.4 Fault LED

The red FAULT LED indicates that one of several fault conditions is in effect, or has occurred since the last key-up attempt. Some faults which are self clearing, such as PA overcurrent or excess reverse power , will remain in effect until the next key-on event. The transmitter is defeated if any fault is signaled. Fault codes are described in more detail in section 6.6.12.

4.1.5 LCD Display

A single row, 16 alphanumeric character LCD is used to provide textual user information. Idle state LCD display shows received signal level in dBm, or three asterisks is no signal is present.

4.2 Controls

4.2.1 Up/Down Scroll

The up/down scroll buttons are used to alter parameters under a specific menu function. An example is the use of the up/down keys to call up a specific receive threshold in dBm. The up/down keys can be used to change a parameter by pressing repeatedly, or when applicable, will automatically sequence through available entries if pressed and held down. Software prevents scrolling beyond allowable values for any given programmable function.

For functions that require a yes/no or toggle entry, either key will toggle the state.

4.2.2 Menu

The select/menu pushbutton is used to step through available menu functions. The up/down keys are then used to change the parameter associated with that function.

In the default operating mode after power-up, the menu key sequences through normal user functions. To enter the service/calibration menu, the one holds down the up and down keys simultaneously, and then (while still holding the up/down keys) one presses the menu key.

4.2.3 Reset

The recessed reset button can be actuated by inserting a nonconductive pointed object through the hole provided in the front panel.

5 User Functions

5.1 *Idle State (Default) Display*

When no user function is being programmed, the LCD displays currently received signal strength in dBm. If the input signal is below the AGC limit setting, three asterisks will be displayed instead of a numeric readout.

`>>>    -65dBm  <<<`

5.2 *General Usage of Buttons*

All user programming functions operate in a similar manner. Pressing the menu key sequences through available programmable features. When the desired feature is displayed on the LCD, the up/down keys can be used to manipulate the selected parameter. This either involves scrolling though a numeric range of settings, or toggling between a yes/no set of options.

When a function is called up, the current setting is displayed. Any changes are retained once the menu key is pressed, and the next function is called up.

Repeated pressing of the menu key sequences through all available functions and the idle screen display. The screen reverts to idle automatically if no keypad activity occurs for 3 minutes.

The up/down keys can be stepped by repeated keypresses, or can be held down to rapidly scroll through the available range.

All functions can be adjusted at any time regardless of whether the OFR is keyed on or not.

5.3 *Main User menu*

5.3.1 Receive Threshold

`RxThresh:  -89dBm`

The first function in the menu determines the minimum input RF level in dBm above which the transmitter will be energized and repeater operation occurs. It is good practice to set this threshold about 6 dB above the lowest normal received signal level to allow for slow fading and other long term propagation variations. Excessively low threshold settings may increase susceptibility to false triggering on interference or self-oscillation.

The receive trigger threshold can be set anywhere within the maximum available range of –95 to –20 dBm. However, if an AGC limit level has been set, then the range of trigger signal levels that selected be set is limited to values higher than the programmed ACG limit plus 2 dB.

If the receive threshold is reduced to a level lower than the AGC limit plus the AGC hysteresis, then the hysteresis setting is automatically reduced, as required, to allow the receive threshold to approach the AGC limit.

Default receive threshold setting is –95 dBm. (Maximum sensitivity).

5.3.2 Transmit Power

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Tx Power: +30dBm
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Transmit output power can be set anywhere in the range of 20 to 30 dBm using this function.

Default setting is +30 dBm, (Maximum Power)

Note that this power setting applies to the total composite power at the OFR output. It does not correspond to individual carrier power except when only one carrier is present.

5.3.3 Hang Time

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Hang:      +0*100ms
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To avoid key-on delays incurred during short dropouts in the received signal, it is possible to keep the transmitter energized for a programmed length of time after received signal is lost.

Hang time can be programmed in 100 ms increments between zero and 3 seconds.

The hang time counter starts when received signal drops below the programmed receive threshold. If the hang time expires, then the transmitter will be keyed off.

During hang time, the receive signal indicator indicates presence or absence of an actual input signal. The transmit indicator will remain on during hang time regardless of whether any actual RF is being output. Because an input signal may be absent, and the transmitter may not be developing full power, forward power fault detection is temporarily defeated during hang time. Also, power leveling is temporarily suspended at the last setting in effect when the received signal dropped below threshold.

The function setting ranges from zero to 30. The "*100ms" multiplier message is displayed as a cue to interpretation of the reading.

During hang time, the AGC continues to function, however, AGC will only go to the AGC limit maximum gain set using the AGC limit function. This is to prevent self oscillation from occurring during hang time, when the received signal is absent and the OFR wants to command more gain.

For this reason, it is imperative that the AGC limit be properly set before attempting to use the hang time feature.

5.3.4 TX Defeat

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TX Defeat:      NO
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It is possible to manually defeat the transmitter for setup, service or alignment purposes. The up/down arrows toggle between the Yes and No states. When Yes is displayed, the transmitter will not energize regardless of detected input signal level. This is useful during initial setup.

5.3.5 Automatic AGC Limit

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AutoAGCLimit:NO
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This function triggers a (Patent Pending) unique feature of Kaval OFRs that greatly simplifies field installation. The automatic AGC limit setting function automatically sets the AGC limit to accommodate system antenna isolation and prevent self-oscillation. After execution, the receive threshold function setting range is automatically constrained to safe settings that will not result in system self –oscillation. This function can also be used to automatically measure how much of its own output signal the OFR "sees".

To initiate an automatic AGC limit determination, use the up or down key to toggle the display to the "Yes" state and then press menu. The next screen asks for input of the AGC limit margin. This is a value between zero and 20 dB. The auto AGC function will set the AGC limit to a value equal to the self-oscillation threshold plus the selected AGC limit margin. Margins of at least 10 dB are recommended. The default margin called up is 10 dB.

Pressing the menu key after optional manipulation of the margin setting triggers the automatic AGC limit function. The IF section is disconnected from the transmitter and the internal test oscillator is turned on. The transmitter will output the current selected power output and the receiver measures received signal level. The AGC limit is automatically set to that receive level plus the AGC limit margin. The receive threshold function will than allow settings only between the AGC limit and –20 dBm.

```
AGCMargin:+10dBm
```

The AGC limit can be manually adjusted at any time after an automatic adjustment.

It is imperative that all transmitters feeding signals to the OFR be turned off during an automatic AGC limit operation. If not, then the OFR will interpret these desired signals as feedback and set the threshold above the level needed to properly process signals. If it is not possible to defeat these transmitters, then the manual AGC limit function should be used.

It is recommended that the automatic AGC limit function be executed at periodic intervals to accommodate long term changes in antenna isolation due to seasonal foliage variations or new construction in the vicinity of the antennas.

5.3.6 Manual AGC Limit

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AGCLimit: -85dBm
```

The AGC limit can be manually set. This should be done with caution as excessively low AGC limits increase the possibility of system self-oscillation. The AGC limit should be set to a level at least 10 dB above the level of its own output signal that the OFR receives.

As an operating note, the higher the AGC limit is set, the faster the key on time of the transmitter. When signals are being received from fixed base stations, it is good practice to set the AGC limit about 10 to 20 dB below the nominal received signal from the desired base station.

The default AGC limit setting is to minimum input level (<95 dBm) The LCD display will show "OFF" instead of a dBm reading in such case.

5.3.7 AGC Hysteresis

AGC Hyst: +6dB

AGC hysteresis is the difference between the input level at which the OFR energizes its transmitter and the (lower) input level below which the transmitter is de-energized. It is a good idea to maintain at least some hysteresis to prevent signals right near the input threshold from unnecessarily triggering the OFR on and off with minor level fluctuations.

The AGC hysteresis can be manually set anywhere from 0 dB (no hysteresis) to 20 dB.

The hysteresis cannot be set to a level higher than the current difference between the receive threshold and AGC limit level.

The default hysteresis setting is 6 dB. This is suitable for OFRs repeating fixed base stations. When repeating mobile signals, a higher hysteresis, corresponding to normal fast fading level variations should be used.

Please note that high hysteresis settings effectively reduce the available sensitivity of the OFR for triggering purposes.

If the receive threshold is set to a level lower than the current AGC limit plus the hysteresis, the hysteresis is automatically reduced as required.

5.3.8 Test Oscillator

Int. Osc. On: NO

The internal test oscillator can be manually activated. In this operating state, the OFR will continuously transmit a single unmodulated carrier in the middle of its passband. This function is useful for testing of antenna systems, functional verification of the OFR transmit section, and to perform field strength surveys. The receive signal is disconnected from the transmitter when the test transmitter is on, but the RX indicator LED will continue to operate normally.

If the RX LED turns on at the exact time that the test oscillator is activated, then there is a strong likelihood that system self oscillation may occur if normal operation is attempted.

5.4 Fault Indications

If a fault condition is detected, the fault LED is turned on, the fault relay closes and a text message appears in the LCD display. Fault messages are listed and described below. All fault conditions defeat the transmitter.

Over-Temp!

Power amplifier temperature has exceeded 90C. Transmitter will be defeated and fault condition will persist until temperature decreases to below 60C.

PA Overcurrent!

Power amplifier has drawn 25% more current than normal. Transmitter has shut down for remainder of current key-on cycle. Re-energization will be attempted on next key-up. Overcurrent may be the result of system self-oscillation or an internal failure.

PA Undercurrent!

Transmitter was keyed on but consumed less than 50% of normal supply current. Undercurrent is usually a sign of an internal failure of the final transmitter stage.

Fwd Power High!

Transmitter power exceeds user selected setpoint. This indicates a failure of the transmitter leveling circuitry or internal self-oscillation in the IF/Upconverter. This fault latches until next key-on cycle.

Fwd Power Low!

Transmitted power is less than 50% of selected power output. This is usually an indication of an internal failure, but may appear when an extremely poor VSWR is encountered at output.

PA Supply Fail!

This message indicates that the 24V switchmode supply is not providing 24V to the final transmitter stage.

Excess Rev Power!

The RF output load VSWR is greater than approximately 2:1. This usually indicates a failure in external cabling or antennas. This fault is latched until next key on cycle.

Input Overdrive!

An input RF signal has exceeded the AGC systems ability to maintain level output. This condition may occur for input signals above -20 dBm.

Uncalibrated!

Proper and safe operation of the OFR requires that the transmitter power leveling system and AGC calibration have been done in the factory, or in accordance with this manual If for some reason, the OFR control unit has not had its calibration tables set up in nonvolatile memory, or EEPROM contents have been lost, the transmitter is defeated until calibration has been performed. This fault condition may also appear with certain types of control unit failures.

Replacement of the front-end, IF/Transmitter or control PCB requires recalibration.

6 Theory of Operation

6.1 Identification of Modules

NOTE: Photo or diagram of module locations to be added here

6.2 Overall Function

NOTE: System block diagram to be added here

6.3 Front End

The front end module amplifies and converts the incoming RF signal to the final IF of 21.4 MHz.

The RF is first passed through a single PI lowpass filter that removes L.O. leakage to the input at above 2 GHz for FCC compliance. The signal is then passed to a three pole helical preselector FL101. The signal is amplified by a MMIC low noise amplifier IC101 and applied to the first downconversion mixer IC102. A tripled local oscillator signal at 689.1108 MHz converts the RF to a first IF of 251.1063 MHz where it is amplified by IC103 and IC104. Image and L.O. are filtered by a two pole helical filter FL102 and a two stage PI filter before being passed to the second downconversion mixer IC105. This mixer takes the L.O. signal at 229.7036 and converts the first IF to the final 21.4 MHz. IC106 provides further amplification at 21.4 MHz.

The overall gain of the front end is between 18 and 22 dB.

The local oscillator is buffered by IC107 and applied to the second mixer. The output is also applied to a single transistor tripler Q106. Which multiples the frequency by a factor of 3. The desired harmonic is filtered by FL103, amplified by IC108 and applied to the first mixer.

The main supply to the front end is applied at 9.6V. Resistor R135 drops the voltage to 7.1V. A two transistor switch (Q108, Q109) can be used as a power-down function. This is not implemented in this product.

6.4 Local Oscillator

The self-contained local oscillator module generates the 229.7063 main L.O. signal that is fed to the front end and upconverter. By using the same L.O. for down and up conversion, the OFR imparts no frequency shift to the applied signal.

A temperature compensated crystal oscillator Y1 generates the fundamental frequency at 25.5229 MHz. This is a 1.5 PPM crystal. Q4 buffers its output and selects the main harmonic. Q1 multiplies the frequency by three to about 75 MHz. Q2 provides a second tripling to yield the final L.O. signal. This is filtered by two two pole helical filters FL1 and FL2, and a further harmonic filter L7/L8. A two output LC Wilkinson divider splits the L.O between the front end and upconverter. Splitter must be tuned to ensure good isolation between front end and upconverter L.O. signals to ensure no parasitic feedback path for RF around the L.O. loop.

6.5 IF/Transmitter

6.5.1 General

The IF/Transmitter module converts the IF signal from the front end module to the final output frequency of 940.225 MHz using the 229.7036 local oscillator signal. It accommodates input signals in the range of –75 dB to 0 dBm with between 1 and 4 carriers within its 36 kHz passband. An automatic gain control maintains constant output signal over this dynamic range. The transmitter section can output user selected power levels between +20 and +30 dBm. All amplification is type A or AB to ensure linear operation. This is significantly different from other OFR repeaters.

The AGC contains special circuitry to constrain AGC excursions to gain settings that do not violate site-specific antenna isolation limits.

The transmitter includes heavy filtering of local oscillator and image frequencies. The transmitter gain is controlled by a slow control loop to compensate for gain changes that may impair intermodulation. Transmitter keying is done using a timed ramp to prevent spurious transient signals.

Reverse power protection is also provided.

The transmit/IF module runs off 9.6 VDC and +24 VDC. Consumption at 9.6 VDC is approximately 530 mA (5W). Consumption at +24V is about 450 mA, or about 11W.

6.5.2 IF

The IF subsystem receives an input signal from the front end at 21.4 MHz, at a level of between –75 and 0 dBm. It filters and amplifies this signal to a level of –10 dBm which is fed to the upconverter. Almost 80 dB of gain control is provided to maintain a constant output level at the IF output. A complex AGC control loop maintains this constant level and provides necessarily fast attack and decay times. A (patent pending) programmable AGC clamp circuit constrains AGC excursion to ensure that overall gain never exceeds the gain margin of the OFR installation (dependent upon antenna isolation, and hence site-dependent).

A test oscillator is also included which can be used to test the transmitter and for performing open-loop antenna isolation measurements, either manually, or automatically.

The AGC control voltage is used for Received Signal Strength Indication (RSSI). The Control unit reads this voltage and makes decisions on whether to key up the transmitter.

The AGC roughly detects average power plus any envelope modulation within the IF AGC loop bandwidth. For that reason, individual carrier level will vary depending upon the number of carriers present (one to four). Power will roughly be divided equally between carriers, with an additional approximately 1 dB per carrier added due to envelope phenomena. When single carrier output is set to –10 dBm, two carriers will be output at about –12 dBm, and four carriers will be output at –14 dBm. This behaviour is desirable as a means of managing intermodulation by keeping output power at the transmitter constant.

The IF is supplied by the 9.6V rail, and consumes a maximum of 130 mA.