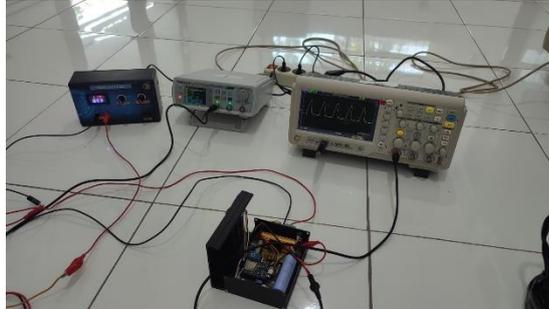# LAMPIRAN

Lampiran 1 Dokumentasi Pengujian Alat

Lampiran 2 Pemrograman

```cpp
#include <LiquidCrystal_I2C.h>
#include <driver/rmt.h>
#include <driver/dac.h>

/* --- CHANGEABLE VARIABLE --- */
/* Comment this out to disable prints and save space */
#define BLYNK_PRINT Serial
#define DEBUG_SERIAL true //True jika ingin melakukan debugging lewat serial monitor

/* Fill in information from Blynk Device Info here */
#define BLYNK_TEMPLATE_ID "TMPL6t7d3a2Kd"
#define BLYNK_TEMPLATE_NAME "Monitoring"
#define BLYNK_AUTH_TOKEN "CvkjS3XdishR_SJgUGVSBZuCNlXdaC8e"
// #define BLYNK_TEMPLATE_ID "TMPL6IBV_ccij"
// #define BLYNK_TEMPLATE_NAME "Surge Counter"
// #define BLYNK_AUTH_TOKEN "zcGnL0SKwGzpPVJZ3tuptpNB0-TqEG_4"

// Your WiFi credentials.
// Set password to "" for open networks.
// char ssid[] = "ZAYN";
// char pass[] = "10072024";
char ssid[] = "Galaxy A02s7631";
char pass[] = "qwerty989";
// Your WiFi credentials.
// Set password to "" for open networks.
// char ssid[] = "Qiyan";
// char pass[] = "123456789";

const unsigned long publishInterval = 30000; // periode publish
const int LCDUpdate = 500; //periode update lcd
const unsigned long backlightTimeout = 2500; // 2 detik maks nyala backlight
```

```
const unsigned long connectTimeout = 30000;  // 10 detik maksimum koneksi

// Konfigurasi RMT
#define RMT_RX_CHANNEL    RMT_CHANNEL_0
#define RMT_RX_GPIO       GPIO_NUM_35
#define DAC_PIN           DAC_CHANNEL_2

#define RMT_CLK_DIV       80   // 1 tick = 1 µs
#define RMT_MEM_BLOCK     1

//volatile int cnt = 0;   // counter asli, naik tiap pulsa
bool ledState = LOW;     // opsional: toggle LED debug
/* --- END OF CHANGEABLE VARIABLE --- */

/* --- LIBRARY --- */
#include "DHTesp.h"
#include "esp_wifi.h"
#include <LiquidCrystal_I2C.h>
#include <Ticker.h>
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

#define DHTPIN 2
#define VOLTAGEPIN 35

/* --- OBJECT --- */
DHTesp dht;
LiquidCrystal_I2C lcd(0x27, 16, 2);

volatile bool signalHigh = false;
volatile bool prevSignalHigh = false;
```

```
volatile float temp = 0.0, hum = 0.0;
volatile long cnt_container = 0;
volatile long cnt_synced = 0;
volatile long count = 0;
volatile bool syncDone = false;
bool connected = false;
bool inLightSleep = false;
bool fromDashboard = false;
unsigned long publishDoneAt = 0;
bool lcdActive = true;
unsigned long lastValueChange = 0;
volatile int stableHighCount = 0;
volatile int stableLowCount = 0;
float lastTemp = -999;
float lastHum = -999;
int lastCNT = -1;


/* --- TIMING --- */
unsigned long lastLCDUpdate = 0;
unsigned long lastPublishTime = 0;
static unsigned long lastPCNTLog = 0;

/* --- Multitasking --- */
Ticker dhtTicker;

hw_timer_t *adcTimer = NULL;
portMUX_TYPE timerMux = portMUX_INITIALIZER_UNLOCKED;

/* --- FINITE STATE MACHINE --- */
enum State {
  CONNECTING,
```

```
  PUBLISHING,
  SLEEPING
};

State currentState, lastState = CONNECTING;
unsigned long stateStartTime = 0;
```

```
/* Final PCNT + FreeRTOS (refactored)
   Perbaikan sinkronisasi antara PCNT (ESP32) dan Blynk dashboard.
   Strategy:
   - maintain pcnt_total: monotonic total derived from PCNT unit (never decreased
except when server has larger value)
   - protect shared variables with portMUX
   - on Blynk sync: if server > local -> adopt server; if server < local -> push local
to server
   - display 'count' = pcnt_total for publishing/display
*/


#include "Header.h"
#include <driver/pcnt.h>
#include <driver/dac.h>
#include "freertos/FreeRTOS.h"
#include "freertos/task.h"
#include "esp_attr.h"


// ====== PCNT config ======
#define PCNT_INPUT_SIG_IO   GPIO_NUM_35
#define PCNT_UNIT_USED      PCNT_UNIT_0
#define PCNT_CHANNEL_USED   PCNT_CHANNEL_0


// DAC reference
#define DAC_VAL         8


// Filter noise (pulse < 2us akan diabaikan)
const float MIN_PULSE_US = 5.0;


// --- shared state (Header.h should declare extern where appropriate) ---
// We'll assume Header.h declares:
//   volatile uint32_t cnt_synced; // last server acknowledged total (optional)
//   volatile uint32_t count;      // exposed count (for display/publish)
```

```
//    volatile bool syncDone;

//    float temp, hum;

//    ... etc


// Internal: raw last counter read from PCNT (signed 16-bit as pcnt returns
int16_t)

volatile int16_t lastPCNTRaw = 0;

// Monotonic total derived from PCNT deltas (never decreases except when
adopting server larger)

volatile uint32_t pcnt_total = 0;


// Protect shared counter updates between tasks

portMUX_TYPE cntMux = portMUX_INITIALIZER_UNLOCKED;


// ====== PCNT setup ======
void setupPCNT() {
  pcnt_config_t pcnt_config = {};
  pcnt_config.pulse_gpio_num = PCNT_INPUT_SIG_IO;
  pcnt_config.ctrl_gpio_num = PCNT_PIN_NOT_USED;
  pcnt_config.unit = PCNT_UNIT_USED;
  pcnt_config.channel = PCNT_CHANNEL_USED;
  pcnt_config.pos_mode = PCNT_COUNT_INC;   // Count rising edge
  pcnt_config.neg_mode = PCNT_COUNT_DIS;   // Abaikan falling edge
  pcnt_config.lctrl_mode = PCNT_MODE_KEEP;
  pcnt_config.hctrl_mode = PCNT_MODE_KEEP;
  pcnt_config.counter_h_lim = 32767;
  pcnt_config.counter_l_lim = 0;


  pcnt_unit_config(&pcnt_config);


  // Filter untuk noise < MIN_PULSE_US
  uint16_t filter_ticks = (uint16_t)(MIN_PULSE_US * 80.0 + 0.5); // 80 MHz
base clk (approx)
```

```
  if (filter_ticks < 1) filter_ticks = 1;
  pcnt_set_filter_value(PCNT_UNIT_USED, filter_ticks);
  pcnt_filter_enable(PCNT_UNIT_USED);


  pcnt_counter_pause(PCNT_UNIT_USED);
  pcnt_counter_clear(PCNT_UNIT_USED);


  // initialize last raw reading to 0 (will be re-read in loop soon)
  lastPCNTRaw = 0;
  pcnt_counter_resume(PCNT_UNIT_USED);
}


/* === utility: compute delta between two int16_t PCNT reads, handling wrap
===
   PCNT counter configured 0..32767. Since we only count up, delta should be
>=0,
   but if PCNT wrapped due to hitting limit, we handle forward wrap by adding
32768.
*/
static int32_t pcnt_compute_delta(int16_t last_raw, int16_t now_raw) {
  int32_t delta = (int32_t)now_raw - (int32_t)last_raw;
  // if negative and magnitude indicates wrap-around forward (e.g. last near top)
  if (delta < 0) {
    // assume forward wrap: add (counter_range + 1)
    delta += 32768; // since counter range 0..32767
  }
  return delta; // should be >= 0
}


/* === Blynk Virtual Write Handler ===
   V2: authoritative server total (dashboard).
   Merge logic:
   - If serverValue > localTotal -> adopt serverValue (maybe someone updated
server externally)
```

- If serverValue < localTotal -> server is behind -> set flag so PUBLISHING sends our local total back to server
*/

```
BLYNK_WRITE(V2) {
  uint32_t serverValue = (uint32_t) param.asInt();

  portENTER_CRITICAL(&cntMux);
  uint32_t localTotal = pcnt_total;
  if (serverValue > localTotal) {
    // server has bigger value -> adopt it (to avoid roll-back surprises)
    pcnt_total = serverValue;
    count = pcnt_total;
    cnt_synced = serverValue;
    // reset publish flag (we already in sync with server)
    syncDone = true;
  } else if (serverValue < localTotal) {
    // server behind -> we'll make sure to publish localTotal on next publish
    // but still record server value as last seen
    cnt_synced = serverValue;
    // do NOT reduce pcnt_total; keep our local accurate higher value
    // mark syncDone so state machine can proceed (we'll push our local value when publishing)
    syncDone = true;
  } else {
    // equal
    cnt_synced = serverValue;
    syncDone = true;
  }
  portEXIT_CRITICAL(&cntMux);
}

/* === DHT read === */
void readDHT() {
```

```
  TempAndHumidity data = dht.getTempAndHumidity();
  if (dht.getStatus() == 0) {
    // use portMUX only if temp/hum are shared; assume they're safe
    temp = data.temperature;
    hum = data.humidity;
  }
}

/* === LCD helper === */
void printStatusLCD(const String &line1, const String &line2 = "") {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print(line1.substring(0, 16));
  lcd.setCursor(0, 1);
  lcd.print(line2.substring(0, 16));
}

/* === Setup === */
void setup() {
  if (DEBUG_SERIAL) {
    Serial.begin(115200);
    delay(1500);
  }

  pinMode(VOLTAGEPIN, INPUT);

  // DAC hampir 0V (Vref op-amp)
  dac_output_enable(DAC_CHANNEL_2); // GPIO26
  dac_output_voltage(DAC_CHANNEL_2, DAC_VAL);

  lcd.init();
  lcd.backlight();
```

```
  printStatusLCD("Surge Counter", "Init...");

  dht.setup(DHTPIN, DHTesp::DHT11);
  dhtTicker.attach(5.0, readDHT);

  // Start PCNT
  setupPCNT();

  // Read an initial PCNT snapshot to initialize lastPCNTRaw
  {
    int16_t snapshot = 0;
    pcnt_get_counter_value(PCNT_UNIT_USED, &snapshot);
    lastPCNTRaw = snapshot;
    // pcnt_total stays 0 initially (unless you want to persist across resets)
    pcnt_total = 0;
    count = (uint32_t) pcnt_total;
    cnt_synced = 0;
    syncDone = false;
  }

  // Start network & Blynk (core 1)
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, pass);
  Blynk.config(BLYNK_AUTH_TOKEN);
  Blynk.connect(); // non-blocking

  stateStartTime = millis();
}

/* === Loop (core 1) === */
void loop() {
  Blynk.run(); // keep Blynk alive
```

```
unsigned long now = millis();

// 1) Periodically read PCNT and accumulate into pcnt_total every LCDUpdate
ms
static unsigned long lastPCNTUpdate = 0;
if (now - lastPCNTUpdate >= LCDUpdate) {
  int16_t rawNow = 0;
  pcnt_get_counter_value(PCNT_UNIT_USED, &rawNow);

  // compute delta safely
  int32_t delta = pcnt_compute_delta((int16_t) lastPCNTRaw, (int16_t)
rawNow);
  lastPCNTRaw = rawNow;

  // update monotonic total in critical section
  portENTER_CRITICAL(&cntMux);
  pcnt_total += (uint32_t) delta; // pcnt_total is monotonic
  // keep count in sync for display/publish
  count = pcnt_total;
  portEXIT_CRITICAL(&cntMux);

  // Also update LCD values (but avoid blocking)
  // show only when changed to reduce flicker
  if (currentState != PUBLISHING) {
    static float lastTemp = NAN;
    static float lastHum = NAN;
    static uint32_t lastDisplayCount = UINT32_MAX;
    if (temp != lastTemp || hum != lastHum || count != lastDisplayCount ||
currentState != lastState) {
      printStatusLCD(
        "T:" + String(temp, 2) + " H:" + String(hum, 2),
        "Counter: " + String(count)
      );
```

```
      lcd.backlight();

      lcdActive = true;

      lastValueChange = now;


      lastTemp = temp;

      lastHum  = hum;

      lastDisplayCount = count;

      lastState = currentState;

    }

  }

  lastPCNTUpdate = now;

}


// 2) Backlight auto-off

if (lcdActive && (now - lastValueChange >= backlightTimeout)) {

  // lcd.noBacklight(); // optional

  lcdActive = false;

}


// 3) Serial log setiap 1 detik

static unsigned long lastSerialLog = 0;

if (now - lastSerialLog >= 1000) {

  lastSerialLog = now;

  int16_t snapshotCnt = 0;

  pcnt_get_counter_value(PCNT_UNIT_USED, &snapshotCnt);

  portENTER_CRITICAL(&cntMux);

  uint32_t localTotal = pcnt_total;

  uint32_t lastSynced = cnt_synced;

  uint32_t dispCount = count;

  portEXIT_CRITICAL(&cntMux);


    Serial.printf("[LOG] RawPCNT=%d, pcnt_total=%u, Synced=%u,
Count=%u\n",
```

```
            snapshotCnt, (unsigned) localTotal, (unsigned) lastSynced, (unsigned)
dispCount);
  }


  // 4) State machine (CONNECTING, PUBLISHING, SLEEPING)
  switch (currentState) {
   case CONNECTING:
     if (WiFi.status() == WL_CONNECTED) {
      if (!Blynk.connected()) {
       Blynk.connect();
      } else {
       Blynk.run();
       // Force a sync from server to get remote authoritative value
       if (!syncDone) {
         Blynk.syncVirtual(V2);
         stateStartTime = now;
       }
       // wait until syncDone or timeout
       if (syncDone || (now - stateStartTime > 2000)) {
         currentState = PUBLISHING;
         stateStartTime = now;
       }
      }
     } else if (now - stateStartTime > connectTimeout) {
       currentState = SLEEPING;
       stateStartTime = now;
     }
     break;


   case PUBLISHING: {
     // prepare data snapshot
     uint32_t snapshotTotal;
     portENTER_CRITICAL(&cntMux);
```

```
snapshotTotal = pcnt_total;
portEXIT_CRITICAL(&cntMux);


String alldata = String(round(temp * 100) / 100) + ";" +
            String(round(hum * 100) / 100) + ";" +
            String(snapshotTotal);


Blynk.virtualWrite(V0, temp);
Blynk.virtualWrite(V1, hum);


// Merge/publish logic:
// - If server (cnt_synced) < local snapshotTotal -> push our local to V2 (server
behind)
// - Else server >= local -> still write count (keeps dashboard in sync)
// In practice always write snapshotTotal; additionally, if server was behind we
will overwrite it.
Blynk.virtualWrite(V2, (int) snapshotTotal);
Blynk.virtualWrite(V3, alldata);


printStatusLCD("Publish OK", "Tunggu...");
lcd.backlight();
lcdActive = true;
lastValueChange = now;


// After short delay, disconnect and go to sleep
if (publishDoneAt == 0) publishDoneAt = now;
if (now - publishDoneAt >= 500) {
  // record that we've pushed server-acknowledged value
  portENTER_CRITICAL(&cntMux);
  cnt_synced = snapshotTotal;
  syncDone = true; // we've published
  portEXIT_CRITICAL(&cntMux);
```

```
      Blynk.disconnect();
      WiFi.disconnect(false);
      WiFi.mode(WIFI_OFF);
      esp_wifi_stop();
      btStop();

      publishDoneAt = 0;
      stateStartTime = now;
      currentState = SLEEPING;
      Serial.printf("[Published] snapshotTotal=%u\n", (unsigned) snapshotTotal);
     }
   } break;

   case SLEEPING:
     if (now - stateStartTime >= publishInterval) {
       // wake up wifi & blynk and reconnect
       WiFi.disconnect(true);
       WiFi.mode(WIFI_STA);
       esp_wifi_start();
       WiFi.begin(ssid, pass);
       Blynk.config(BLYNK_AUTH_TOKEN);
       Blynk.connect();

       stateStartTime = now;
       currentState = CONNECTING;
       syncDone = false; // request a fresh sync on connect
     }
     break;
  }
}
```

Lampiran 3 Datasheet

«NOVATEK-ELECTRO» Ltd
Intelligent industrial electronics

NOVATEK
ELECTRO

CURRENT
TRANSFORMER

SCT-T24 100A/5A
SCT-T24 200A/5A
SCT-T36 400A/5A
SCT-T36 600A/5A,
SCT-T50 800A/5A

OPERATING MANUAL

Quality control system on the development and production complies with requirements
ISO 9001:2015

Dear customer,
Company NOVATEK-ELECTRO Ltd. thanks you for purchasing our products.
You will be able to use properly the product after carefully studying the Operating Manual.
Keep the Operating Manual throughout the service life of the product.

Review the Operating manual before using the product

This product is safe for use in case of compliance with operating rules.

UKRAINE, Odessa   **www.novatek-electro.com**

~2~

ATTENTION! ALL REQUIREMENTS OF THIS OPERATING MANUAL ARE COMPULSORY TO BE MET!

⚠️ **ATTENTION! It is not allowed to leave the secondary winding of the current transformer unconnected if the measured current is passing through the primary winding.**

TO ENSURE SAFE OPERATION OF THE SCT-T, IT IS STRICTLY FORBIDDEN TO USE PRODUCTS WITH MECHANICAL DAMAGE TO THE CASING.

During operation and maintenance the regulatory document requirements must be met, namely:
– Regulations for Operation of Consumer Electrical Installations;
– Safety Rules for Operation of Consumer Electrical Installations;
– Occupational Safety when in Operation of Electrical Installations.

Installation, adjustment and maintenance of the product must be performed by qualified personnel having studied this Operating Manual.

In compliance with the requirements of this Operating Manual and regulations the product is safe for use.

This operation manual is intended for description, principle of work, construction, mode of work and maintenance of the SCT-T series Current Transformer of the following models: SCT-T24 100A/5A, SCT-T24 200A/5A, SCT-T36 400A/5A, SCT-T36 600A/5A, SCT-T50 800A/5A (hereinafter referred to as the product, SCT-T).

Terms and abbreviations: EN 60947-1; EN 55011.

Harmful substances, in more than allowed concentration, are not available.

1 APPLICATION

SCT-T series split core current transformers are designed for quick and easy installation. Split core transformers are ideal for installation on an existing electrical network by snapping the product around the conductor. This method allows for a safer, simpler and more portable current measurement.

2 TECHNICAL CHARACTERISTICS

- Rated primary currents depending on SCT-T model: 100 A, 200 A, 400 A, 600A, 800 A (AC)
- Secondary current: 5 A
- Accuracy: see table 1
- Insulation voltage: 600 V AC
- Maximum voltage: 2000 VAC (insulated conductor)
- Operating temperature: -15 ... 55 °C
- Frequency range: 50-400Hz
- Degree of protection: IP 20
- Relative humidity: 5 - 85%

Table 1

Model	R_H (Om)	Inner window diameter	Dimensions (HxBxL)	Rated primary current (In)	Accuracy		
					from 5% to 120% In	2 × In	3 × In
SCT-T24 100A/5A	≤ 0.05	24 mm	67x35x54 mm	100 A	1,5 %	10 %	-
SCT-T24 200A/5A	≤ 0.1	24 mm	67x35x54 mm	200 A	1 %	1 %	5 %
SCT-T36 400A/5A	≤ 0.1	36 mm	87x43x68 mm	400 A	1 %	1 %	5 %
SCT-T36 600A/5A	≤ 0.1	36 mm	87x43x68 mm	600 A	1 %	1 %	5 %
SCT-T50 800A/5A	≤ 0.1	50 mm	120x60x100 mm	800 A	1 %	1 %	5 %

Notes: R_H is the load resistance in the secondary circuit.

3 PRODUCT DESCRIPTION

The SCT-T consists of an openable core with a hole for the primary winding and a secondary winding wound around the core. The whole structure is placed in a plastic insulating case.

A bus or cable is passed through the opening of the magnetic circuit, which serves as the primary winding of the product. For ease of installation, the magnetic circuit is made detachable. The product is fastened to the

CURRENT TRANSFORMER   *NOVATEK-ELEKTRO*

~4~

conductor, which serves as the primary winding, using plastic clamps. Terminal blocks of the secondary winding have flexible leads soldered into the housing.

The current flowing through the secondary of an SCT-T is proportional to the current flowing through its primary.

4 SERVICE LIFE AND WARRANTY

Service life – is 3 years. Contact manufacturer upon the expiry of the service life.
Guaranteed storage life – is 3 years.
Warranty period of the product operation is 1year from the date of sale.

ATTENTION! IF THE PRODUCT HAS BEEN OPERATED WITH VIOLATION OF THE REQUIREMENTS OF THIS OPERATION MANUAL, BUYER WILL FORFEIT THE RIGHT TO WARRANTY SERVICE.

Warranty service is performed at the place of purchase or by the Manufacturer of the product.
Post-warranty service is performed by the Manufacturer at current rates.
Before sending for repair, the product should be packed in the original or other packaging excluding mechanical damage.

Earnest request: indicate the reason for return in the notice of faults field at the return of the device or in case of submitting for warranty service or post-warranty service.

5 TRANSPORTATION AND STORAGE

The product in the shipping box should be stored indoors at a temperature of -45 to +60 °C and relative humidity of no more than 80% with no vapors available in the air.

6 ACCEPTANCE CERTIFICATE

SCT-T is manufactured and accepted in accordance with the applicable technical documentation and considered as fit for use.

Head of quality division   Date of manufacture
_____   _____

Stamp

7 NOTICES OF CLAIMS

_____
_____
_____
_____
_____
_____

The Company is grateful to you for the information about the quality of the device and suggestions for its operation.

♦♦♦♦♦

With questions and comments, please contact manufacturer at the following address:
"Novatek-Electro" Ltd.
59, Admiral Lazarev str.,
Odesa, Ukraine, 65007.
Tel: +38 048 738-00-28; +38 0482 37-48-27;
Fax: +38 0482 34 36 73.
www.novatek-electro.com

Sale date_____   **VN250304**
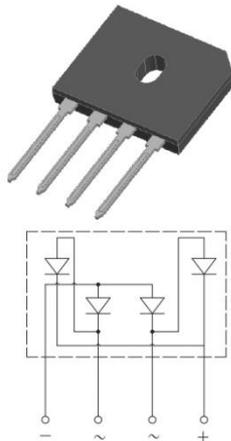*NOVATEK-ELECTRO*   *CURRENT TRANSFORMER*

GBU15005 THRU GBU1510

RoHS
COMPLIANT

Bridge Rectifier

Features
● UL recognition, file #E230084
● Ideal for printed circuit boards
● High surge current capability
● Solder dip 275 °C max. 7 s, per JESD 22-B106

Typical Applications
General purpose use in AC/DC bridge full wave rectification for monitor, TV, printer, power supply, switching mode power supply, adapter, audio equipment, and home appliances applications.

Mechanical Data
● **Package**: GBU
Molding compound meets UL 94 V-0 flammability rating, RoHS-compliant
● **Terminals**: Tin plated leads, solderable per J-STD-002 and JESD22-B102
● **Polarity:** As marked on body

■Maximum Ratings (Ta=25℃ Unless otherwise specified）

PARAMETER		SYMBOL	UNIT	GBU15005	GBU1501	GBU1502	GBU1504	GBU1506	GBU1508	GBU1510
Device marking code				GBU15005	GBU1501	GBU1502	GBU1504	GBU1506	GBU1508	GBU1510
Repetitive peak reverse voltage		V_{RRM}	V	50	100	200	400	600	800	1000
Average rectified output current @60Hz sine wave, R-load	With heatsink T_C =100℃	I_O	A	15						
	Without heatsink T_a =25℃			3.2						
Surge(non-repetitive)forward current @60Hz half sine wave, 1 cycle, Tj=25℃		I_{FSM}	A	200						
Current squared time @1ms≤t≤8.3ms Tj=25℃, Rating of per diode		I^2t	A^2s	166						
Storage temperature		T_{stg}	℃	-55 ~+150						
Junction temperature		T_j	℃	-55 ~+150						
Dielectric strength @terminals to case, AC 1 minute		V_{dis}	KV	2						
Mounting torque @recommend torque：5kg・cm		Tor	kg・cm	8						

■Electrical Characteristics （Ta=25℃ Unless otherwise specified）

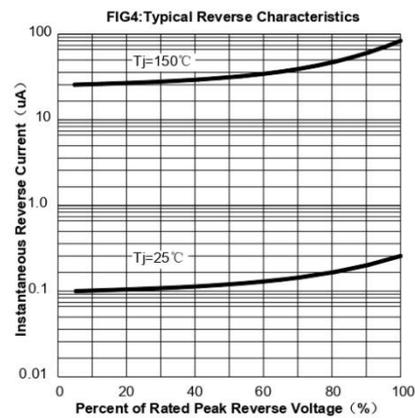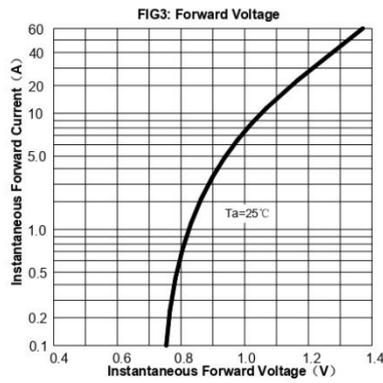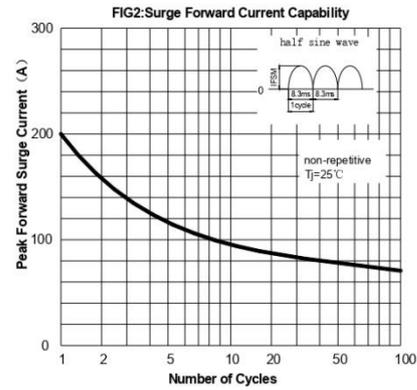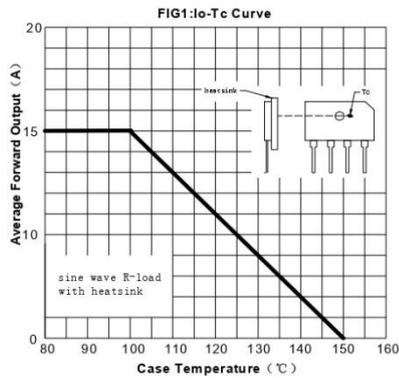| PARAMETER	SYMBOL	UNIT	TEST CONDITIONS	GBU15005	GBU1501	GBU1502	GBU1504	GBU1506	GBU1508	GBU1510
Maximum instantaneous forward voltage drop per diode	V_F	V	I_{FM}=7.5A	1.1						
Maximum DC reverse current at rated DC blocking voltage per diode	I_{RRM}	μA	VRM=V_{RRM}	10						

GBU15005 THRU GBU1510

■Thermal Characteristics （Ta=25℃ Unless otherwise specified）

PARAMETER		SYMBOL	UNIT	GBU15005	GBU1501	GBU1502	GBU1504	GBU1506	GBU1508	GBU1510
Thermal Resistance	Between junction and ambient, Without heatsink	RθJ-A	℃/W	23						
	Between junction and case, With heatsink	RθJ-C		1.8						

■Ordering Information (Example)

PREFERED P/N	PACKING CODE	UNIT WEIGHT(g)	MINIIMUM PACKAGE(pcs)	INNER BOX QUANTITY(pcs)	OUTER CARTON QUANTITY(pcs)	DELIVERY MODE
GBU15005 THRU GBU1510	B1	Approximate 3.97	20	1000	2000	TUBE
GBU15005 THRU GBU1510	A1	Approximate 3.97	250	250	4000	BOX

■ Characteristics (Typical)

FIG1:Io-Tc Curve

FIG2:Surge Forward Current Capability

FIG3: Forward Voltage

FIG4:Typical Reverse Characteristics

2 / 4

GBU15005 THRU GBU1510

■ **Outline Dimensions**

GBU

AC

Dimensions in millimeters
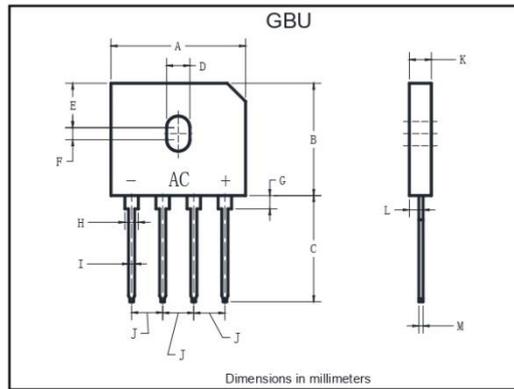
GBU		
Dim	Min	Max
A	21.80	22.30
B	18.30	18.80
C	17.50	18.00
D	3.50	4.10
E	7.40	7.90
F	1.65	2.16
G	1.91	2.54
H	2.06	2.54
I	1.02	1.27
J	4.83	5.33
K	3.30	3.56
L	2.40	2.66
M	0.46	0.56

GBU15005 THRU GBU1510

Disclaimer

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The product listed herein is designed to be used with ordinary electronic equipment or devices, and not designed to be used with equipment or devices which require high level of reliability and the malfunction of with would directly endanger human life (such as medical instruments, transportation equipment, aerospace machinery, nuclear-reactor controllers, fuel controllers and other safety devices), Yangjie or anyone on its behalf, assumes no responsibility or liability for any damages resulting from such improper use of sale.

This publication supersedes & replaces all information previously supplied. For additional information, please visit our website http:// www.21yangjie.com , or consult your nearest Yangjie's sales office for further assistance.

	Forming Lead Shapes			
	I	II	III	IV
	P > F		P < F	
	0mm < P-F ≤ 3mm	3mm < P-F ≤ 8mm	3mm < F-P ≤ 5mm	0mm < F-P ≤ 3mm
	F ± 1.0mm; A ≤ 5.0mm; B=4.5 ± 0.5mm			

Specifications

Reference Standard:	GB/T 6346 (IEC 60384-11)
Climatic Category :	55/105/21
Rated Temperature:	85°C
Operating Temperature Range:	-55°C~105°C
	(+85°C to +105°C: decreasing factor 1.25% per °C for V_R(dc))
Rated Voltage:	50V、63V/100V、250V、400V
Capacitance Range:	0.0001μF~0.47μF
Capacitance Tolerance:	±5% (J)、±10% (K)、±20% (M)
Voltage Proof:	2.0U_R(5S)
Dissipation Factor:	≤1.0% (20°C, 1KHz)
Insulation Resistance:	≥30 000MΩ, C_R≤0.1μF
	≥10 000MΩ, C_R > 0.1μF (20°C, 1min)

■ Main Specifications

| Model | Rated power at 25°C (W) | | Resistance range (Ω) | Resistance tolerance (%) | Temperature Coefficient (×10 -6 /°C) | Withstand voltage (V) |
	With heat sink	Without heat sink				
	5	3	0.01~1K	±1, ±5	±100, ±50	1000
	10	8	0.01~1.5K			
	25	12.5	0.01~10K			
	50	20	0.01~33K			
	100	50	0.01~51K			2000
	200	50	0.01~62K			
	300	75	0.01~75K			
	500	200	0.01~82K			

■ Main inspection items, test methods and performance requirements

Test items	Performance requirements	experiment method
Solderability	The solder can flow freely and wet with the leads	Slot welding 235±5°C, 2s
Terminal strength	△R ≤ ±(1%R+0.05Ω)	40N
Rapid temperature change	△R ≤ ±(1%R+0.05Ω)	-55°C/+155°C, 5 cycles
Short-time overload	△R ≤ ±(1%R+0.05Ω)	10P R 5s
Constant heat and humidity	△R ≤ ±(5%R+0.1Ω)	40±2°C 93 eq\o(\s\up 7(+2),\s\do 3(-3)) +2-3 % 21天
Shock	△R ≤ ±(1%R+0.05Ω)	490m/s 2 11ms 18次
Vibration	△R ≤ ±(1%R+0.05Ω)	10−50Hz 98 m/s 2 6h
Room temperature durability	△R ≤ ±(5%R+0.1Ω)	Room temperature P R 1000h
Resistance to welding heat	△R ≤ ±(1%R+0.05Ω)	350±10°C 3.5±0.5s
Surface temperature rise	≤ 275°C	V R

XL4005 Step Down Module (5A)

XL4005 Step Down Module (5A)

- Module properties: non-isolated step-down module (BUCK)
- Rectification: non-synchronous rectifier
- Input voltage: DC 4V ~ 38V
- Output voltage: DC 1.25V ~ 32V (adjustable)
- Output current: 0A ~ 5A
- Output power: 75W (more than 50W please add heat sink)
- Operating Frequency: 180KHz
- Operating Temperature: -40?C ~ +85?C
- Load regulation: S(I)?0.8%
- Voltage regulation: S(u)?0.8%

SKU: 25592

Safe shopping

Your data is always protected

EEM3™

Lithium-ion Battery
DATA SHEET

Battery Model: LIR18650

Prepared	Authorized	Approved

This Specification describes the requirements of the lithium ion battery with Lithium nickel manganese cobalt material supplied by EEMB Co., Ltd.

1.0 BASIC CHARACTERISTICS

1.1	Battery Type	LIR18650
1.2	Nominal Capacity	3000mAh (0.2C, 2.75V discharge))
	Minimum Capacity	2850mAh (0.2C, 2.75V discharge))
1.3	Max Charging Voltage	4.35±0.03 V
1.4	Nominal Voltage	3.78V
1.5	Charging Method	CC-CV (constant voltage with limited current)
1.6	Charging Current	Standard charge: 1475mA Rapid charge : 2950mA
1.7	Charging Time	Standard charge : 3hours Rapid charge : 2.5hours
1.8	Max. Charge Current	2950mA(ambient temperature 25℃
1.9	Max. Discharge Current	5900mA(ambient temperature 25℃
2.0	Discharge Cut-off Voltage	2.75V
2.1	Cell Weight	48.0g max
2.2	Cell Dimension	Height : 65.00mm max Diameter : 18.40mm max
2.3	Operating Temperature	Charge: 0～45℃ Discharge: -20℃～60℃
2.4	Storage Temperature	1 year: -20~25℃ 3 months: -20~25℃ 1 month: -20~50℃

Note (1): If the cell is kept as ex-factory status (50% of charge),
 the capacity recovery rate is more than 80%.

2.0 Appearance

There shall be no such defects as scratch, rust, discoloration, leakage which may adversely affect commercial value of the cell.

3.0 Standard Testing Conditions

3.1 Environmental Conditions

Unless otherwise specified, all tests stated in this specification are conducted at temperature25±5℃ and humidity 65±20%

3.2 Measuring Equipment

(1) Ammeter and Voltmeter

The ammeter and voltmeter should have an accuracy of the grade 0.5 or higher.

(2) Slide caliper

The slide caliper should have 0.01 mm scale.

(3) Impedance meter

The impedance meter with AC 1kHz should be used.

4.0 Electrical Characteristics

4.1 Standard Charge

This "Standard Charge" means charging the cell with charge current 1475mA and constant voltage 4.35V at 25℃for 3hours.

4.2 Standard Discharge Capacity

The standard discharge capacity is the initial discharge capacity of the cell, which is measured with discharge current of 590mA with 2.75V cut-off at 25℃within 1hour after the standard charge.

Standard Discharge Capacity≥2850mAh

4.3 Initial internal impedance

Initial internal impedance measured at AC 1kHz after rated charge.

Initial internal impedance≤100mΩ

4.4 Temperature Dependence of Discharge Capacity

Capacity comparison at each temperature, measured with discharge constant current 590mA and 2.75V cut-off after the standard charge is as follows.

Charge Temperature	Discharge temperature			
25℃	-10℃	0℃	25℃	40℃
Relative Capacity	50%	80%	100%	80%

Note: If charge temperature and discharge temperature is not the same,the interval for temperature change is 3 hours.

Percentage as an index of the capacity at 25℃(=2850mAh) is 100%.

4.5 Temperature Dependence of Charge Capacity

Capacity comparison at each temperature, measured with discharge constant current 590mA and 2.75V cut-off after the standard charge is as follows.

	Charge temperature			Discharge temperature
	0℃	25℃	45℃	25℃
Relative Capacity	80%	100%	80%	

Note: If charge temperature and discharge temperature is not the same,the interval for temperature change is 3 hours.

Percentage as an index of the capacity at 25℃(=2850mAh) is 100%.

4.6 Charge Rate Capabilities

Discharge capacity is measured with constant current 590mA and 2.75V cut-off after the cell is charged with 4.35V as follows.

	Charge Condition			
Current	0.2C (590mA)	0.5C (1475mA)	1.0C 2950mA)	2.0C (5900mA)
Cut-off	7h or 0.05C	3.0h or 0.05C	2.5h or 0.05C	2.5h or 0.05C
Relative Capacity	100%	95%	90%	80%

4.7 Discharge Rate Capabilities

Discharge capacity is measured with the various currents in under table and 2.75V cut-off after the standard charge.

	Disharge Condition			
Current	0.2C (590mA)	0.5C (1475mA)	1.0C (2950mA)	2.0C (5900mA)
Relative Capacity	100%	95%	90%	80%

Note: Percentage as an index of the capacity at 25℃(=2850mAh) is 100%.

4.8 Cycle Life

Each cycle is an interval between the charge (charge current 1475mA) with 3.0h or 0.05C cut-off and the discharge (discharge current 1475mA) with 2.75V cut-off.Capacity after 299cycles and plus 1 day, measured under the same condition in 7.2

Capacity≥1995mAh(70% of the capacity at 25℃)

4.9 Storage Characteristics

Capacity after storage for 30days at 25℃from the standard charge,measured with discharge current 590mA with 2.75V cut-off at 25℃

Capacity retention(after the storage)≥2280mAh (80% of the capacity at 25℃)

5.0 Mechanical Characteristics

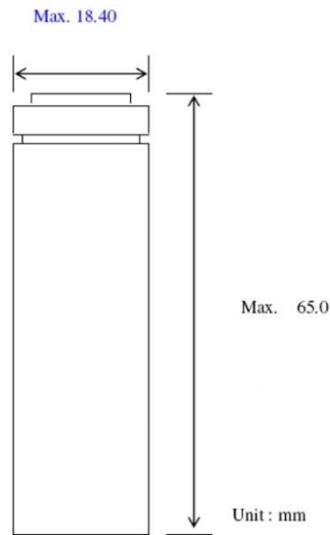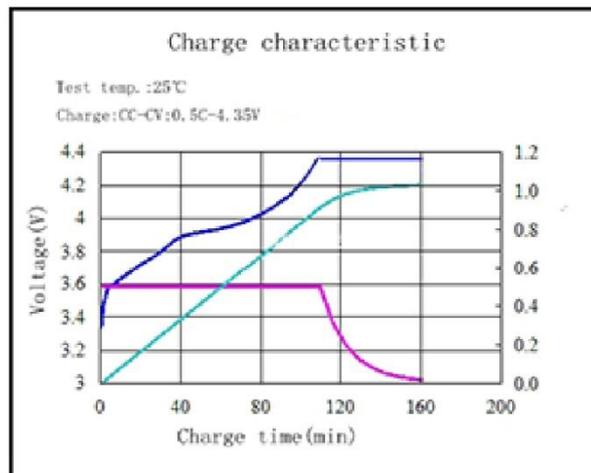| No.	Item	Criteria	Test Instructions
5.1	Drop	No leakage	Cell(as of shipment or full charged) drop onto the oak-board(thickness:≥30mm) from 1.5m height at a random direction 6 times.
5.2	Vibration	No leakage,	Cell(as of shipment) is vibrated along 2 mutually perpendicular axes with total excursion of 1.6mm and with frequency cycling between 10Hz and 55Hz by 1Hz/min.

6.0 Safety Characteristics

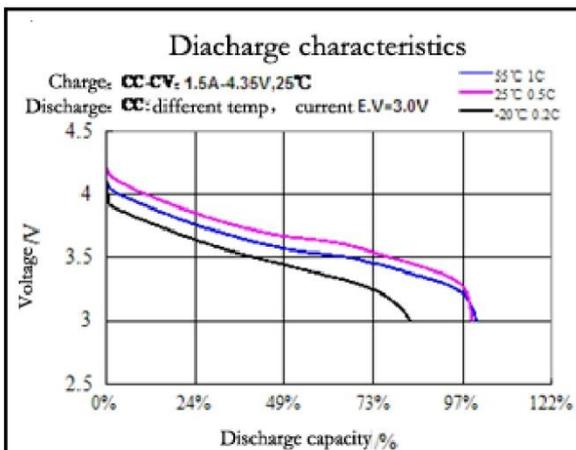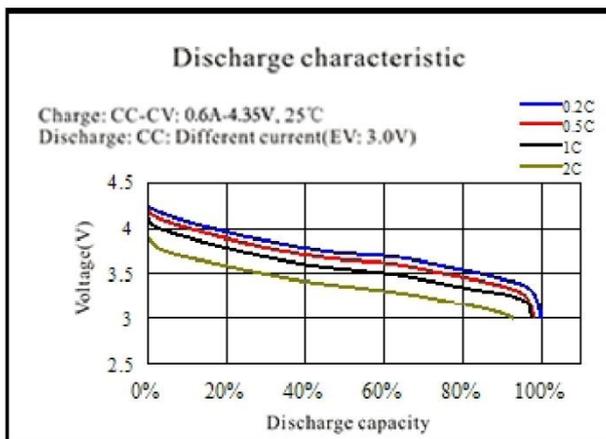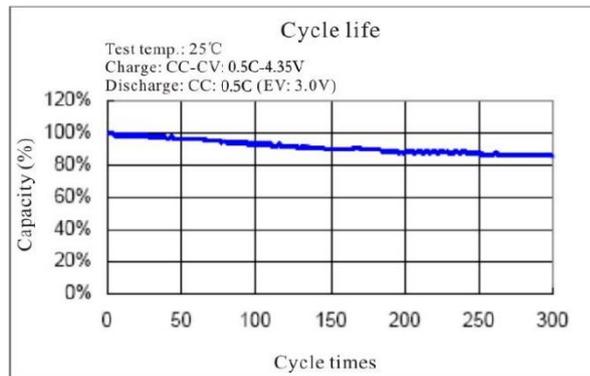| No.	Item	Criteria	Test Instructions
6.1	Overcharge	No fire or explosion	To charge the standard charged cell with 12V and 2.95A at 25℃ for 2.5 hours.
6.2	Short-Circuit	No fire or explosion;	To short-circuit the standard charged cell by connecting positive and negative terminal by less than 50mΩ wire for 3hours.
6.3	Reverse Charge	No fire or explosion;	To charge the standard charged cell with charge current 2.95A By –12V for 2.5 hours.
6.4	Heating	No fire or explosion	To heat up the standard charged cell at heating rate 5℃ per minute up to 130℃ and keep the cell in oven for 60 minutes.

EMB™

7.0 Outline Dimensions（Unit：mm）

Max. 18.40

Max. 65.0

Unit : mm

8.0 DISCHARGE CHARACTERITICS.

Discharge characteristic

Charge: CC-CV: 0.6A-4.35V, 25℃
Discharge: CC: Different current(EV: 3.0V)

- 0.2C
- 0.5C
- 1C
- 2C

Diacharge characteristics

Charge: CC-CV: 1.5A-4.35V, 25℃
Discharge: CC: different temp, current E.V=3.0V

- 55℃ 1C
- 25℃ 0.5C
- -20℃ 0.2C

Cycle life

Test temp.: 25℃
Charge: CC-CV: 0.5C-4.35V
Discharge: CC: 0.5C (EV: 3.0V)

6.0 Protection

When Li-ion rechargeable battery is used over the permitted voltage or current, electrolyte may disassemble, and this case will affect safety performance of Li-ion rechargeable battery. So protection circuit module were used in order to prevent overcharge, over discharge and over current.

<div align="center">

WARNINGS!

</div>

1) Do not immerse the battery in water or seawater, and keep the battery in a cool dry surrounding if it stands by.

2) Do not use or leave the battery near a heat source as fire or heater

3) When recharging, use the battery charger specifically for that purpose

4) Do not reverse the position (+) and negative (-) terminals

5) Do not connect the battery to an electrical outlet

6) Do not discard the battery in fire or heat it

7) Do not short-circuit the battery by directly connecting the positive (+) and negative (-) terminal with metal objects such as wire.

8) Do not transport or store the battery together with metal objects such as necklaces, hairpins etc.

9) Do not strike or throw the battery

10) Do not directly solder the battery and pierce the battery with a nail or other sharp object.

<div align="center">

CAUTIONS!

</div>

1) Do not use or leave the battery at very high temperature (for example, at strong direct sunlight or in a vehicle in extremely hot weather). Otherwise, it can overheat or fire or its performance will be degenerate and its service life will be decreased.

2) Do not use it in a location where static electricity is great, otherwise, the safety devices may be damaged, causing hidden trouble of safety.

3) If the battery leaks, and the electrolyte get into the eyes. Do not rub eyes, instead, rinse the eyes with

clean running water, and immediately seek medical attention. Otherwise, it may injure eyes or cause a loss of sight.

4) If the battery gives off an odor, generates heat, becomes discolored or deformed, or in any way appear abnormal during use, recharging or storage, immediately remove it from the device or battery charger and stop using it.

5) In case the battery terminals are dirt, clean the terminals with a dry cloth before use. Otherwise power failure or charge failure may occur due to the poor connection with the instrument.

6) Be aware discarded batteries may cause fire, tape the battery terminals to insulate them.

Special notice!

Keep the cells in 50% charged state during long period storage. We recommend to charge the battery up to 50% of the total capacity every 3 months after receipt of the battery and maintain the voltage 3.6~4.2V. And store the battery in cool and dry place.

Note: Any representations in this brochure concerning performance, are for informational purposes only and are not construed as warranties either expressed or implied, of future performance.

TVS Diodes
### Axial Leaded – 1500W > 1.5KE series

1.5KE Series

Uni-directional

Bi-directional

Agency Approvals

Agency	Agency File Number
℞	E230531

Maximum Ratings and Thermal Characteristics
(T_A=25°C unless otherwise noted)

Parameter	Symbol	Value	Unit
Peak Pulse Power Dissipation (Fig.2) by 10/1000μs Test Waveform (Fig.4) (Note 1) -Single Die Parts	P_{PPM}	1500	W
Peak Pulse Power Dissipation(Fig.2) by 10/1000μs Test Waveform(Fig.4)(Note 1) -Stacked Die Parts (Note 4)	P_{PPM}	2000	W
Steady State Power Dissipation on Infinite Heat Sink at T_L=75°C	P_D	6.5	W
Peak Forward Surge Current, 8.3ms Single Half Sine Wave Unidirectional Only (Note 2)	I_{FSM}	200	A
Maximum Instantaneous Forward Voltage at 100A for Unidirectional Only (Note 3)	V_F	3.5/5.0	V
Operating Junction and Storage Temperature Range	T_J, T_{STG}	-55 to 175	°C
Typical Thermal Resistance Junction to Lead	$R_{θJL}$	15	°C/W
Typical Thermal Resistance Junction to Ambient	$R_{θJA}$	75	°C/W

Notes:
1. Non-repetitive current pulse , per Fig. 4 and derated above T_J (initial) =25°C per Fig. 3.
2. Measured on 8.3ms single half sine wave or equivalent square wave, duty cycle=4 per minute maximum.
3. V_F < 3.5V for single die parts and V_F < 5.0V for stacked-die parts.
4. For stacked die component details, please refer to part numbers labeled by * in Electrical Characteristics.

Functional Diagram

Bi-directional

Cathode ○——▷|——○ Anode

Uni-directional
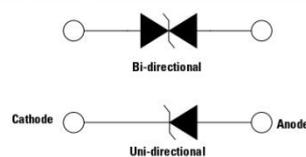
Description

The 1.5KE Series is designed specifically to protect sensitive electronic equipment from voltage transients induced by lightning and other transient voltage events.

Features

- 1500W peak pulse capability at 10/1000μs waveform, repetition rate (duty cycles):0.01%
- Glass passivated chip junction in DO-201 Package
- Fast response time: typically less than 1.0ps from 0 Volts to BV min
- Excellent clamping capability
- Typical failure mode is short from over-specified voltage or current
- Whisker test is conducted based on JEDEC JESD201A per its table 4a and 4c
- IEC-61000-4-2 ESD 30kV(Air), 30kV (Contact)
- ESD protection of data lines in accordance with IEC 61000-4-2
- EFT protection of data lines in accordance with IEC 61000-4-4
- Low incremental surge resistance
- Typical I_R less than 1μA when V_{BR} min>12V
- High temperature to reflow soldering guaranteed: 260°C/30sec / 0.375"(9.5mm) lead length, 5 lbs., (2.3kg) tension
- V_{BR} @ T_J = V_{BR} @25°C x (1+αT x (T_J - 25)) (αT:Temperature Coefficient, typical value is 0.1%)
- Plastic package is flammability rated V-0 per Underwriters Laboratories
- Matte tin lead–free plated
- Halogen free and RoHS compliant
- Pb-free E3 means 2nd level interconnect is Pb-free and the terminal finish material is tin(Sn) (IPC/JEDEC J-STD-609A.01)

Applications

TVS devices are ideal for the protection of I/O interfaces, V_{CC} bus and other vulnerable circuits used in telecom, computer, industrial and consumer electronic applications.

### Additional Infomarion

Datasheet

Resources

Samples

Littelfuse
Expertise Applied | Answers Delivered

TVS Diodes
Axial Leaded – 1500W > 1.5KE series

Electrical Characteristics (T$_A$=25°C unless otherwise noted)

Part Number (Uni)	Part Number (Bi)	Reverse Stand off Voltage V$_R$ (Volts)	Breakdown Voltage V$_{BR}$ (Volts) @ I$_T$		Test Current I$_T$ (mA)	Maximum Clamping Voltage V$_C$ @ I$_{PP}$ (Volts)	Maximum Peak Pulse Current I$_{PP}$ (A)	Maximum Reverse Leakage I$_R$ @ V$_R$ (µA)	Agency Approval
			Min.	Max.					
1.5KE6.8A	1.5KE6.8CA	5.80	6.45	7.14	10	10.5	144.8	1000	X
1.5KE7.5A	1.5KE7.5CA	6.40	7.13	7.88	10	11.3	134.5	500	X
1.5KE8.2A	1.5KE8.2CA	7.02	7.79	8.61	10	12.1	125.6	200	X
1.5KE9.1A	1.5KE9.1CA	7.78	8.65	9.50	1	13.4	113.4	50	X
1.5KE10A	1.5KE10CA	8.55	9.50	10.50	1	14.5	104.8	10	X
1.5KE11A	1.5KE11CA	9.40	10.50	11.60	1	15.6	97.4	5	X
1.5KE12A	1.5KE12CA	10.20	11.40	12.60	1	16.7	91.0	5	X
1.5KE13A	1.5KE13CA	11.10	12.40	13.70	1	18.2	83.5	1	X
1.5KE15A	1.5KE15CA	12.80	14.30	15.80	1	21.2	71.7	1	X
1.5KE16A	1.5KE16CA	13.60	15.20	16.80	1	22.5	67.6	1	X
1.5KE18A	1.5KE18CA	15.30	17.10	18.90	1	25.2	60.3	1	X
1.5KE20A	1.5KE20CA	17.10	19.00	21.00	1	27.7	54.9	1	X
1.5KE22A	1.5KE22CA	18.80	20.90	23.10	1	30.6	49.7	1	X
1.5KE24A	1.5KE24CA	20.50	22.80	25.20	1	33.2	45.8	1	X
1.5KE27A	1.5KE27CA	23.10	25.70	28.40	1	37.5	40.5	1	X
1.5KE30A	1.5KE30CA	25.60	28.50	31.50	1	41.4	36.7	1	X
1.5KE33A	1.5KE33CA	28.20	31.40	34.70	1	45.7	33.3	1	X
1.5KE36A	1.5KE36CA	30.80	34.20	37.80	1	49.9	30.5	1	X
1.5KE39A	1.5KE39CA	33.30	37.10	41.00	1	53.9	28.2	1	X
1.5KE43A	1.5KE43CA	36.80	40.90	45.20	1	59.3	25.6	1	X
1.5KE47A	1.5KE47CA	40.20	44.70	49.40	1	64.8	23.5	1	X
1.5KE51A	1.5KE51CA	43.60	48.50	53.60	1	70.1	21.7	1	X
1.5KE56A	1.5KE56CA	47.80	53.20	58.80	1	77.0	19.7	1	X
1.5KE62A	1.5KE62CA	53.00	58.90	65.10	1	85.0	17.9	1	X
1.5KE68A	1.5KE68CA	58.10	64.60	71.40	1	92.0	16.5	1	X
1.5KE75A	1.5KE75CA	64.10	71.30	78.80	1	103.0	14.8	1	X
1.5KE82A	1.5KE82CA	70.10	77.90	86.10	1	113.0	13.5	1	X
1.5KE91A	1.5KE91CA	77.80	86.50	95.50	1	125.0	12.2	1	X
1.5KE100A	1.5KE100CA	85.50	95.00	105.00	1	137.0	11.1	1	X
1.5KE110A	1.5KE110CA	94.00	105.00	116.00	1	152.0	10.0	1	X
1.5KE120A	1.5KE120CA	102.00	114.00	126.00	1	165.0	9.2	1	X
1.5KE130A	1.5KE130CA	111.00	124.00	137.00	1	179.0	8.5	1	X
1.5KE150A	1.5KE150CA	128.00	143.00	158.00	1	207.0	7.3	1	X
1.5KE160A	1.5KE160CA	136.00	152.00	168.00	1	219.0	6.9	1	X
1.5KE170A	1.5KE170CA	145.00	162.00	179.00	1	234.0	6.5	1	X
1.5KE180A	1.5KE180CA	154.00	171.00	189.00	1	246.0	6.2	1	X
1.5KE200A	1.5KE200CA	171.00	190.00	210.00	1	274.0	5.5	1	X
1.5KE220A	1.5KE220CA	185.00	209.00	231.00	1	328.0	4.6	1	X
1.5KE250A	-	214.00	237.00	263.00	1	344.0	4.4	1	X
-	1.5KE250CA*	214.00	237.00	263.00	1	344.0	5.9	1	X
1.5KE300A*	1.5KE300CA*	256.00	285.00	315.00	1	414.0	4.9	1	X
1.5KE320A*	1.5KE320CA*	273.00	304.00	336.00	1	441.0	4.6	1	X
1.5KE350A*	1.5KE350CA*	300.00	332.00	368.00	1	482.0	4.2	1	X
1.5KE400A*	1.5KE400CA*	342.00	380.00	420.00	1	548.0	3.7	1	X
1.5KE440A*	1.5KE440CA*	376.00	418.00	462.00	1	602.0	3.1	1	X
1.5KE480A*	1.5KE480CA*	408.00	456.00	504.00	1	658.0	3.1	1	-
1.5KE510A*	1.5KE510CA*	434.00	485.00	535.00	1	698.0	2.9	1	-
1.5KE530A*	1.5KE530CA*	451.00	503.50	556.50	1	725.0	2.8	1	-
1.5KE540A*	1.5KE540CA*	460.00	513.00	567.00	1	740.0	2.8	1	-
1.5KE550A*	1.5KE550CA*	468.00	522.50	577.50	1	760.0	2.7	1	-
1.5KE600A*	1.5KE600CA*	512.00	570.00	630.00	1	828.0	2.5	1	-

For bidirectional type having V$_R$ of 10 volts and less, the I$_R$ limit is double.
For parts without A, the V$_{BR}$ is ±10% and V$_C$ is 5% higher than with A parts, the parts without A are currently available, but not recommended for new designs. The parts with A are preferred.
For stack-die parts, use * to label the part number.

TVS Diodes
Axial Leaded – 1500W > 1.5KE series

I-V Curve Characteristics

Uni-directional

Bi-directional
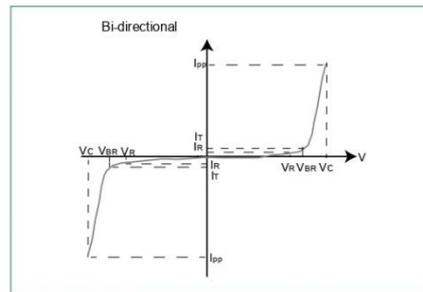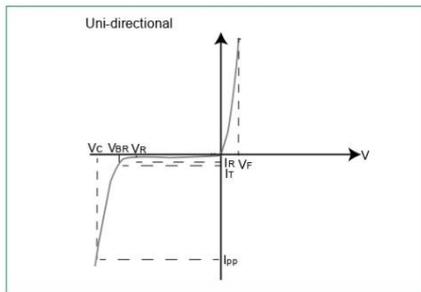
P_{PPM} **Peak Pulse Power Dissipation** – Max power dissipation
V_R **Stand-off Voltage** – Maximum voltage that can be applied to the TVS without operation
V_{BR} **Breakdown Voltage** – Maximum voltage that flows though the TVS at a specified test current (I_T)
V_C **Clamping Voltage** – Peak voltage measured across the TVS at a specified Ippm (peak impulse current)
I_R **Reverse Leakage Current** – Current measured at V_R
V_F **Forward Voltage Drop for Uni-directional**

Ratings and Characteristic Curves (T_A=25°C unless otherwise noted)

Figure 1 - TVS Transients Clamping Waveform

Voltage Transients

Voltage Across TVS

Current Through TVS

Voltage or Current

Time
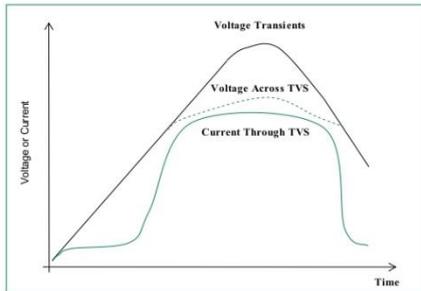
Figure 2 - Peak Pulse Power Rating

T_J initial = T_{amb}

stacked-die, 2kW
at 10x1000µs, 25°C

Single die, 1.5kW
at 10x1000µs, 25°C

P_{PPM}-Peak Pulse Power (kW)

t_d-Pulse Width (ms)

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TVS Diodes
Axial Leaded – 1500W > 1.5KE series
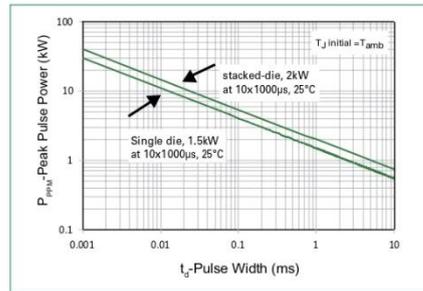
Ratings and Characteristic Curves (T_A=25°C unless otherwise noted) (Continued)

Figure 3 - Peak Pulse Power Derating Curve
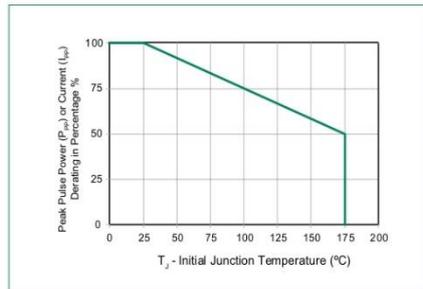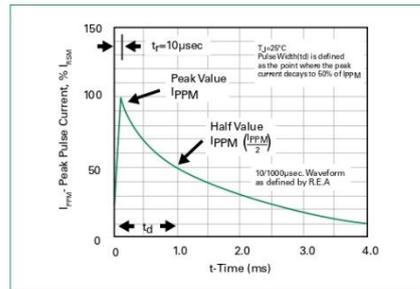

Figure 4 - Pulse Waveform
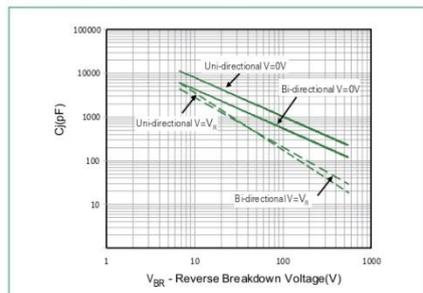

Figure 5 - Typical Junction Capacitance

Figure 6 - Typical Transient Thermal Impedance
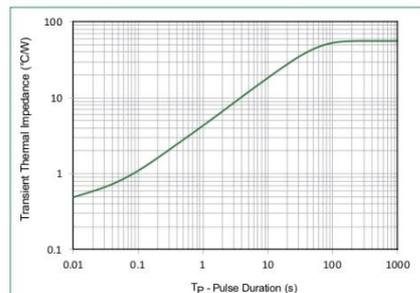
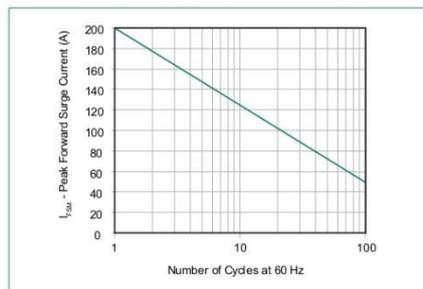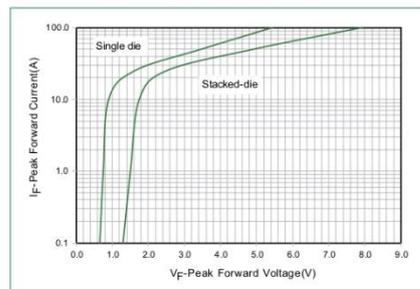**Figure 7 - Maximum Non-Repetitive Peak Forward Surge Current Uni-Directional Only**

**Figure 8 - Peak Forward Voltage Drop vs Peak Forward Current (Typical Values)**

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TVS Diodes
Axial Leaded – 1500W > 1.5KE series

Soldering Parameters

Reflow Condition		Lead–free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 120 secs
Average ramp up rate (Liquidus Temp (T_L) to peak		3°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		3°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_L)	60 – 150 seconds
Peak Temperature (T_p)		260$^{+0/5}$ °C
Time within 5°C of actual peak Temperature (t_p)		30 seconds max
Ramp-down Rate		6°C/second max
Time 25°C to peak Temperature (T_p)		8 minutes Max.
Do not exceed		260°C
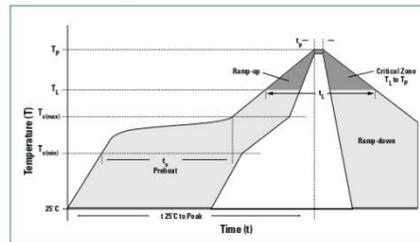
Flow/Wave Soldering (Solder Dipping)

Peak Temperature :	265°C
Dipping Time :	10 seconds
Soldering :	1 time

Physical Specifications

Weight	0.045oz., 1.2g
Case	JEDEC DO-201 molded plastic body over passivated junction.
Polarity	Color band denotes the cathode except Bipolar.
Terminal	Matte Tin axial leads, solderable per JESD22-B102.

Environmental Specifications

High Temp. Storage	JESD22-A103
HTRB	JESD22-A108
Temperature Cycling	JESD22-A104
H3TRB	JESD22-A101
RSH	JESD22-B106

Dimensions

Cathode Band
(for uni-directional products only)

DO-201
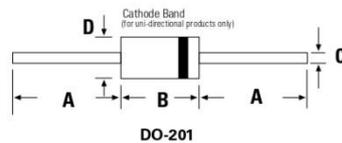
Dimensions	Inches		Millimeters	
	Min	Max	Min	Max
A	1.000	-	25.40	-
B	0.285	0.375	7.20	9.50
C	0.038	0.042	0.96	1.07
D	0.190	0.210	4.80	5.30

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TVS Diodes
Axial Leaded – 1500W > 1.5KE series

Part Numbering System

1.5KE xxx **XX** **X**

Option Code:
Blank Reel Tape
-B Bulk Packaging

Type Code:
A Uni-Directional (5% V_{BR} Voltage Tolerance)
CA Bi-Directional (5% V_{BR} Voltage Tolerance)

V_{BR} Voltage Code
(Refer to the Electrical Characteristics table)

Series Code

Part Marking System

Cathode Band
(for uni-directional products only)

Littelfuse Logo

Trace Code Marking
YY: Year Code
WW: Week Code

1.5KEXXX ── **Product Type**
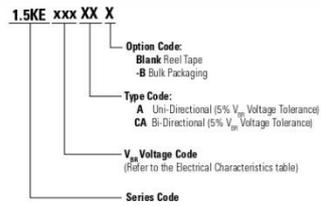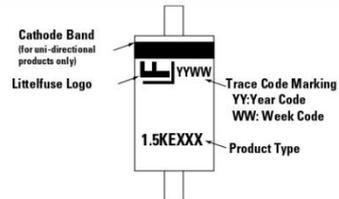
Packaging

Part Number	Component Package	Quantity	Packaging Option	Packaging Specification
1.5KExxxXX	DO-201	1200	Tape & Reel	EIA STD RS-296
1.5KExxxXX-B	DO-201	500	BULK	Littelfuse Spec.

Tape and Reel Specification
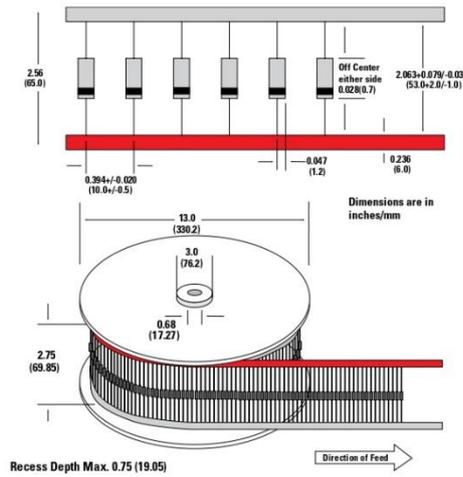
2.56 (65.0)

Off Center either side 0.028(0.7)

2.063+0.079/-0.039 (53.0+2.0/-1.0)

0.394+/-0.020 (10.0+/-0.5)

0.047 (1.2)

0.236 (6.0)

Dimensions are in inches/mm

13.0 (330.2)

3.0 (76.2)

0.68 (17.27)

2.75 (69.85)

Recess Depth Max. 0.75 (19.05)

Direction of Feed

# 1N4728 THRU 1N4764

ZENER DIODES

DO-41 Glass
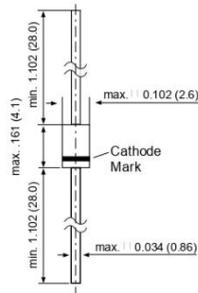
Dimensions in inches and (millimeters)

FEATURES

♦ Silicon Planar Power Zener Diodes

♦ For use in stabilizing and clipping circuits with high power rating.

♦ Standard Zener voltage tolerance is ±10%. Add suffix "A" for ±5% tolerance. Other Zener voltages and tolerances are available upon request.

♦ These diodes are also available in the MELF case with type designation ZM4728 thru ZM4764
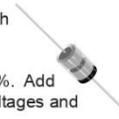
MECHANICAL DATA

Case: DO-41 Glass Case
Weight: approx. 0.35 g

MAXIMUM RATINGS

Ratings at 25°C ambient temperature unless otherwise specified.

	SYMBOL	VALUE	UNIT
Zener Current (see Table "Characteristics")			
Power Dissipation at T_{amb} = 25°C	P_{tot}	$1.0^{(1)}$	Watts
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	− 65 to +175	°C

Characteristics at Tamb = 25 °C

	SYMBOL	MIN.	TYP.	MAX.	UNIT
Thermal Resistance Junction to Ambient Air	R_{thJA}	–	–	$170^{(1)}$	°C/W
Forward Voltage at I_F = 200 mA	V_F	–	–	1.2	Volts

NOTES:
(1) Valid provided that electrodes at a distance of 10mm from case are kept at ambient temperature

GENERAL SEMICONDUCTOR®

12/3/98

1N4728 THRU 1N4764

ELECTRICAL CHARACTERISTICS

Ratings at 25°C ambient temperature unless otherwise specified.

| Type	Nominal Zener voltage[3] at I_{ZT} V_Z V	Test current I_{ZT} mA	Maximum Zener impedance[1]			Maximum reverse leakage current		Surge current at $T_A = 25°C$ I_R mA	Maximum regulator current[2] I_{ZM} mA
			Z_{ZT} at I_{ZT} Ω	Z_{ZK} Ω	at I_{ZK} mA	I_R μA	at V_R V		
1N4728	3.3	76	10	400	1.0	100	1	1380	276
1N4729	3.6	69	10	400	1.0	100	1	1260	252
1N4730	3.9	64	9	400	1.0	50	1	1190	234
1N4731	4.3	58	9	400	1.0	10	1	1070	217
1N4732	4.7	53	8	500	1.0	10	1	970	193
1N4733	5.1	49	7	550	1.0	10	1	890	178
1N4734	5.6	45	5	600	1.0	10	2	810	162
1N4735	6.2	41	2	700	1.0	10	3	730	146
1N4736	6.8	37	3.5	700	1.0	10	4	660	133
1N4737	7.5	34	4.0	700	0.5	10	5	605	121
1N4738	8.2	31	4.5	700	0.5	10	6	550	110
1N4739	9.1	28	5.0	700	0.5	10	7	500	100
1N4740	10	25	7	700	0.25	10	7.6	454	91
1N4741	11	23	8	700	0.25	5	8.4	414	83
1N4742	12	21	9	700	0.25	5	9.1	380	76
1N4743	13	19	10	700	0.25	5	9.9	344	69
1N4744	15	17	14	700	0.25	5	11.4	304	61
1N4745	16	15.5	16	700	0.25	5	12.2	285	57
1N4746	18	14	20	750	0.25	5	13.7	250	50
1N4747	20	12.5	22	750	0.25	5	15.2	225	45
1N4748	22	11.5	23	750	0.25	5	16.7	205	41
1N4749	24	10.5	25	750	0.25	5	18.2	190	38
1N4750	27	9.5	35	750	0.25	5	20.6	170	34
1N4751	30	8.5	40	1000	0.25	5	22.8	150	30
1N4752	33	7.5	45	1000	0.25	5	25.1	135	27
1N4753	36	7.0	50	1000	0.25	5	27.4	125	25
1N4754	39	6.5	60	1000	0.25	5	29.7	115	23
1N4755	43	6.0	70	1500	0.25	5	32.7	110	22
1N4756	47	5.5	80	1500	0.25	5	35.8	95	19
1N4757	51	5.0	95	1500	0.25	5	38.8	90	18
1N4758	56	4.5	110	2000	0.25	5	42.6	80	16
1N4759	62	4.0	125	2000	0.25	5	47.1	70	14
1N4760	68	3.7	150	2000	0.25	5	51.7	65	13
1N4761	75	3.3	175	2000	0.25	5	56.0	60	12
1N4762	82	3.0	200	3000	0.25	5	62.2	55	11
1N4763	91	2.8	250	3000	0.25	5	69.2	50	10
1N4764	100	2.5	350	3000	0.25	5	76.0	45	9

NOTES:
(1) The Zener impedance is derived from the 1KHz AC voltage which results when an AC current having an RMS value equal to 10% of the Zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK}. Zener impedance is measured at two points to insure a sharp knee on the breakdown curve and to eliminate unstable units
(2) Valid provided that electrodes at a distance of 10mm from case are kept at ambient temperature
(3) Measured under thermal equilibrium and DC test conditions

GENERAL SEMICONDUCTOR®

RATINGS AND CHARACTERISTIC CURVES 1N4728 THRU 1N4764

**Admissible power dissipation
versus ambient temperature**

Valid provided that leads are kept at ambient
temperature at a distance of 10 mm from case
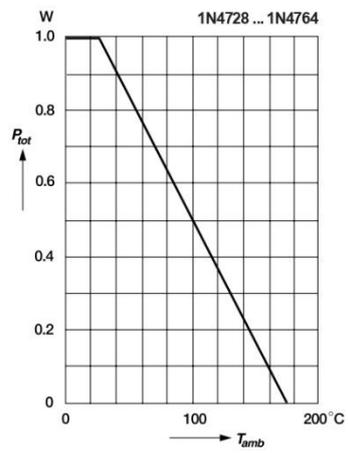
1N4728 ... 1N4764

LM111, LM211, LM311
DIFFERENTIAL COMPARATORS WITH STROBES

SLCS007H – SEPTEMBER 1973 – REVISED AUGUST 2003

- **Fast Response Times**
- **Strobe Capability**
- **Maximum Input Bias Current . . . 300 nA**
- **Maximum Input Offset Current . . . 70 nA**

- **Can Operate From Single 5-V Supply**
- **Available in Q-Temp Automotive**
  - **High-Reliability Automotive Applications**
  - **Configuration Control/Print Support**
  - **Qualification to Automotive Standards**

LM111 . . . JG PACKAGE
LM211 . . . D, P, OR PW PACKAGE
LM311 . . . D, P, PS, OR PW PACKAGE
(TOP VIEW)

EMIT OUT	1	8	V_{CC+}
IN+	2	7	COL OUT
IN–	3	6	BAL/STRB
V_{CC-}	4	5	BALANCE
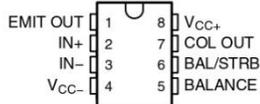
LM111 . . . FK PACKAGE
(TOP VIEW)
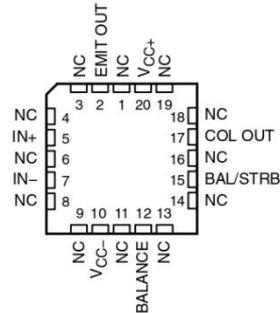
NC – No internal connection

description/ordering information

The LM111, LM211, and LM311 are single high-speed voltage comparators. These devices are designed to operate from a wide range of power-supply voltages, including ±15-V supplies for operational amplifiers and 5-V supplies for logic systems. The output levels are compatible with most TTL and MOS circuits. These comparators are capable of driving lamps or relays and switching voltages up to 50 V at 50 mA. All inputs and outputs can be isolated from system ground. The outputs can drive loads referenced to ground, V_{CC+} or V_{CC-}. Offset balancing and strobe capabilities are available, and the outputs can be wire-OR connected. If the strobe is low, the output is in the off state, regardless of the differential input.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

LM111, LM211, LM311
DIFFERENTIAL COMPARATORS WITH STROBES

SLCS007H – SEPTEMBER 1973 – REVISED AUGUST 2003

description/ordering information

ORDERING INFORMATION

T_A	V_{IO} max AT 25°C	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–0°C to 70°C	7.5 mV	PDIP (P)	Tube of 50	LM311P	LM311P
		SOIC (D)	Tube of 75	LM311D	LM311
			Reel of 2500	LM311DR	
		SOP (PS)	Reel of 2000	LM311PSR	L311
		TSSOP (PW)	Reel of 150	LM311PW	L311
			Tube of 2000	LM311PWR	
–40°C to 85°C	3 mV	PDIP (P)	Tube of 50	LM211P	LM211P
		SOIC (D)	Tube of 75	LM211D	LM211
			Reel of 2500	LM211DR	
		TSSOP (PW)	Reel of 150	LM211PW	L211
			Reel of 2000	LM211PWR	
–40°C to 125°C	3 mV	SOIC (D)	Tube of 75	LM211QD	LM211Q
			Reel of 2500	LM211QDR	
–55°C to 125°C	3 mV	CDIP (JG)	Tube of 50	LM111JG	LM111JG
		LCCC (FK)	Tube of 55	LM111FK	LM111FK

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
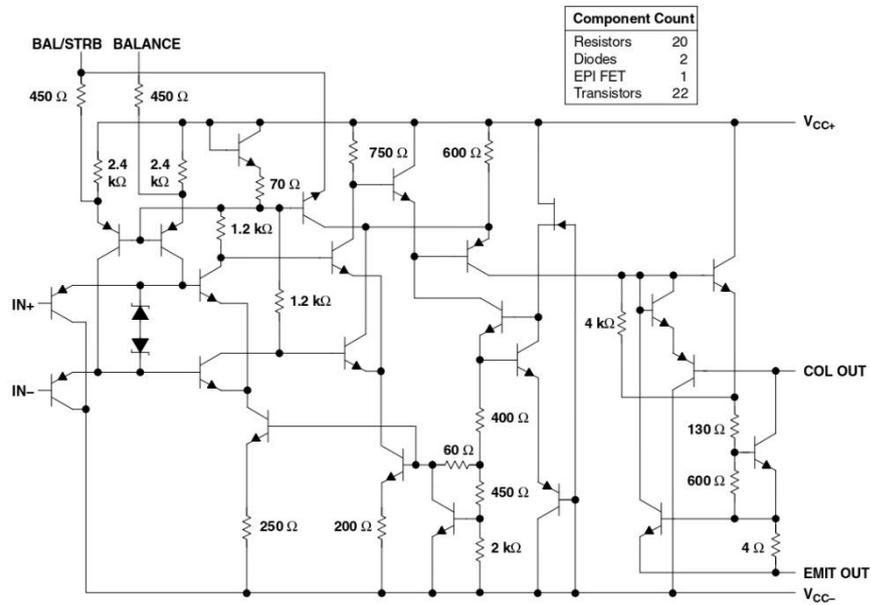
functional block diagram

schematic

Component Count	
Resistors	20
Diodes	2
EPI FET	1
Transistors	22

All resistor values shown are nominal.