# Power Monitoring in Multicarrier systems

It is the responsibility of the engineer to fully understand the hardware used in their design and reduce the risk of not delivering the requirements included in a bid. This paper will discuss power monitoring on multicarrier RF networks. The difference between single carrier power measurement and multicarrier measurement will be discussed in detail. Understanding the difference in multicarrier power measurements is important because erroneous readings can create confusion and in some cases not deliver the required expectation. Customers are becoming sensitive to the need to understand the actual amount of power being delivered to the antenna. In the past this was not possible because we did not have power monitoring equipment that could measure the power of multiple transmit signals on a single cable. Improvements in technology as well as increasing awareness that the cost of adding power monitoring equipment is indicative of reliability and system utilization is causing this change in bids and customer requirements. This paper will show a feature and price comparison between utilizing individual components for power monitoring and the APM monitoring technique. While being positioned as a solution, this paper will demonstrate how some hardware solutions do not provide the information our customers are expecting and requiring in their bids.

## Single carrier power vs. Composite power

For years technicians have used Bird 43 Wattmeters to evaluate the power output of transmitters. This instrument has been the benchmark of all RF Technicians and service shops. The Bird 43 Wattmeter utilizes a directional diode detector to convert the RF power into a voltage that can be measured. This technique provides an Average power reading and is reliable as long as the modulation is constant such as analog FM type transmitters. This instrument is not designed for new digital modulation such as TDMA because measurement of digitally modulated RF requires True Averaging power monitoring. When multiple transmitters of different frequencies are combined to a single antenna, the power produced is called **Composite Power**. The characteristic of the resulting composite power is the complex vector sum of the fundamental signals. A diode detector Wattmeter such as the Bird 43 cannot accurately measure this signal. When the composite power is measured with a True Averaging power monitor, the resultant will essentially be the simple mathematical sum of the individual powers. Only a True Averaging Wattmeter will produce this result.

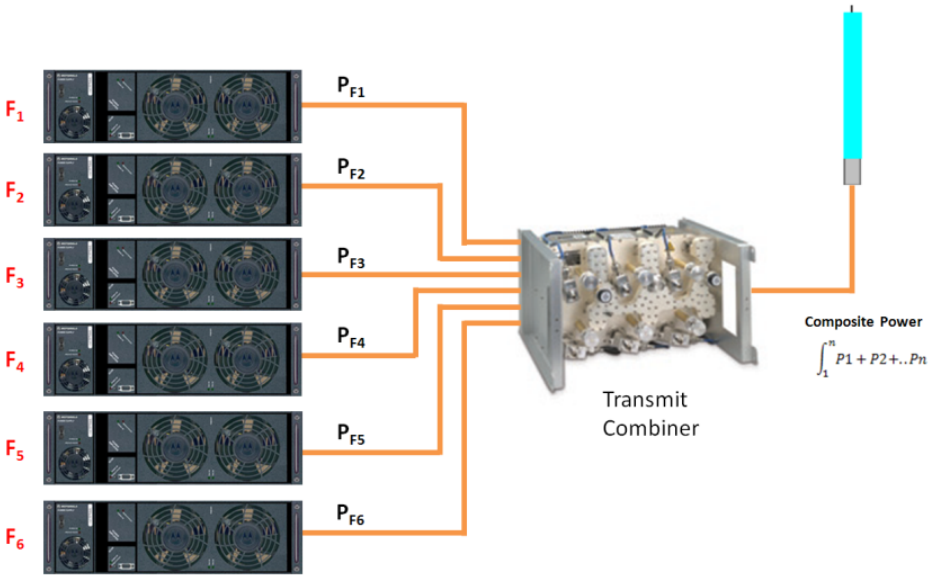


***Figure 1***
***Typical LMR multicarrier Transmit Network***

**Figure 1** shows the combining of six transmitters to a single antenna. This is a typical example of transmitter combining utilized in Land Mobile systems. If the composite power is measured the result will depend on the number of transmitters active at any given time. Simple measurement of the Composite Power will not reflect the actual power of any component nor provide information on how much power is being transferred to the antenna for each frequency or transmitter. To accurately measure the power delivered to the antenna, the individual signals must be analyzed individually.

# Bird Power Monitoring Systems and Accessories

## Sample System Design utilizing Bird power monitoring components ***(Figure 2)***

While Bird has been the standard for power monitoring for decades, it is important to fully understand the capabilities and limitations of this type of equipment in today's systems. There are several power monitoring products that are being engineered into our systems that have severe limitations and capabilities. Shown below ***(Figure 2)*** is a sample system design recently utilized to measure input power and output VSWR. The bid requirements were very simple, measure the power out of each transmitter and the VSWR associated with the transmit antenna. The system must have alarm capabilities with dry contact closures.

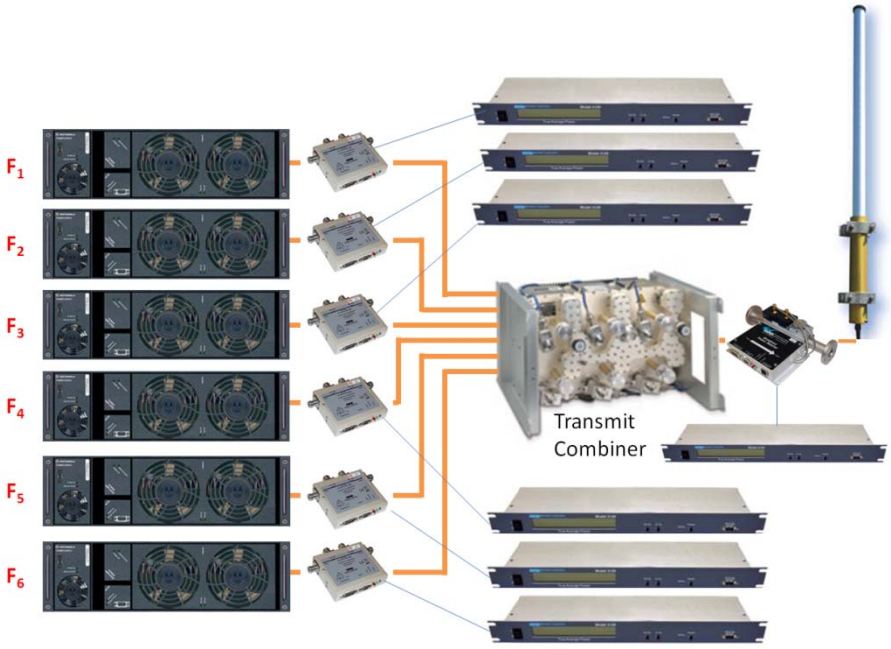


*Figure 2*
*Example Bird monitoring installation*

## Capabilities delivered with sample system in Figure 2

- Combiner input Power monitored for each transmitter
  - Maximum Power
  - Minimum Power
- Output VSWR monitored for transmit antenna
- Contact closure for alarms
- Individual monitoring capabilities of each device with 3129 interface

## Capabilities NOT delivered with sample system

- Combiner output power
- Individual channel power delivered to transmit antenna
- Combiner insertion loss
- Individual channel VSWR for each frequency
- Compact monitoring ability (Requires 7 rack units of display equipment)

**Sample system will cost close to $20k**

## Bird ACM Series Antenna and Cable Monitor


*Figure 3*
*Bird ACM Power Monitor*

The ACM ***(Figure 3)*** is designed to monitor RF Distribution networks and to detect antenna and cable faults while monitoring the forward power from the transmitter. It utilizes True Power detection that can be used with any modulation. Normally utilized for low (Below 500 W) power applications.

### Advantages and capabilities of the ACM

- Measures forward power from 12.5 W to 100 W (500 W model available)
- Measures and alarms on Max power and Min power
- Alarm contact closures available
- Interfaces with 3129 Remote Monitor Interface
- Measures and alarms on VSWR
- Compact design with internal monitoring capabilities
- Measures True Average power

### Disadvantages of ACM

- Monitors single power component
- Cannot distinguish between frequencies
- Limited to Combiner input power for individual frequency measurement
- Cost over $3k for power monitor and display for one channel

## Bird Broadcast Power Monitor (BPM)


*Figure 4*
*Bird BPM Power Monitor*

The BPM ***(Figure 4)*** is sold to monitor high power digital waveforms such as broadcast and digital FM signals. Because the BPM responds to digital waveforms and can monitor very high power levels, it is being used to measure the output power of a combiner. The BPM will interface with contact closures for alarms and Ethernet interface for dedicated software. Interface with 3129 Remote Monitor Panel is required for remote display.

### Advantages and capabilities of the BPM

- Measures forward power from 250 W to 1 kW
- Ethernet interface
- Interfaces with 3129 Remote Monitor interface
- Measures True Average power
- Measures and alarms on Max power and Min power
- Measures and alarms on VSWR
- Alarm contact closures available
- Compact design with internal monitoring capabilities

### Disadvantages of BPM

- Monitors single power component
- Cannot distinguish between composite power and single frequency power
- Cannot distinguish between frequencies
- Limited to Combiner input power for individual frequency measurement
- Requires one for each transmit network (Antenna)
- Will not perform Maximum and Minimum alarming on multicarrier systems
- Measures VSWR at the combiner not the antenna
- Cost over $6k for power monitor and display for one channel

## Bird PCTool Software interface

Bird offers a software interface to display information collected in either the BPM or ACM power monitor. This allows the user a convenient method to display data on one screen. The major disadvantage of this technique is that it only displays the information associated with one power monitor.

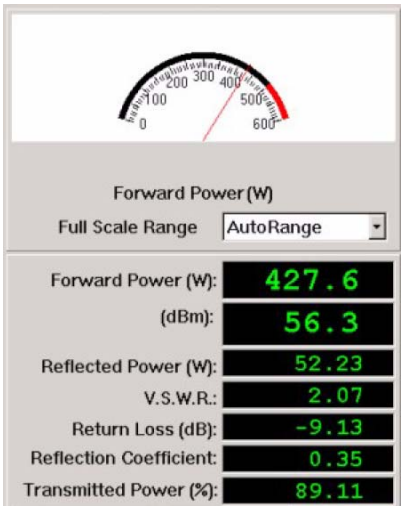


*Figure 5*
*Sample display from PCTool Software*

## Bird 3129 Remote Monitor Interface


*Figure 6*
*Bird 3129 Remote Monitor Interface*

The Bird 3129 Remote Monitor interface ***(Figure 6)*** is designed to allow a direct on-site monitoring interface of one power monitoring device. The 3129 will interface with either the ACM or BPM. One 3129 will be needed for each power monitor device in the system.

# RFI Advanced Power Monitoring Systems and Accessories

## Sample System Design utilizing RFI power monitoring components *(Figure 7)*

The **Advanced Power Monitor (APM)** was developed exclusively for Motorola Solutions and provides the latest technology required for individual channel power monitoring. The major difference in the APM and other power monitoring products is how it measures the power. The APM evaluates and measures power by frequency. It breaks the composite RF signal into its individual frequency components before measuring the True Average power. This technique allows each frequency or channel power to be monitored. Alarming the output power level on a channel by channel basis is possible with this technique and provides confidence in the actual delivered power to the antenna. Monitoring transmit forward power after the combiner while monitoring antenna VSWR provides an accurate understanding of the power delivered to the antenna for system coverage. This technique takes the uncertainty out of the transmit system operation. Additionally, by accounting for feedline loss, the APM is capable of displaying VSWR and Return Loss at the base of the antenna rather than just at the output of the combiner.

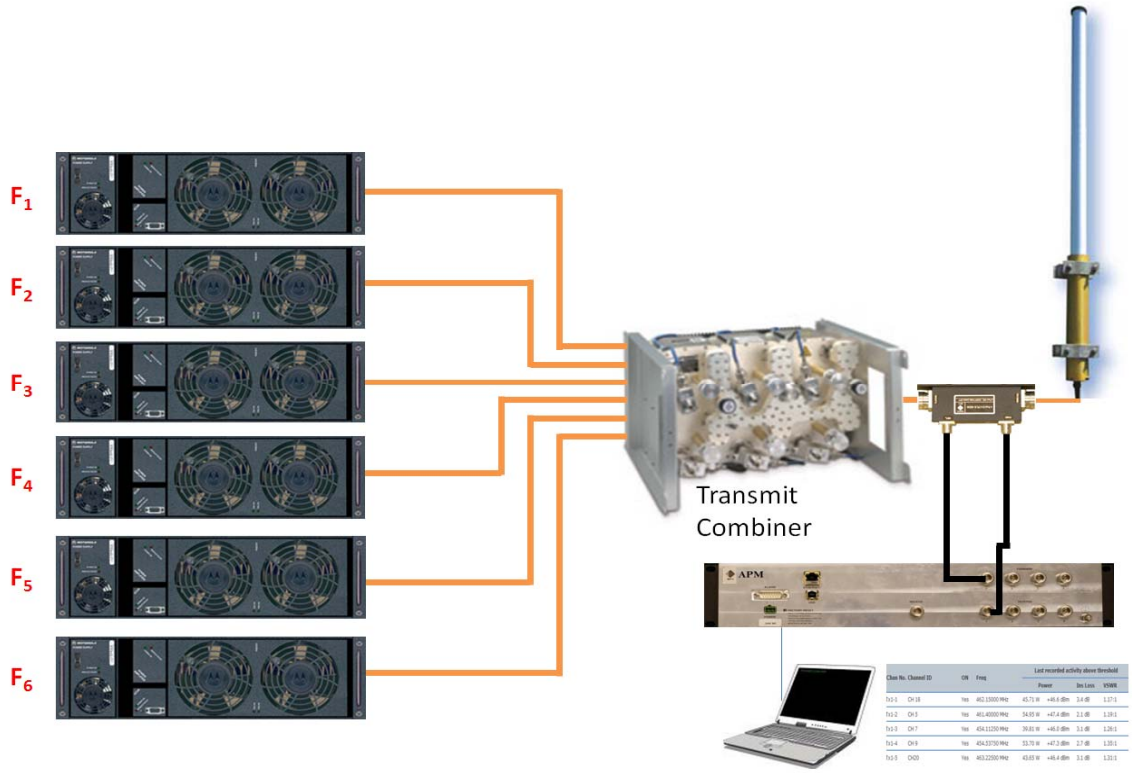


*Figure 7*
*RFI Advanced Power Monitoring System*

### Capabilities delivered by RFI APM with sample system in Figure 7

- Minimal hardware required (1 APM panel)
- Expandable to 4 antenna networks
- Combiner output Power monitored for each transmitter
  - Individual channel Maximum Power
  - Individual channel Minimum Power
  - Individual channel Output VSWR monitored for transmit antenna
  - Combiner Insertion Loss
- Contact closure for alarms (capable of individual channel alarm)
- Histogram for power history analysis over time
- GUI interface with Web Browser (No external software required)
- Alarm history file download

APM Sample system **(Figure 7)** will cost approximately 1/3rd of the Bird sample system **(Figure 2)**

## Operation of the APM *(Figure 8)*

The APM evaluates each frequency and accurately determines the True Average power for each frequency. This is used to evaluate the alarm thresholds and establish the alarm state of Maximum, Minimum, and VSWR for each frequency. Additionally, by comparing the input combiner power to the measured power, the combiner insertion loss can be evaluated and monitored. This level of analysis cannot be accomplished with any other power monitor.

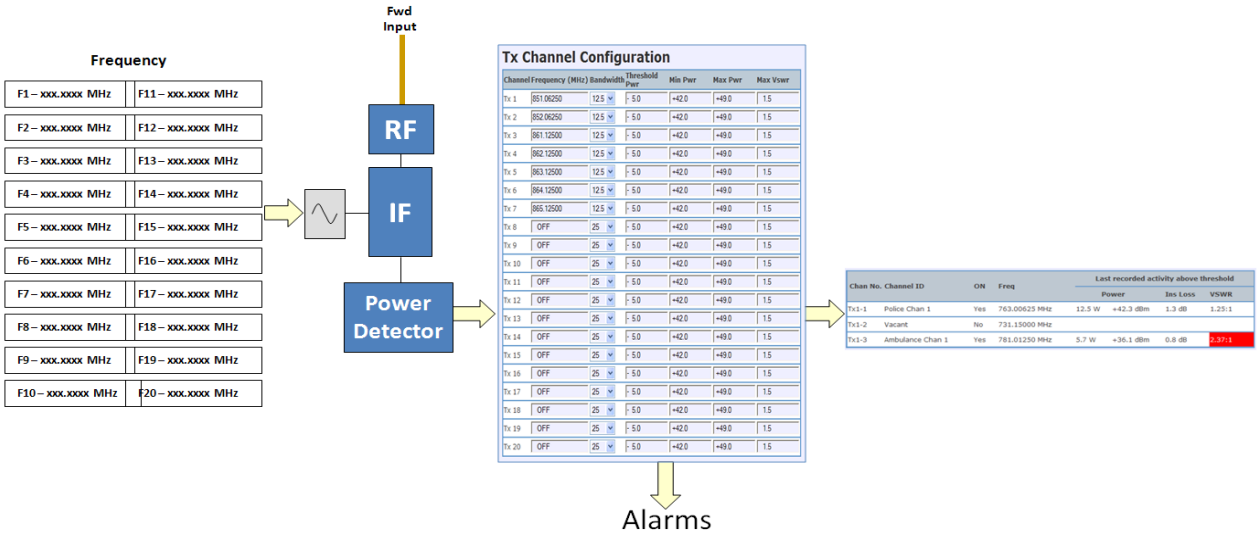


*Figure 8*
*APM Operation*

## Directional Coupler *(Figure 9)*

The directional Coupler is the heart of the APM. The directional coupler provides 40 dB of coupling to the forward port while maintaining over 65 dB of directivity on the reverse port. This allows sampling the forward signal while maintaining isolation between the forward power and reflected power. The reflected power is used to measure the VSWR of the antenna.

*Figure 9*
*APM Operation*

## Advanced Power Monitor (APM)

*Figure 10*
*APM Panel*

The APM panel performs the individual frequency analysis to establish the power for each channel. One APM panel can accommodate up to 4 different antenna networks with only a directional coupler for each additional network required. Development is underway to provide an on-site real-time display for the APM. This development is aimed at reducing the number of display devices. Having a cluttered rack of displays is a distraction. The real-time display for the APM will provide a compact display that will allow anyone on site to fully understand the system operation. The basic APM cost is approximately $5k.

## Summary

Most of the current products utilize True Average power monitoring. These are very accurate when utilized on a single frequency but not on a multicarrier signal. True Average power monitors respond to the composite signal as if the signal was a single carrier. Even though the signal may have several frequencies, the indicated power is the composite of the signals. Monitoring composite power will not allow validation of actual channel power delivered to the antenna for coverage. Unless the individual channel power is known, the only way the composite power meter can be used is to take the system down and measure each channel individually. Operationally this does not provide any benefits. In Land Mobile Radio (LMR) systems, the primary concern is the actual power per channel delivered to the antenna. The Advanced Power Monitor (APM) is the only product capable of performing this analysis without interrupting the operation of the system. VSWR measurement at the combiner provides some resolution of operation, but actual VSWR and Return Loss (RL) at the antenna is better. Knowing the VSWR by frequency at the antenna allows a full understanding of antenna operation. Since the purpose of the antenna is to radiate the individual carriers, it seems logical that measurement of that ability for each channel provides an improved understanding of system operation. Not only do the customers want indications that the power is being delivered to the antenna properly, but also that the RF network is performing properly. Combiner tuning has always been an "As Needed" test and required the system to be removed from operation during the test. The APM allows tuning and monitoring of combiner performance in a non-intrusive manner. Not disturbing the system operation and allowing the user's continuous operation is vital to good system performance. The APM is the clear choice for power monitoring on vital systems. Instead of requiring multiple units such as the ACM before the combiner, only one APM is required. Because of the methodology used by the APM to capture power data, a single panel can monitor all frequencies in one or multiple antenna networks. This significantly reduces the cost of monitoring by as much as 70% or more per site.

## More information is available on the Compass site:

Manual:
http://www.rfi-motorola.com/Portals/RFI-Motorola/Docs/APM/UsersManualAPMxxxxSeries205.pdf

Design Guide:
http://www.rfi-motorola.com/Portals/RFI-Motorola/Docs/APM/DesignGuideAPMxxxxSeries20.pdf

Marketing Sheet
http://www.rfi-motorola.com/Portals/RFI-Motorola/Docs/APM/APM.pdf

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