Constant Current Regulated Buck Controller with Active Power Factor Correction

Features

- High Voltage JFET Technology is Applied for Direct Power Supply of IC with No MLCC Buffer
- Capacitance Amplifier Technology is Applied for Loop Compensation with No MLCC Compensation
- Real Time Compensating Technology for High Precision (±3%) LED Current Control, Excellent Line and Load Regulation
- Soft Driving and Critical Conduction Mode Operation for Low EMI Optimization with Both Conduction and Radiation
- Constant On Time Control for Active PFC for High Power Factor (>0.95) and Low THD (<15%)
- Build-in 800V JFET and Integrated 650V MOSFET for 440 Vac Operation
- Programmable Current Dropping at High Line (e.g. > 265Vac) for Thermal and Reliability Performance
- Fixed OVP:250V
- Maximum Switching Frequency Clamping for System Reliability and High Efficiency
- ESOP5 Package

Protection

- Built-In Soft Start
- Thermal Regulation
- LED Open and Short Protection
- Cycle by Cycle Current Limit
- Leading Edge Blanking for Current Sensing
- Leading Edge Blanking for Zero Crossing Detection
- VCC Under Voltage Lock Out (UVLO) and Clamping

Application

- Non-isolated APFC BUCK LED Driver

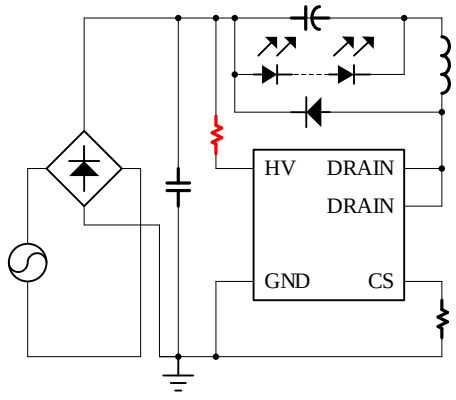


Fig. 1. Typical application circuit

- Recommended Operation Conditions With India Line Voltage (90-440Vac)

Part No.	MOSFET	Output Spec.
YT2181GTE5	650V2.1ohm	*144V300*mA

Address: Room 1501, Block A3, West Jianzhu Rd. 777, Binhu District, Wuxi, Jiangsu , China
Phone/Fax: 86-510-85388846

Package and Ordering Information

Part No.	Material Type	Package	Operating Temperature	Built-in MOSFET SPEC	Packing Method
YT2181GTE5	Green	ESOP5	-40 ℃ to 105 ℃	650V2.1ohm	Tube 50 pcs/Tube

Pin Configuration

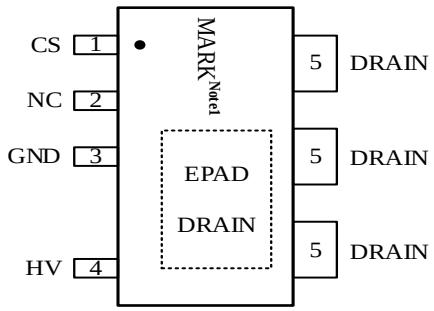


Fig. 2. Pin configuration for ESOP5

Note 1: Please refer to the "Marking Rule".

Pin Definition

Pin No.	Name	Description
1	CS	Current Sense. Connect A Resistor to GND to Sense the Inductor Current.
2	NC	No Connection.
3	GND	Ground.
4	HV	High Voltage Input to The Internal JFET for Power Supply and Line Detection. A 15kohm Resistor Should be Connected from This Point to The HV Pin to Withstand the Surge.
5	DRAIN	Internal HV MOSFET Drain.

Internal Block Diagram

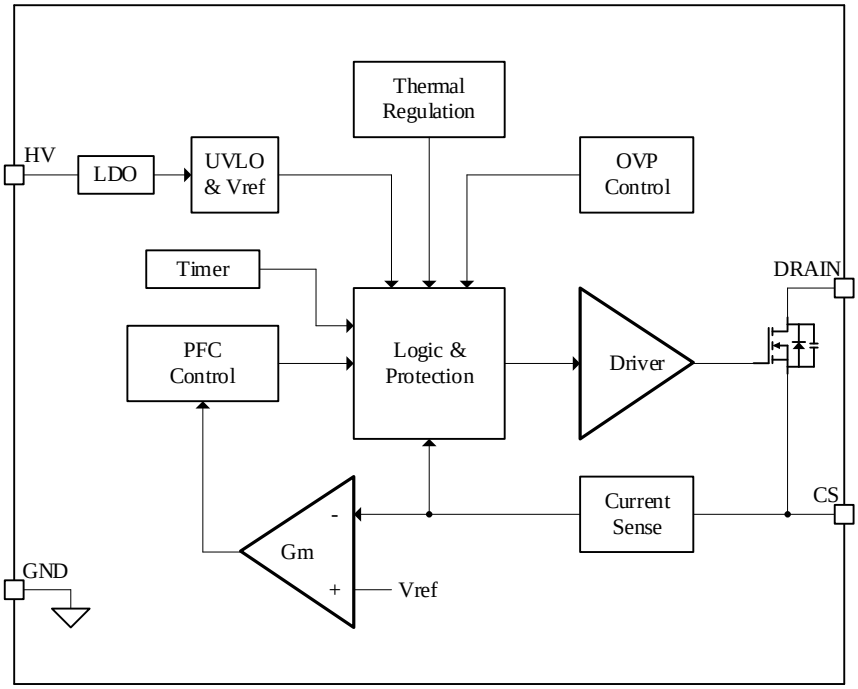


Fig. 3 Internal block diagram

Absolute Maximum Ratings[Note2]

Parameters	Symbol	Range	Units
"HV" voltage range	V_{HV}	-0.3 ~ 800	V
"CS" and "OVP" voltage range	V_{CS}, V_{OVP}	-0.3 ~ 6	V
Guaranteed minimum "DRAIN" voltage[Note3]	V_{DS_min}	650	V
ESD Human mode[Note4]	ESD_{hbm}	3000	V
Operating junction temperature range	T_j	-40 ~ 150	℃
Ambient temperature range	T_a	-40 ~ 105	℃
Storage Temperature Range	T_{stg}	-40 ~ 150	℃
Welding temperature (< 20 *s* welding)	T_{lead}	260	℃
Junction to ambient thermal resistance	θ_{thja}	80	℃/W

Note 2: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

Note 3: Depending on the different built-in MOSFET SPEC, see the corresponding relationship between the model and the built-in MOSFET.

Note 4: Electrical components and circuit boards will be aware of the situation in the discharge is not easy. Although this product has a special electrostatic protection circuit, but in the case of high-energy electrostatic discharge, the chip may have damage and loss of function or performance degradation. Therefore, users still need to take appropriate preventive measures ESD.

Electrical Characteristics[Note5] (Unless otherwise specified, T_a = 25 ℃)

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
HV						
Operating Current	I_{HV_OP}	HV=40V		200	360	μA
PWM						
Minimum On Time	T_{on_min}			1.1		μs
Maximum On Time	T_{on_max}			16		μs
Minimum Off Time	T_{off_min}			2		μs
Maximum Off Time	T_{off_max}		450	500	650	μs
Maximum Frequency	f_{max}		144	160	176	kHz
CS						
Internal Reference Voltage	V_{REF}		0.204	0.210	0.216	V
CS Sampling Clamp Voltage	V_{CS_LMT}		1.1	1.2	1.3	V
CS Leading Edge Blanking Time	T_{LEB_CS}			350		ns
Switch off Delay Time	T_{DELAY_OFF}			200		ns
OVP						
OVP Voltage	V_{OVP}		250			V
MOSFET						
Drain-Source Breakdown Voltage	BV_{DSS}		650			V
Drain-Source On Resistance	R_{DS_ON}			2.1		ohm
Thermal Regulation						
Thermal Regulation Temperature	T_{OTR_TH}			110		℃

Note 5: The max and minimum parameters specified are guaranteed by test, the typical value are guaranteed by design, characterization and statistical analysis.

Application Suggestion

YT2181GTE5 is a high precision active PFC driver integrating 800V JFET and 650V power MOSFET, specially designed for non-isolated buck offline constant current LED lighting. Operating in critical conduction mode, the driver achieves high power factor, low THD and high efficiency.

Start Up And Supply

When AC line is applied, main bus voltage can be built, then the JFET of the IC supply the inner operation. When the voltage of HV reaches VCC_ON, PWM is enabled; If the voltage of HV drops below the VCC_UVLO, PWM is disabled and restart is necessary.

Principle of The Active Power Factor Correction (APFC)

Constant on time (T_{on}) control with boundary conduction mode (BCM) operation is the key principle to achieve active power factor correction, thereby high power factor and low THD can be expected.

The power inductor is charged during the fixed T_{on} of the MOSFET, i_L increase linearly to the peak (i_{pk}) from zero; when MOSFET tuned off, the freewheeling diode release the inductor current, i_L decrease linearly from i_{pk} to zero and next switching cycle is triggered.

Fig. 4 shows the Key waveforms of the CC controlled buck with APFC.

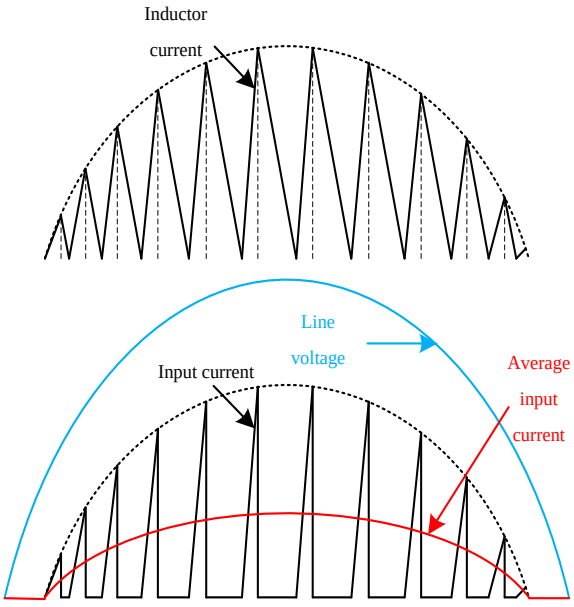


Fig. 4 Key waveforms of the CC controlled buck with APFC

Constant Current Control

In order to achieve high precision (±3%) output current (I_o) control, excellent line and load regulation, YT2181GTE5 operates in BCM and makes the real time sensing to the inductor current. I_o can be calculated with formula (1)

$$I_o = \frac{V_{ref}}{R_{cs}} \quad (1)$$

Where V_{ref} is the reference voltage, R_{cs} is the current sensing resistance.

Zero Current Detection (ZCD) and Valley Switching Technique

The zero crossing of the inductor current is detected for PWM turn-off signal, thereby the valley turn-on of the MOSFET and BCM operation of the inductor current can be achieved.

Maximum Off Time

Maximum off time (T_{off_max}) is set to avoid the condition that ZCD block missing the zero crossing event of the inductor current.

Minimum Off Time

Minimum off time (T_{off_min}) is set to limit the maximum switching frequency (f_{sw_max}), then the switching loss and EMC performance can be guaranteed. As shown in Fig. 5, PWM is triggered at the first valley after T_{off_min}.

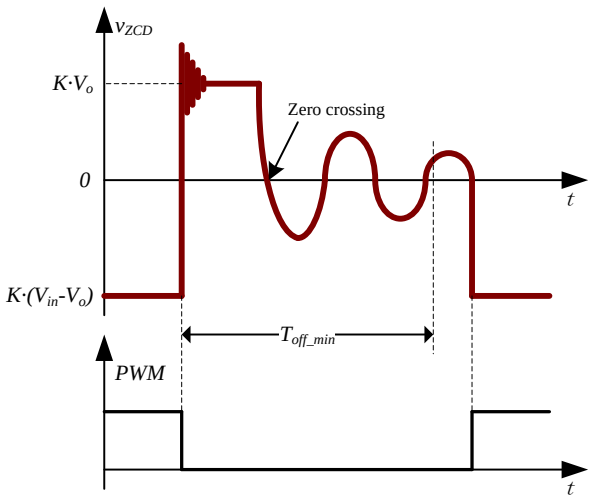


Fig. 5 Minimum off time

ZCD Blanking

Fig. 6 shows ZCD blanking time (T_{LEB_ZCD}) is set to avoid the fault trigger by the oscillation after the turn off.

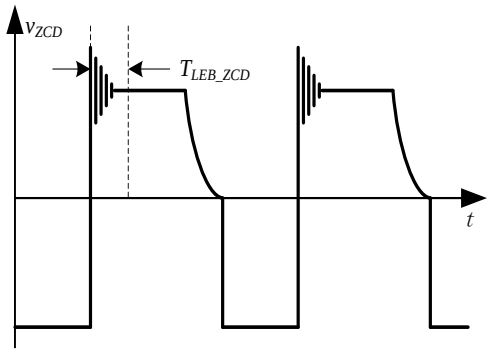


Fig. 6 ZCD blanking

CS Blanking

Fig. 7 shows CS blanking time (T_{LEB_CS}) is set to avoid the fault trigger by the oscillation after the turn on.

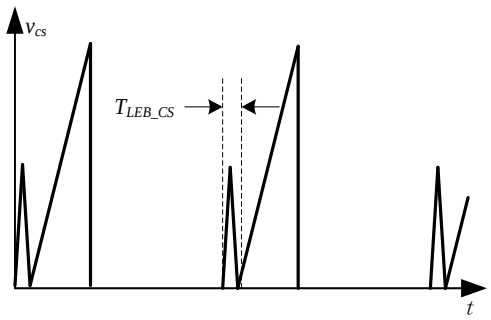


Fig. 7 CS blanking

Cycle by Cycle Current Limiting

When LED short or inductor saturation happens, CS pin voltage (V_{CS}) goes higher than regulation. However, CS voltage limit (V_{CS_LMT}) can help to stop PWM cycle by cycle to protect the MOSFET and the other power devices.

Over Temperature Regulation (OTR)

When the junction temperature goes higher than the threshold of the over temperature regulation (T_{OTR_TH}), chip will reduce the output current (I_o) by reducing the internal reference (V_{ref}). This is helpful to regulation the system temperature, guarantees the stability of both the driver and LED chip, and improves the reliability of the LED lighting system. Fig. 8 shows the principle of the over temperature regulation, where I_{o1} is the output current before OTR triggered; I_{o2} is the output current during OTR triggering and the junction temperature is T_{j2} for I_{o2}.

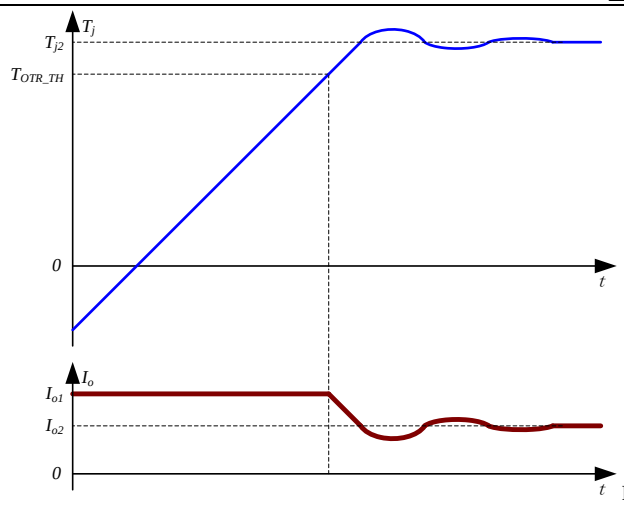


Fig. 8 Principle of the over temperature regulation

Over Voltage Protection

The output OVP voltage is fixed at 250V. However, HV resistor has the affection to OVP voltage. Higher OVP voltage can be obtained by slightly increasing the HV resistance.

Current Dropping

Programmable current dropping at high line (e.g. > 265Vac) is designed to reduce the temperature of the components and system to improve the thermal and reliability performance.

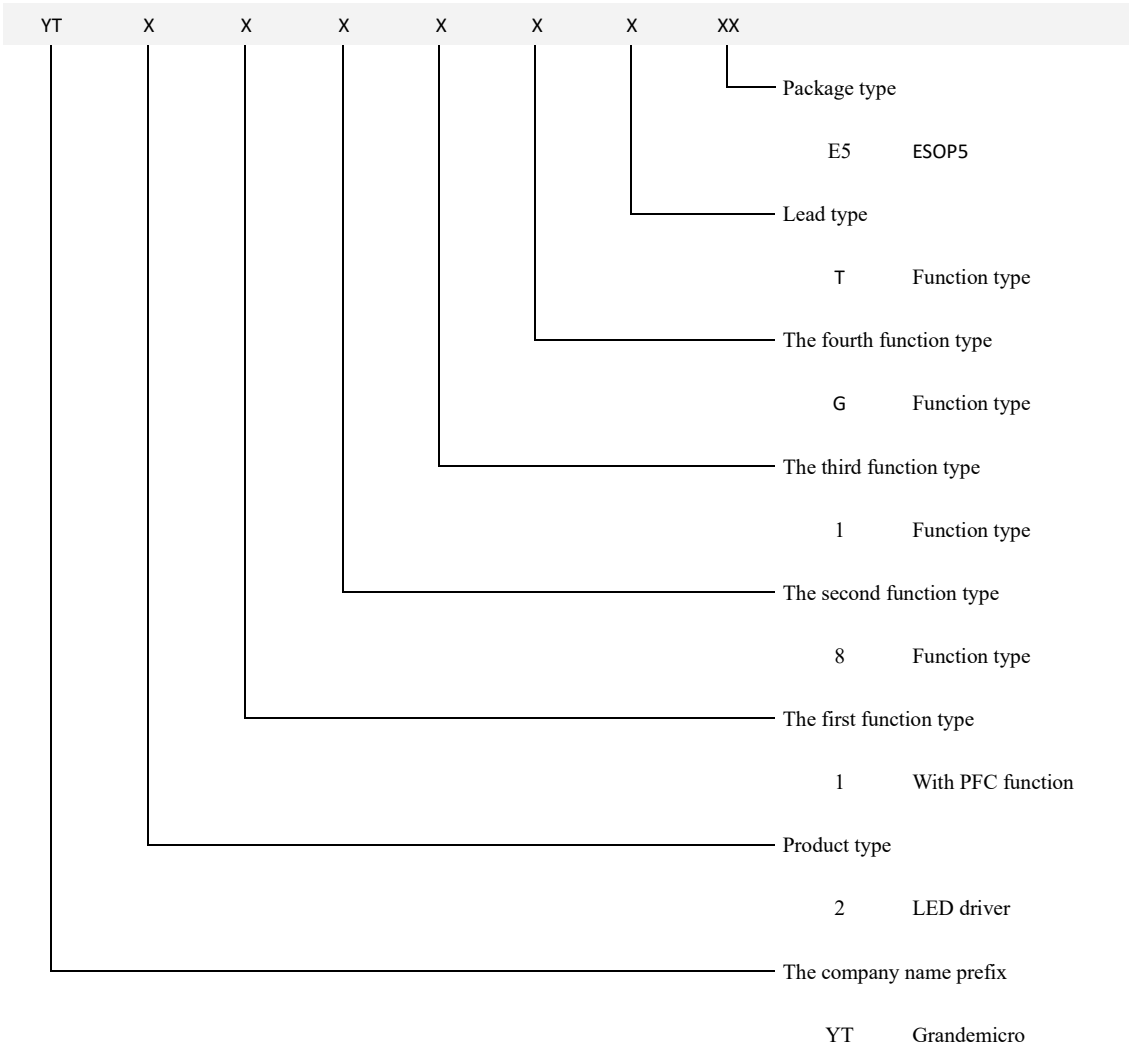
Restart after Protection

When PWM is stopped by any protection, chip increases the power dissipation to force VCC UVLO happen. Chip can only be restarted by VCC UVLO to remove the protection scheme.

PCB Design Guide

1. Current sensing resistor (R_{cs}) shall be placed very close to the chip, minimize the loop from CS pin to R_{cs} and GND pin.
2. Separate the power ground and the signal ground.
3. Minimize the loop from input capacitor (C_{in}) to MOSFET and the freewheeling diode to improve the system stability and EMC performance.

Marking Rule

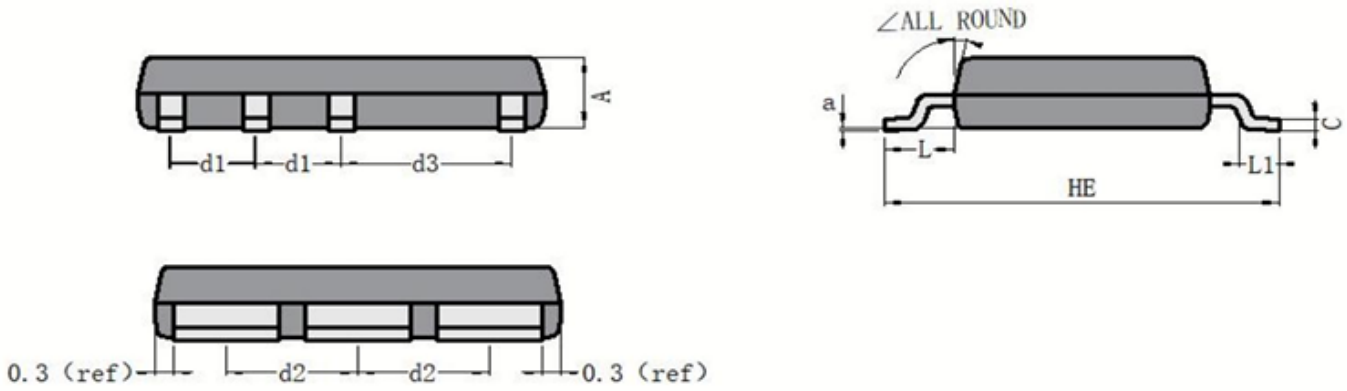


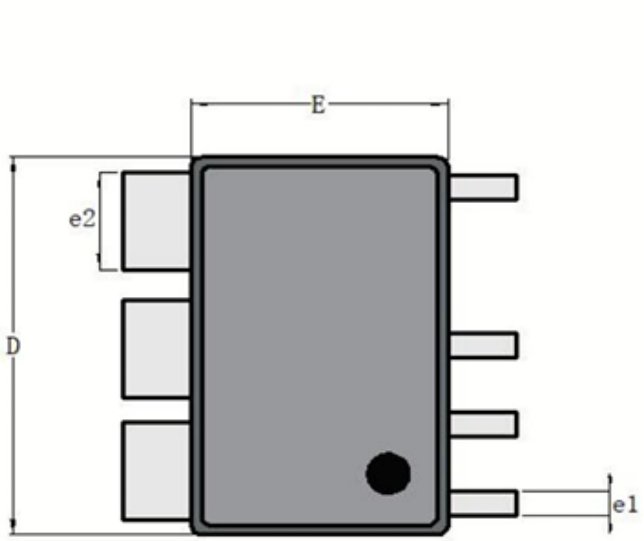
Naming Rule

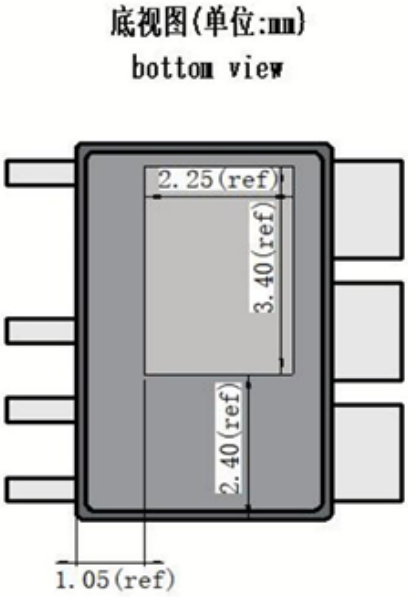
●	Part No. Date Code Special Note
Part No.	YT2181GT
Date Code	P: Packing site; Y: Year; W: Week; S: Series; F: MOSFET.
Special Note	Use obvious mark like “H”, “L” to distinguish the key features like CS reference or OVP reference etc. if necessary.

Package

ESOP5







Unit		A	C	D	E	HE	d1	d2	d3	e1	e2	L	L1	a	∠
mm	max	1.25	0.22	6.4	4.1	6.1	1.35	2.05	2.65	0.45	1.65	1.15	0.80	0.2 (ref)	12°
	typ	1.15	0.20	6.2	3.9	6.0	1.30	2.00	2.60	0.40	1.60	1.05	/		
	min	1.05	0.15	6.0	3.7	5.9	1.25	1.95	2.55	0.35	1.55	0.95	0.40		
mil	max	49	9	252	161	240	53	81	104	18	65	45	31	8 (ref)	
	typ	45	8	244	154	236	51	79	102	16	63	41	/		
	min	41	6	236	146	232	49	77	100	14	61	37	16		

Version History

Version	Date	Description
A0	May. 2025	Draft
A1	May. 2025	Released