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Application Note

Remote Health Monitoring for Air Traffic Control RADAR

This Application Note describes persistent health monitoring and diagnostic solutions for remote Air Traffic Control (ATC) assets, including RADAR, navigational aids and communications facilities. Opportunities to reduce risk of failure, downtime, and operational costs are highlighted.

Civilian and military Air Traffic Control (ATC) systems depend upon continuous performance of remote RADAR installations, navigation aids, and communications facilities. Typically lacking on-site engineers, and with a long service supply chain, they are at risk of surprise failure, extended downtime and high preventative maintenance and failure recovery costs. In particular:

- Remote ATC facilities of all kinds are susceptible to unmonitored grid power quality variations, and outages
- Rotating antenna RADAR systems are susceptible to unmonitored environmental and mechanical degradation
- On-time preventative maintenance (PM) is expensive and inefficient, lacking leading indicator data to optimize PM and part replacement intervals, and to preplan parts logistics
- On-site failure investigation, lacking expert remote fault isolation in advance, can result in increased downtime and cost.

Figure 1: ATC RADAR scanner

- Backup power and UPS systems add an additional layer of operational risk, and are typically un-monitored
- Lack of centralized expert oversight impacts both service cost, system reliability, and fleet management efficiency

The generic requirements for managing remote installations, such as ATC facilities, are:

- Fleet power and critical system operational status is centrally visible at all times
- Event and trend data to generate immediate actionable alerts
- Leading indicator sensors to enable fault avoidance and postponement, and for PM planning

- Comprehensive data and event capture to accelerate failure root cause analysis and recovery planning
- Simple installation, versatile configuration, and global network integration
- Field-proven solutions and partners

Fortunately, there is a tried and tested solution for these requirements, which has been deployed for diverse mission-critical global monitoring applications including ATC RADAR facilities.

Powersides PQube 3: a field-proven solution for ATC Facility Monitoring

PQube 3, figure 2, is a versatile monitoring solution for power quality, load metering, and sensor telemetry, whose key characteristics include:

- Up to 14 AC source/load channels monitored by a single device
- Synchronized data capture across channels for unambiguous cause and effect determination
- Comprehensive power quality analysis per IEC 61000-4-30 Ed3 Class A
- Optional application-specific sensor modules: multi-axis vibration, pressure, temperature, humidity, fluid level, facility intrusion
- 4 AC or DC custom sensor channels per unit, with options for more
- Event triggers with programmable thresholds
- Immediate alert transmission and actionable data: e.g. waveforms, switching transients, power instability
- Daily, weekly and monthly trend reports on key power indicators, and on alerts: e.g. power, voltage, current, transients, outages, harmonics, emissions, imbalance etc.
- Multi-channel load metering per ANSI C 12.20 0.2%
- A range of backhaul solutions and protocols: ethernet, modem, Modbus, email, IOT
- Robust data security protocols
- Optional UPS modules to ensure critical data is captured and transmitted post-outage

Figure 2: Powerside PQube 3 Power Analyzer module

Powerside customers have deployed 50,000+ PQube 3 systems in a wide range of mission-critical applications.

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ATC RADAR and Facility Monitoring Applications

The typical sensor/analysis suite for monitoring a remote ATC facility can include:

- Grid: Total facility load and comprehensive power quality
- Sub-load (motors, Variable Frequency Drives (VFD), RF, telecommunications, etc.): load and power quality
- Facility: temperature, humidity, intrusion detection
- Genset: output, power quality, fuel level, starter battery voltage/current
- Solar: output, power quality, storage current
- Scanner: gearbox and motor vibration, gearbox lubricant level

Other sensors may be added for specialised applications. These sensors and analytics support four broad use cases, table 1.

Use Case	Supporting Data & Information	Sensors							
		Power Consumption	Subload consumption	Power Quality	Temperature & Humidity	Genset/solar monitoring	Genset fuel, battery I/V	Gearbox vibration	Lubricant level
Operational Oversight "What is happening?"	Real time load, variation, and trends	x	x			x			
	Grid and/or backup feed status	x		x		x			
	Real time failure alerts, signature capture	x	x	x	x	x	x	x	x
	Facility ambient conditions				x				
Failure avoidance "What could go wrong?"	Grid and backup power quality events and trends	x		x		x			
	Documented genset and ATS performance tests	x	x	x	x	x	x		
	Radar scanner vibration and trends							x	
	Radar scanner lubricant level and trend								x
	Motor drive currents and trends		x						
	Genset fuel, battery voltage and charging current					x	x		
Failure recovery "Quick, what is the plan?"	Failure detection and fault isolation	x	x	x	x	x	x	x	x
	Root cause/corrective action plan, fast parts logistics	x	x	x	x	x	x	x	x
Preventative Maintenance "What needs attention, when?"	Remote PM: trend analysis	x	x	x	x	x	x	x	x
	On-condition PM scheduling and parts logistics	x	x	x	x	x	x	x	x

Table 1: Use Cases and Sensors for ATC RADAR and facility monitoring

Operational Oversight answers the most pressing questions for remote facilities; are systems running normally, and are there any immediate threats to normal operation? For the ATC case, the grid and backup power supply status and total load, sub-load, and gearbox vibration are primary indicators of normal operation. Genset output, fuel level and battery charge status, or solar output, indicate

readiness for grid-fail contingencies. Real-time failure alerts provide immediate actionable information direct to headquarters in case of failure or impending failure.

Failure avoidance is a key use case for ATC facility monitoring, given the number of potential failure modes. First, the integrity and quality of the local power supply is of over-riding concern. PQube 3 supports a comprehensive range of power quality analytics, capturing long term trends as well as transient events, such as lightning strikes, arcing, sags and swells, imbalances, frequency deviations, etc.. In managing a local utility, as in maintaining backup power capability, the availability of incontrovertible cause and effect data, including event waveforms and trends, is fundamental to driving durable improvement.

Second, Gensets and their associated automatic transfer switches are a common reliability problem, since they sit idle for extended periods and may fail to start, or to deliver quality power, during an outage. Whilst periodic test is a normal precaution, in-depth data capture and documentation of each test is critical to ensuring that rigorous procedures (e.g. test duration, temperature, at-load) are followed. Capture of transient phenomena (startup, ATS performance, frequency stability) is also critical to ensuring reliable operation, and for directing fault recovery if necessary.

A third category in failure avoidance is the RADAR scanner mechanism itself. In a PQube installation, precision vibration sensors are used to monitor the scanner gearbox and drive motors, and the main bearing and the support structure, figure 3. Together with gearbox lubricant level, temperature sensors, and motor drive voltage and current monitors, these provide not just a status snapshot, but leading indicators of system degradation and wear. Accelerated change in sensor readings away from baseline can provide a clear indication of the need for preventive maintenance.

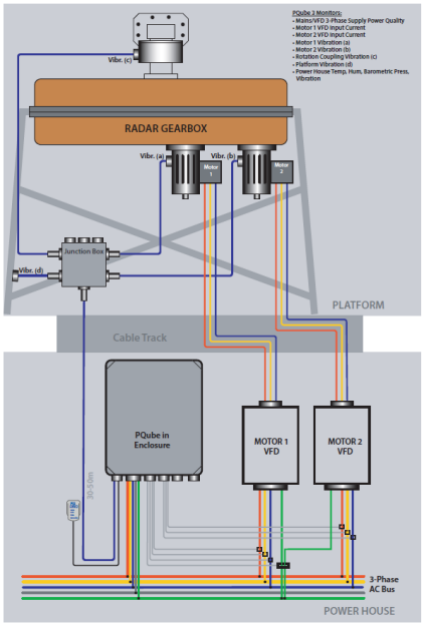

Figure 3: Motor drive and vibration sensors for RADAR scanners

Failure recovery is generally slow and costly for unmonitored remote installations. This is because root cause investigation can't begin until an expert engineer is on-site, which may take hours or even days. Further, lack of a clear signature of failure, or trend data, will delay root cause analysis and, in the worst case, faults may not be identified or corrected at all, leading to repeat failures. Finally, the right replacement parts, once identified, may take time to arrive, resulting in overall extended downtime and high costs. The situation can be contrasted with a remote monitored system, where fault isolation, root cause determination, resource scheduling, and parts logistics can commence just as soon as the failure is identified. Even if an on-site visit is required to confirm the diagnosis, the engineer arrives with a clear picture of what may be at fault, and what is known not to be at fault, and appropriate replacement parts; thus, the recovery process is considerably accelerated.

Time-based Preventative Maintenance (PM) for un-monitored remote facilities can be inefficient and costly. Whilst low cost consumables, such as air filters, predictably need periodic replacement, more expensive components may wear at rates dependent on utilization as well as temperature and other factors. Remote analysis of trend and utilization data (e.g. hours run at temperature) enables optimum on-condition PM intervals, advanced scheduling and parts logistics, and higher uptime with lower parts and labor costs.

Conclusion

Remote monitoring capability can make a major improvement in the reliability, uptime and cost of service for remote ATC facilities and assets. The right sensor suite can deliver leading indicators of electrical and mechanical failure, enabling optimised on-condition preventative maintenance. Immediate alerts and trend data provide real-time operational oversight, as well as new opportunities for failure avoidance and accelerated failure recovery. Powersides PQube 3 has been field tested and specified for ATC facility and RADAR monitoring.

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