SIGNAL / RF + MICROWAVE JOURNAL

2026 / ISSUE 02

IMPULSE TECHNOLOGIES INC.
AN INTERNATIONAL COMPANY

SIGNAL

POWER / LOSS / MISMATCH / HEAT / RADIATION

EVERY dB GOES SOMEWHERE.

A field guide to the real RF signal path

INSIDE THE POWER BUDGET

OPENING ESSAY

LOSS IS NOT AN ABSTRACTION.

A signal path never loses power in the abstract. Energy is reflected, dissipated, divided, leaked, converted, radiated or absorbed. The arithmetic is compact; the consequences are physical.

The useful question is not simply how many decibels disappeared. It is where the energy went, whether the hardware can tolerate that destination, and whether the system still has enough margin to do its job.

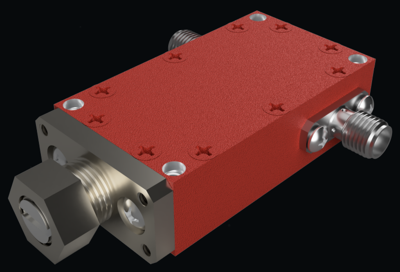
That is why a line item as ordinary as insertion loss can become a thermal problem, a range problem, a calibration problem or a procurement problem. The specification must connect the number to the operating condition.

This issue follows power from source to aperture, then back through the receiver and the measurement bench. Along the way we separate ratios from absolute levels, mismatch from dissipation, and nominal performance from released hardware.

-3 dB

APPROXIMATELY HALF POWER

A ratio. Not an absolute level.



REFLECT	DISSIPATE	DELIVER
MISMATCH	HEAT	LOAD

FOLLOW THE ENERGY - THEN WRITE THE CONDITION.

The magazine begins with the system, not with an isolated product card.

ISSUE 02

THE POWER PATH

20 PAGES / ONE CONNECTED SYSTEM

PLUS: MEASUREMENT / INDUSTRY RADAR / RF PRIMER

FROM THE EDITOR

A NUMBER BECOMES A REQUIREMENT.

"Conditions are part of the value."

An insertion-loss number without frequency, temperature, power, connector state and measurement reference plane is not yet a usable requirement. It is a fragment.

Good RF work turns fragments into an operating envelope. It asks what the source delivers, what the load accepts, what the interfaces remove, what the passive hardware must dissipate, and what the receiver can still resolve.

The same discipline should shape a magazine. The pages that follow are not isolated product cards. They are a continuous engineering argument, moving from units to physics to hardware to verification.

Impulse Technologies has built RF and microwave components in Bay Shore, New York since 1991. That experience belongs inside the larger system story: phase, level, transition and radiation are linked decisions, not separate boxes.

Use this issue as a working field guide. Mark the equations. Challenge the assumptions. When a value matters, attach its conditions before it enters a drawing, a purchase order or a test plan.

EDITORIAL RULE / 02

dB

IS A RATIO

dBm IS A LEVEL

WATTS ARE POWER

Do not let one unit stand in for another. Translate deliberately, then preserve the reference condition.

SIGNAL EDITORIAL / 2026

SYSTEM VIEW

EVERY dB GOES SOMEWHERE.

Power leaves a source with an address. The system decides whether it reaches the load, returns to the source, warms a passive device, divides across branches or escapes through an aperture.

A complete budget is a map of those destinations. It adds gain and loss in logarithmic form, then checks the physical limits in linear units: watts, temperature, voltage, current and field strength.

The map must also include frequency and state. A cable may be benign at one band and dominant at another. A passive component may meet a small-signal loss target but fail a power or thermal requirement. A mismatch may be acceptable at the receiver and dangerous near a transmitter.

The engineering advantage comes from following the same power through the entire chain. Local choices become visible as system consequences, and margin stops being a number hidden at the bottom of a spreadsheet.

THE COVER STORY STARTS WITH UNITS - AND ENDS WITH RELEASED HARDWARE.

RF POWER LANGUAGE

POWER HAS A LANGUAGE.

RATIOS / LEVELS / LINEAR POWER

dB

10 log10(P2 / P1)

A dimensionless power ratio. It says how much changed, not the absolute power.

dBm

10 log10(PmW)

An absolute power level referenced to one milliwatt.

W

10^((dBm - 30) / 10)

Linear power. Use it for dissipation, heating and hardware limits.

THE 10 dB LADDER

1 W 30 dBm	+1	10 W 40 dBm	+1	100 W 50 dBm	+1	1 kW 60 dBm

Use decibels to add gains and losses along a chain. Return to watts whenever the question is physical: device dissipation, source capability, thermal rise or safety margin.

A 3 dB change is approximately a factor of two in power. A 10 dB change is exactly a factor of ten. The sign tells direction: gain is positive; loss is commonly entered as negative in a running sum or as a positive magnitude in a loss table.

Do not mix amplitude and power formulas. For voltage ratios, 20 log10 applies only when the compared impedances are the same. State the reference and preserve the units.

REFLECTED POWER

THE POWER THAT COMES BACK.

Mismatch is not insertion loss. It is the part of incident power that the load does not accept at the reference plane.

INCIDENT POWER

LOAD

REFLECTED POWER

ACCEPTED FRACTION

1 - |GAMMA|^2

At the same reference plane

01 **REFLECTION COEFFICIENT**

`Gamma = (ZL - Z0) / (ZL + Z0)`

02 **RETURN LOSS**

`RL = -20 log10 |Gamma|`

03 **VSWR**

`VSWR = (1 + |Gamma|) / (1 - |Gamma|)`

Return loss describes mismatch; dissipative loss describes energy converted inside the component or path. A measured transmission result can contain both effects unless the reference planes and error terms are controlled.

Near a transmitter, reflected power can change device stress and delivered output. Near a sensitive receiver, the same numerical mismatch may be tolerable. Context sets the limit.

DISSIPATED POWER

ATTENUATION BECOMES HEAT.

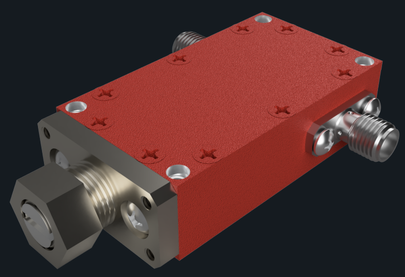
For a matched passive attenuator, the ideal first check is simple: subtract output power from input power in linear units. The difference must go somewhere, and much of it becomes heat inside the device.

ENERGY BALANCE / MATCHED FIRST CHECK

$$P\_DISS = P\_IN - P\_OUT$$

CALCULATE IN WATTS, NOT dB

The result is only the beginning. Real hardware adds mismatch, conductor loss, mounting, airflow, duty cycle, ambient temperature and peak behavior.



THE THERMAL QUESTIONS

01 AVERAGE OR PEAK?

02 CW OR PULSED?

03 WHAT DUTY CYCLE?

04 WHAT AMBIENT?

05 HOW IS IT MOUNTED?

Verify the approved model-specific datasheet and operating conditions before release. A nominal attenuation value is not a thermal rating.

RATING = VALUE + CONDITIONS

Power / waveform / mismatch / environment

TRANSITIONS

THE INTERFACES OWN THE MARGIN.

A system can contain excellent active and passive devices and still lose the budget at the joints. Cable length, connector condition, launch geometry and transmission-mode transitions all accumulate.

01 **CABLE**

Loss rises with frequency and length. Bend, routing and temperature matter.

02 **CONNECTOR**

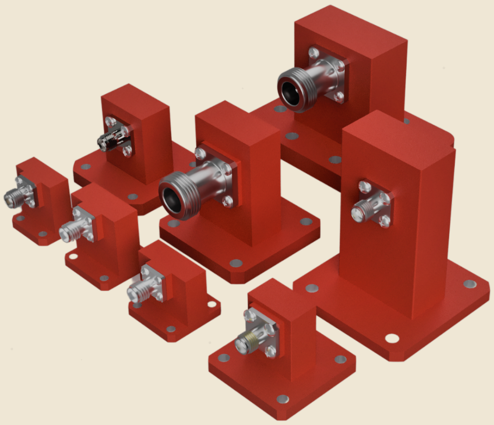
Torque, cleanliness, wear and repeatability change the reference plane.

03 **ADAPTER**

Every added interface introduces mismatch and transmission loss.

04 **MODE TRANSITION**

Coax-to-waveguide geometry must launch the intended field structure.



IMPULSE WG-COAX ADAPTER HARDWARE

Transparent product cutout / representative configuration / not to scale

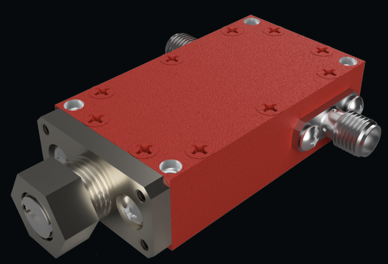
INTERFACE LOSS REGISTER

SEGMENT	STATE / LENGTH	IL	RL
01 TEST CABLE	installed routing	___ dB	___ dB
02 CONNECTOR	clean / torqued	___ dB	___ dB
03 ADAPTER	model + orientation	___ dB	___ dB
04 TRANSITION	band + mode	___ dB	___ dB

INSIDE THE CHAIN

SET LEVEL. SET PHASE. ROUTE WITH INTENT.

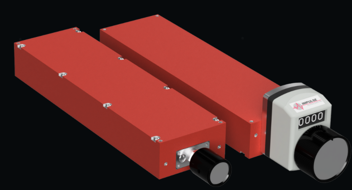
01 / LEVEL



VARIABLE ATTENUATION

CONTINUOUS LEVEL CONTROL

02 / PHASE



PHASE CONTROL

MECHANICAL PHASE POSITIONING

Level control protects receivers, establishes test conditions and balances branches. A continuously variable attenuator is useful when the operating point must be set between discrete values.

Phase control aligns paths in feed networks, simulation systems, phased arrays and test fixtures. Electrical length, frequency and temperature define what a phase number means.

Dividers, combiners, hybrids and directional couplers distribute or sample power. The budget must track every port, isolation term and termination state - including the energy that is intentionally sent away from the main path.

Product photography supplied by Impulse Technologies. Verify model-specific data before release.

PASSIVES + PROTECTION

PASSIVE DOES NOT MEAN LOW RISK.

At high power, the quiet parts of a signal chain become the boundary conditions: peak voltage, average heating, contact current, multipaction risk, breakdown, arc paths and termination capability.

01	02	03	04	05	06
SOURCE	CONTROL	ROUTE	TRANSITION	RADIATE	MEASURE
available power	level + phase	split + switch	cable + guide	gain + pattern	traceable result

FIVE CHECKS BEFORE THE POWER NUMBER IS REAL

01	WAVEFORM	CW, pulse width, repetition rate and crest factor.
02	ENVIRONMENT	Ambient, altitude or vacuum, airflow and mounting.
03	MISMATCH	Load condition and the reflected-power case.
04	INTERFACE	Connector family, waveguide band, torque and transition.
05	FAILURE MODE	Heating, voltage breakdown, current crowding or arcing.

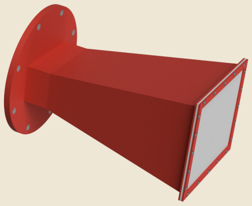
RELEASE RULE A POWER RATING IS VALID ONLY WITH ITS TEST AND OPERATING CONDITIONS.

Use approved model-specific documentation for final design and procurement.

APERTURE

THE APERTURE FINISHES THE ARGUMENT.

The antenna converts guided power into a spatial distribution. Gain, beamwidth, polarization, sidelobes and pointing determine which part of that power reaches the intended direction.



GAIN HORN

KNOWN RADIATION GEOMETRY

EIRP = TRANSMITTER POWER - FEED LOSS + ANTENNA GAIN

All terms in compatible logarithmic units; state the polarization and pointing assumptions.

Gain does not create power. It describes directional concentration relative to a reference radiator. Beam shape decides where that concentration exists.

Feed loss reduces the power available to the aperture. Pointing error, polarization mismatch and radome loss can remove additional margin after the nominal antenna gain is applied.

For test antennas and gain horns, preserve distance, alignment, polarization and reference-plane definitions. A photograph cannot establish electrical performance; approved data and calibration do.

OUT AND BACK

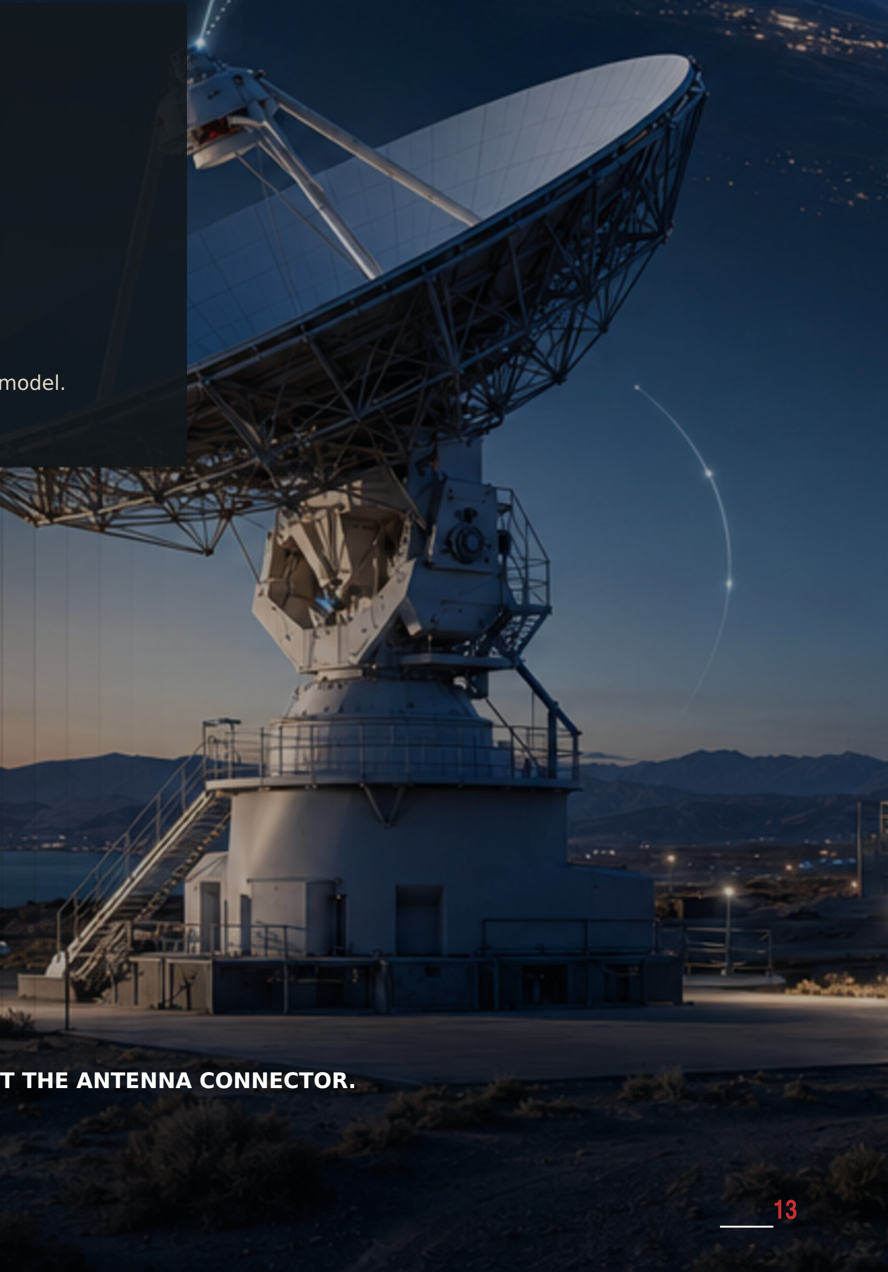
RADAR PAYS FOR RANGE TWICE.

The transmitted wave spreads on the way to the target. The scattered return spreads again on the way back. In the ideal monostatic radar equation, received power therefore carries a 1/R^4 dependence.

SIMPLIFIED MONOSTATIC FORM

$$P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4 L}$$

Use the form, units and loss terms defined by the program model.



01	**TRANSMIT**	Pt, waveform, feed loss
02	**APERTURE**	gain, polarization, pointing
03	**TARGET**	radar cross section and aspect
04	**RECEIVE**	noise, bandwidth, processing

THE BUDGET MUST CLOSE AT THE DETECTOR - NOT AT THE ANTENNA CONNECTOR.

ONE-WAY BUDGET

THE LINK BUDGET IS A CONTRACT.

A link budget is a traceable agreement between transmitter, path,

$$P_r = P_t + G_t - L_t - L_{path} + G_r - L_r$$

LOGARITHMIC FORM / ADD GAINS / SUBTRACT LOSSES

01		02		03		04		05		06
TRANSMIT	+	TX GAIN	-	FEED LOSS	-	PATH	+	RX GAIN	-	RX LOSS
P_t		G_t		L_t		L_{path}		G_r		L_r

THE TERMS THAT GET FORGOTTEN

Pointing loss, polarization mismatch, radome or atmospheric loss, implementation loss and aging margin often determine whether a nominally positive budget survives operation.

Receiver sensitivity is not a universal endpoint. Noise temperature, bandwidth, modulation, coding, required error rate and implementation determine the usable threshold.

NASA small-spacecraft guidance treats communications as a complete subsystem trade: spectrum, ground segment, antenna, data rate, orbit and operations are linked choices.

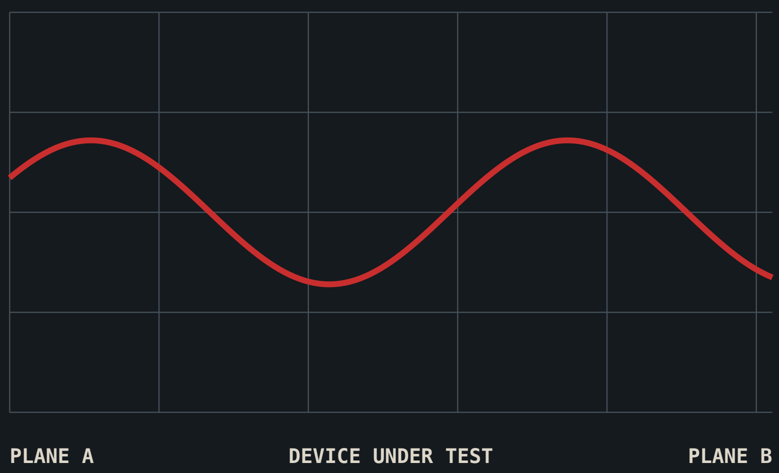
CLOSE THE BUDGET IN BOTH NOMINAL AND WORST-CREDIBLE CONDITIONS.

TRACEABILITY

THE REFERENCE PLANE IS REAL.

A measurement begins where the calibration says it begins. Cables, adapters, fixtures, drift and connector repeatability live between the instrument and the device unless the method removes or includes them deliberately.

MEASURED RESPONSE / CONTROLLED PLANES



A RELEASED RESULT NEEDS

- 01 CALIBRATION STATE
- 02 REFERENCE PLANE
- 03 FREQUENCY + POWER
- 04 TEMPERATURE + STATE
- 05 UNCERTAINTY
- 06 PASS / FAIL RULE

NIST traceable RF power procedures emphasize comparison, calibration factors and uncertainty. A value without an uncertainty statement and method is not the whole result.

Repeatability is evidence. Reconnect the device, preserve the setup state and confirm that the result survives ordinary handling. One perfect trace is not enough.

01 CALIBRATE — 02 CONNECT — 03 STABILIZE — 04 MEASURE — 05 RECONNECT

RELEASE BLOCK

WRITE A REQUIREMENT THAT CAN BE BUILT.

The fastest RF procurement cycle begins with an operating envelope, not a part-family name. Give engineering enough context to select, verify or

01	FUNCTION	attenuate / phase / divide / couple / transition / radiate
02	FREQUENCY	band, tuning range and out-of-band expectations
03	RF LEVEL	average, peak, duty cycle, waveform and mismatch
04	PERFORMANCE	loss, flatness, VSWR, isolation, accuracy and phase
05	INTERFACES	connector or waveguide, sex, orientation and envelope
06	ENVIRONMENT	temperature, vibration, altitude or vacuum, humidity
07	VERIFICATION	test method, reference planes, uncertainty, acceptance
08	DELIVERY	quantity, schedule, documentation and configuration control

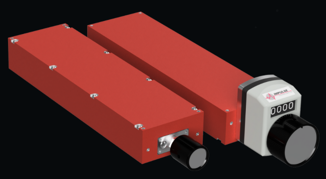
DO NOT COPY A TYPICAL VALUE INTO A GUARANTEED REQUIREMENT.

Define the acceptance condition and the document that controls it.

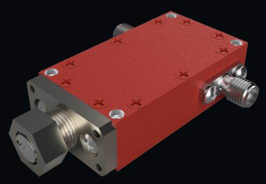
MADE IN BAY SHORE

CONTROL. TRANSITION. RADIATION.

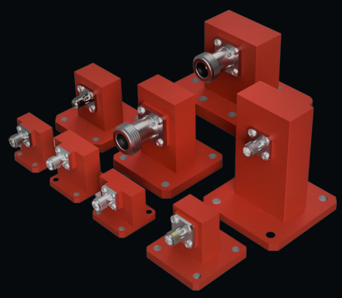
Impulse Technologies manufactures and supplies RF and microwave hardware that lives at the points where the signal path changes level, phase, transmission mode or radiation geometry.



01 **PHASE CONTROL**



02 **LEVEL CONTROL**



03 **MODE TRANSITION**

Authentic transparent product cutouts / representative configurations / not to scale

THE SYSTEM VIEW

Phase shifters and variable attenuators set controlled electrical states inside a chain. Their value is the repeatable system condition that each setting creates.

Waveguide-to-coax adapters preserve the intended mode while connecting transmission formats. Interface geometry belongs in both the electrical budget and the mechanical drawing.

Gain horns and antenna hardware turn guided power into known spatial behavior. Broader assemblies may combine manufactured and partner technologies around one program requirement.

Final selection and performance are controlled by the approved model-specific quotation and datasheet.

2026 WATCH LIST

WHAT CHANGES NEXT CHANGES THE BUDGET.

New bands, denser arrays, smaller spacecraft and stricter coexistence targets
ke

01 IMT-2030

In February 2026, ITU-R Working Party 5D completed draft minimum technical performance requirements for IMT-2030. The standardization path now converts broad 6G ambitions into measurable radio-system criteria.

02 SMALL SPACECRAFT

NASA's current small-spacecraft communications guidance treats spectrum, antenna, radio, data rate, ground segment and operations as one trade space. Mass and power constraints make every interface visible.

03 TRACEABLE POWER

Modern source-measure workflows extend traceable RF power metering into automated test. The opportunity is faster evidence, provided uncertainty, calibration state and reference planes remain explicit.

04 HIGHER INTEGRATION

More functions are moving into compact RF assemblies. Integration reduces cable and connector count, but raises the importance of thermal paths, isolation, serviceability and configuration control.

SOURCES AND FURTHER READING ON PAGE 19.

KEEP THE REFERENCES

THE FIELD NOTES BEHIND THE ISSUE.

RF PRIMER / FIVE DISTINCTIONS

dB	RATIO	Describes change between two levels.
dBm	LEVEL	Power referenced to one milliwatt.
RL	MISMATCH	Return loss describes reflected amplitude ratio.
IL	TRANSMISSION	Insertion loss compares delivered transmission states.
EIRP	RADIATION	Transmitter level plus directional gain minus feed loss.

PRIMARY SOURCES

IMPULSE TECHNOLOGIES - Standard Catalogue and official product pages: impulse-tech.com

NIST Technical Note 1379 - Direct Comparison Transfer of Microwave Power Sensor Calibration.

NIST - Traceable RF Power Metering Procedures Using Thermoelectric Sensors (2024).

NASA Small Spacecraft Systems Virtual Institute - State of the Art: Communications (2024 edition).

NASA - Small Spacecraft RF and Optical Link Trade Studies and link-budget design resources.

ITU-R Recommendation M.2160 - Framework and overall objectives for IMT-2030.

ITU - IMT-2030 technical requirements for the 6G future, published March 2026.

TECHNICAL NOTE: EDUCATIONAL OVERVIEW ONLY. USE APPROVED PROGRAM DATA FOR DESIGN RELEASE.

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Product specifications are subject to the approved quotation and model-specific documentation.