Antenna System Monitoring

The measurement, monitoring and reporting of the performance of wireless network infrastructure has come a long way over past years. Many modern base station repeaters provide integrated measurement capabilities, but the use of combining and/or isolators in the RF path from the base station transmitter output to the antenna isolates the repeaters from reporting most problems that may occur within the combiner and antenna sub-systems.

The inherent inaccuracies of using in-line wattmeters (or sampler detectors) to measure forward and reverse power on multi-carrier systems, due to the carriers’ ever-changing random phase relationships, results in random and inaccurate measurement values. Connecting such devices into multi-carrier locations within the system often introduces intermodulation into the system, risking optimum network performance.

The use of an Antenna System Monitor (ASM) facilitates the per-channel measurement of each transmitter’s forward and reverse power, the system’s transmit-to-receive isolation, receive signal levels and much, much more…. 

Overview

The Antenna System Monitor can be used to measure and monitor the following network performance parameters for up to 80 channels that may be distributed across up to four (or more) separate combiner systems;

- Transmitters’ Forward Power (from -50dBm to +60dBm per channel)
- Antenna VSWR (from 1:1 to 20:1 per channel)
- Receive (RSSI) levels (from -110dBm to -50dBm per channel)
- Tx-Rx Antenna Isolation, Rx System Gain/Ripple, and Tx Carrier Rejection (for up to 20 frequencies)

These measurements are logged and stored in non-volatile memory, with historical performance data available for review or downloading. The following data from logging can be shown graphically or downloaded as a CSV text file;

- Transmitter Power (Max/Min)
- Antenna VSWR (Max/Min)
- Receive Channel Utilisation (%)
- GUI Login Event Log
- Rx System Gain
- SAM Inputs (if optional SAM fitted)
- Transmitter Channel Utilisation (%)
- Receive Level (Max/Min)
- Alarm Event Log
- Antenna Isolation
- Tx Rejection

Once installed, the ASM is non-intrusive to the network and continuously monitors the RF performance of the site “24x7” on a detailed per-channel basis. This enables coverage-impacting issues at a site to be detected, measured and reported as soon as they occur – often before network users experience them. The extensive testing capability of the ASM allows most Periodic Maintenance Inspections (PMIs) to be performed without the usual site outages and their impact on network availability.

Optional Site Alarm Modules (SAMs) may be connected to an ASM, adding the monitoring of temperature, analogue voltages and digital inputs - in addition to providing multiple relay outputs - to enhance an ASM’s functionality.
Interconnection

When installed at a network site, an ASM can measure base station transmitter output powers and antenna VSWRs, and receive levels from network terminals, remote RTUs or adjacent network sites – all on a per-channel basis. In addition, the site’s transmit-to-receive system isolation can be measured and benchmarked.

The programming of alarm thresholds values can be set based on network user’s coverage requirements, coverage overlap from adjoining sites, and maintenance obligations. Alarm events can notify maintenance personnel of a developing fault. Subject to the severity of the fault’s impact on a user, an appropriate response can be actioned.

For example, if an antenna VSWR alarm is configured to trigger when it reaches 1.8:1, a decision can be made on the priority of response required. If the event occurred at 2am on Saturday morning, and the site benefitted from coverage overlap from surrounding sites, a response decision might be to schedule the maintenance activity for 9am Monday morning as the level of impact may be determined as ‘minor’. This may save an after-hours callout for a rigger and after-hours duty technician – potentially saving thousands of dollars. However, the VSWR could then be monitored and any further degradation could still result in an escalation in response if required.

Alternatively, if a fault showed a “low” base station Tx output level, but a good antenna VSWR, then the response might be to send the duty technician with base station spares – rather than taking a rigger and a crew with a spare antenna. Another significant saving in response costs.

Applications

The Antenna System Monitor is ideally suited to a wide range of applications supporting wireless networks. Its capabilities cater for analogue, digital, FDMA and TDMA modulations. An integral webservice in the ASM provides a user-friendly Graphical User Interface (GUI) that allows the programming of channel information and alarm thresholds on a per-channel basis, site and customer details, and other ASM operating parameters.

The relay, SNMP, Email, Manager Messages and SAM alarm interfaces can be implemented to provide various alarm notifications, and the GUI provides configuration programming and status monitoring compatibility for computer, tablet, mobile phone and mainframe users. Current measurement values and alarm statuses can also be viewed locally or remotely.

When an optional SAM module is fitted, the digital inputs of the SAM can be configured to provide logical ‘AND’ functionality with the ASM’s measured Tx or Rx levels, allowing a wide range of various Tx PTT, Trunking, Rx Unsq, Voting Shelf, Tx Steering Shelf and other system architecture functionality to be monitored and alarmed.

Network Site Monitoring

When installed at a network site, an ASM can measure base station transmitter output powers and antenna VSWRs, and receive levels from network terminals, remote RTUs or adjacent network sites – all on a per-channel basis. In addition, the site’s transmit-to-receive system isolation can be measured and benchmarked.

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Alternatively, if a fault showed a “low” base station Tx output level, but a good antenna VSWR, then the response might be to send the duty technician with base station spares – rather than taking a rigger and a crew with a spare antenna. Another significant saving in response costs.
A comprehensive Alarm Log is also available to provide a history of alarm events. This log can also be downloaded as a CSV text file and used to create KPI reports such as the number of faults, operating duration, MTBF, or MTTR. When coupled with the History Log, this could be used to provide a series of datasets on recurring faults, unreliable equipments and related maintenance metrics.

If intermittent or sagging RF output power is suspected, the Tx Power History Chart can show the performance of the channels over a selected period of time. In the GUI, hovering the mouse cursor at the top of any bargraph line will display the actual value represented.

The time and date stamped History Log can be viewed to identify or analyse specific event times. The log can also be downloaded as a CSV text file and used to create customised reports.

OMCS & PMCS Software Integration – Manager Messages

The ASM also offers Manager Messages. These are UDP IP message packets that contain Traffic and Status data created by the ASM measurement cycles. These ASM messages can be sent to nominated IP addresses where they can be processed and the data utilised in third party software applications.

Importantly, if an outage was required to exchange a partially faulty antenna, but the level of impact was 'minor', then a routine outage could be planned for a future date – rather than an 'urgent' outage on short notice – whilst still monitoring the fault in case it degraded further. In addition to the cost saving in delaying an unnecessary urgent response, the network users are not inconvenienced by an unplanned outage on short notice, a significant issue in operations-critical networks.

Measurements from multiple sites can be collected, collated, and presented in user-generated reports showing overall network performance.

An “Activity” indicator (Act) next to the reading for each channel indicates if the value displayed was active during the last measurement cycle, or whether it is an old reading from past traffic on the channel.
Channel Diagnostics

The ASM also provides a GUI screen called Channel Diagnostics. When this screen is being viewed, the normal per-channel measurement and data logging of all of the programmed frequencies is paused, and only the Tx and/or Rx frequency selected on this Channel Diagnostics page is monitored and measured. This allows a faster measurement refresh cycle to be provided during this focussed measurement activity.

Tx Monitoring

When Monitor Tx Channel is selected and the Start button clicked, the nominated frequency is measured. This may be considered similar to a digital power meter, with both Tx Forward Power and VSWR being displayed. This capability may be used to assist base station or combiner tuning and/or testing activities, or to monitor one transmitter constantly.

Rx Monitoring

When Monitor Rx Channel is selected in "Channel" mode, the nominated frequency is continuously monitored when the Start button is clicked. Rx Monitoring may be used for several testing purposes. It can be used to monitor the subscriber terminal inbound or uplink signal. This is the base station’s received signal (RSSI), and the resulting keyed Tx output is displayed as the Tx Fwd Pwr. A displayed inbound Rx level, without a corresponding Tx Fwd Pwr value may indicate a faulty base station – or an illegal user or other interfering signal operating on the monitored Rx frequency.

When the Monitor Rx Channel is in “Frequency” mode, any frequency may be selected from the drop-down fields (or entered directly) and monitored when the Start button is clicked.

Transmitters at the site not being directly measured by the ASM will usually be measurable on the ASM’s Rx port at a level attenuated by the Rx system's preselector rejection and Tx-Rx antenna isolation at the monitored Tx frequency. This feature may be used to monitor other frequencies at the site, assisting in fault finding activities such as desense or intermodulation analysis by monitoring the level and co-incidence of other site users’ Tx or Rx activity.

In each of the Tx and Rx measurement fields the unit of measure can be selected for user convenience. When the user navigates to another GUI screen, or if the Channel Diagnostics screen has not been used for a period of time, then the normal per-channel measurement and data logging of all the ASM’s programmed frequencies automatically resumes.
Adjacent Sites-Monitoring

If an ASM is installed at a dominant network site, it can also be configured to ‘off-air’ monitor channels from surrounding network sites. In trunking networks, this is particularly useful for monitoring a control channel from adjacent sites.

This concept requires adequate isolation between the ASM site’s Tx antenna and the off-air Rx antenna and provides basic monitoring of coverage - yet confirms the continuing operation of other sites within the network.

Adding more ASMs to other sites adds more data, providing more than one signal level reading from each site – more thoroughly confirming network and coverage performance.

Multiple sites’ data can also be collected, collated and presented to identify performance impacting changes in network coverage performance.
Base Station Failure

When fitted with an (optional) Site Alarm Module (SAM), the ASM can provide Base Station monitoring in DMR (and other) radio systems. The alarm status from each monitored channel can be assigned to a SAM relay output, and a failure on a base station channel can create an alarm output that is connected back to the trunking controller or individual bases to de-allocate the failed channel.

Using the “Digital Input” affiliated to each SAM relay output ensures that the trunking base station’s keying is monitored, and a total RF output failure is recognised – rather than interpreted as valid “no channel activity”. SAM outputs can also be manually activated and de-activated via the GUI if the deactivation of one or more channels is desired.

Site Equipment Monitoring

When fitted with a Site Alarm Module (SAM), the ASM can also provide monitoring of temperature, analogue voltages and test points, and general purpose digital logic and alarm lines.

The alarm status from each input is represented in the webserver GUI, and alarm events trigger SNMP traps, SMTP (Email) messages and Manager Messages for alarm reporting.

A selection of temperature, analogue voltages and digital logic levels can be monitored by one SAM, with ten (10) alarm relay outputs that can be mapped to any ASM monitored channel’s alarms. Up to ten (10) SAM’s can be connected to one ASM for additional monitoring capacity if required.
Antenna Change-Over

Another application for the Antenna System Monitor (ASM) is to control an automatic Antenna Change-Over unit (ACO). Antenna performance can be monitored by the Tx forward power and VSWR measurement cycle of the ASM.

If an alarm is detected on one (or more) transmitter antennas, the alarm relay output(s) of the ASM can be used to activate a coaxial relay to switch in a stand-by antenna (or antennas). ASM outputs can also be manually activated and de-activated via the GUI if the manual change-over or testing of antennas is desired. This capability is beneficial on remote sites where access to the site could be restricted for prolonged periods due to seasonal weather.

Remote Base Station Control

The relay outputs of the Antenna System Monitor (ASM), or a Site Alarm Module (SAM) if additional output capacity is required, can be controlled via the ASM GUI. These outputs can be used to control external equipment items – including base stations. Coverage drive-testing can be assisted by activating test transmitters remotely via the ASM GUI. The ease of access of the GUI provides flexible control functionality that can be used to facilitate remote control capabilities at a communications site.
Non-Intrusive Periodic Maintenance Inspections (PMIs)

The Antenna System Monitor (ASM) is non-intrusive to a network once its sampling coupler is installed. The ASM measures and reports on the monitored RF performance parameters on a continuous "24x7" basis, allowing the measured values to be logged during normal network operation and without impacting its users. In addition, alarm events (when the programmable alarm thresholds are exceeded) can be reported back to a Network Operations Control Center (NOCC) or maintenance personnel via the Alarm Relays, SAMs, SNMP, Emails or Manager Messages interfaces.

Using the ASM’s collected History and Alarm event data, in conjunction with accessing the unit and its current performance measurements “real-time” via its friendly Graphical User Interface (GUI) when required, provides the ability to measure and confirm most network RF performance parameters without a planned or unplanned network outage. In many circumstances, this capability can remove (or greatly reduce) the need for regular PMIs - and their associated network outages and the impact these have on operations-critical network users.

The benefits in network maintenance cost reductions in minimising the number of visits to sites, particularly ones that are remote or that have otherwise limited access, can be significant. The availability of downloadable data that can be formatted and presented in regular reports further improves network availability, fault and mean time to repair (MTTR) monitoring and KPI measurement.

Coupled with the capability to more intuitively assess network RF performance problems and the “network-availability” effects of alarm events as they unfold, the Antenna System Monitor offers a very attractive Return-On-Investment (ROI) proposition for its inclusion in every network or site build.

New Features, Upgrades, and Documentations

There is an active product development plan for the Antenna System Monitor. New features are available in regular firmware releases. Firmware updates can be easily uploaded (locally or remotely) to an ASM. Firmware update files, SNMP MIB files, Service Bulletins and User Manuals are available in the “Monitoring” products category at www.rfiwireless.com.au
Features and Benefits

- Allows most PMI’s to be performed non-intrusively, without a site outage impacting network users (i.e. no more scheduled network outages)
- Observe network RF performance locally, or remotely, via a user friendly webserver GUI - with SNMP, SMTP (Email), Manager Messages, and relay outputs available for alarm notifications.
- Measure and monitor the output of high power multi-carrier transmit combiners on a per-channel basis – without the limitations of in-line wattmeters and RF “samplers”
- Measure and monitor other network RF parameters (receive levels, system isolation, etc)
- Allows and Tx and Rx frequencies to be analysed to assist in the identification of interference (IM, desense, etc), illegal carriers, frequency re-use problems and other performance impacting issues.
- Measure and monitor site alarms and equipment operating status’ using (optional) Site Alarm Module(s) using temperature, analogue and digital inputs. Map individual ASM channel alarms to ASM and or SAM alarm relay outputs for remote control, antenna change-over, hot/standby, and other applications.
- Store historical data for later display or download
- 24x7 non-intrusive monitoring and the setting of minimum and/or maximum alarm thresholds allows the speedy detection and notification of performance-impacting changes in the networks performance
- Configuration data (frequencies, alarm thresholds, etc) is easily entered via an integral webserver GUI, or via a Configuration File Load/Save selection.
- Allows intuitive assessment of site faults prior to despatching personnel to site
- Assists in determining the need for specialised personnel (i.e. riggers) and likely required spares (such as antennas) to be determined prior to travelling to site in response to a reported fault, minimising unnecessary maintenance costs.
- Reduces maintenance effort by enabling better analysis of the likely fault cause prior to deploying resources to site, and allows appropriate spares to be taken to site
- Allows earlier planning of network outages if required for fault rectification. Reduces ‘unplanned’ outages on short notice
- Detects the onset of fault conditions “as they occur” and often before network user’s notice the impact of the fault – allowing a faster response to be initiated and resulting in better Mean Time To Repair (MTTR) performance to be achieved
- Facilitates a more detailed assessment of the impact of the fault on network performance. Is it a minor reduction of coverage, is it on just one channel, or is it a more extensive impact on the network’s grade of service?
- Provides detailed data of ongoing network performance, faults and restorations – within the RF environment. Downloadable log files allow the importation and processing of data into spreadsheets, producing network performance, maintenance and other KPI reports.
The Antenna System Monitor (ASM) provides channel specific forward and reflected transmitted power monitoring, Rx RSSI levels for up to 80 channels, and system isolation measurements. Four paired sets of forward and reflected Tx power measurement inputs facilitate monitoring via high power in-line couplers. The low loss Antenna Line Coupler is inserted after the Tx combiner on the antenna feeder cable. All frequencies, channel bandwidths and alarm level thresholds are software definable on a per-channel basis. A DB15 rear mounted connector provides alarm reporting outputs that can be hardwired into most alarm reporting facilities. The LED’s on the front panel of the APM allow visual confirmation of the hardwired alarm outputs. Configuration, diagnostics and communication management is facilitated through the use of an on-board webserver GUI. Optional Site Alarm Monitors (SAMs) may be added to enhance measurement and alarm output capabilities.

- Individual channel monitoring of Tx forward and reflected power and Rx levels in multi-channel, multi-carrier systems.
- Non-intrusive 24x7 measurement, monitoring and alarm reporting of a system’s RF performance parameters.
- Capable of monitoring up to 80 channels across multiple combiner systems
- Analogue, Digital, FDMA and TDMA compatible
- Local or Remote configuration and firmware updating via RJ45 Ethernet port and integral webserver.
- ASM supplied with one Antenna Line Coupler, additional couplers may be ordered separately if required.

### Antenna System Monitor

<table>
<thead>
<tr>
<th>Specification</th>
<th>ASM</th>
</tr>
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<tbody>
<tr>
<td>Frequency Range (4 separate frequency models)</td>
<td>132-174MHz, 380-520MHz, 746-870MHz or 870-960MHz</td>
</tr>
<tr>
<td>Maximum number of monitored channels</td>
<td>80</td>
</tr>
<tr>
<td>Available Tx forward power / VSWR monitoring port inputs</td>
<td>4 pairs</td>
</tr>
<tr>
<td>Available Rx RSSI level monitoring ports</td>
<td>1</td>
</tr>
<tr>
<td>Rx monitoring port input range</td>
<td>-110dBm to -50dBm</td>
</tr>
<tr>
<td>Frequency channel step size (Tx &amp; Rx)</td>
<td>1.25kHz</td>
</tr>
<tr>
<td>Channel measurement bandwidths</td>
<td>12.5kHz and 25kHz</td>
</tr>
<tr>
<td>Max spurious or IM products</td>
<td>-30dBm</td>
</tr>
<tr>
<td>Conducted emissions Complies with CISPR22 Part B, FCC Part 15 (15.207)</td>
<td></td>
</tr>
<tr>
<td>Radiated emissions Complies with CISPR22 Part B, FCC Part 15 (15.209)</td>
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<tr>
<td>RF Termination connectors</td>
<td>N (F)</td>
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<tr>
<td>Communication interface ports</td>
<td>2 x rear mounted TCP/IP Ethernet ports (RJ45)</td>
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<tr>
<td>Internal alarm relay contacts output connector</td>
<td>Rear mounted DB15 (M)</td>
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<tr>
<td>Visual alarm notification</td>
<td>Front panel mounted LED’s</td>
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<tr>
<td>Configurable alarms</td>
<td>Summary Fault / Tx FWD power / VSWR / RSSI &amp; Ant Isolation</td>
</tr>
<tr>
<td>Alarm support</td>
<td>GUI / Relay Output / SNMP V2c Traps / SMTP Email / UDP Packets</td>
</tr>
<tr>
<td>Power supply options</td>
<td>11-36VDC, 36-60VDC or 100-240VAC</td>
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<tr>
<td>DC power connector</td>
<td>Polarised 2-pin Phoenix connector</td>
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<tr>
<td>Mounting</td>
<td>2RU 19&quot; rack mounting</td>
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<tr>
<td>Dimensions</td>
<td>483x50x89mm / 19x2x3.5&quot; (incl connectors)</td>
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<tr>
<td>Weight</td>
<td>&lt; 2kgs / 4.4lbs</td>
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<tr>
<td>Operational temperature range</td>
<td>-10° C to +60° C / 14° F to 140° F</td>
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</table>

### Site Alarm Monitor (optional)

<table>
<thead>
<tr>
<th>Specification</th>
<th>SAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature/Analogue/Digital External Inputs</td>
<td>4</td>
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<tr>
<td>Digital / PTT Inputs</td>
<td>10</td>
</tr>
<tr>
<td>Alarm Outputs</td>
<td>10 Form C Dry Relay (NC/CMN/NO)</td>
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<tr>
<td>Power supply options</td>
<td>11-36VDC, 36-60VDC or 100-240VAC</td>
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<tr>
<td>Mounting</td>
<td>1RU 19&quot; rack mounting</td>
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<tr>
<td>Expansion</td>
<td>10 SAMs per ASM</td>
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</table>

For more detailed information on the ASM and SAM products please refer to the User Manuals, Product Briefs, Service Bulletins, Application Notes, Firmware Updates, SNMP MIB files and other support information located at www.rfiwireless.com.au.