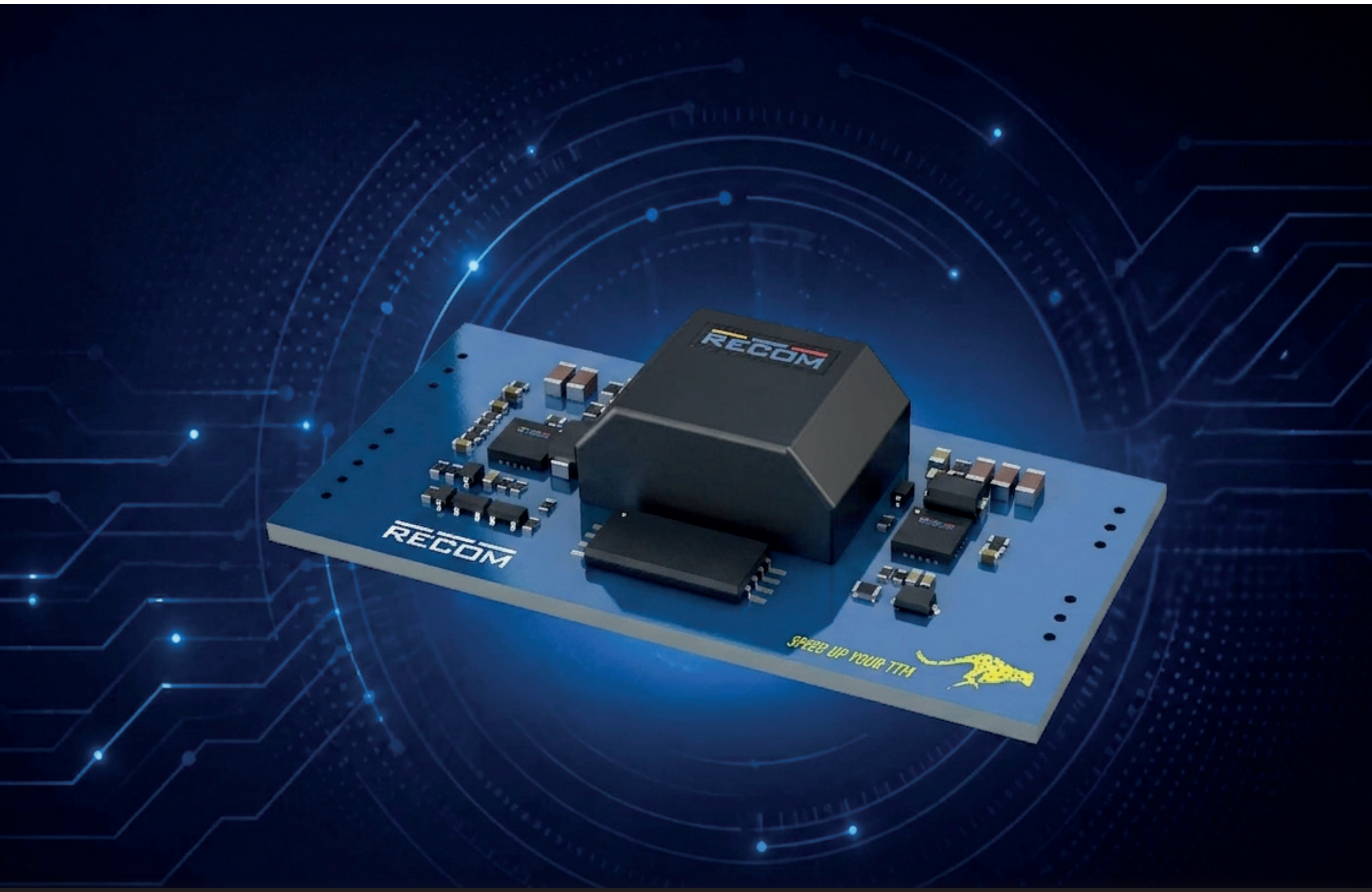
# ISOLATED DC/DC CONVERTERS: IMPLEMENT A DISCRETE SOLUTION OR USE AN INTEGRATED MODULE?




Discover the technical and economic flexibility of RECOM's isolated DC/DC modules and IC-based discrete solutions – from plug-and-play modules to flexible system architectures.

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# INTRODUCTION

RECOM provides its DC/DC conversion technology not only in the form of fully integrated DC/DC modules, but also makes the underlying core components available as discrete building blocks. As a manufacturer of isolated DC/DC modules, RECOM therefore enables direct integration of identical primary-side controller ICs, transformer driver ICs, synchronous rectifier ICs, and magnetics into custom PCB designs.

This technical article analyzes the available technological options and serves as a structured decision guide for selecting between a pre-qualified, certified DC/DC module and an IC-based discrete power architecture.

The use of an isolated module provides a fully validated design with defined EMC performance, verified isolation (functional or reinforced isolation), and minimal integration effort. Development risk, design complexity, and time-to-market are significantly reduced.

A discrete solution, in contrast, provides maximum flexibility in topology, transformer design, layout, and thermal integration. Particularly at high production volumes, optimized bill of materials and application-specific design can result in significant cost advantages.

## Isolated DC/DC Transformer Drivers from RECOM

An isolated DC/DC converter is fundamentally based on two functionally critical components: a primary-side transformer driver or controller IC and a galvanically isolating high-frequency transformer. The quality of these two elements largely determines efficiency, magnetic utilization, EMC behavior, and overall power architecture reliability.

RECOM offers a broad portfolio of discrete isolated transformer driver ICs and flyback controller ICs for common topologies such as push-pull, full-bridge, and flyback.

### Push-Pull and Full-Bridge Transformer Driver ICs

Push-pull and full-bridge architectures operate with a primary-side square-wave drive of the transformer. The driver ICs generate precise complementary gate signals with defined dead time to prevent cross-conduction (shoot-through).
The resulting high-frequency AC signal is stepped up or down according to the transformer turns ratio. On the secondary side, rectification is performed either by Schottky diodes or by a synchronous rectifier IC to reduce conduction losses. Output filtering is typically implemented using a capacitive or LC filter (C_OUT or LC).

**For unregulated transformer driver ICs, the output voltage is primarily determined by:**

- Input voltage
- Turns ratio
- Load condition
- Efficiency

In applications requiring higher output accuracy, a downstream LDO or additional regulation stage may be implemented.

### Flyback Controller ICs

In contrast to pure transformer driver ICs, flyback controller ICs integrate closed-loop PWM regulation. Energy transfer occurs discontinuously or continuously through magnetic energy storage in the transformer (coupled inductor).

**Depending on type, RECOM flyback controllers are equipped with:**

- Integrated power MOSFET
- External MOSFET drive capability
- Primary-side regulation (PSR) or secondary-side feedback

The flexible choice between internal and external switching enables higher voltages and output power levels. The RVPW series supports both primary-side and secondary-side regulation concepts. In non-isolated configurations, direct current sensing is also possible.
RECOM therefore covers both unregulated isolated transformer drivers for compact, efficient push-pull or full-bridge architectures, and fully regulated flyback controller ICs for power- and voltage-flexible applications.

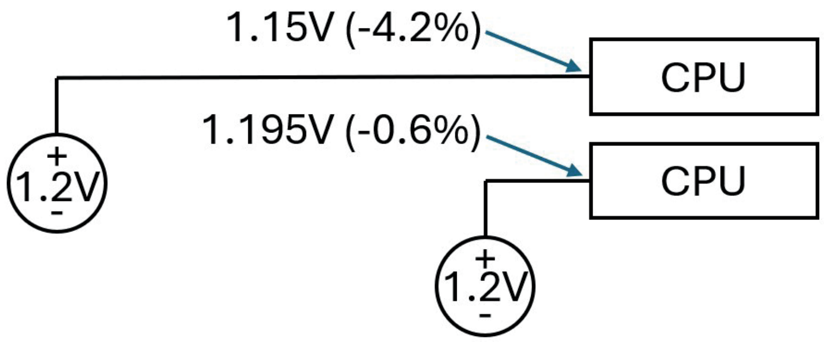



**Figure 1. Block diagram of an isolated power supply using off-the-shelf (OTS) silicon, an OTS or custom transformer, and one or more DC outputs. RECOM flyback driver ICs provide feedback from either the primary or secondary side for internal voltage regulation**

RECOM offers a coordinated portfolio of isolated transformer driver ICs, flyback controller ICs, SMD transformers, and synchronous rectifier ICs (see Table 3). This enables consistent technological implementation of various isolated DC/DC architectures.
**The representative components RVP001, RVP010, and RVPW011 correspond to three established topologies in isolated power electronics:**

- RVP001 – Full-Bridge Transformer Driver
- RVP010 – Push-Pull Transformer Driver
- RVPW011 – regulated flyback controller IC

These three architectures cover a wide range of typical power levels and application requirements for isolated DC/DC converters – from compact, unregulated push-pull or full-bridge solutions to power-flexible, closed-loop flyback regulation concepts.

| | RVP001 | RVP010 | RVPW011 |
|---|---|---|---|
| Topology | Full-Bridge | Push-Pull | Flyback |
| Input voltage | 3V–6V | 2.8V–6V | 5V–50V |
| Current limit | 0.9A peak, 0.5A continuous | 1.7A peak, 1A continuous | Programmable peak |
| Max. output power | 2W | 3W | 30W |
| Switching frequency | 340kHz | Selectable: 217kHz and 390kHz | Variable: 9kHz–330kHz |
| Package | DFN2x2-6<br>2.0mmx2.0mmx0.75mm | SOT23-6<br>2.9mmx2.8mmx1.25mm | QFN<br>5mmx5mmx0.75mm |
| Protection | Continuous short-circuit protection, thermal shutdown, automatic recovery | Continuous short-circuit protection, thermal shutdown, automatic recovery | Continuous short-circuit protection, thermal shutdown, automatic recovery |

**Table 1. Comparison of Full-Bridge, Push-Pull, and Flyback Driver ICs**

The RVP transformer driver ICs integrate a precise internal oscillator to generate complementary gate signals with defined dead time. Symmetrical drive ensures balanced magnetization of the transformer core and minimizes magnetic flux imbalance. The integrated dead time prevents cross-conduction (shoot-through) between switches.
The RVPW series, by contrast, operates with integrated PWM regulation for driving a flyback transformer and enables primary-side or secondary-side regulation depending on configuration.

**Push-Pull vs. Full-Bridge – Structural Differences**
Push-pull and full-bridge topologies differ in both transformer construction and switch current stress.
Push-pull designs require a transformer with a primary-side center tap. During each half-cycle, only one half of the primary winding is energized. Each MOSFET conducts only the current of its respective winding half.

Full-bridge designs do not require a center tap. During each half-cycle, the entire primary winding is energized. Each switch must therefore be rated for the full primary current.

**As a result:**

- Push-pull architectures are advantageous at lower input voltages and higher currents.
- Full-bridge topologies perform optimally at higher input voltages and lower currents.

Both IC families are specified for an industrial temperature range of –40°C to +125°C.

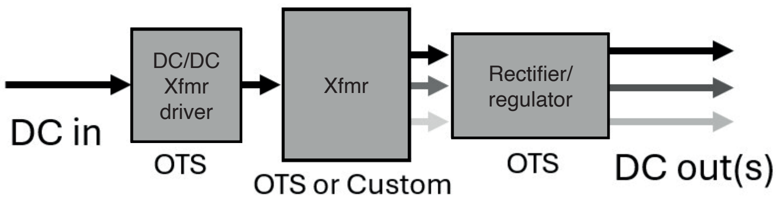



**Figure 2. Driver topologies in operation. The red wiring indicates the energized windings during each half-cycle of the AC switching period.**

The **RVP001** (Figure2, left) implements a full-bridge topology with integrated 0.25Ω high-side P-channel MOSFETs and two 0.13Ω low-side N-channel MOSFETs. Due to the bridge structure, the entire primary winding is energized during each half-cycle, as shown in Figure2 (left, highlighted in red).

The full-bridge architecture enables efficient utilization of the primary winding at a given input voltage, reducing the required number of turns. This positively impacts copper losses, leakage inductance, and ultimately transformer cost. However, each switch must be rated for the full primary current, which must be considered in thermal design.

The RVP010 (Figure2, right) is based on a push-pull topology with integrated 24V N-channel LDMOS MOSFETs with a typical RDS(on) of 0.1Ω. It is designed for output voltages from 3.3V to 24V.

In push-pull configuration, only one half of the primary winding is activated per switching phase. Each MOSFET therefore conducts only the current of the corresponding winding half. The use of exclusively N-channel devices results in lower conduction losses compared to the P-channel high-side structure of the full-bridge variant.

However, only one half of the primary transfers energy at a time, influencing magnetic utilization per switching period and requiring precise symmetrical drive to prevent core saturation.

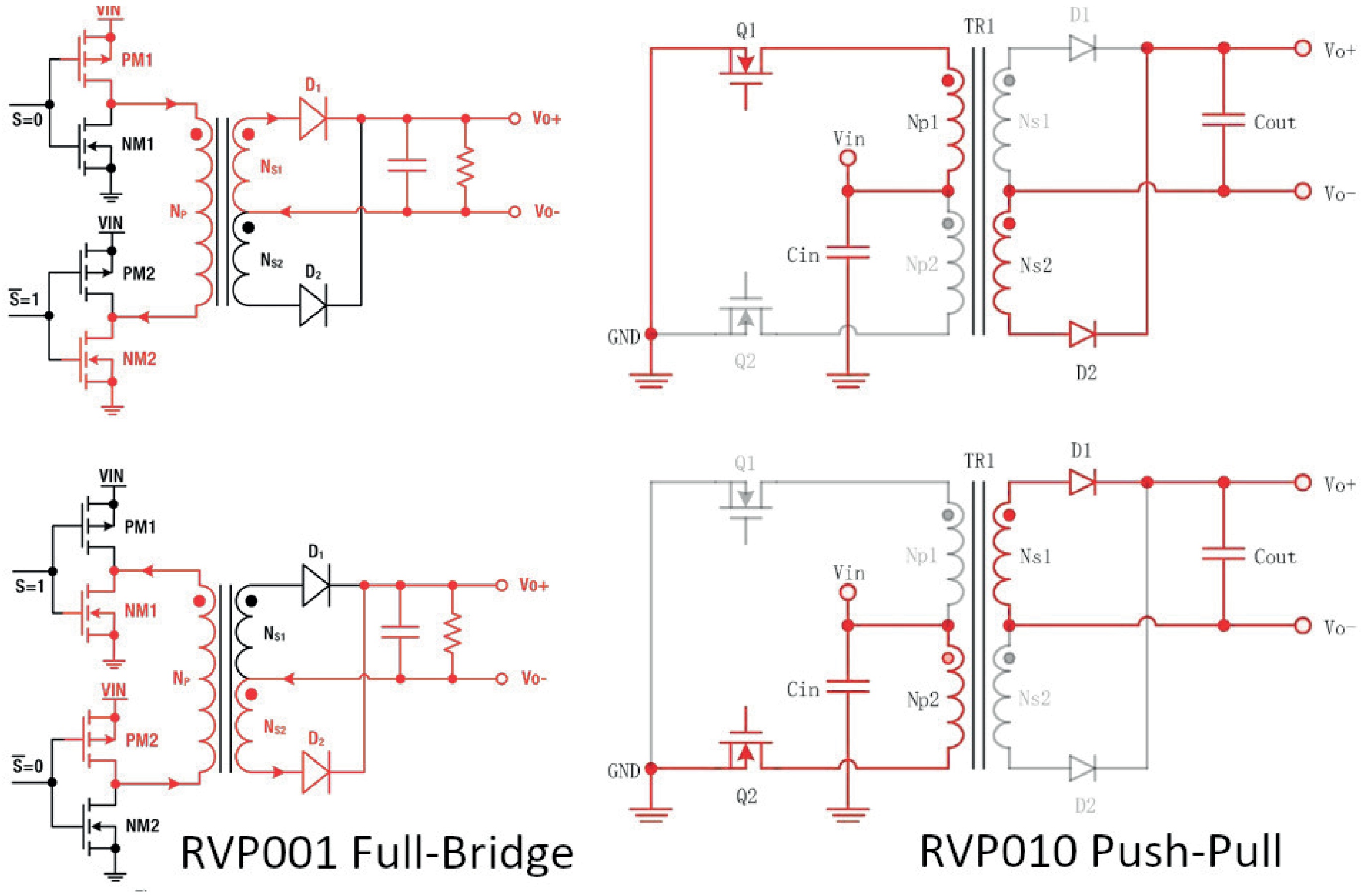



Figure 3. Driver output waveforms with integrated dead time (TBBM) for RVP001 (left) and RVP010 (right).

The integrated dead time is intentionally kept very short, allowing an effective duty cycle close to 100%. As a result, the primary winding is driven for nearly the entire switching period, improving magnetic utilization and increasing transferable power per cycle.
During dead-time intervals, however, no energy is transferred from the primary to the secondary side. The load current must be supplied entirely by the output filter during this phase.

**An appropriately dimensioned output capacitor, typically in the range of 4.7µF to 10µF depending on load current, switching frequency, and allowable ripple voltage, provides this buffering function. Its dimensioning directly influences:**

- Output voltage ripple
- Transient response
- Downstream load stability

Selection should consider ESR, RMS current capability, and temperature behavior.

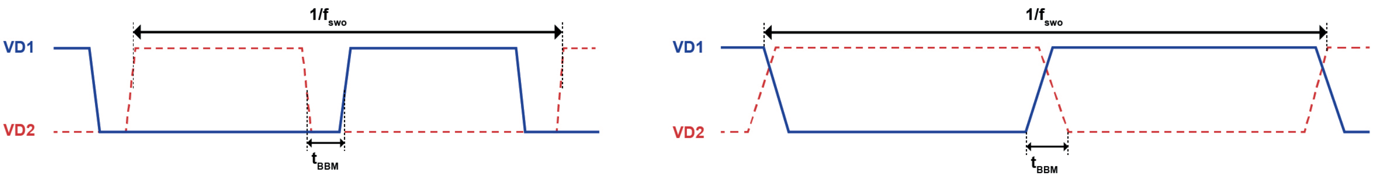



Figure 4. Flyback driver configured for primary-side regulation, with voltage applied to the flyback primary winding NP, controlled by internal MOSFET drains (DRN), and primary-side regulation via winding NA.

Flyback topologies offer high power and voltage flexibility and are particularly suitable for applications with variable input voltage or multiple output voltages.
Unlike unregulated transformer driver architectures, flyback controller ICs integrate closed-loop PWM regulation. Output voltage is sensed via a feedback path—either primary-side regulation (PSR) or secondary-side feedback—and processed internally.

**The internal control structure enables:**

- Precise voltage regulation over a wide load range
- Integrated cycle-by-cycle current limiting
- Protection functions such as OCP, OTP, and UVLO
- Controlled startup behavior (soft-start)

Due to energy storage in the transformer (coupled inductor), output power can be scaled via switching frequency, duty cycle, peak current limit, and transformer design. Flyback topologies are therefore particularly suitable for low- to mid-power applications requiring tight regulation and wide input voltage range.

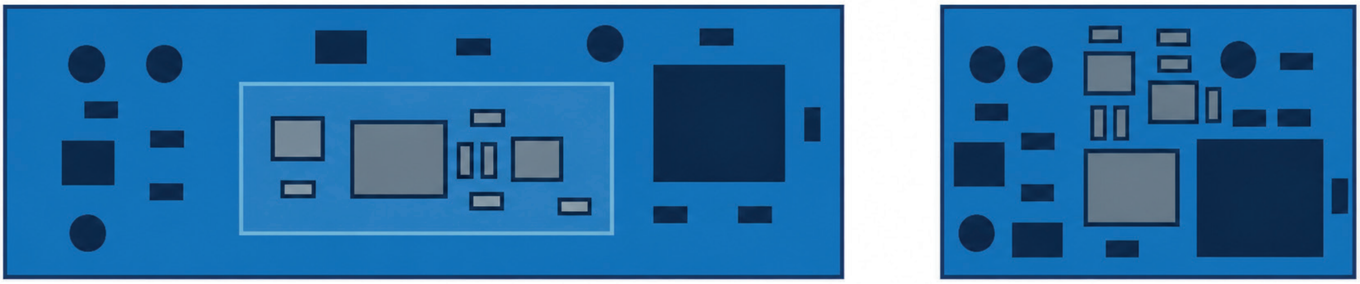


**Figure 5. Flyback output waveform with indicated sampling window.**

The flyback topology differs fundamentally from push-pull and full-bridge architectures because it does not provide complementary drive signals with continuous energy transfer. Instead, power transfer occurs discontinuously in two distinct phases:

1. Primary conduction phase – Energy is stored in the magnetic field of the transformer.
2. Secondary conduction phase – Stored energy is transferred to the secondary side.

The resulting secondary current waveform is pulsed and directly dependent on PWM duty cycle and peak current. Continuous power transfer, as in push-pull or full-bridge, does not occur.

**The output therefore relies on a properly dimensioned output filter. The output capacitor must:**

- Supply load current entirely during the primary conduction phase
- Smooth pulsed energy transfer
- Maintain specified ripple voltage
- Support regulation stability

Dimensioning must consider load current, switching frequency, operating mode (DCM or CCM), ESR, and allowable ripple. At higher load currents or lower output voltages, RMS current rating becomes particularly critical.

## Decision Factors for Discrete Components vs. Modules

Project managers, system architects, and design engineers will inevitably face a fundamental make-or-buy decision:
Use a standardized DC/DC module, or implement a discrete isolated power architecture? The answer is rarely purely technical. It results from a combination of performance requirements, isolation concept, time-to-market, production volume, mechanical constraints, and internal power design expertise.
The following sections categorize the key decision parameters.

### Power Supply Design Expertise

**Even at single-digit watt levels, isolated DC/DC converter design requires multidisciplinary expertise:**

- Magnetics design (core material, flux density, leakage inductance, winding topology)
- Control theory (stability analysis, compensation, load transients)
- EMC-optimized layout (loop minimization, dv/dt control)
- Thermal design (loss distribution, hot-spot analysis)

The transformer is not a commodity component but a functional core element. Switching frequency, maximum flux density, cooling conditions (natural convection or forced air), and isolation requirements (functional or reinforced isolation) must be coherently designed. If such expertise is not available internally, a certified DC/DC module often represents the lowest-risk approach, offering validated EMC performance and verified isolation.

Through close collaboration with RECOM's applications and magnetics engineering teams, development risk in discrete designs can also be significantly reduced.

## Time-to-Market and Development Effort

**With aggressive project timelines, a DC/DC module is typically the pragmatic choice. Integration is limited to:**

- Electrical connection
- Thermal interface
- System-level EMC validation

**A discrete design requires:**

- Transformer design
- Layout iteration
- Stability and EMC optimization
- Prototyping and characterization

**However, evaluation changes if:**

- Custom voltages or multiple outputs are required
- Special isolation requirements exist
- High production volumes are planned

In such cases, higher initial development investment may be economically justified.

### PCB Area and Manufacturing Considerations

A DC/DC module has a fixed footprint. Where sufficient PCB area is available, this is typically uncritical.
**In highly integrated designs with:**

- Limited space
- Irregular PCB geometry
- Defined thermal zones

**Discrete solutions provide significant advantages. Placement of transformer, controller IC, and synchronous rectifier can be optimized along current paths and heat sources, enabling:**

- Reduced current loops
- Lower parasitic inductance
- Improved thermal distribution

Fully SMT-based discrete designs integrate seamlessly into reflow processes, eliminating additional THT assembly steps.
The decision between DC/DC module and discrete solution is therefore a strategic system architecture choice with technical, economic,

and organizational implications.

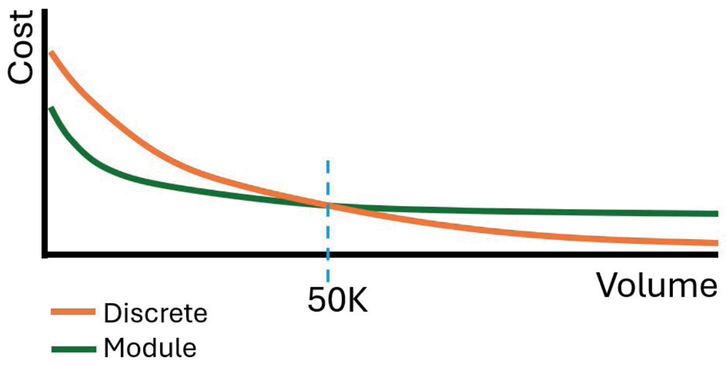



**Figure 6. DC/DC modules (left) require fixed placement, whereas discrete solutions (right) are better suited for space-constrained PCB layouts.**

## Manufacturing Aspects and Process Costs

DC/DC modules with THT leads or non-standard form factors often require an additional assembly step outside the automated SMT line. Manual or selective soldering increases throughput time and may significantly raise assembly cost.
A fully discrete SMT-based design integrates seamlessly into standard reflow processes, improving process stability, scalability, and automation.

**Conversely, a DC/DC module significantly reduces BOM line items, simplifying:**

- Material planning
- Inventory management
- Supplier qualification
- Component-level quality assurance

The decision represents a trade-off between manufacturing integration and logistical simplification.

## Production Volume and Cost Structure

Standardized DC/DC modules benefit from manufacturer economies of scale. Development, validation, and certification costs are amortized across large sales volumes.

**In discrete architectures, the following costs are project-specific:**

- Circuit and layout development
- Magnetics design
- Prototyping and validation
- EMC optimization
- Manufacturing ramp-up

At low-to-medium volumes, DC/DC modules are generally economically advantageous.
With increasing volume, however, cost structure shifts. Optimized transformer design, targeted component selection, and elimination of module margin enable discrete designs to achieve significant cost advantages.

Internal cost analyses indicate a typical crossover point around 50000units/year. Above this level, IC-based discrete solutions may offer lower total unit cost, provided development resources and technical risk management are available.

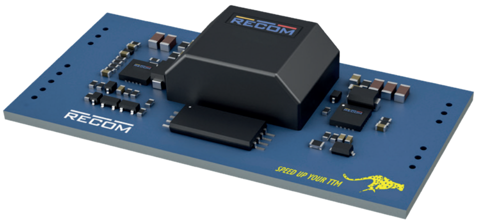


**Figure 7. Discrete designs have higher initial cost, but become more economical above approximately 50000units/year (based on TCO).**

## Use of Standardized DC/DC Modules

Clear specifications, minimal integration complexity.
A standardized isolated DC/DC module is particularly suitable when the application does not require unusual voltage levels, power ranges, form factors, or regulation concepts.

**Typical cases include:**

- Standard output voltages (3.3V, 5V, ±12V, ±15V)
- Defined power ranges
- Sufficient PCB space
- No application-specific magnetics requirements

RECOM isolated DC/DC modules are fully characterized, EMC-tested, and, depending on series, certified according to relevant safety standards (functional or reinforced isolation per IEC62368-1). Documentation includes electrical specifications, derating curves, isolation data, MTBF information, and layout guidelines.

**Benefits for the development team:**

- Reduced design iteration
- Lower EMC risk
- Shortened qualification phase
- Accelerated time-to-market

## Discrete Components for Isolated DC/DC Architectures

**For custom isolated power supplies, RECOM provides coordinated discrete core components:**

- Primary-side transformer driver ICs (push-pull, full-bridge)
- Flyback controller ICs with integrated PWM regulation
- Synchronous rectifier ICs for the secondary side
- Standard SMD transformers for isolated applications

Beyond standard offerings, RECOM develops and manufactures custom isolation transformers meeting specific turns ratio, isolation class, power range, package, or multi-output requirements.

## Transformer Design Expertise and Technical Support

The design of a custom high-frequency transformer is a specialized discipline that requires deep expertise in magnetic design, isolation technology, and thermal engineering. Many development teams have extensive experience in digital or analog circuit design, but not necessarily in advanced transformer engineering.

RECOM therefore supports discrete isolated DC/DC architectures not only at the IC level, but also provides transformer design and manufacturing services. Based on electrical, mechanical, and regulatory requirements, a custom isolation transformer is designed and typically delivered as a prototype within approximately 20 working days.
This timeframe is often shorter than the duration required for circuit development, layout iterations, and PCB prototyping. As a result, custom magnetics design can be integrated into the overall project timeline without significantly impacting time-to-market.

### Typical Applications for Custom Transformer-Based Solutions

**Typical applications that benefit from discrete solutions with custom transformers include:**


- Power supply from a 3.6V lithium source with a required 12V output
- Asymmetric gate driver supplies, e.g. +15V / –3V for SiC or GaN devices
- Multiple outputs for supplying high-side inverter stages

In addition to transformer design, RECOM can provide complete application-specific kits consisting of controller IC, magnetics, rectifier, and supporting components, including technical integration support.

#### From Architecture Concept to Mass Production

DC/DC modules offer low initial cost, a reduced number of BOM items, and simplified SKU management. Certified modules can also streamline regulatory approval processes. A discrete isolated power architecture, on the other hand, provides maximum flexibility in topology, layout, and thermal integration. At high production volumes, it enables an optimized cost structure and full control over PCB design and system integration.
The decision between a module and a discrete solution is therefore a strategic trade-off between development effort, manufacturing depth, and long-term cost optimization.

## Decision Checklist

| Yes | No | "Yes" indicates an advantage for: | Discrete | Modul |
|---|---|---|---|---|
| | | Is there a module that meets the requirements for voltage, current, and power? | | + |
| | | Do the available modules fit within the mechanical space? | | + |
| | | Does the design team have expertise in DC power supply design? | + | |
| | | Is the PCB space limited or irregularly shaped? | + | |
| | | Are there special or non-standard electrical specifications? | + | |
| | | Will the annual production volume exceed 50,000 units? | + | |

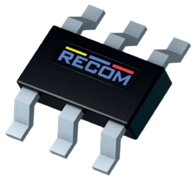
Table 2. Key parameters for the decision between modular and discrete design

## DC/DC Modules from RECOM

The selection of a suitable DC/DC module is application-specific and based on input voltage range, output power, isolation requirements, and form factor. RECOM offers a broad portfolio of isolated DC/DC modules with rated power ranging from 0.5W to the double-digit watt range.

**The modules are available in various package and mounting options, including:**

- Through-hole (THT) versions
- SMT variants
- Leaded and leadless SMD packages
- Compact SIP, DIP, or flat SMD packages




Depending on the series, options include functional or reinforced isolation, various input voltage ranges, and single- or dual-output configurations. This enables fast, low-risk integration of isolated DC/DC converters into existing system architectures with clearly defined electrical characteristics.

## Discrete Components for Isolated DC/DC Architectures

**For the implementation of custom isolated power supplies, RECOM offers a coordinated portfolio of discrete core components, including:**

- Primary-side transformer driver ICs (push-pull, full-bridge)
- Flyback controller ICs with integrated PWM regulation
- Synchronous rectifier ICs for the secondary side
- Standard SMD transformers for isolated applications

These components are functionally aligned and enable a consistent, scalable system architecture.

Beyond the standard portfolio, RECOM develops and manufactures custom isolation transformers that meet specific requirements in terms of turns ratio, isolation class (functional or reinforced isolation), power range, form factor, or multiple outputs.
This significantly expands the achievable parameter space of isolated DC/DC converters beyond the limitations of standardized modules.

**Intelligent transformer driver IC – unregulated**

3V–6V ............................RVP001 ........................0,5A Full-Bridge
6V–30V ..........................RVP003 ........................0,3A Full-Bridge
6V–30V ..........................RVP003S ......................0,3A Full-Bridge
6V–30V ..........................RVP005 ........................0,6A Full-bridge with external clock generator
2,8V–6V .........................RVP010 ........................1A Push-pull with adjustable frequency
2,8V–6V .........................RVP6501 ......................0,5A Push-pull, pin-compatible with SN6501
Intelligent features: anti-shoot-through, enable pin, frequency selection, OCP, OTP, SCP

**Intelligent transformer driver IC – regulated**

5V–85V ..........................RVPW011.....................30W Flyback controller with integrated switch
4V–125V ........................RVPW012.....................30W Flyback controller with integrated switch
4V–80V ..........................RVPW014.....................6W Flyback controller with integrated switch
4V–125V ........................RVPW015.....................6W Flyback controller with integrated switch
4V–100V ........................RVPW016.....................Flyback controller with external switch
Intelligent features: multifunction feedback pin (triple function), UVLO/OVLO, frequency selection, OCP, OTP, SCP

**Intelligent bridge rectifier IC**

2V–6V ............................RVS002 .........................0,3A Smart bridge rectifier in DFN2×2 package
5V–100V ........................RVSY018 ......................Synchronous bridge rectifier in SOT23-5 package
Intelligent features: self-synchronization, lower voltage drop and power loss than discrete diodes

**SMD transformer**

0.5kVDC to 6kVAC with functional, basic, or reinforced isolation
6mm to 18mm clearance and creepage distance
Flat toroidal or ER/EE power transformer

## Summary

Isolated DC/DC converters are fundamental building blocks of modern electronic systems. They provide point-of-load voltage supply, ensure galvanic isolation, and significantly influence efficiency, EMC behavior, and thermal performance.

**Advantages of a DC/DC module:**

- Minimal integration effort
- No deep internal power design expertise required
- Shortened development and qualification time
- Pre-validated isolation, EMC performance, and protection functions

**Advantages of a discrete isolated power architecture:**

- Freely defined input and output specifications
- Optimizable layout and thermal integration
- Extended parameter range (multiple outputs, asymmetric voltages)
- Economic benefits at high production volumes

RECOM supports both approaches from a technologically consistent platform, enabling project-specific strategic decisions between validated plug-and-play modules and individually optimized discrete DC/DC architectures.

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