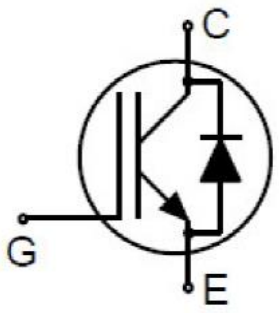
# Trench FS IGBT with Full Rated Diode

# GKU40N65EH5

## Features

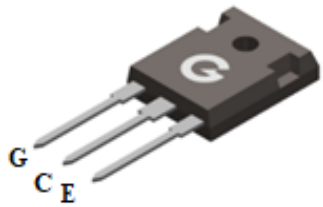
HF

- High breakdown voltage to 650V for improved reliability
- Trench-stop technology offering:
  - High speed switching
  - High ruggedness, temperature stable behavior
  - Low $V_{CE(SAT)}$
  - Easy parallel switching capability due to positive temperature coefficient in $V_{CE(SAT)}$
- Enhanced avalanche capability
- RoHS compliant with Halogen-free




## Applications

- Uninterruptible power supplies
- Solar inverter




TO-247

## Mechanical Data

- Case: TO-247
- Molding Compound: UL Flammability Classification Rating 94V-0
- Terminals: Matte tin-plated leads; solderability-per MIL-STD-202, Method 208

## Ordering Information

| Part Number | Package | Shipping Quantity | Marking Code |
|---|---|---|---|
| GKU40N65EH5 | TO-247 | 30 pcs / Tube | KU40N65EH5 |

## Maximum Ratings (@ $T_C$ = 25°C unless otherwise specified)

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-to-Emitter Voltage | $V_{CES}$ | 650 | V |
| Gate-Emitter Voltage | $V_{GES}$ | ±20 | V |
| DC Collector Current ($T_C$ = 25°C, limited by maximum $T_J$) | $I_C$ | 80 | A |
| DC Collector Current ($T_C$ = 100°C, limited by maximum $T_J$) | | 40 | A |
| Diode Continuous Forward Current ($T_C$ = 25°C, limited by maximum $T_J$) | $I_F$ | 80 | A |
| Diode Continuous Forward Current ($T_C$ = 100°C, limited by maximum $T_J$) | | 40 | A |
| Pulsed Collector Current (Pulse width limited by maximum $T_J$, $V_{GE}$ = 15V) | $I_{CM}$ | 160 | A |
| Pulsed Source-Drain Current (Pulse width limited by maximum $T_J$) | $I_{FM}$ | 160 | A |
| Soldering Temperature, Wave Soldering 1.6mm (0.063in.) from case for 10s | $T_{sold}$ | 260 | °C |
| Power Dissipation ($T_C$ = 25°C) | $P_D$ | 250 | W |
| Operating Junction Temperature Range | $T_J$ | -55 ~ +175 | °C |
| Storage Temperature Range | $T_{STG}$ | -55 ~ +150 | °C |

## Thermal Characteristics

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Thermal Resistance Junction-to-Case, IGBT | $R_{\theta JC}$ | - | 0.48 | 0.6 | °C/W |
| Thermal Resistance Junction-to-Case, Diode | | - | 0.72 | 0.8 | °C/W |
| Thermal Resistance Junction-to-Air | $R_{\theta JA}$ | - | - | 40 | °C/W |

## Electrical Characteristics of the IGBT (@ $T_J$ = 25°C unless otherwise specified)

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Static Characteristics** | | | | | | |
| $V_{(BR)CES}$ | Collector-Emitter Breakdown Voltage | $V_{GE}$ = 0V, $I_C$ = 250μA | 650 | - | - | V |
| $I_{CES}$ | Collector-Emitter Leakage Current | $V_{CE}$ = 650V, $V_{GE}$ = 0V | - | - | 40 | μA |
| $I_{GES}$ | Gate to Emitter Leakage Current | $V_{GE}$ = ±20V, $V_{CE}$ = 0V | - | - | ±200 | nA |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $V_{GE}$ = 15V, $I_C$ = 40A, $T_J$ = 25°C | - | 1.8 | 2.3 | V |
| | | $V_{GE}$ = 15V, $I_C$ = 40A, $T_J$ = 175°C | - | 2.5 | - | V |
| $V_{GE(th)}$ | Gate Threshold Voltage | $V_{CE}$ = $V_{GE}$, $I_C$ = 250μA | 3.6 | 4.4 | 5.2 | V |
| $R_G$ | Gate Resistance | $V_{GS}$ = 0V, f = 1MHz | - | 1.84 | - | Ω |
| **Dynamic Characteristics** | | | | | | |
| $Q_G$ | Total Gate-Charge | $V_{CC}$ = 520V, $V_{GE}$ = 15V, $I_C$ = 40A | - | 67 | - | nC |
| $C_{ies}$ | Input Capacitance | $V_{CE}$ = 30V<br>$V_{GE}$ = 0V<br>f = 1MHz | - | 2192 | - | pF |
| $C_{oes}$ | Output Capacitance | | - | 87 | - | |
| $C_{res}$ | Reverse Transfer Capacitance | | - | 7 | - | |
| **Switching Characteristics** | | | | | | |
| $t_{d(on)}$ | Turn-on Delay Time | $V_{CE}$ = 400V<br>$V_{GE}$ = 15V<br>$I_C$ = 40A<br>$R_G$ = 20Ω<br>$T_J$ = 25°C | - | 42 | - | ns |
| $t_r$ | Turn-on Rise Time | | - | 84 | - | |
| $t_{d(off)}$ | Turn-Off Delay Time | | - | 124 | - | |
| $t_f$ | Turn-Off Fall Time | | - | 80 | - | |
| $E_{on}$ | Turn-On Switching Loss | | - | 1.37 | - | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | - | 0.58 | - | |

## Electrical Characteristics of the Diode (@ $T_J$ = 25°C unless otherwise specified)

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Dynamic Characteristics** | | | | | | |
| $V_{FM}$ | Diode Forward Voltage | $I_F$ = 40A, $V_{GE}$ = 0V | - | 1.75 | - | V |
| $t_{rr}$ | Reverse recovery time | $V_{GS}$ = 0V, $I_F$ = 40A<br>di/dt = 300A/μs | - | 97 | - | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 428 | - | nC |
| $I_{rrm}$ | Peak Reverse Recovery Current | | - | 8.3 | - | A |

## Ratings and Characteristics Curves (@ $T_A$ = 25°C unless otherwise specified)

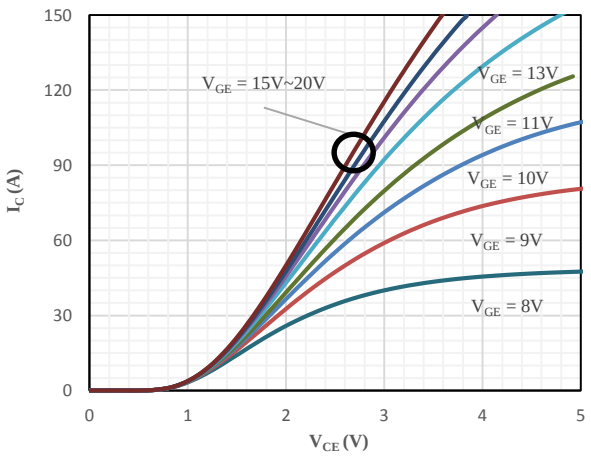



Fig 1 Typical Output Characteristics

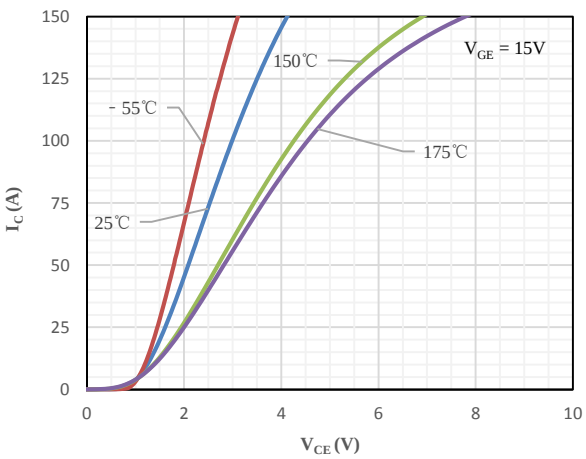



Fig 2 Saturation Voltage Characteristics

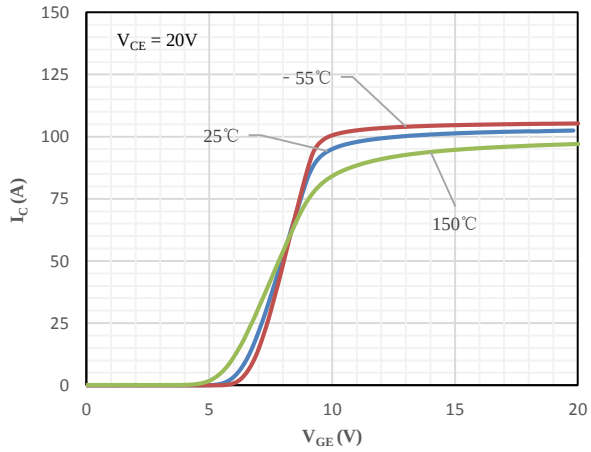



Fig 3 Transfer Characteristics

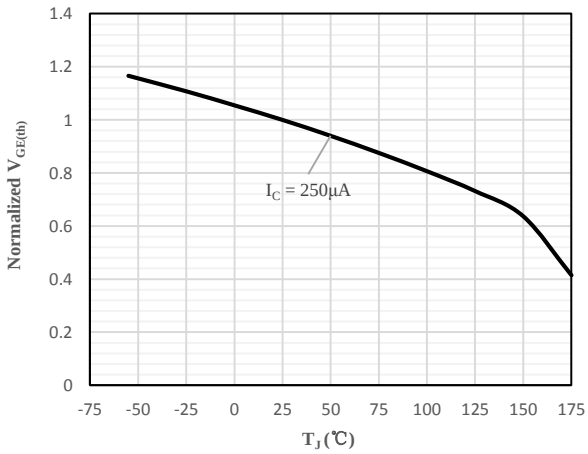



Fig 4 Normalized $V_{GE(th)}$ vs. Junction Temperature

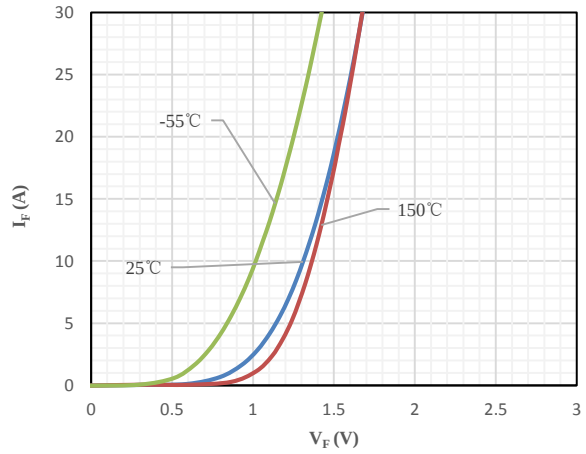



Fig 5 Diode forward current as a function of forward voltage $V_F$ vs. $I_F$

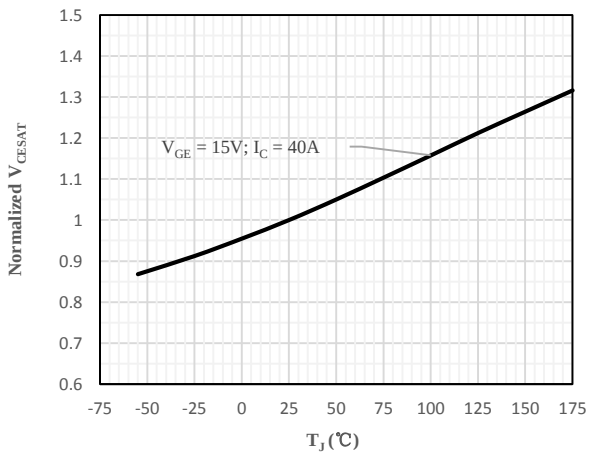



Fig 6 Normalized Collector-Emitter Saturation Voltage vs. Junction Temperature

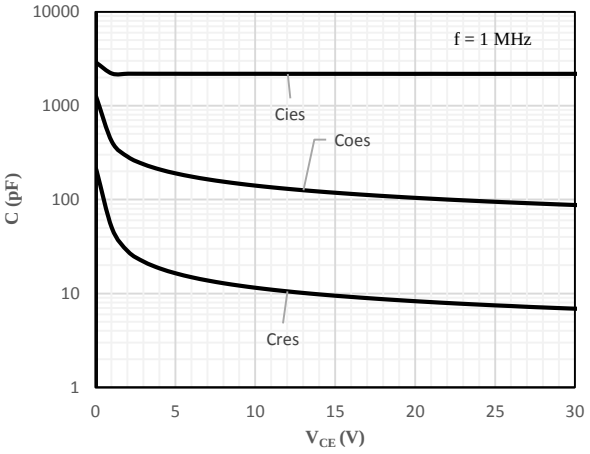



Fig 7 Capacitance Characteristics

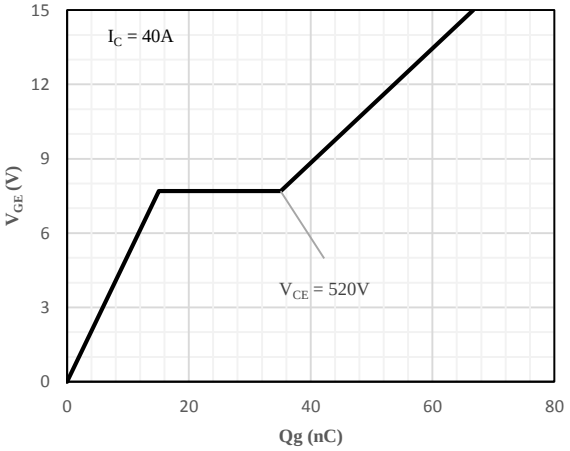



Fig 8 Gate-Charge Characteristics

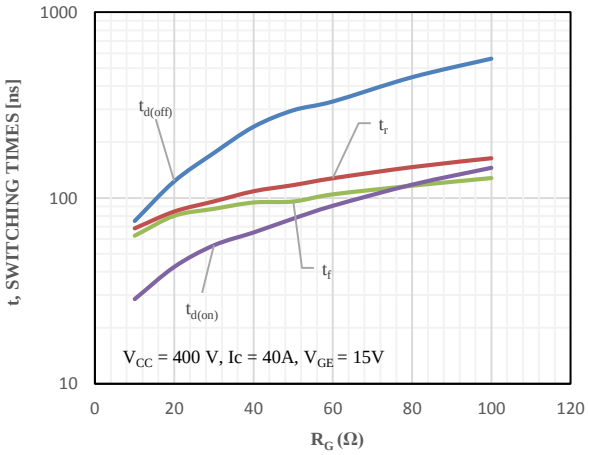



Fig 9 Switching Times vs. Gate Resistor

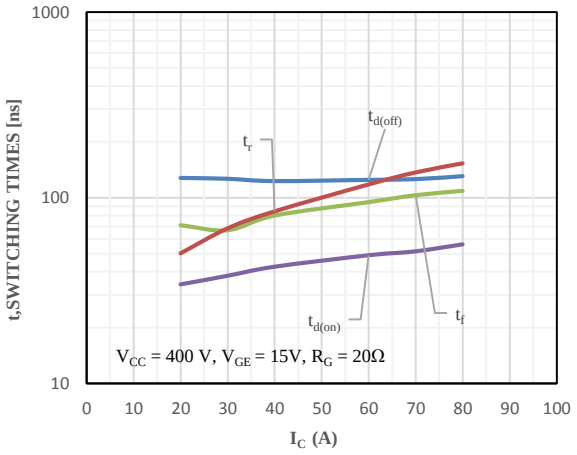



Fig 10 Switching Times vs. Collector Current

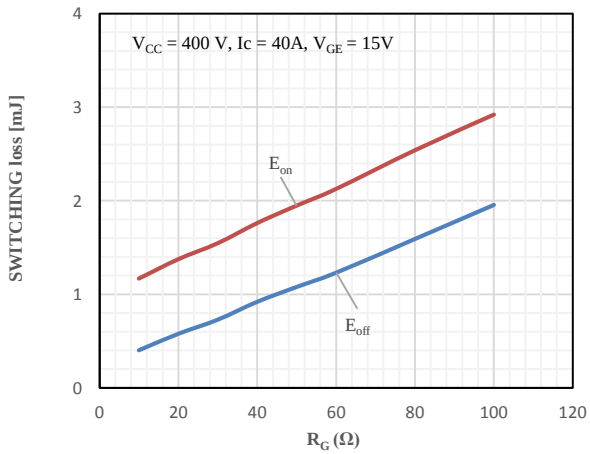



Fig 11 Switching Loss vs. Gate Resistor

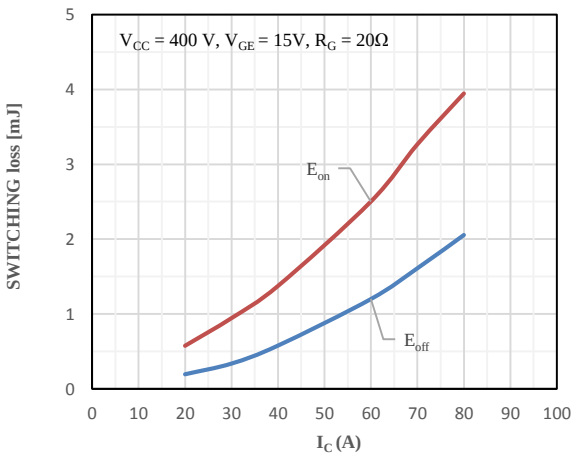



Fig 12 Switching Loss vs. Collector Current

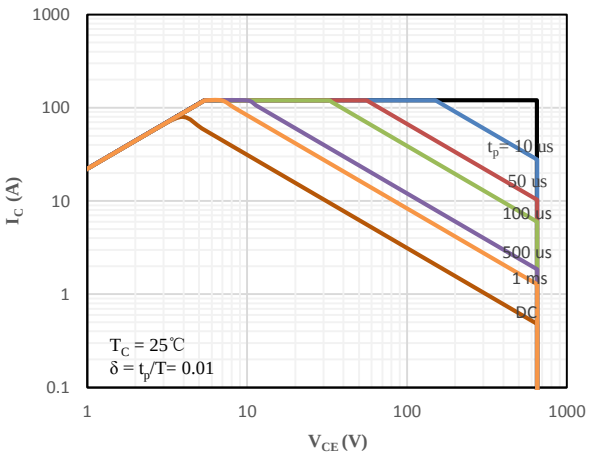



Fig 13 SOA characteristics

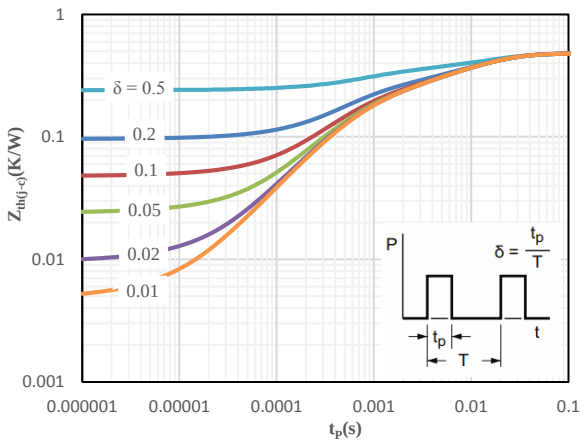



Fig 14 Maximum transient thermal impedance

## Waveform definitions

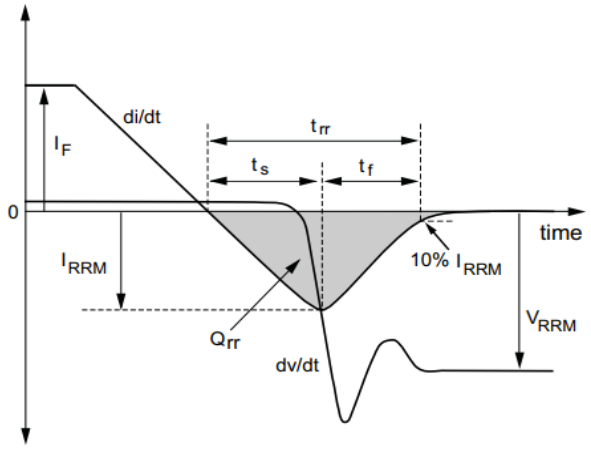



Fig 1 Diode Reverse Recovery Waveform Definitions

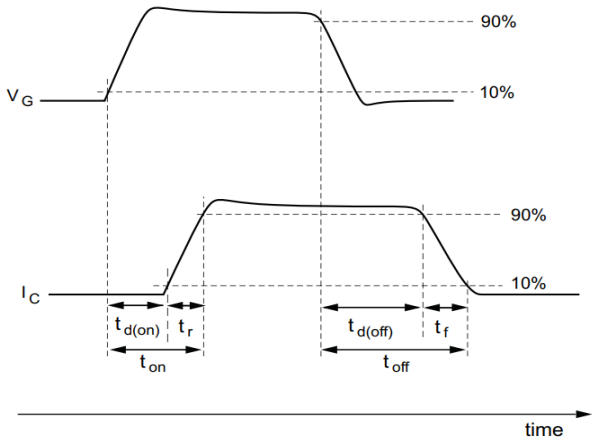
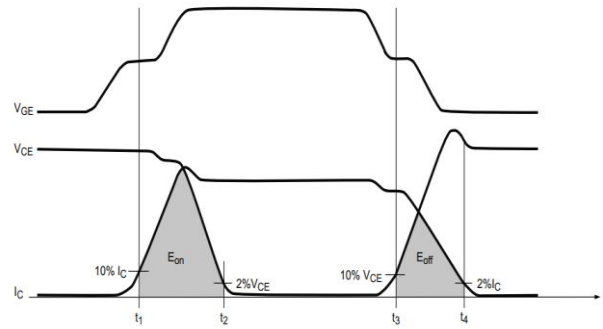



Fig 2 IGBT Switching Times Definitions



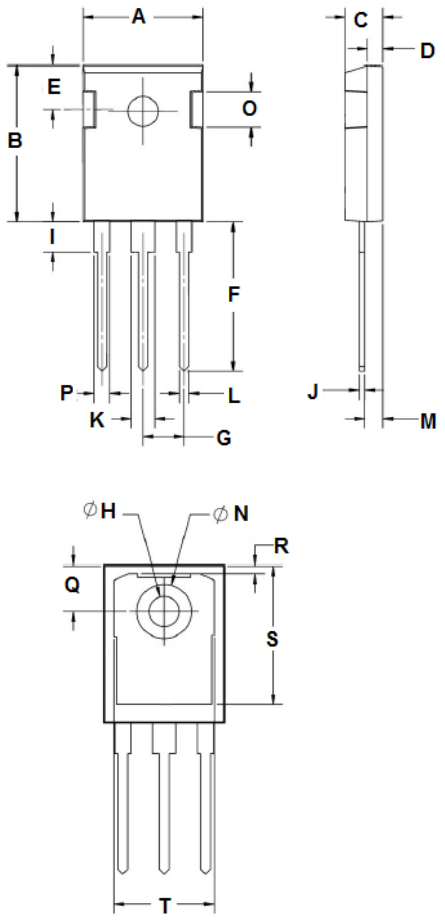

Where

$$E_{on}=\int_{t_1}^{t_2} V_{CE}\, I_C\, dt$$

$$E_{off}=\int_{t_3}^{t_4} V_{CE}\, I_C\, dt$$

Fig 3 IGBT Switching Energy Loss Definitions

## Package Outline Dimensions (Unit: mm)




| TO-247 | | |
|---|---|---|
| **Dimension** | **Min.** | **Max.** |
| A | 15.50 | 16.10 |
| B | 20.70 | 21.30 |
| C | 4.70 | 5.30 |
| D | 1.80 | 2.20 |
| E | 5.20 | 5.80 |
| F | 19.70 | 20.30 |
| G | 5.20 | 5.60 |
| H | 3.30 | 3.70 |
| I | 3.90 | 4.30 |
| J | 0.50 | 0.70 |
| K | 2.80 | 3.20 |
| L | 1.00 | 1.40 |
| M | 2.20 | 2.60 |
| N | 7.00 | 7.20 |
| O | 4.90 | 5.30 |
| P | 1.80 | 2.20 |
| Q | 5.70 | 6.10 |
| R | 0.80 | 1.20 |
| S | 17.00 | 17.80 |
| T | 13.60 | 14.20 |