

TECH NOTE

How Intelligent Transmitter Design Can Deliver 1+1 Levels of Performance

A study of the redundancy available on the ECRESO FM 5kW Transmitter



How can Intelligent Design deliver 1+1 levels of performance?

In the development of the latest addition to the ECRESO FM Transmitter range, WorldCast Systems has adopted an innovative new approach to high power transmitter design. Within this new design, redundancy is a key factor and the system has been designed to offer maximum, dedicated redundancy at every stage.

*This paper seeks to detail the various techniques and methodology that make up this intelligent design approach and to outline how they have been incorporated into the new ECRESO FM 5kW Transmitter.**

Standard redundancy methods

Ensuring that your station stays on air when broadcasting is a priority for most broadcasters. Traditionally, there are three different 'back-up' approaches which a broadcaster can adopt; each providing different levels of redundancy and requiring different levels of investment.

Dual Drive

A Dual Drive solution is the least expensive option but only provides redundancy for the exciter stage within the transmitter. For transmitters with enough inherent redundancy on their power amplifier stage, this can provide adequate protection.

N+1

N+1 is an intermediate solution offering a good balance between cost and benefit and perfectly adequate redundancy in the case of a single program failure. On the negative side, there is no protection should two transmitters fail at the same time and, in terms of RF cabling, communication and management, this solution can be extremely complex for the engineer to install, operate and maintain.

1+1

A 1+1 configuration offers the highest level of redundancy using two complete transmitters as main and reserve systems for the same program. However, this is also, clearly, the most expensive solution, as the broadcaster will have to purchase two complete systems comprising transmitter, RF switch, control unit, RF lines and much more. For a high power transmission system, the cost may be completely prohibitive.

While each solution outlined above may meet a broadcaster's expectations of redundancy or fit within their budget, it is unlikely that any one of them can deliver on both criteria. The perfect scenario would be to benefit from the redundancy level afforded by a 1+1 system without the associated cost i.e. only requiring a minimum investment.

This is exactly what we have set out to achieve with the new design approach of the ECRESO FM 5kW.

* All references throughout this paper to the Egreso FM 5kW Transmitter refer to the full redundant system with all options and functionality selected.

How can Intelligent Design deliver 1+1 levels of performance?

New approach to redundancy

Our innovative new approach delivers redundancy that is “as solid as a 1+1”. It is the result of ECRESO’s 60 years’ experience in the field of RF design and is inspired by similar concepts within other mission-critical industrial applications.

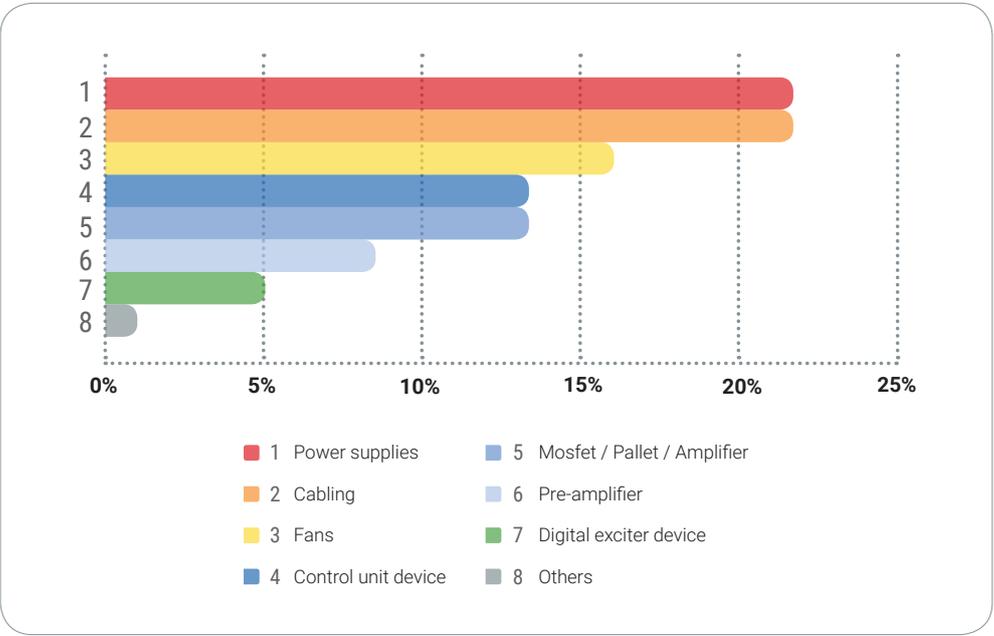
The premise of the approach is that, instead of requiring two complete and independent transmitters and switching between them if a failure occurs (usually a -3dB alarm), redundancy can, and should, be an intrinsic part of the transmitter design itself. With this approach, each critical constituent part has its own redundancy and overall, costs are dramatically reduced.

Intelligent design - failure analysis & research

As with all development, the research & development phase provides critical information that feeds into the design process. Intelligent Transmitter Design requires that every single part of the transmitter must be analyzed to assess the probability of failure and the associated impact of such a failure on the RF output power.

Failure ratios and the causes for those failures on FM Transmitters vary greatly depending on manufacturer, designs and environment. However, based on generally accepted statistics and the experience of many broadcasters, we have produced the bar graph below which shows the main causes of failure on FM Transmitters at sites worldwide.

Failure distribution
All failures= 100%



These average statistics do not include external off-air causes such as power losses or antenna issues (VSWR), where the transmitter will protect itself and go off air despite available redundancies.

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Intelligent design-methods

With the knowledge of where failure is most likely to occur, the reasons for those failures and the impact of a failure on the total system, we can then devise methods to reduce the likelihood of failure and minimize or eliminate its effects. Combined, these methods will increase the reliability, redundancy and resilience of the transmitter and, in particular, those parts which directly impact the on-air broadcast.

Below is a non-exhaustive list of the main actions that can be taken and details of how each of these methods are implemented in the new ECRESO FM 5kW to ensure it is "As Solid As a 1+1".

REMOVAL OF SINGLE POINTS OF FAILURE

- **IPA**

Some FM transmitters require an Intermediate Power Amplifier (IPA) after the exciter stage in order to step up the power fed to the main amplifiers. Given its central role within the transmitter, the IPA constitutes a single point of failure and, should a fault occur, it would be catastrophic for the entire system. The new ECRESO FM 5kW has no IPA at all; its power amplifiers are directly fed by the modulation stage thus removing hardware and the risk of complete failure.

- **CABLES**

Within the intelligent design of the ECRESO FM 5kW Transmitter, cables connecting power supplies, power amplifiers, coupler, fans, loads and other elements are replaced by robust and direct hot plug connectors. By doing so, we dramatically reduce the likelihood of errors and mishandling such as incorrect tightening. Overall, the failure rate is reduced and the efficiency is increased.

- **CIRCUITRY**

There are several elements onboard an amplifier module such as cables and capacitors that can introduce the risk of failure. The amplifier of the ECRESO FM 5kW offers a new planar design which means that these critical components are no longer present. In this way, production, maintenance, performance and consistency are improved.

- **CONTROL UNIT**

The ability for the transmitter to continue operating even under failure conditions is a key consideration. In the event of a complete failure of the control unit on the ECRESO FM 5kW, the transmitter stays on-air with its last known parameters.



Control Unit for the ECRESO FM 5kW Transmitter

EXTREME COMPONENT RELIABILITY

As with any equipment, a transmitter is only as robust as its weakest component. It is therefore vital that all parts are thoroughly researched and selected for their durability and resilience.

On the ECRESO FM 5kW

- The RF coupler and the RF filter are large, rugged, and completely passive. They do not include any circuitry or components so it is almost impossible to break these stages, even in the most extreme conditions.

- Where active components are required, only those which meet the highest specification and lifespan criteria have been selected. For the ECRESO FM 5kW Transmitter, several methods have been used to analyze and identify appropriate components. These include the FMEA method (Failure Modes and Effects Analysis), PSA (Part Stress Analysis) and HALT (Highly Accelerated Life Test). These tests enable us to test the extreme operational limits of each component, identify any sensitivity to certain conditions and remove or improve any issues identified.

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ADDED REDUNDANCY AND OVERSIZED MODULES

On the ECRESO FM 5kW Transmitter, all critical modules are redundant and oversized.

- **POWER SUPPLIES**

The ECRESO FM 5kW accommodates from three to four 3500W load-sharing power supplies which provide total power from 10.5kW to 14kW. Bear in mind that less than 6.75kW are required in order to broadcast at 5kW output power so you can see there is substantial headroom. All power supplies are used in parallel and at reduced power to ensure maximum redundancy and increased lifespan.

- **POWER AMPLIFIERS**

The ECRESO FM 5kW utilizes three 2100W power amplifiers which is significantly more than is required to deliver 5kW of power. By providing three 2100W (6 MOSFETS in total), we ensure that each amplifier has sufficient headroom and is working at reduced power. In this way, component heat is reduced and the redundancy and lifespan of the transmitter increases.

- **COUPLING LOAD**

A surefire test of the redundancy of an FM transmitter is how it handles power unbalances, especially extreme unbalances, at the coupler input. The coupling load module and associated cooling on ECRESO FM 5kW have been designed in such a way to not only professionally manage these unbalances but to do so for an unlimited period of time and with maximum available output power. This is in contrast to some other transmitters who place time constraints on their ability to manage an unbalanced situation.

- **COOLING**

In order to cool the ECRESO FM 5kW, one inlet fan and one outlet fan powered by a single PSU is all that is required. However, the system, with its "as solid as a 1+1" intelligent design, instead includes four fans and two power supplies for total redundancy. The fans operate at half speed, again to increase the lifespan of these components. They are cross-fed by the two power supplies to ensure that the cooling system benefits from full 1+1 redundancy.

- **DIGITAL EXCITER**

The Digital Exciter which is at the heart of the ECRESO FM 5kW is based on the design of the well-respected ECRESO FM 100W. Two complete and independent 100W devices work in dual drive mode to offer full redundancy at this stage of the transmitter.



ECRESO Digital Exciter

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So, with the key points of failure removed, components selected for extreme reliability and a surfeit of redundancy and power, the design of the ECRESO FM 5kW is set to deliver unparalleled redundancy.

However, it is not the theoretical results but the actual performance of the system that really counts. So, let's see if the ECRESO FM 5kW really delivers performance that is "as solid as a 1+1" in practice.

From theory to practice

Given that our aim was to design an FM Transmitter that is "as solid as a 1+1", it is natural that we should compare the results of the ECRESO FM 5kW against those of a traditional 1+1 system.

We performed failure tests that compare our new redundancy concept with a traditional 1+1 system and the following table shows the typical output power delivered on each system under various fault conditions.

Redundancy comparison

Failure	Traditional 1+1	ECRESO FM 5kW
1 PSU	5kW (Switched)	5kW
1 Mosfet	4kW	5kW
1 PA	5kW (Switched)	2.7kW
Exciter	5kW (Switched)	5kW
Control Unit	5kW (Switched)	5kW
Output RF Switch	0kW	5kW (not present)
Other	unknown	unknown

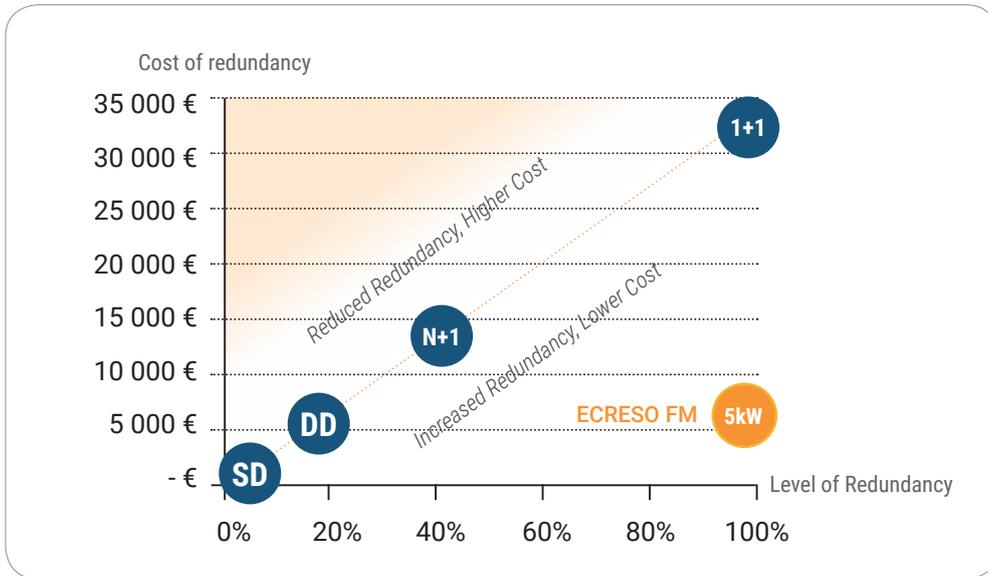
The traditional 1+1 system used in this test is that of a well-known manufacturer, using 1x5kW amplifier and 1 main power supply. The 1+1 switching occurs on -3dB criteria. Nominal output power: 5kW.

Performing the same comparison with a traditional N+1 system, provides results which are much the same as above in the case of single transmitter failures, but significantly worse than a 1+1 when failures occur on several transmitters. In addition, the redundancy benefits of the system always need to be evaluated together with the costs of acquiring that redundancy.

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Let's examine an example of a station running 3 programs. In the graph below we have plotted the typical redundancy level (0 if no redundancy and 100 for perfect redundancy) with the average purchasing cost of that level of redundancy together with any reserve transmitters and switching systems required.

The graph clearly illustrates that the cost/benefit ratio of the ECRESO FM 5kW makes it the most economical and professional proposition on the market.



Based on average estimates

Benefits

So far, we have established that our new approach to redundancy offers performance that is analogous to that of a full 1+1 system for considerably less cost but let's look more in detail at the other benefits.

Cost savings

Looking first at the initial purchase price, we can see that the ECRESO FM 5kW solution is on average 65% less expensive than a traditional 1+1 solution and 30% less expensive than a traditional 3+1 system. Given that the 5kW is a single system in a single rack, savings can also be made on packaging and transport costs with costs reduced by up to 50%. It is also worth noting that fewer spare parts will be required for maintenance.

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Overall, when compared to a full 1+1 system, there are significant savings to be made on the initial purchase price. However, purchase price is not the only consideration. There are other areas where savings and efficiencies can be made:

Reduced Space

Traditional 1+1 solutions include two complete transmitters, a switching system and possibly a dummy load. The ECRESO FM 5kW occupies a single 29U cabinet with a 600x1000mm footprint, meaning that space savings of up to 50% can be achieved.

Easier installation & maintenance

Traditional 1+1 and N+1 solutions are comprised of many different hardware and software elements. With their additional rigid lines, RF switches, dummy loads, cabling and control unit, they can be incredibly challenging to install, configure and maintain.

With the ECRESO FM 5kW there is only one transmitter to manage so configuration is easier, especially with our intuitive graphical Web GUI. There is no need to configure 1+1 or N+1 switching rules and, with only one transmitter and fewer peripherals, monitoring and maintenance are also much simpler.

Higher efficiency

By removing the requirement for RF lines and reserve transmitters in this intelligent design approach, RF losses and electrical consumption are reduced. As a result, we see that the overall efficiency of the ECRESO FM 5kW is increased, which in turn has a direct (and positive!) impact on the total cost of ownership.

Higher redundancy

Compared to traditional N+1 systems where 3 or 4 programs are broadcast at the same site, you can achieve much greater levels of redundancy with the ECRESO FM 5kW.

It is entirely possible for several transmitters to suffer simultaneous faults and an N+1 solution will not be able to provide back-up to multiple transmitters at the same time. With the ECRESO FM 5kW, each transmitter and therefore each station has its own, dedicated redundancy for ultimate peace of mind.

Summary

Throughout this paper, we have outlined how the intelligent design of the ECRESO FM 5kW can deliver the redundancy and performance of a full 1+1 system for a much reduced initial investment and a lower Total Cost of Ownership. Such is our level of confidence in the performance and innovative design of the ECRESO FM 5kW that we offer a warranty of up to 10 years on the system; a guarantee that is without parallel in today's transmitter market.



Contact us for further information about our new high power range and redundancy solutions.



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