Le79555 Switching Regulator Application Update

Subscriber Line Interface Circuit (SLIC Device)

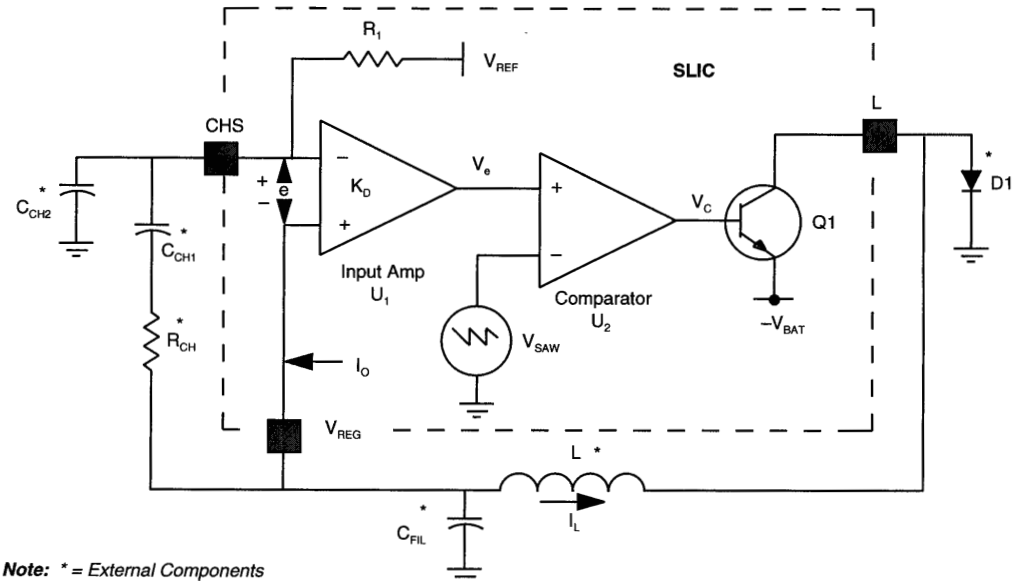
APPLICATION NOTE

This application note provides additional information for applications using the Le79555 Switching Regulator SLIC device. Recommended component values and their manufacturers are given. A discussion of why switching regulator technology is useful in high density or power sensitive applications is also provided.

SWITCHING REGULATOR TOPOLOGY

Buck topology is used by the Le79555 SLIC device. This topology allows a higher voltage to be regulated to a lower voltage with minimal losses. While there are some losses, the losses are small and controllable by component selection. The regulator consists of a series switch, a shunt diode, a series inductor, and a shunt filter capacitor. Refer to Figure 1 below.

Figure 1. Le79555 Simplified Switching Regulator Schematic



The switch element is transistor "Q_1", which is provided internally. The energy storage elements are external to the SLIC device. These consist of the inductor "L" and capacitor "C_{FIL}". The diode "D_1" must be provided externally because of the required diode ratings. Two external capacitors, C_{CH1} and C_{CH2}, and an external resistor, R_{CH}, are also required to compensate or stabilize the regulator.

SWITCHING REGULATOR OPERATION

For details on switching regulator operation, please refer to the application note "SLIC Device Switcher Circuit," Legerity Publication #080151. This application note provides equations and detailed discussion of circuit operation. The "SLIC Device Switcher Circuit" application note also provides information on older Legerity parts, which are very similar to the Le79555 SLIC device. The Le79555 device is a newer design and incorporates more efficient circuits allowing it to provide significant power and space savings over previous designs.

RECOMMENDED REGULATOR PARTS

Table 1. gives alternative parts combinations that can be used with this SLIC device. Several manufacturer part numbers are given for surface mount along with one set of through-hole part numbers is given.

Table 1. Alternative Parts Combinations for SLIC device

Ref	Value	Tol%	Voltage/Wattage	Type	Mfr.	P/N
L	1mH		125 mA	6 Ω	Coiltronics	SD25-102
			100 mA	14 Ω	J. W. Miller	77F102J
D_1	1 A		100 PIV 50 ns	SMA case	On Semiconductor	MURA
			100 PIV 50 ns	SMA case	Central Semiconductor	CMR1U-01
			100 PIV 50 ns	DO-41	On Semiconductor	MUR120
C_{FIL}	0.47 µF	20	50/63 V	X7R	Kemet	C1812C474M5RAC
					AVX	18125C474MAT
					Vishay	MKT1817-817447064
C_{CH2}	560 pF	5	50 V	COG	Kemet	C0603C561J5GAC
					AVX	06035A561JAT
C_{CH1}	15 nF	10	50 V	X7R	Kemet	C0805C153K5RAC
					AVX	08055C153KAT
					Murata	RPE110X7R153J050V
R_{CH}	1.30 kΩ	1	1/10 w		Panasonic	ERJ-6ENF
			Axial		BCC	5043ED1301F12AF5

The following sections discuss the advantages of using the parts recommended in Table 1.

DIODE APPLICATION INFORMATION

The diode must be an “ultra fast” diode for high efficiency, be rated at 1 A continuous current, have a TRR of less than 100 ns, and have a reverse voltage of 100 V or greater. Diodes listed in Table 1 above, are suitable for this application.

Note that smaller diodes with lower current ratings can be used with reduced efficiency. However, these diodes are only marginally smaller, marginally cheaper, and are not recommended.

INDUCTOR APPLICATION INFORMATION

In the original “SLIC Device Switcher Circuit” application note, it was suggested that an axial leaded “rod core” inductor be used. The part actually implemented on the SLIC device evaluation PCB was the JW Miller 9220-28, a 1 mH 16.5 Ω 80 mA inductor. But the JW Miller 9220-28 is physically large and unshielded, meaning that magnetic flux radiates from the ends of the core. Such an inductor should only be implemented when a limited number of SLIC devices are used, since the unshielded inductors can couple to each other unless mounted orthogonally. This kind of inductor is cheap, but is large and limits the placement options for the device.

The newly recommended inductor is much smaller and is SMT. It is made by the Coiltronics division of Cooper Electronic Technologies, and is part number SD25-102. This inductor is 1 mH ± 20%, and drops 25% in inductance at 125 mA. It’s DCR is approximately 6 Ω. Because the Le79555 only needs a peak current of 90 mA, the inductor has some margin before saturation is reached.

An inductor other than the one recommended above can certainly be used. However, to ensure low power loss, choose a series resistance less than 20 Ω. But, be aware that a very low series resistance may cause oscillation at

the frequency where the inductor resonates with C_{FIL}. A Bode plot should be generated using actual parameters to verify loop stability.

Inductors also have inter-winding capacitance that creates a parasitic capacitor. The inductance will resonate with this capacitance. If the resonance is at a sufficiently high frequency it will not affect the application, but one must account for this source of phase shift when determining stability of the loop.

Note:

Legerity SLIC devices include a circuit that disables the switcher for long loops to further reduce the possibility of half frequency operation. Even under these conditions, the above components values should still be adhered to for optimum performance.

CAPACITOR APPLICATION INFORMATION (C_{FIL})

C_{FIL} must be a good quality ceramic or film type capacitor with at least a 63 V rating, it must maintain its value over the applied DC voltage range, and have a low effective series resistance (ESR) of less than 3 Ω. Because of cost and size considerations, values should be limited to no more than 0.47 µF at 100 V DC. Only film dielectric or X7R ceramic can be used. Many other ceramic dielectric materials have severe capacitance reductions with increasing applied voltage. A reduction in capacitance can cause half frequency operation due to insufficient filtering of the 128 kHz ripple. Overall loop stability can also be affected.

Film capacitors were at one time preferred, but new X7R ceramic SMT components are now favored for C_{FIL}. (A through-hole film capacitor is included in the suggested parts). Both AVX and Kemet capacitors permit operation of their 50 V rated parts at 63 V, continuously. Application measurements for the SLIC device ratings suggest that such operation is conservative.

CAPACITOR APPLICATION INFORMATION (C_{CH2} AND C_{CH1})

C_{CH2} and C_{CH1} perform the stabilizing function for the loop; therefore, their values must be stable in order to maintain loop stability margins for worst case conditions.

Capacitor C_{CH2} is connected between pin CHS and ground, and is subjected to DC bias voltages of up to 60 V depending on the SLIC device. It is important that this capacitor be as stable as possible because of its influence on half frequency operation, as well as the loop stability. A 10% tolerance ceramic with a COG temperature stability characteristic is recommended because of its stability and immunity to DC bias changes.

Capacitor C_{CH1} must also be relatively stable. A 10% tolerance ceramic capacitor with an X7R temperature characteristic would be satisfactory. The voltage rating must be able to withstand at least the battery voltage, which permits use of the 50 V capacitor.

Use of ceramic capacitors designed primarily for bypassing with EIA Z5U dielectric, EIA Y5V dielectric, or EIA X5R dielectric stability characteristics must be avoided. These capacitors can exhibit up to a 66% reduction in capacitance from their nominal value due to tolerance and temperature effects. With such large variations in capacitance, the loop can become unstable under worst case conditions.

RESISTOR APPLICATION INFORMATION

The resistor R_{CH} dissipates minimal power, but on a transient basis may have voltages as high as V_{BAT} for very short periods. The recommended wattage rating is less than 100 mW (1/10 W), and film resistors with a tolerance of 1% or 2% are suggested. Use of smaller SMT resistors is not recommended because of the transient voltage. Table 1 also lists a through-hole resistor. Other smaller but more expensive through-hole resistors can be used.

SWITCHER OPERATION ADVANTAGES

The parts recommended in this document provide the means to build a high-efficiency switching regulator for the Le79555. Measurements show that the regulator, if configured as recommended, stabilizes approximately 0.6 ms after a load step similar to a dial pulse is applied. This amount of time can add a small amount of dial pulse distortion; however, the distortion should be less than 1%. The switching regulator also produces a low-level ripple at the switching frequency when the line is off-hook. When the Le79555 is on-hook, the switcher is disabled. V_{BAT} minus the SLIC device overhead is applied to the Tip and Ring. The switcher ripple should be less than 50 mV peak to peak at 256 kHz, amounting to approximately 18 mV RMS. The ripple appearing at Tip and Ring should be less than 10 mV RMS. The switcher operation reduces the SLIC device power dissipation to approximately the idle power plus 6.5 V times the loop current. This low dissipation permits high density line cards.

WEBSITE INFORMATION

Web addresses for the recommended manufacturers are listed below.

- J. W. Miller
  www.jwmiller.com
- Coiltronics
  www.cooperet.com
- Murata
  www.murata.com
- Kemet
  www.kemet.com
- AVX
  www.avxcorp.com
- Panasonic
  www.panasonic.com
- On Semi
  www.onsemi.com
- Central Semi
  www.centralsemi.com
- BCC
  www.bccomponents.com
- Vishay
  www.vishay.com

Mailing: P.O. Box 18200
Austin, TX 78760-8200
Shipping: 4509 Freidrich Lane
Austin, TX 78744-1812

Telephone: (512) 228-5400
Fax: (512) 228-5510
North America Toll Free: (800) 432-4009

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Americas

ATLANTA
6465 East Johns Crossing, Suite 400
Duluth, GA USA 30097
MainLine: 770-814-4252
Fax: 770-814-4253

AUSTIN
4509 Freidrich Lane
Austin, TX USA 78744-1812
MainLine: 512-228-5400
Fax: 512-228-5510

BOSTON
6 New England Executive Park Suite 400
Burlington, MA USA 01803
MainLine: 781-229-7320
Fax: 781-272-3706

CHICAGO
8770 W. Bryn Mawr, Suite 1300
Chicago, IL USA 60631
MainLine: 773-867-8034
Fax: 773-867-2910

DALLAS
4965 Preston Park Blvd., Suite 280
Plano, TX USA 75093
MainLine: 972-985-5474
Fax: 972-985-5475

HUNTSVILLE
600 Boulevard South, Suite 104
Huntsville, AL USA 35802
MainLine: 256-705-3504
Fax: 256-705-3505

IRVINE
1114 Pacifica Court, Suite 250
Irvine, CA USA 92618
MainLine: 949-753-2712
Fax: 949-753-2713

NEW JERSEY
3000 Atrium Way, Suite 270
Mt. Laurel, NJ USA 08054
MainLine: 856-273-6912
Fax: 856-273-6914

OTTAWA
600 Terry Fox Drive
Ottawa, Ontario, Canada K26 4B6
MainLine: 613-599-2000
Fax: 613-599-2002

RALEIGH
2500 Regency Parkway, Suite 226
Cary, NC USA 27511
MainLine: 919-654-6843
Fax: 919-654-6781

SAN JOSE
1740 Technology Drive, Suite 290
San Jose, CA USA 95110
MainLine: 408-573-0650
Fax: 408-573-0402

Asia

HONG KONG
Units 2401-2, 24th Floor
Jubilee Centre, 18 Fenwick Street
Wanchai, Hong Kong
MainLine: 852-2864-8300
Fax: 852-2866-1323

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135-090 18th Fl., Kyoung Am Bldg
157-26, Samsung-dong, Kangnam-ku
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Fax: 82-2-565-3788

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Fax: 86-21-54233254

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Fax: 86-755-3706-520

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P.O. Box 537
Singapore 915502
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Fax: 65-2855869

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Fax: 81-3-5339-2012

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MainLine: 39-02-3355521
Fax: 39-02-33555232

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SE-16970 Solna
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KT3 3ST New Malden, Surrey UK
MainLine: 44-208-241-2125
Fax: 44-208-241-2126

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or email: americalit@legerity.com

To order literature in Europe or Asia, call: 44-0-1179-341607
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Asia — asialit@legerity.com